Handbook

of

HUMANITARIAN

HEALTH CARE

LOGISTICS

Designing the Supply Network and

Managing the Flows of

Information and Health Care Goods in

Humanitarian Assistance during

Complex Political Emergencies

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To all those not content with mediocrity

and those who have not lost their enthusiasm

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ABOUT THE AUTHOR

George Mc Guire, born in Austria, was a volunteer with the Austrian Red Cross where he trained as an emergency medical technician and also rendered services as conscientious objector. He trained, and for five years practiced, as a nurse and published a specialists' book on intensive care nursing in 1994 ("Pflegeprobleme Intensivmedizin", Springer).

He earned a MSc in Logistics and Supply Chain Management from Cranfield University in 2000, developing an inventory management strategy for an international humanitarian organization in Geneva for his thesis. Following the acceptance of his thesis ("Development of a supply chain management framework for health care goods provided as humanitarian assistance in complex political emergencies") by the Institute for Transport and Logistics Management, he received a doctorate from the Vienna University of Economics and Business 2006.

He started humanitarian work in two small primary health care projects in the North of Vietnam in 1995, participated in an emergency vaccination campaign in Liberia the same year and then worked in Afghanistan for more than two years. In 1999 he worked in North Kenya, providing services to a surgical field hospital as well as health programmes in South Sudan. In 2001 he undertook various short missions to Sudan, the Democratic Republic of Congo, the Russian Federation, Rwanda and Kenya. Following the war in Afghanistan in 2001, he worked at a logistics centre in Pakistan for two years with a short mission to Baghdad at the beginning of the Iraq war in 2003. After a short mission to Darfur in 2004, he worked at a regional logistics centre in Nairobi with short missions to Uganda and Somalia.

Since 2005 he has been working at the headquarters of an international humanitarian organization in Geneva and undertaken, among others, numerous field missions to Pakistan after the earthquake in 2005, to Beirut during the Lebanon war in 2006, Liberia, Pakistan, Israel and the Occupied Territories, Jordan, Afghanistan, Pakistan, Iraq, Sudan, Kenya, Chad, the Democratic Republic of Congo, Sri Lanka, Zimbabwe and the Ivory Coast. In 2010 he participated in the first emergency response to the Haiti earthquake and worked during the conflict in South Kyrgyzstan. During his 14 years of humanitarian work, he spent a total of 10 years in the field in 50 different places in 25 countries.

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NOTATION

α	Smoothing constant alpha, level of significance of test
B	tolerable error bond
BO	backorder
C_t	cyclicality for time period t
d	aggregate customer demand
$\bar{d}$	average demand
d_t	value of aggregate demand for time period t
F	forecast
F_{t+1}	forecast for time period t+1
k	order of moving averages
IP	inventory position
LT	(expected) replenishment lead time
$\overline{LT}$	average replenishment lead time
t	time period
N	number of time periods for which values are available, population
P_t	periodicity for time period t
Q	fixed order quantity
Q_o	variable order quantity
Q_{EOQ}	economic order quantity
r	coefficient of correlation
r^2	coefficient of determination
R	review period (length of)
R_t	randomness for time period t
σ	standard deviation
σ_d	standard deviation of aggregate customer demand
σ_{LT}	standard deviation of expected replenishment lead time
s	reorder level
S	order-up-to-level
S_{IL}	imprest level (order-up-to-level)
SoH	stock on hand
SoO	stock on order
SS	safety stock
$s_{y,x}$	standard error of estimates

T_t	trend for time period t
Var	variability (of aggregate demand)
z	safety factor
°	degree (Celsius)

ABBREVIATIONS AND ACRONYMS

A

A	Ampere
ac	ante cibum (before meals)
A/C	air-conditioning, aircraft
A/D	analogue-to-digital
a/m	above mentioned
A/W	actual worth, airworthy
ABC	activity-based costing, airway breathing circulation
abdom.	abdominal
ABP	arterial blood pressure
ABS	acrylonitrile butadiene styrene (plastic)
abs.	absolute(ly)
AC	air-conditioning, alternating current
AC/DC	alternating current / direct current
acad.	academic
ACE	Angiotensin-converting enzyme
ACF	autocorrelation function
acft	aircraft
acog	aircraft on ground
acpt.	acceptance
ACT	artemisin derivative combination (therapy)
act.	active
ad us. ext.	ad usum externum (for external use)
AD	auto-disable (syringe)
ADH	antidiuretic hormone
adm.	administration, administrative
ADR	adverse drug reaction
AEFI	adverse events following immunization
Af.	Africa(n)
AFB	acid-fast bacilli
AFP	Agence France-Presse
Afr.	Africa(n)
Ah	Ampere hour

AICF	Action International Contre la Faim
AIDS	acquired immune deficiency syndrome
AKA	above-knee amputation
alb.	albumin
alc.	alcohol
ALITE	Augmented Logistics Intervention Team for Emergencies (WFP)
ALNAP	Active Learning Network on Accountability and Performance in Humanitarian Assistance
alt.	altitude
AMA	against medical advice
Amb.	ambulance
amp.	ampere, amplitude, ampoule
AMTOR	Amateur Microprocessor Teledata over Radio
anaes.	anaesthesia, anaesthetic
anal.	analogue, analogous
anat.	anatomy, anatomical
ANC	ante natal care
ANS	American National Standards
ans.	answer
ANSI	American National Standards Institute
aob	any other business
aog	aircraft on ground
AP	antipersonnel (mine)
API	active pharmaceutical ingredient
apmt.	appointment
app.	apparatus, appendix, approximately
APR	adjustable pallet racking
Apr.	April
aq. dest.	aqua destillata (distilled water)
aq.	aqua (water), aqueous
AQL	acceptable quality level
AR	autoregressive, autoregression
ar.	arrival, arrived
ARI	acute respiratory infections
ARIMA	autoregressive integrated moving average
ARMA	autoregressive moving average

ARQ	automatic repeat request mode
arr.	arrival, arrived
ARV	antiretroviral
asap	as soon as possible
ASCII	American Standards Code for Information Interchange
ASN	Advance Shipping Notice (Notification)
assmt.	assessment
assoc.	associated, association
at.	atmosphere, atomic
ATA	Admission Temporaire/Temporary Admission, actual time of arrival
ATC	air traffic control, anatomical therapeutic chemical (classification)
ATD	actual time of departure
ATM	automatic teller machine
atm.	atmosphere (unit of pressure), atmospheric
ATT	antitetanus toxoid
att.	attached
attn.	attention, for the attention of
attrib.	attribution
ATV	all-terrain vehicle
Aug.	August
auth.	authentic, author, authorized
auto.	automatic, automobile, automotive
aux.	auxiliary
AV	atrioventricular
av.	average
avg.	average
avia.	aviation
avn	aviation
AWB	air waybill

B

b.d.	bis die (twice daily)
B/L	bill of lading
b/w	black and white
B/W	black and white
BCG	Bacille Calmette-Guérin vaccine (for tuberculosis)

bef.	before
betw.	between
BGAN	Broadband Global Area Network
BI	bomb injury, bone injury
BID (b.i.d.)	bis in die (two times a day)
biochem.	biochemistry
biol.	biological, biology
BIOS	basic input-output system
bit	binary digit
BKA	below-knee amputation
bl	bill of lading
bl.	bale, black, blue
bldg	building
BMI	body-mass index
BMJ	British Medical Journal
BNF	British National Formulary
BOM	bill of materials, beginning of mission
BP	British Pharmacopoeia, blood pressure
bpm	beats per minute
BPP	Bin Packing Problem
bps	bits per second
Bq	becquerel
BS	British standard
Bs/L	bills of lading
bsc	basic
BSI	British Standards Institution
BThU	British thermal unit
btl.	bottle
btm.	bottom
BTS	blood transfusion services
Btu	British thermal unit
BW	body weight, bonded warehouse
bx	box

C

c	centi-, concentration, cubic

c.	capacity, centigram, copyright
C	Celsius
C&E	Customs and Excise
c&f	cost and freight
C/D	customs declaration
c/o	care of
c/s	cycles per second
C/S	cycles per second
ca.	circa (about)
cal	calorie
Cal	kilocalorie
cal.	calendar
calc.	calculate, calculated
CAM	computer-aided manufacture, computer-assisted manufacture
canc.	cancellation, cancelled
CAO	Cargo Aircraft Only
cap.	capacity
caps.	capsule
CAPD	continuous ambulant peritoneal dialysis
caps.	capsule
CARE	Cooperative for Assistance and Relief Everywhere, Cooperative for American Relief Everywhere
carr.	carriage
cas.	casualty
cat.	catalogue, category
cath.	cathode
CBFA	community based first aid
CBFLT	counterbalanced forklift truck
CC	chamber of commerce
cc	carbon copy, cubic centimetre(s)
CCC	Customs Cooperation Council
CCIS	cold chain information series
CCM	cold chain monitor (card)
ccw	counter clockwise
CD	compact disc
CDC	Center for Disease Control and Prevention

CDD	control of diarrhoeal diseases
CD-ROM	compact disc read-only memory
CE	Conformité Européene
CEIS	computerized EPI information system
Cel(s).	Celsius
CEN	Comité Européen de Normalisation (European Committee for Standardization)
cen.	central, centre
cent.	centigrade, central
CEO	Chief Executive Officer
CEP	Certificate of suitability to the European Pharmacopoeia
CFA	Clearing and forwarding agent
CFC	chlorofluorocarbon
cfm	confirm(ation)
CFR	Cost and Freight
cft	craft
cg	centigram, centre of gravity
cge	carriage, charge
cGMP	current good manufacturing practice
cgo	cargo
CH	Charier
chan.	channel
chap.	chapter
char.	character
CHE	complex humanitarian emergency
CHF	Swiss Francs
chg.	change, charge
chq.	cheque
chron.	chronological
CHW	community health worker
CIDA	Canadian International Development Agency
CIF	Cost, Insurance and Freight
CIP	Carriage and Insurance Paid to
CIPS	Chartered Institute of Purchasing and Supply
cir.	circa, circle, circular, circulation, circumference
circ.	circa, circuit, circle, circumference

CISG	Contracts for the International Sale of Goods
cit.	citrate
cl	carload, centilitre
Cl	chlorine
clin.	clinic, clinical
cm	centimetre
CMI	co-managed inventory
CMS	central medical store
CNS	central nervous system
cntr.	container
COD	cash on delivery, collect on delivery
Cod.	codex
coeff.	coefficient
conc.	concentrate, concentrated, concentration
cons.	consignment, consecutive
const.	constant
constr.	construction
cont.	container, contents
contr.	contract, control
corr.	correct, corrected, correspondence
COS	cash on shipment
COSHH	Control of Substances Hazardous to Health
COT	course of therapy
CoV	coefficient of variation
cp	carriage paid
CPD	Carnet de Passage en Duane
CPE	complex political emergency
CPI	Corruption Perception Index
cpi	characters per inch
cpm	cycles per minute
CPP	certificate of pharmaceutical product
Cpt.	captain
CPT	Carriage Paid To
CPU	central processing unit
CR	claim report

crg.	carriage
CRT	cathode-ray tube
CS	carbon steel
CSF	cerebrospinal fluid
CSL	customer service level
CSSD	central sterile supplies department
CTCSS	continuous tone controlled squelch system
ctn	carton
ctr.	centre
cts.	crates
cu.	cubic
cub.	cubic
ctf.	certificate, certify
cum.	cumulative
Cur.	currency
CUSUM	cumulative sum
CV	curriculum vitae
cw.	clockwise
CXR	chest X-ray
cyc.	cycle
cyl.	cylinder

D

d	day, deci-, diameter, relative density, thickness
D	diameter
D/A	digital-to-analogue
D/C	discharge (of a patient)
D/W	dead weight
D5W	5% dextrose in water
DAF	Delivered At Frontier
DALY	disability-adjusted life years, disease-adjusted life years
DANIDA	Danish International Development Assistance
DAP	Action Programme on Essential Drugs
DART	disaster assistance relief team
dB	decibel
DB	database

DBA	database administrator
dbl.	double
DBR	debridement
DC	distribution centre, direct current
dcg	decigram
dct	document
dd	due date, due day
DDD	defined daily dose
DDP	Delivered Duty Paid
DDU	Delivered Duty Unpaid
dec.	decimal
Dec.	December
DEC	decimal (measurement for diameter of sutures)
deg.	degree
del.	delivered
dem.	demurrage
demur.	demurrage
dep.	department, departure
DEQ	Delivered Ex Quay
DES	Delivered Ex Ship
desp.	despatch
destn	destination
DFID	Department for International Development (UK)
DFMS	deep field mailing system
DG	dangerous goods
dg	decigram
DGD	dangerous goods declaration
DHA	Department of Humanitarian Affairs
dia.	diagnose, diagram, diameter
diag.	diagnose, diagonal, diagram
diam.	diameter
diet.	dietary
diff.	difference
dil.	dilute, dilution, diluted
DIN	Deutsches Institut für Normung (German national Standards Organization)

dir.	direct
DIS	diagnostic imaging services
dis.	discharge, dispense, distribute
disc.	discount
disp.	dispensary, dispense
diss.	dissolve
dist.	distance, distilled, district
distr.	distribution, distributor
dl	decilitre
DM	disaster management
dm	decimetre
DMA	double moving averages
DMF	drug master file
dmg.	damage
DMIS	drug management information system
DMO	district medical officer
DNA	deoxyribonucleic acid
Doc.	doctor
doc.	document(s)
docu.	document, documentation
Domed	doctor of medicine
DOS	days of supply
DOTS	Directly Observed Treatment Short Course (schedule)
doz.	dozen
DP	displaced person
DPC	delayed primary closure
dpl.	diploma, duplex
DPT	diphtheria, pertussis, tetanus (vaccine)
dpt	department, depot
Dr	doctor
DRA	drug regulatory authority
DRCF	Disaster Relief Communication Foundation
DrMed	doctor of medicine
DRP II	distribution resources planning
DRP	distribution requirements planning

DRSE	drug-related side-effects
Dsg	dressing
dstn	destination
DT	diphtheria-tetanus toxoid (vaccine)
DTP	diphtheria-tetanus-pertussis (vaccine)
dup.	duplicate
DVT	deep-vein thrombosis
dw	dead weight, delivered weight
DWT	deadweight tonnage
dy	delivery
dz.	dozen

E

ea.	each
EAN	European Article Number
e/c	enteric-coated
EC	European Commission
ECG	electrocardiogram, electrocardiograph
ech.	echelon
ECHO	Equipment for Charity Hospitals Overseas
ECHO	European Community Humanitarian Office
ECR	efficient consumer response
ed.	edition, editor
EDA	expected date of arrival
EDD	earliest due date
EDI	electronic data interchange
EDL	essential drug list
edn	edition
EDP	extended delivery point
EDTA	ethylene diamine tetra-acetate
EEG	electroencephalogram
EF	external fixation
EFTA	European Free Trade Association
eg	exempli gratia (for example)
el.	electric, electrical, electricity
elec.	electric(al), electricity

electr.	electrical
ELISA	enzyme-linked immunosorbent assay
elix.	elixir
EMS	emergency medical service
EMT	emergency medical technician
EN	European norms
En.	engineer
enc.	enclosed, enclosure
encl.	enclosed, enclosure
eng.	engine, engineering
ENT	ear, nose and throat
EO	ethylene oxide
EOI	economic order interval, expression of interest
EOM	end of mission
EOQ	economic order quantity
EP	European Pharmacopoeia
EPI	Expanded Programme on Immunization
epid.	epidemic
EPROM	electrically erasable, programmable, read-only memory
equip.	equipment
ERP	enterprise resource planning, economic review period
ERT	emergency response team
ERU	emergency response unit
esp.	especially
ESR	erythrocyte sedimentation rate
et. al.	et alii (and others)
ETA	estimated time of arrival
ETD	estimated time of departure
ETO	ethylene oxide
EU	European Union
EWMA	exponentially weighted moving average
exp.	expired, export
expl.	explosion, explosive
ext.	external, extraction
EXW	Ex Works

F

f.	following (page)
FA	first aid
facs.	facsimile
FAO	Food and Agriculture Organization
FAP	first aid post
FAS	Free Alongside Ship
fax	facsimile transmission
f/c	film-coated
FCA	Free Carrier
FCFS	first come, first served
FCL	full container load
fcty	factory
FDA	Food and Drug Administration
FDC	fixed-dose combination
Feb	February
FEFO	first expiry, first out
fem.	female
ff.	following (pages)
FFD	focus film distance
FG	French gauge (catheter scale, diameter)
fgt	freight
FIFO	first in, first out
FILO	first in, last out
FIP	Fédération Internationale Pharmaceutique
fit	free in truck
Flt	flight
FLT	forklift truck
FOB	Free On Board
FOC	free of charge
fos	free on ship
FOT	free on truck
fow	free on wagon
FPA	free of particular average
FR	French (catheter scale, diameter)

freq.	frequency
frm	from
frt	freight
ft	foot, feet
FTL	full truckload
fut.	future
FW	freeze watch indicator
fwd	forward
fwdg	forwarding

G

g	gram
G	Gauge
g.	gauge
GA	general anaesthesia
gal	gallon
GAVI	Global Alliance for Vaccines and Immunization
GDDP	good drug donation practice
GDP	good distribution practice, gross domestic product
gds	goods
GenSet	generator set
GH	general hospital
GHTF	Global Harmonization Taks Force
GI	gastrointestinal
GIEWS	global information and early warning system
GIGO	garbage in, garbage out
GIS	geographic information system
g/l	grams per litre
GLC	gas-liquid chromatography
GMP	good manufacturing practice
GMT	Greenwich Mean Time, Greenwich Meridian Time
GNP	gross national product
Gov.	government, governor
GP	general practitioner
GPS	Global Positioning System
GPUS	general purpose ultra sound scanner

gr.	gram
grm	gram
GRT	gross registered tonnage
GSM	Global System for Mobile communications
GSP	good storage practices
GSW	gunshot wound
gt	gutta (drop)
gtd	guaranteed
GTDP	good trade and distribution practices
gtt.	guttae (drops)
guar.	guarantee(d)
gvt	government
GVW	gross vehicle weight
GWP	global warming potential
Gy	gray (SI unit)
gyn.	gynaecological, gynaecology

H

H x W x L (D)	height by width by length (depth)
h	height, hospital
h.	height, hour
ha	hectare
HA	humanitarian assistance
HAC	Humanitarian Action in Crisis (WHO)
har.	harbour
HAV	hepatitis A virus
haz.	hazardous
Hb	haemoglobin
hbr	harbour
HBV	hepatitis B virus
HC	health centre
HCFC	hydrochlorofluorocarbon
hCG	human chorionic gonadotropin
HCl	hydrochloride
HCT	haematocrit
HCV	hepatitis C virus

HDL	high-density lipoprotein
HDPE	high density polyethylene
HDV	heavy-duty vehicle
hel.	helicopter
hem.	haemoglobin, haemorrhage
HEPA	high efficiency particulate air [filter]
HepB	Hepatitis B
HEWS	humanitarian early warning system
HF	high frequency
HFC	hydrofluorocarbon
HGV	heavy goods vehicle
Hib	haemophilus influenzae type b (vaccine)
HINAP	High Intelligence Network for Advance Contingency Planning
HIP(S)	high impact polystyrene
HIS	health information system
hist.	histology
HIT	health information team
HIV	human immunodeficiency virus
HLA	human lymphocyte antigen
hmd	humid
hms	hours, minutes, seconds
hor.	horizontal
hosp.	hospital
hp	horse power
HP	horsepower
HPLC	high-performance (or high-pressure) liquid chromatography
hq	headquarters
hr	hour
HR	heart rate, human resources
HRC	Rockwell hardness (scale)
hrs	hours
HSV	herpes simplex virus
hum.	human
hund.	hundred
hyd.	hydraulic

hyg.	hygiene
hyp.	hypodermic
Hz	Hertz

I

I	electric current, iodine
IAPSO	Inter-Agency Procurement Services Office (United Nations)
IAS	international accounting standards
IATA	International Air Transport Association
IBC	intermediate bulk container
i/c	in charge
ICAO	International Civil Aviation Organization
ICB	international competitive bidding
ICC	International Chamber of Commerce
ICD	inland container depot, international classification of diseases
ICH	International Conference on Harmonisation (of Technical Requirements for Registration of Pharmaceuticals for Human Use)
ICRC	International Committee of the Red Cross
ICT	information and communication technology
ICU	intensive care unit
id	inner diameter
id.	idem (the same)
ID	intradermal, identification, inside diameter
ID card	identification card
IDA	International Dispensary Association
IDC	indwelling catheter
IDD	insulin-dependent diabetes
IDP	internally displaced person
ie	id est (that is)
IEHK	interagency emergency health kit
IFB	invitation for bids
IFR	instrument flying regulations
IFRC	International Federation of Red Cross and Red Crescent Societies
IHL	International Humanitarian Law
IID	insulin-independent diabetes
I/L	import licence

ILO	International Labour Organization
ILR	ice-lined refrigerator
im	intramuscular
IM	intramuscular
IMARSAT	International Maritime Satellite Organization
IMF	International Monetary Fund
IMI	intramuscular injection
immun.	immunity, immunization
IMO	International Maritime Organization, International Meteorological Organization
Imp.	imperial, importer
IMPACT	International Medical Products Anti-Counterfeiting Taskforce
in.	inch(es)
INCB	International Narcotics Control Board
incl.	include, including
INCO (term)	international commercial (term)
incr.	increased, increasing
ind.	independent, industrial
indiv.	individual
infl.	inflammable
info.	information
INGO	international non-governmental organization
inj.	injection, injury
Inmarsat	International Maritime Satellite Organization
INN	international nonproprietary name
in s.	in situ
insp.	inspect, inspected
inst.	instrument
Inst.	institute
instr.	instrument
IO	international organization
I/O	input-output
IOM	International Organization for Migration
IP	International Pharmacopoeia, ice-pack
IPV	inactivated polio vaccine
IQ	intelligence quotient

irreg.	irregular
ISO	International Standards Organization
isol.	isolate, isolated
it	in transit
IT	information technology
ITN	insecticide treated mosquito nets
ITR	inventory turn ratio
ITSH	(inland) internal transport, storage and handling
ITT	invitation to tender
ITU	International Telecommunication Union
iu	international unit
IU	international unit
I.U.	international unit
iv	intravenous(ly)
IV	intravenous(ly)
IVB	Immunization, Vaccine and Biologicals (World Health Organization)

J

J	joule
Jan	January
JE	Japanese encephalitis
JIT	just-in-time
JP	Japanese Pharmacopoeia
Jul.	July
Jun.	June

K

k	kilo-
K	Kilo- (computing), potassium (element)
kb	kilobar
KB	kilobyte
kcal	kilocalorie
kg	kilogram
kHz	kilohertz
kid.	kidney
kJ	kilojoule

km	kilometre
kmph	kilometres per hour
kPA	kilo Pascal
kph	kilometres per hour
KPI	key performance indicator
kt	knot
kV	kilovolt
kVA	kilovolt-ampere
KVO	keep vein open
kW	kilowatt
kWh	kilowatt hour

L

l	litre
L	left, litre
L&D	loss and damage
LA	local anaesthesia
lab.	label, laboratory, labour
laev.	laevus (left)
LAMA	leave against medical advice
LAN	local-area network
lang.	language
lat.	lateral
lb	libra (pound)
LB	local battery (system)
LC	land cruiser, landing craft, letter of credit, liquid chromatography
L/C	letter of credit
LCA	logistics capacity assessment
LCD	liquid-crystal display
LCL	less-than-carload lot, less-than-container load, lower control limit
Ld	limited (company)
LDC	less developed country
lds	loads
LED	light-emitting diode
LEOS	low earth orbit satellite
let.	letter

lic.	licence, licensed
LIFO	last in, first out
LIFR	line item fill rate
LILO	last in, last out
lim.	limited
liq.	liquid, liquor
LLDC	least developed countries
LLDPE	linear low density polyethylene
ln	natural logarithm
loc	letter of credit
loc.	local
LP gas	liquid propane gas
LPG	liquefied petroleum gas
LPM	litres per minute
LQL	limiting quality level
LRRD	linking relief, rehabilitation and development
LSB	lower side band
LSD	lysergic acid diethylamide
lst	local standard time
LST	local standard time
LTL	less-than-truckload-lot
ltr	letter, litre
LTSH	landside transport, storage and handling
lub(r).	lubricant, lubricate
LW	long wave

M

m	metre, milli-, million, molality
m.	male, meridies (noon)
m^2	square metre
m^3	cubic metre
mA	milliampere
MA	moving average
MAC	maximum allowable concentration
mach.	machinery
MAD	mean absolute deviation

MAE	mean absolute error
man.	manual, manufacturer
manf.	manufacturer
MAPE	mean average percentage error
Mar.	March
marit.	maritime
max.	maximum
mb	millibar
MB	megabyte
mbar	millibar
MBP	mean blood pressure
MCH	mother and child health
MD	medicinae doctor (doctor of medicine)
MdM	Médecins du Monde
ME	mean error
MEFO	most exposed, first out (VVM)
mega-	million
memo.	memorandum
MERLIN	Medical Emergency Relief International
MES	mobile earth station
MESC	Material and Equipment Standards and Code
MFA	Ministry of Foreign Affairs
mfd	manufactured
mfg	manufacturing
mfr.	manufacture, manufacturer
mfst	manifest
mg	milligram, morning
mge	message
mgr	manager
Mgr	manager
mgt	management
MHE	mechanical handling equipment
MHz	megahertz
MI	mine injury, myocardial infarction
mi.	mile, minute

micro-	one-millionth
mid.	middle
milit.	military
mill.	million
min.	minimum, minute
Min.	ministry
MIS	management information system
MKT	mean kinetic temperature
ml	millilitre
mm	millimetre
mmHg	millimetre of mercury
mmol	millimole
MMR	measles-mumps-rubella (vaccine)
mnm	minimum
MoD	Ministry of Defence
MODEM	modulator demodulator
MOF	Ministry of Finance
MOH	Ministry of Health
mol.	molecular, molecule
MOPH	Ministry of Public Health
MOQ	minimum order quantity
morph.	morphological, morphology
mort.	mortality, mortuary
MoT	Ministry of Transport
mot.	motor, motorized
MOU	memorandum of understanding
mPa	milli Pascal
MPE	mean percentage error
MPH	Master of Public Health
mph	miles per hour
MPP	multisource pharmaceutical product
mps	metres per second
MR	measles-rubella (vaccine)
m/r	modified-release
MRI	magnetic resonance imaging

MRP	material requirements planning
MRPII	manufacturing resource planning
MSc	master of science
MSD	mean squared deviation
MSE	mean squared error
MSF	Médecins sans Frontières
msg.	message
MSH	Management Sciences for Health
mt	metric ton
mth	month
mtr	metre
MUAC	mid-upper-arm circumference
mV	millivolt
mW	milliwatt
MW	megawatt
M/W	midwife

N

n	nano-
N	newton, population (statistics)
n/a	not applicable, not available
N/A	not available
Na	sodium
NaCl	sodium chloride
nat.	national
natl	national
NATO	North Atlantic Treaty Organization
NBS	National Bureau of Standards
NBTS	National Blood Transfusion Service
nc	no charge
ND	normal distribution
NEDL	national essential drug list
neg.	negative
NEHK	New Emergency Health Kit
NF1	naive forecast 1
NF2	naive forecast 2

NG	nasogastric
ng	not given
NGO	non-governmental organization
NGP	nominal group process
NGT	nasogastric tube
NHS	National Health Service
NiCd	nickel-cadmium (battery)
NID	national immunization day
nis	not in stock
NNT	neonatal tetanus
no.	north, number
norm.	normal
nos	not otherwise specified
nos.	numbers
Nov.	November
NOX	nitrogen oxide
npo	nil per os, ne per oris (nothing oral)
nr	number
NSAID	non-steroidal anti-inflammatory drug
ntfy	notify
num.	number
nutr.	nutrition
NVOCC	nonvessel operating common carriers

O

obstet.	obstetric, obstetrician
OBV	ocean boarding vessel
OC	organization chart
occ.	occasional
OCHA	Office for the Coordination of Humanitarian Affairs (United Nations)
OCT	order cycle time
Oct.	October
od	omni die (once a day)
od	outer diameter
OD	optical density
O/D	on deck

ODI	Overseas Development Institute
OECD	Organization for Economic Cooperation and Development
OEM	original equipment manufacturer
OFR	order fill rate
OK	all correct
om	omni mane (in the morning)
on	omni nocte (at night)
OPD	outpatients' department
ophthal.	ophthalmic, ophthalmology
ops	operations
OPT	optimized production technology
OPV	oral polio vaccine
OR	operations research
orig.	original
ORS	oral rehydration salt
ORT	oral rehydration therapy (treatment)
OTC	over-the-counter
OTIF	on-time, in-full
OUL	order-up-to-level
OXFAM	Oxford Committee for Famine Relief
oz	ounce

P

p	page, pressure, pulse
p.	page
P	pressure
PA	polyamide
PABX	private automatic branch exchange
PACTOR	PACket radio and amTOR (combination of)
PAHO	Pan American Health Organization
part.	partial
pass.	passenger
PATH	Program for Appropriate Technology in Health
PAX	private automatic telephone exchange
PBB	polybrominated biphenyls
PBDE	polybrominated piphenyl ethers

PBX	private automatic branch exchange
pc	post cibum (after food)
pc.	piece, percentage, price
PC	personal computer
pcl	parcel
pcs	pieces, prices
PDM	physical distribution management
PE	polyethylene
PEP	peak envelope power, post-exposure prophylaxis
PER	product evaluation reporting scheme
PET	polyethylene terephthalate
pH	acidity / alkalinity scale
PH	public health
phar(m).	pharmacist, pharmacopoeia, pharmacy
PHC	primary health care
phys.	physical, physician, physiology
physiol.	physiological
PIC	Pharmaceutical Inspection Convention
PIS	product information sheet
pkg	packing, parking
pkg.	package
PL	packing list
PLMN	public land mobile network
PMR	private mobile radio
po	per os (by mouth)
POD	place of delivery
POM	prescription only medicines
POP	plaster of Paris [gypsum bandage]
port.	portable
pos.	position, positive
POW	prisoner of war
powd.	powder
pp	post prandium (after a meal)
pp.	pages
PP	polypropylene

ppm	parts per million
PPM	planned preventive maintenance
PQS	Performance, Quality, Safety
pr	per rectum
press.	pressure
priv.	private
proj.	project
PS	polystyrene
psf	pounds per square foot
PSF	Pharmaciens sans Frontières
psi	pounds per square inch
PSTN	public switched telephone network
psych.	psychological, psychology
PTB	Pulmonary tuberculosis
PTFE	polyetrafluorethylene
pts	parts
PTSD	post-traumatic stress disorder
pub.	public
pulv.	pulvis (powder)
pur.	purchase, purchaser
PUR	polyurethane
purch.	purchaser
PV	photovoltaic
PVC	polyvinyl chloride (synthetic resin)
PVO	private voluntary organization
pvt(e)	private

Q

QA	quality assurance
QC	quality control
QD (q.d.)	quaque die (once a day)
QDS (q.d.s.)	quater in die sumendus (four times daily)
QID (q.i.d.)	quater in die (four times a day)
QIPS	quick impact projects
qlty	quality
qnty	quantity

QOTIF	quality, on-time, in-full
qt.	quantity
qty	quantity
quant.	quantity

R

r.	radius, right
R	right
R11	type of refrigerant
R12	type of refrigerant
ra.	radio
radar	radio detection and ranging
radn	radiation
RAM	random-access memory
RAP	rapid assessment procedures
RBC	red blood cell, red blood count
RBM	roll back malaria
RC/RC	Red Cross / Red Crescent
rcd	received
R&D	research and development
RDF	revolving drug fund
rec.	receipt, record
recom.	recommended
ref.	reference
refrig.	refrigerate, refrigeration, refrigerator
reg.	register, registration
rel.	relative
req.	request, required
resp.	respiration
RF	radio frequency
RFID	radio frequency identification
RFP	request for proposal
RFQ	request for quotation
RH	relative humidity, reproductive health
Rh	rhesus factor
RHF	rural health (care) facility

RL	Ringer's lactate (infusion solution)
rnd	round
rnwy	runway
RO	reverse osmosis
ROL	reorder level
ROM	read-only memory
ro-ro	roll on-roll off (ferries)
rpm	revolutions per minute
R&R	rest and recreation
R/T	radio telegraph
RTP	returnable transport packaging
rwy	railway

S

s	second
san.	sanitary
SATCOM	satellite communications
SATPHONE	satellite telephone terminal
sc	subcutaneous
sc.	scientific
SC	Security Council, subcutaneous
s/c	sugar-coated
scd	scheduled
SCF	Save the Children Fund
sch.	schedule
sec.	second, security
SED	shipper's export declaration
sep.	separate
Sep.	September
SES	single exponential "smoothing"
SFr	Swiss franc
SGS	Société Généralle du Surveillance
sh.	sheet
S&H	shipping and handling
shpt	shipment
SI	security incident, shelling injury, Système International (d'Unités)

sic.	siccus (dry)
sign.	signature
SITA	Société International de Télécommunications Aéronautiques
SITOR	simplex teleprinter over radio
SitRep	situation report
SKU	stock-keeping unit
SL	shelf-life
SMA	simple moving averages
SMF	site master file
sml.	small
SMS	short message service
S/N	shipping note
so.	southern
So.	southern
SOP	standard operating procedure
SPC	summary of product characteristics
spec.	specification
SPT	shortest processing time
sq.	square
SR	stock requisition
SRO	statuary rules and orders
SSB	single side band
stand.	standard, standardized
stat.	statistics, statim (immediately)
STD	sexually transmitted disease
std	standard
stk	stock
subst.	substitute
suff.	sufficient
sum.	summary
Sun.	Sunday
sup.	superior, superficial
supp(l).	supplement(ary)
surg.	surgeon, surgery, surgical
Sv	sievert

sw.	switch
SW	short wave
S/W	software
SWG	standard wire gauge
SWOT	strengths, weaknesses, opportunities, threats
SWR	standing wave ratio
syr.	syrup
syst.	system, systematic
sz.	size

T

t	thickness, tonne, Celsius temperature
T	telephone, temperature
tab.	tablet
TB	tuberculosis
TBA	traditional birth attendant
TBC	tuberculosis
TBPM	time based process mapping
Td	tetanus-diphtheria toxoid (vaccine)
tds	ter die sumendum (three times a day)
tel.	telegram, telephone
tel. no.	telephone number
telecom.	telecommunication(s)
teleph.	telephon(y)
temp.	temperature, temporary
ter.	territory
tet. tox.	tetanus toxin
TEU	twenty-foot equivalent unit
text.	textile(s)
tfc	traffic
TFC	therapeutic feeding centre
TFP	therapeutic feeding programme
th.	thermal
THC	terminal handling charges
theor.	theoretical
therap.	therapeutic

therm.	thermometer
thk	thick
TID (tid)	ter in die (three times a day)
TIR	Transport International Routier (International Road Transport)
tis.	tissue
TL	truck load
TLC	thin-layer chromatography
TM	trademark
TNC	terminal node controller
TOD	time of delivery
tonn.	tonnage
TOR	teleprinter over radio, terms of reference
ToT	training of trainers
tot.	total
tox.	toxic, toxicology
TQC	total quality control
TQM	total quality management
TR	transport request
transf.	transferred
transp.	transport, transportation
trav.	travel
trf	tariff
trf.	transfer
T/S	transhipment
tsp.	teaspoon
TST	time, (saturated) steam and temperature (sterilization indicator)
TT	tetanus toxoid (vaccine)
TTM	time temperature monitor
tub.	tubular
tuberc.	tuberculosis
tx	tax

U

u.	unit
UCL	upper control limit
UHF	ultra-high frequency

UIC	Union Internationale des Chemins de Fer (International Union of railways)
UL	unit load
ULD	unit load device
u/m	under mentioned
umbl.	umbilical
UN	United Nations
unacc.	unaccompanied
UNCITRAL	United Nations Commission on International Trade Law
UNDCP	United Nations Drug Control Programme
UNDHA	United Nations Department of Humanitarian Affairs
UNDP	United Nations Development Programme
UNDRO	United Nations Disaster Relief Organization
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFPA	United Nations Fund for Population Activities
UNHCR	United Nations High Commission for Refugees
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
UNIENET	United Nations Electronic Mail System
UNIPAC	United Nations International Packing Centre
univ.	universal
UNJLC	United Nations Joint Logistics Centres
UNO	United Nations Organization
unpub.	unpublished
UNRWA	United Nations Relief and Works Agency for Palestine Refugees in the Near East
unsat.	unsatisfactory
UNSECOORD	United Nations Security Coordinator
UOM	unit of measurement
up.	upper
UPS	uninterrupted power supply
ur.	urin, urinary
URI	upper respiratory infection
urol.	urology
US	ultra sound
USB	upper side band, universal serial bus

USP	United States Pharmacopeia
UTC	universel temps coordonné (coordinated universal time)
UTI	urinary-tract infection
UV	ultraviolet
UXO	unexploded ordnance

V

v	velocity, volume
V	volt, volume, five
VA	volt ampere, value-added
VAC	voltage alternating current
vacc.	vaccination, vaccine
VAD	vitamin A deficiency
val.	value
valid.	validate, validation
VAM	vulnerability analysis and mapping
vapor.	vaporization
vasc.	vascular
VAT	value-added tax
VDC	voltage direct current
VDRL	venereal disease research laboratory
veh.	vehicle
VEN	vital, essential, non-essential
vent.	ventilate, ventilation
vert.	vertebral, vertical
ves.	vesica (bladder)
vet.	veterinarian
VFR	visual flight rules
VGA	video graphics array
VHF	very high frequency
VHS	video home system
VHW	village health worker
vis.	viscosity, visibility
visc.	viscosity
VITA	Volunteers in Technical Assistance
vl	vial

vltg.	voltage
VMI	vendor managed inventory
VoIP	voice over internet protocol
vol.	volatile
vs.	versus (against)
VSAT	very small aperture terminal
vv	vice versa (the other way)
v/v	volume in volume
VVM	vaccine vial monitor

W

W	watt, weight
war.	warrant
warn.	warning
WatSan	water and sanitation
wb	waybill
WB	World Bank for Construction and Development, waybill
WBC	white blood cell, white blood count
wc	wheel chair
WCO	World Customs Organization
west.	western
WFI	water for injection
WFP	World Food Programme
wg	weighing
wh.	white
Wh	watt hour
WHIS	World Health Imaging System
WHIS-RAD	World Health Imaging System for Radiography
WHO	World Health Organization
whs.	warehouse
W/M	weight or measurement
WMA	weighted moving average
WMO	World Meteorological Organization
w/o	without
wr	war risk
WRI	war risk insurance

wro	war risks only
W/T	wireless telegraphy
WTO	World Trade Organization
w/v	weight to volume
ww	war-wound(ed), weapon-wound(ed)
w/w	weight for weight, weight in weight
www	World Wide Web

X

X	X-ray
XL	extra large
xmit	transmit

Y

yds	yards
YF	yellow fever
yr	year
yrs	years

Z

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1 INTRODUCTION

This handbook intends to provide national and expatriate staff with guidance for a systematic, consistent, effective and efficient approach to designing the supply network and managing the flow of health care goods provided as humanitarian assistance in the field. It attempts to provide all necessary knowledge and practical advice for managing the flow of information as well as the flow of physical goods throughout the entire supply network. It takes into account the constraints and limitations logisticians will find in less developed countries facing complex political emergencies.

This book focuses on the down stream legs of the supply network in the field rather than the legs in developed countries, where head offices and logistics centres may be based. Ample literature on all aspects of logistics and supply chain management on the later are already available. For the same reason this handbook focuses on humanitarian assistance rather than on disaster management.

This text is based on the assumption that the same underlying principles of supply chain management apply to all services provided to health care programmes in humanitarian assistance, regardless of their scale. For example the same principles for managing medical stocks apply to small medical stores, such as in clinics and hospital pharmacies, as to medium sized and large stores.

This handbook tries to cover all aspects of supply chain management from managing information and communication, carrying out an assessment, setting up medical stores, selecting and sourcing health care goods, transport and distribution. All chapters are written independently and can be understood without having to read any other chapter.

An attempt is made to balance theory and practice, to provide the theoretical knowledge and understanding while always focusing on the practical work of logisticians and providing practical, feasible and tested solutions. It should therefore be useful for logisticians who want to increase their knowledge and skills in a particular area as well as for logisticians who want to solve a practical problem or manage a situation which is new to them. Finally it should be a useful resource for any training in this field.

There seems to be a notion that not everyone can be a nurse or a surgeon but anybody can be a logistician. While it is true that anybody can manage health care goods, not everyone can manage them professionally, effectively and efficiently. It is the final intention of this book to contribute to improving the professionalism of humanitarian workers managing health care goods.

1.1 Audience

This book is intended for practitioners and humanitarian workers who are involved in managing health care goods in humanitarian assistance programmes. This includes staff whose primary responsibilities are providing logistics services at all levels of the supply network such as logistics managers, health care logisticians, medical purchasers, warehouse managers, storekeepers as well as staff managing transport. But it is also intended as a resource for health programme staff such as programme managers and health professionals working in health care facilities and which may be in charge of managing logistics. This handbook intends to provide professionally trained logisticians with the knowledge which is needed for managing the supply network in humanitarian assistance as well as the intricacies of managing health care goods. Moreover logisticians, even with ample experience in humanitarian assistance, who have managed other humanitarian assistance goods such as food and essential household

items may not be familiar with many issues specific to health care goods. Even experienced health care logisticians may find some interesting ideas and concepts which will allow them to improve their management and services.

On the other hand it is hoped that it will also be a valuable resource for health professionals which often have to manage health care goods without having been trained as logisticians and without having been prepared. Moreover health programme managers must understand the problems and limitations of supply chain management in humanitarian assistance even if they are not directly involved in logistics and it is vital to consider supply chain management from the very beginning of planning any health programme.

This handbook focuses on the particularly difficult situation of humanitarian assistance in acute and chronic complex political emergencies but most of the text applies to humanitarian assistance in general such as development work, especially since assistance in emergencies and development work is becoming more and more blurred.

The text does not require a professional background in either health or logistics and supply chain management. It is written for staff without experience in logistics but will hopefully also be a valuable resource for experienced staff and even specialists. All issues are discussed in simple language and all special terms are explained. A comprehensive glossary intends to assist the reader and explain a large variety of terms.

One important intention of this handbook is providing national staff, who may not have access to libraries or the Internet, with a complete resource. After all it is them, who carry out most of the work in day to day management of health care goods.

1.2 Concept

A vast number of academic publications and textbooks on supply chain management, humanitarian assistance and various specialized topics, such as cold chain management, are available. Literature on supply chain management focuses almost entirely on commercial supply chain management in developed countries or on development work. Literature on various specialist topics is available but difficult to find. Literature on logistics management in humanitarian assistance very often focuses on food aid and transportation management. Handbooks published by humanitarian organizations tend to focus on their administrative procedures and practical management rather than on the scientific foundation.

It is therefore the primary intention of this handbook to apply principles of supply chain management to the special environment of humanitarian assistance and to adapt them to the management of health care goods. One intention is also to show that managing health care goods is far more complex than managing storage and transport, a notion that is unfortunately quite common.

This handbook presents no new knowledge or ideas. Rather it is an attempt to compile and integrate information from various scattered sources, into a comprehensive text. In practice health care logisticians require knowledge on a variety of topics such as supply chain management, health care, pharmacology as well as engineering.

While the focus of this handbook is to be practical, it also attempts to be well founded rather than draw only on practical experience. Consequently a large number of documents have been carefully studied and references are made throughout the text. This should also allow the interested reader to study various topics in more detail.

This handbook is based on the assumption that sophisticated information technology (ERP, EDI, bar code technology etc.), taken for granted in academic textbooks, as well as

sophisticated storage and materials handling equipment will not be available and simple solutions are needed.

This text is built upon the belief that much of the knowledge, systems and methods which are useful in supply chain management in humanitarian assistance have already been developed in other fields and there is much to learn especially from commercial supply chain management. Very often there is no need to reinvent the wheel and waste precious resources which, despite the effort, may not lead to satisfactory solutions. Rather the issue is how to apply available knowledge to the specific circumstances of humanitarian assistance. Moreover the situations humanitarian workers face are not new but, especially in the field of logistics and supply chain management, there is a lack of documenting their experiences and allowing others to learn from them. This handbook includes the experience of the author which will allow others to built on.

Throughout this handbook the notion of customer service and the importance of continuously improving services is stressed. The title of the book stresses the importance of focusing on customers, health professionals and eventually patients, and focusing on managing their demand rather than on the upstream stages of the supply network and moving goods downstream through the supply network.

Another important notion is that logistics staff must focus on management of the supply network rather than being concerned with the administrative process or internal procedures. Logistics and supply chain management is far more than clerical processing of orders and filling the right papers.

The terminology in logistics and supply chain management is sometimes confusing because different references use different terms. Even in scientific literature different terms may be used in different ways by different authors. Often there is no consensus on the "right" meaning of a word. The meaning of the most important terms, as used in this handbook, is presented in the glossary with the respective reference. Great care is taken to use terminology consistently throughout the handbook. An effort is also made to avoid slang expression which are often ambiguous and can cause confusion.

Mathematics, especially in the chapter on inventory control, will be presented in the most basic way and without proofs. The interested reader can consult the listed references for more detailed studies. In principle the metric systems as well as SI (Système International) units are used throughout the handbook. While kilogram is the unit of mass, not weight, it is acknowledged that kilogram is commonly used as the unit of weight and the difference is insignificant (The United States Pharmacopoeia. Rockville: United States Pharmacopoeia Convention, Inc. 1995, Rockville, MD, 13).

The Internet is becoming an invaluable resource for humanitarian workers for technical information as well as information on complex political emergencies. While the Internet is not available in the field everywhere, it is a very efficient and fast means of obtaining information compared with ordering books or references from head offices. As far as possible references are made to documents which can be downloaded from the Internet free of charge.

The publication of this resource on the Internet is a means of worldwide distribution and at almost no cost, available to anybody with access to the Internet.

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2 HUMANITARIAN ASSISTANCE

The following chapter introduces humanitarian assistance and analyses the objectives, context and constraints of humanitarian organizations as well as the characteristics of health care goods.

2.1 Introduction

In the sixty years following the end of the Second World War a total of 228 armed conflicts in 148 locations throughout the world have been recorded, of which 118 took place in only 16 years after the end of the Cold War (Harbom, L., and P. Wallensteen 2005, 623).

During the fifty five years following the end of the Second World War 20 million people were killed and 50 were million injured in 160 major armed conflicts (Slim, H. 1997) and one hundred million people were forced to flee (Hanquet, G. (ed.) 1997, 7).

Worldwide a total of 31 high intensity conflicts, 24 crises with violent force and 7 wars, took place in 2009 (HIIK 2009, 1). All of these were intrastate conflicts while only 6 of the 112 medium intensity conflicts were interstate conflicts (HIIK 2009, 2). At the beginning of 2009, 26 million people worldwide were forcibly displaced due to conflict and violence (IDMC and NRC 2010, 3).

During nearly 60 years following the end of the Second World War on average 62 medium or high intensity conflicts were raging with civil wars typically lasting seven years on average (Collier, P. et al. 2003, 14), six times longer than interstate wars (Collier, P., A. Hoeffler, and M. Söderbom 2003, 2).

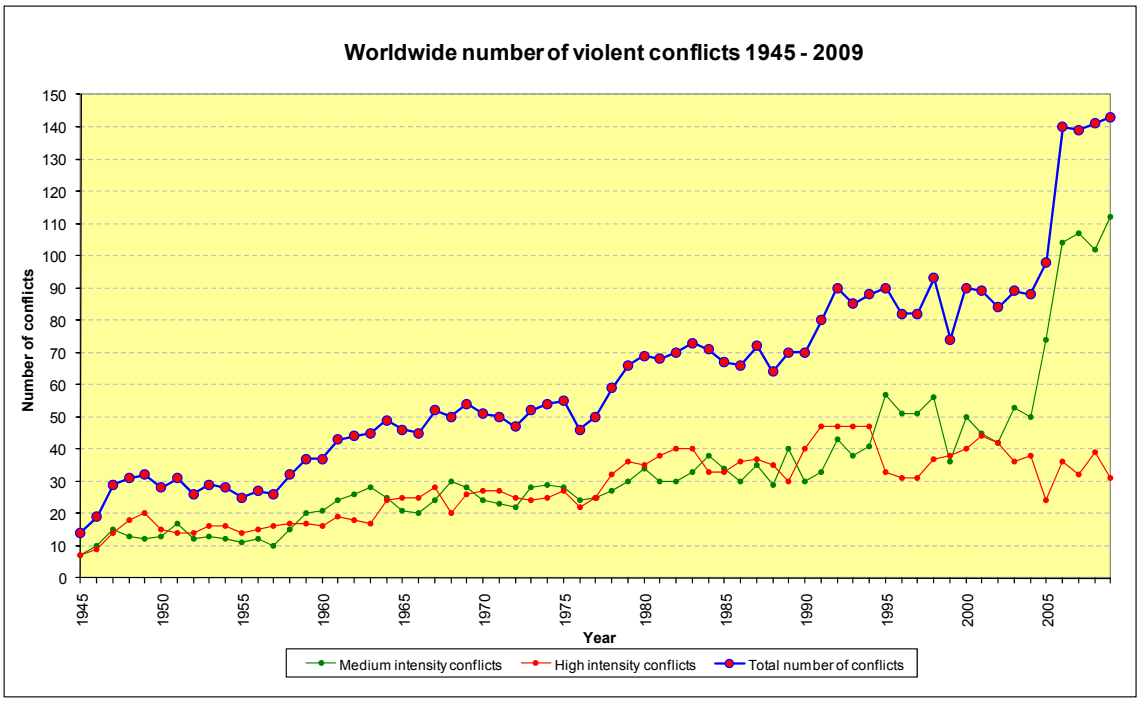

Figure 2.1 Worldwide number of conflicts 1945-2009 (HIIK 2009, 1)

Figure 2.1 gives an overview of the development of the total number of medium and high intensity conflicts since the end of the Second World War.

The origins of humanitarian assistance can be traced back to the charitable orders in the middle ages (Macalister-Smith, P. 1985, 9) who cared for the wounded and sick. In the 18th century England provided bilateral assistance to Lisbon after the city was devastated by an earthquake.

The Battle of Solférino (Italy) in 1859 prompted the establishment of voluntary organizations for assisting wounded combatants as well as development of international humanitarian law and led to the founding of the Red Cross movement (Grossrieder, P. 2002, 26). Activities were later extended to the provision of humanitarian assistance goods which required transport and establishing warehouses.

Due to the collapse of industry, disruption of agricultural production, requisitioning as well as the blockade of ports, nine million people in France and Belgium were threatened by famine during the First World War. Over a period of five years, the neutral Commission for Relief sustained a whole population by operating an entire fleet of ocean vessels and purchasing, shipping and distributing five million tonnes of humanitarian assistance goods (Macalister-Smith, P. 1985, 11).

In the aftermath of the First World War individual states were overwhelmed with millions of refugees in Europe, notably from Russia, and the League of Nations appointed a High Commissioner for Refugees, which among other tasks, provided material assistance. The recognition of the need for states to collaborate in providing and coordinating assistance to people affected by natural disasters prompted 30 states to establish the International Relief Union (IRU).

During the Second World War 40 governments founded the United Nations Relief and Rehabilitation Administration (UNRRA) which marks the beginning of international cooperation in humanitarian assistance. UNRRA was active in more than 20 countries, distributed more than 9 million tons of food over a period of five years and was important in providing material assistance to the over 20 million refugees in Europe after the Second World War.

The Red Cross Movement also played a key role in assistance operations after the Second World War and remained the principal humanitarian actor until the 1960s (Domestici-Met, M.-J. et al. 1998, 4).

The realization of the limited effectiveness of an ad hoc response to natural disasters as well as of the need for emergency preparedness led to the establishment of the Office of the United Nations Disaster Relief Coordinator in 1971.

The crisis in Biafra (Nigeria) from 1967-1970 was a landmark in the development of humanitarian assistance and led to the founding of Médecins sans Frontières in 1968 (Grossrieder, P. 2002, 29).

- Nigeria / Biafra (1967 - 1970)
- Cambodia (1970 - 1975)
- India - Bangladesh (1970 - 1975)
- Burundi (1972 - 1973)
- Rhodesia (1972 - 1979)
- Indochina (1973 - 1976, 1977 - 1991)
- Israel (1973)
- Cyprus - Turkey (1974)
- Indonesia / East Timor (1974, 1976 - 1999)
- Ethiopia / Tigray (1974 - 1991)

- Angola (1975 - 1991)
- Chad (1975 - 1980, 1983 -1990)
- Lebanon (1975 - 1976, 1982 - 1990)
- Somalia - Ethiopia / Ogaden (1976 - 1978)
- Nicaragua (1977 - 1979, 1981 - 1990)
- Mozambique (1978 - 1994)
- Uganda - Tanzania (1978 - 1979)
- China - Vietnam (1979)
- Afghanistan - USSR (1979 - 2000)
- Peru (1980 - 1996)
- Guatemala (1980 - 1999)
- Iran - Iraq / Gulf war I (1980 - 1988)
- Ecuador - Peru (1981, 1995)
- El Salvador (1981- 1992)
- Argentina - United Kingdom / Falklands (1982)
- Sri Lanka / Tamils (1983 - 2001)
- Sudan (1983 - 1988)
- Yemen (1986, 1994)
- Burundi (1988)
- Somalia (1988 - 1999)
- Liberia (1989 - 1995)
- Sudan (1989 - 2002)
- Turkey / Curds (1989 - 1999)
- Iraq - Kuwait / Gulf War II (1990 - 1991)
- Rwanda (1990 - 1994)
- Armenia - Azerbaijan / Nagorno - Karabach (1991 - 1994)
- Croatia (1991 - 1995)
- Russia / Chechnya (1991 - 2002)
- Sierra Leone (1991 - 1999)
- Bosnia - Herzegovina (1992 - 1995)
- Tadjikistan (1992)
- Burundi (1993 - 2003)
- Zaire (1996 - 1999)
- Angola (1997 - 2002)
- Congo Brazzaville (1997)
- Democratic Republic of Congo (1998 - 2004)
- Eritrea - Ethiopia (1998 - 2000)
- Guinea - Bissau (1998 - 2001)
- Columbia (1999 - 2003)
- Pakistan - India (1999)
- Yugoslavia / Kosovo (1999)
- Liberia (2000 - 2003)
- Afghanistan - United States of America (2001 - 2002)
- India / Kashmir (2001)
- Israel - Palestine (2002, 2006)
- Ivory Coast (2002 - 2003)

- Nepal (2002)
- Uganda (2002 - 2003)
- Central African Republic (2003)
- Indonesia / Aceh (2003)
- Iraq - PUK (2003)
- Iraq / Gulf War III (2003 - 2008)
- Sudan / SLM/A - JEM (2004)
- Sudan / Darfur (2005 - 2008)
- Afghanistan / insurgency (2006 - 2009)
- Lebanon - Israel (2006)
- Somalia (2006 - 2009)
- Sri Lanka (2006 - 2009)
- Pakistan / Islamists (2007 - 2009)
- Chad (2008)
- Russia - Georgia (2008)
- Turkey - PKK (2008)
- Israel / Gaza (Hamas) (2009)
- Yemen (2009)

Table 2.1 Major humanitarian crises since 1970 (HIIK, Cosimo 1, 1998 and 1999 to 2009)

During the last two decades the industry has grown significantly and today humanitarian organizations can be divided into governmental, inter-governmental, international non-governmental and international organizations (Domestici-Met, M.-J., et al. 1998, 36).

The United Nations High Commission for Refugees (UNHCR) has a specific mandate to care for refugees and internally displaced persons (IDPs). UNHCR offers protection and assistance to displaced persons in an impartial manner, on the basis of their needs and irrespective of their race, religion, political opinion or gender. The UNHCR pays particular attention to the needs of children and seeks to promote equal rights of women and girls. It sets up refugee camps for tens or even hundreds of thousands of people and provides them with shelter, water and sanitation, food and health care. Wherever possible UNHCR will attempt to care for refugees and displaced populations by supporting them in their community rather than in camps.

The World Food Programme (WFP) was founded in 1963 to eradicate world hunger, is the world's largest international food aid organization and is active in disaster preparedness, prevention of famines, response to nutritional emergencies, rehabilitation programmes as well as in development work. This United Nations agency has established a sub-unit within its logistics service called ALITE (Augmented Logistics Intervention Team for Emergencies) which coordinates all available civil as well as military resources and logistics capacities in an attempt to enhance the organization's logistics emergency response and preparedness capacities.

The United Nations Children's Fund (UNICEF), founded in 1946, seeks to improve the lives of children in general by reducing hunger, disease, poverty and illiteracy as well as advocating children's rights, is a major partner in the Expanded Programme on Immunization (EPI) and assists children and their mothers in natural and man-made disasters.

The World Health Organization (WHO) is mandated by its constitution, among others, to coordinate emergency assistance as well as to provide technical assistance and advice in the field of health (WHO 1996a, 12).

Médecins Sans Frontières (MsF) offers assistance to populations in distress, to victims of natural or man-made disasters as well as to victims of armed conflict. Unlike many other non-governmental organizations, it actively advocates and speaks out in favour of human rights of the people they care for.

Oxford famine relief (OXFAM) is primarily a development agency specializing on small scale community development programmes as well as advocating fair trade and respect for human rights. However the organization also intervenes in complex political emergencies and has gained a reputation for their expertise in providing safe water and sanitation services.

The work of the International Committee of the Red Cross (ICRC), an international organization, is based on the Geneva Conventions which are an important part of International Humanitarian Law (IHL). The ICRC looks after detainees and provides health care services and material assistance to people affected by armed conflicts.

Most humanitarian assistance programmes include the provision of a wide variety of humanitarian assistance goods such as food and potable water, shelter material and clothing, household items as well as health care goods. Their selection, purchase, storage, transportation, distribution, quality assurance and tracking depend on effective, reliable and efficient logistics services. The logistical management is often made difficult by poor infrastructure in less developed countries as well as the insecurity caused by armed conflicts. Moreover the scarcity of humanitarian resources (Stockton, N. 2001, 11) as well as the pressure to increase the professionalism of all aspects of managing humanitarian assistance operations is a further reason for exploring opportunities of improving logistics and supply chain management.

Improving logistics services to humanitarian assistance programmes will help providing health care goods and services faster, more reliably, at an overall lower cost and to a larger number of people affected directly or indirectly by the consequences of armed conflict. This will in turn allow humanitarian organizations to respond to emergencies faster and provide health care services of higher quality more effectively and more efficiently to more people in need, especially in countries with chronically under-resourced health care services.

2.2 Definitions

The definitions and explanations of the following critical terms are important throughout this handbook.

A large number of different definitions for logistics and supply chain management have been proposed without emergence of a universally agreed definition (Ehrmann, H. 2003, 25 and Stabenau, H. 2004, 141). While logistics concerns operational activities such as transportation and storage (Klaus, P., and W. Krieger (ed.) 2004, 294) and focuses on a single organization (Christopher, M. 2005, 18), supply chain management seeks to integrate, coordinate and optimize the flows of goods and information across several organizations from production until delivery to final customers (Waters, D. (ed.) 1999, 29).

For the context of natural and man-made disasters Thomas, A., and L.R. Kopczak (2005, 2) have defined humanitarian logistics as ". . . the process of planning, implementing and controlling the efficient, cost-effective flow and storage of goods and materials, as well as related information, from the point of origin to the point of consumption for the purpose of alleviating the suffering of vulnerable people". This definition also applies to complex political emergencies which are mainly man-made and often compounded by natural factors.

The worldwide 165 less developed countries differ from developed countries in, among others, lower standards of living, lower levels of economic development and education as well as shorter life expectancy.

Events such as floods, tsunamis, earthquakes, landslides, volcanic eruptions, tropical storms (hurricanes, cyclones), extreme hot or cold as well as droughts cause natural disasters. Mudslides from deforestation, famine and desertification are considered as disasters with humans as a factor while armed conflicts and industrial accidents are considered as disasters directly caused by people (Burnham, G.M., and E. Christensen (ed.) 2008, 27).

Man-made disasters which may be complicated by natural disaster(s) have been termed "complex humanitarian emergencies" (Burnham, G.M., and E. Christensen (ed.) 2008, 582). Economic factors such as high levels of poverty, competition for water, territory and arable land as well as environmental degradation can cause or compound emergencies. Important social factors are overpopulation and population displacement as well as cultural, religious and especially ethnic differences. Finally disputed sovereignty (Gundel, J. 1999, 13) as well as weakness or collapse of state authorities with subsequent violence are frequent political factors.

These factors, which sometimes can be cause as well as effect, often interact and compound each other (Mackinlay, J. (ed.) 1996, 19). For example overpopulation causing environmental degradation, leading to shortages of water and food and resulting in conflict. Conversely armed conflict may cause "green famines" when populations can no longer cultivate their land because of displacement or indiscriminate laying of land mines (Kalipeni, E., and J. Oppong 1998, 1638).

Complex Political Emergency (CPE) has emerged as a term to denote a humanitarian emergency which is largely caused by political factors (Milwood, D. (ed.) 1996, 6) and where lives and livelihoods are primarily threatened by high levels of violence and armed conflict (OECD 1999, 5). Unlike inter-state wars, complex political emergencies caused by "internal conflicts" or "civil wars", are often characterized by a multitude of different actors with various conflicting interests. Conflict research uses the threshold of one thousand deaths for defining civil wars (Mack, A. (ed.) 2005, 131).

Humanitarian assistance refers to the provision of material and technical aid in humanitarian emergencies as well as measures for protecting human rights of civilian populations (OECD 1999, 10). It is given to people in need without distinction as to race, ethnicity, creed, nationality, sex, age, physical or mental disability or political affiliation (EC 1257/96, 1996). Donors as well as providers, which may be individuals, governmental, non-governmental or international organizations, are not motivated by making profits.

Potable water, food, sanitation, shelter, basic household items and health care services (The Sphere Project 2004, 226) are provided with the primary objective of ensuring survival of the affected population, saving and protecting lives, preventing and alleviating suffering while respecting the dignity of the recipients (The Sphere Project 2004, 227).

As soon as the security situation permits and where necessary, humanitarian assistance is replaced by assistance for rehabilitation and reconstruction which in turn is followed by development aid although there is no clear dividing line between these three phases (OECD 1997, 10).

The final recipients of humanitarian assistance goods or services are usually individuals, commonly called beneficiaries. However, health care goods are mainly provided to health professionals or health care facilities which in turn use them to provide services to patients.

In a structured health care system three hierarchical levels of health services, which provide preventative and curative services as well as rehabilitation, can be distinguished (Perrin, P. 1996, 208). At the primary level family members, community health workers and traditional healers provide basic treatment for minor illnesses as well as first aid for injuries in the community. At the secondary level health care professionals provide outpatient services at simple health care facilities such as dispensaries, clinics or health centres. District as well as provincial hospitals constitute the tertiary level and provide treatment to outpatients as well as inpatients at the highest level. Other health services which are established for providing humanitarian assistance are first aid posts for treating war-wounded, orthopaedic and rehabilitation centres, vaccination and therapeutic feeding centres, specialized facilities for treating large numbers of patients during cholera epidemics or mental health services.

Health care goods comprise a wide variety of drug products, single use medical devices, appliances and health care equipment used for preventative care, diagnosis, medical and surgical treatment as well as rehabilitation of patients.

2.3 Objectives

Commercial and not-profit-making organizations have much in common, among others their orientation towards serving customers (Badelt (ed.) 2002, 97), but also show important differences. While commercial organizations are motivated mainly by financial profits, not-profit-making organizations have mainly social objectives (Badelt (ed.) 2002, 136). While profits are the "bottom line" in commerce, the ultimate objective of humanitarian logistics services could be seen as ensuring continuity of services provided to people in need which requires preventing stockouts ("the new bottom line). Logistics services need to endeavour to provide excellent services to customers, constantly seek ways of improving their services and thereby become an enabler and facilitator of health care programmes rather than being a constraint.

Although compliance with the "humanitarian imperative" is categorical (Slim, H. 2002b, 6) and concern for people in need is the primary objective of humanitarian organizations, other stakeholders (Badelt (ed.) 2002, 218) as well as a multitude of other objectives (figure 2.2) must also be considered. The following chapter will discuss objectives humanitarian organizations have towards donors and the public, towards recipients as well as their own management objectives.

Even though each humanitarian organization has its own focus and develops its own objectives (Oloruntoba, R., and R. Gray 2003, 6), some objectives are common to most humanitarian organizations.

The analysis below does not intend to be complete but rather indicates issues which have important implications for logistics and supply chain management.

2.3.1 Objectives towards donors and the public

Since humanitarian organizations do not generate any income through their own activities and depend entirely on outside funding, they must consider the interests, requirements and conditions of donors. Furthermore the number of humanitarian organizations competing for limited donor funding is increasing (Thomas, A., and L.R. Kopczak 2005, 2).

Members of the public may fund humanitarian organizations directly through individual contributions or indirectly through tax money which is allocated by governments or government agency. In both cases public opinion is an important consideration as it may affect

individual donations directly or may influence the goodwill of governments or government agencies. Moreover public opinion will have an influence on the overall funding governments are willing to allocate to humanitarian assistance in general (Larragán, A.A., et al. 1998, 98).

Since demand for humanitarian assistance always exceeds supply, humanitarian organizations do not need to market their services towards recipients. However they need to retain donors by marketing the services they provide to people in need (Oloruntoba, R., and R. Gray 2003, 9).

In order to be credible, humanitarian organizations will have to demonstrate their genuine concern for the plight of people affected by humanitarian emergencies as well as their respect for recipients. They will portray themselves as being motivated mainly by humanitarianism rather than their own interests.

Although not legally binding, many humanitarian organizations have voluntarily committed themselves to minimum standards of humanitarian assistance as defined by the Humanitarian Charter (The Sphere Project 2004). Signing of various charters may be a precondition for becoming eligible for funding (Harris-Curtis, E. 2001, 4).

There is general agreement among donors as well as humanitarian organizations that humanitarian assistance must be planned, organized and implemented in a professional manner (Fischer, H., and J. Oraá Oraá 1998, III).

Humanitarian organizations applying for funding by the European Community Humanitarian Office (ECHO) must demonstrate, among others, their administrative, financial, technical and logistical capacity as well as experience in the field of humanitarian assistance (EC 1257/96, Art. 7.2, 1996).

In order to become and remain competitive in obtaining funds, humanitarian organizations need to convince donors of their competence and professionalism.

Humanitarian organizations need to demonstrate the relevance as well as the effectiveness of their interventions (ECHO 1999, 20). Reporting in terms of outputs (Slim, H. 2002a) such as quantities of distributed health care goods is no longer sufficient. Increasingly donors are carrying out evaluations and require humanitarian organizations to demonstrate their contribution to reducing suffering as well as a measurable impact of their interventions such as the reduction of morbidity and mortality (ECHO 1999, 35).

Among different alternatives for achieving stated objectives, humanitarian organizations must choose the option requiring the least resources and demonstrate the efficiency of their logistics management (ECHO 1999, 35).

Since assessing the costs of different options of entire humanitarian assistance programmes is difficult, donors may instead analyse individual components such as transport and distribution costs (ECHO 1999, 52).

Although so far no legal framework for the work of humanitarian organizations has been established (OECD 1999, 19), transparency and accountability towards donors is an indispensable prerequisite for obtaining funds for future humanitarian assistance programmes. Donors will usually grant funds under the condition of receiving detailed reports from humanitarian organizations on their achievements and utilization of funds (ECHO 2003, 2). In addition donors may make funding conditional upon the right to conduct audits at head offices or in the field and have access to all relevant records at any time without prior notice (ECHO 1999, 71). The signatories of the Code of Conduct hold themselves accountable to donors as well as recipients of humanitarian assistance (The Sphere Project 2004, 320).

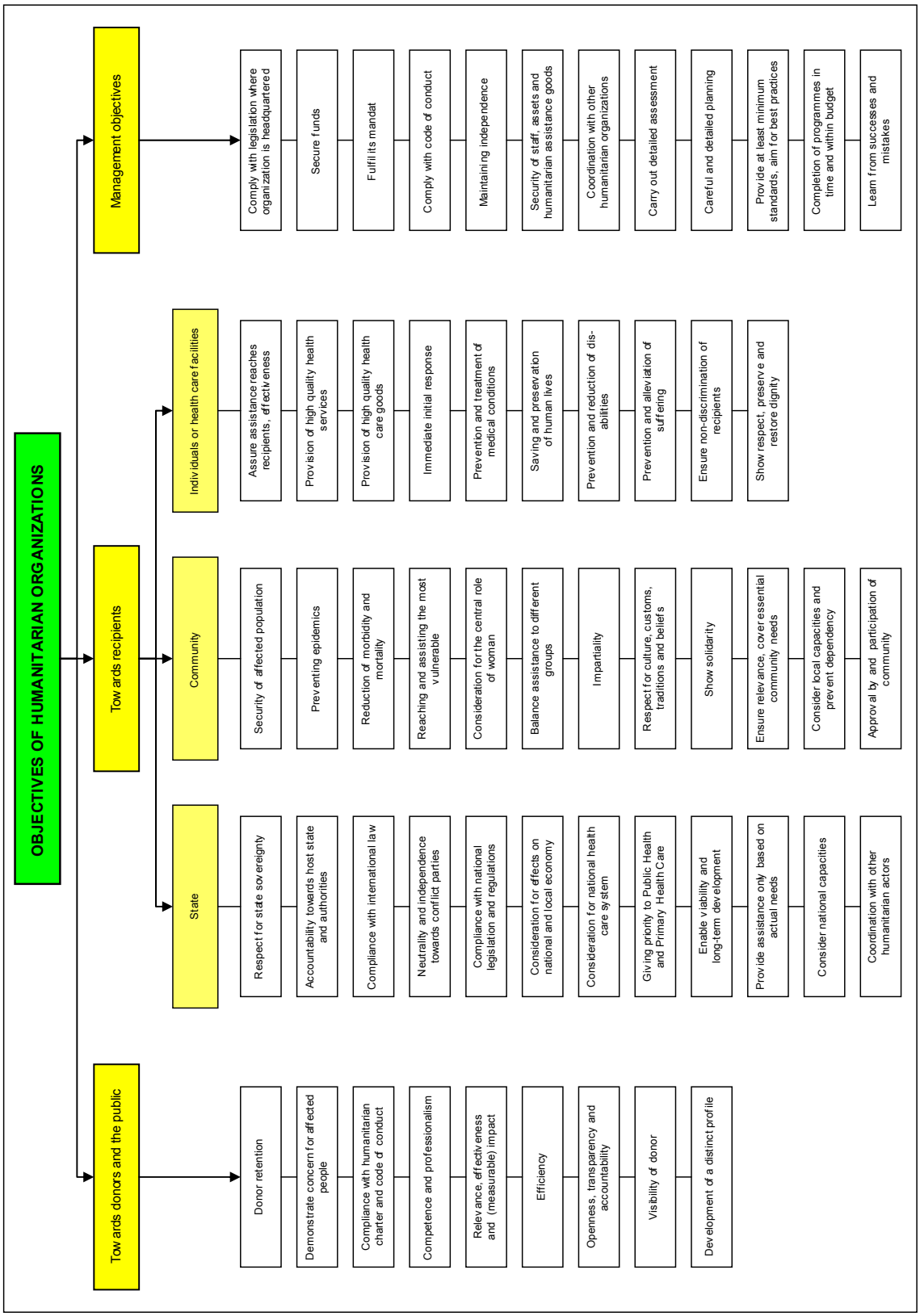

Figure 2.2 Objectives of humanitarian organizations

In order to demonstrate openness in general as well as to account to individual donors who cannot perform audits, humanitarian organizations need to regularly publish reports on their activities and usually publish an overview of their annual accounting.

One of the conditions for granting funds to humanitarian organizations may be the visibility of donors towards recipients and local authorities by printing logos on distributed humanitarian assistance goods or displaying signs on offices, vehicles or stores (ECHO 1999, 57) as well as mentioning donors in public communications such as press releases and reports.

Some humanitarian organizations develop a distinct identity and public image for example by emphasizing their capacity, efficiency, speed, competence, flexibility or advocacy of human rights.

2.3.2 Objectives towards recipients

Humanitarian organizations need to consider their objectives towards the state, the community as well as individual recipients which benefit from or host humanitarian assistance programmes.

The respect for state sovereignty is a central principle of humanitarian assistance and states have a primary role in the initiation, organization, co-ordination and implementation of humanitarian assistance within their territories (UN General Assembly Resolution 43/131, 1988).

Consequently humanitarian organizations must seek approval from the state, the respective authorities or parties in control of the territory for which humanitarian assistance is intended (Stoffels, R.A. 2004, 534) and are accountable towards the host state and authorities for their activities.

States may decide to rely on their own means for providing assistance to the affected population (Fischer, H., and J. Oraá Oraá 1998, 11) or impose restrictions on the implementation of humanitarian assistance programmes.

Humanitarian assistance programmes must meet any applicable provisions of international law (Fischer, H., and J. Oraá Oraá 1998, 3) such as the right of the state to control immigration (Fischer, H., and J. Oraá Oraá 1998, 12).

International organizations may be held accountable for any violations and even be liable to compensate the state (Fischer, H., and J. Oraá Oraá 1998, 14).

According to the United Nations, humanitarian assistance must also be provided in accordance with the principle of neutrality (UN General Assembly Resolution 43/131, 1988), which means that humanitarian organization must not favour any party to the conflict and must not in any way participate in hostilities.

Increasingly humanitarian assistance is becoming part of political and military intervention strategies of donors and states (VENRO 2003, 2). Humanitarian organizations must remain neutral, refrain from favouring any party to the conflict and maintain their independence from political, economic, military or other objectives of any of the actors in the conflict (ECHO 2003, 9). Humanitarian assistance must also not be used as a substitute for political action (Madrid declaration, 2.1) or for furthering political objectives (The Sphere Project 2004, 318).

Humanitarian organizations must also comply with national legislation and regulations (Fischer, H., and J. Oraá Oraá 1998, 3), respect immigration laws, obtain residence and work permits (Larragán, A.A. et al. 1998, 97). Humanitarian workers must have the required professional qualifications required for practicing in the host country, for example as a health professional. Labour and social security laws must be complied with when employing national staff (Mayhew, B. 2004, 15). Foreign driving licences require approval and vehicles must

comply with highway codes and be registered. Operation of aircraft in the host country must consider national legislation and regulations on registration of aircraft, obtaining flight clearances or licensing of pilots. Importation, installation and operation of telecommunication equipment are often subject to strict laws and regulations. Some countries are very restrictive in granting operating licences and assigning appropriate radio frequencies (Klenk, J.S. 1997, 42). The Tampere Convention (1998) seeks to facilitate the use of telecommunication equipment in emergencies by removing regulatory barriers and waiving fees. However the convention is limited to disasters and has so far only been ratified by 30 states.

Drug products and other health care goods must be imported according to the provisions of the respective national drug acts (WHO 1996d, 186) and national pharmaceutical legislation must also be considered for their storage and distribution. In particular regulations concerning narcotic drugs and psychotropic substances which are subject to international control must be adhered to (WHO 1996d, 192).

Trade laws apply in general whenever humanitarian organizations buy goods in the host country, customs laws apply for importation of goods and humanitarian organizations must respect tax and fiscal laws.

All employees of humanitarian organizations have to comply with the respective national civil law as well as provisions of the penal code.

In order to avoid creating shortages with subsequent price increases or a surplus of goods which decreases prices, humanitarian organizations must consider the consequences on the domestic as well as the local economy and avoid any adverse affects on the domestic market (Ockwell, R. A. 1994, 149).

Humanitarian organizations must consider existing national health care systems and possible undesirable consequences of their own programmes. For example providing health services free of charge can damage well established cost recovery systems and may reduce local prices health professionals can charge patients. Introducing drug products, strengths per dosage unit or dosage forms which are not commonly used may undermine standard treatment protocols as well as the use of national essential drug lists.

Provision of free hospital care may disrupt the referral system and cause hospitals to become overwhelmed with patients although the majority of patients could be treated at lower levels of the health care systems more economically.

A well established distribution network for regularly supplying health care facilities may be disrupted by direct deliveries from humanitarian organizations, especially after assistance is withdrawn.
Humanitarian assistance should be based on primary health care principles (The Sphere Project 2004, 264) and give priority to public health which will ensure that the greatest health benefit is provided to the greatest number of people (The Sphere Project 2004, 259). This implies decentralization of health services in order to give a maximum number of people access (Perrin, P. 1996, 195) as well as to avoid a small number of central health care facilities being overwhelmed with patients (Perrin, P. 1996, 196).

Humanitarian organizations must integrate their assistance into existing health care systems and consider the long-term viability and sustainability after their assistance ends (The Sphere Project 2004, 29). Humanitarian organizations should, wherever possible, reinforce existing structures and processes rather than create new ones (Ockwell, R. A. 1994, 22). Humanitarian assistance programmes should consider the link between relief, rehabilitation and

development and, wherever possible, consider long-term development objectives (ECHO 2003, 9).

The second principle of the Code of Conduct states that, wherever possible, humanitarian organizations will carry out thorough assessments (The Sphere Project 2004, 317) and provide humanitarian assistance according to established needs of affected populations.

Signatories also commit themselves to consider local capacities and to strengthen these capacities by employing local staff and purchasing goods locally (The Sphere Project 2004, 319).

According to the Madrid Declaration (signed by UNICEF, WFP, UNHCR, MsF, ICRC and others) providers of humanitarian assistance as well as donors will ensure close coordination in order to achieve maximum impact in reducing suffering (Madrid declaration, 1.2). Moreover donors are encouraging collaboration among humanitarian organizations in order to avoid expensive duplications (Thomas, A., and L.R. Kopczak 2005, 2).

At the next level humanitarian organizations have to consider their objectives towards the communities receiving humanitarian assistance.

Humanitarian organizations must above all consider the security of assisted populations and attempt to minimize any adverse effects humanitarian assistance programmes could have (The Sphere Project 2004, 18). As far as possible, humanitarian assistance must not be provided in insecure places or areas and must not endanger people who try to reach health services.

Although the notion that disasters itself or human remains inevitably cause epidemics is a myth (PAHO 2004, 71), high population densities and poor sanitary conditions together with the deterioration of health services are highly conducive to an increased incidence of communicable diseases. The prevention of epidemics, especially of measles, must be one of the priorities for humanitarian organizations since they may be the leading cause of mortality even during armed conflict (Guha-Sapir, D., and W. van Panhuis 2002, 19).

One of the primary objectives of humanitarian assistance and of providing health services in particular is the reduction of excess morbidity and mortality (Checchi, F., and L. Roberts 2005, 1). Excess morbidity and mortality is calculated by comparing morbidity and mortality before and after the onset of complex political emergencies.

Following a careful assessment of needs, humanitarian assistance must selectively be provided to the most vulnerable recipients, such as children, woman and the elderly, first (Russbach, R., and D. Fink 1994, 6). The importance of women participating in all stages of humanitarian assistance programmes is generally acknowledged (ECHO 1999, 80).

At the same time humanitarian organizations must balance their assistance to different groups and avoid causing resentment, by providing a higher level of services to certain groups, such as displaced people, than to the host community (Perrin, P. 1996, 318).

Humanitarian assistance must respond only to needs and interests of people in need, must be provided in an impartial manner, regardless of age, gender, birth, race, ethnicity, religion, creed, political affiliation or nationality of recipients and without adverse distinction of any kind (ECHO 1999, 64).

Humanitarian workers must also respect national and local culture, customs, traditions and religious beliefs (The Sphere Project 2004, 318). Humanitarian assistance should be motivated by a feeling of solidarity (Russbach, R., and D. Fink 1994, 6) and is also a way for the international community to express solidarity with the suffering population (Oxfam 2000, 10).

Since needs may vary between different communities and different health care facilities, humanitarian assistance must be based on individual assessments, be relevant and cover essential needs (Perrin, P. 1996, 409).

Humanitarian assistance programmes must complement and build on local resources and capacities, by employing staff in the country of operations and supporting local trade (The Sphere Project 2004, 319) and must be coordinated with local authorities. Local health services should be strengthened rather than establishing alternate or parallel health care facilities or services, unless local capacities are exhausted (The Sphere Project 2004, 262). Replacing local services should only be considered as a last resort after all other options have been explored (Perrin, P. 1996, 323).

Even in emergencies humanitarian organizations should assist communities in regaining self-sufficiency and avoid creating dependencies (ECHO 1999, 12).

Communities and local authorities must be consulted, participate in the assessment and programme design and approve implementation of humanitarian assistance programmes (The Sphere Project 2004, 319).

Finally objectives towards the recipients, which may be individuals, health professionals or health care facilities, need to be considered.

Above all, humanitarian organizations must ensure that assistance is effective and goods and services actually reach recipients. The effectiveness of certain health interventions such as mass immunization or antenatal care depends on a high coverage (Simmonds, St., P. Vaughan, and S.W. Gunn (ed.) 1986, 37).

One of the main objectives of the Sphere Project is to enhance the effectiveness and quality of humanitarian assistance (The Sphere Project 2004, 14) which in turn requires, among others, providing high quality health care goods.

Humanitarian organizations applying for funding through ECHO must commit themselves to implementing humanitarian assistance programmes in accordance with best practices and based on the concept of quality of assistance (ECHO 2003, 9). The quality of provided goods and services is also a criterion for the evaluation of humanitarian assistance programmes which receive funds (ECHO 1999, 35).

At the outset of humanitarian emergencies, humanitarian assistance must be provided as quickly as possible (Perrin, P. 1996, 16). Once humanitarian assistance programmes and their supporting supply network are established, uninterrupted availability of health care goods may be assured in other ways such as planning ahead or establishing stocks.

Health care interventions attempt to prevent or at least control outbreaks of diseases and epidemics (The Sphere Project 2004, 279), especially measles, and to ensure treatment of injured and sick people. According to the Sphere Project the effectiveness of health care programmes can be objectively determined by monitoring death rates and their decrease.

Ultimately the main purpose of humanitarian assistance programmes is saving and preserving human lives (EC 1257/96, Art. 2, 1996). Once survival is ensured preventing or at least reducing disabilities, for example by saving organs or limbs, as well as rehabilitation measures are also important concerns.

The "humanitarian imperative" (The Sphere Project 2004, 16) states that all possible steps should be taken to prevent and alleviate human suffering.

Within communities all individuals must be treated as equals and humanitarian assistance must be provided depending on needs alone and without any kind of discrimination (Benoist, J., B. Piquard, and E. Voutira 1998, 5).

The right to life with dignity (The Sphere Project 2004, 17) is one of the two core principles of the Humanitarian Charter. Recipients must be treated with respect and in their communications humanitarian organizations should not present recipients as "objects of pity" (ECHO 2003, 3).

2.3.3 Management objectives

Like any other organization, humanitarian organizations must choose a legal form of corporation and comply with national legislation and regulations in the country of their head office, for example concerning registration and licensing, employment of staff, taxation or exportation of goods.

Since humanitarian organizations do not generate any income through their activities they must first of all secure and maintain sufficient funding for maintaining their organization as well as for implementing humanitarian assistance programmes (Larragán, A.A., et al. 1998, 46). At the same time humanitarian organizations will want to avoid becoming dependent on the means and goodwill of a single donor (The Sphere Project 2004, 318).

Humanitarian organizations will strive to fulfil the mandate they have chosen or they have been assigned. They will also have to focus on their core competencies (Larragán, A.A., et al. 1998, 27) since no humanitarian organization has the capacity, expertise or funding to provide comprehensive assistance to all people in need. Such a focus may be on certain groups of people in need such as children or refugees, certain services such as food aid or health services, certain countries or regions or certain situations such as emergency assistance or long-term development (Oloruntoba, R., and R. Gray 2003, 6).

So far the industry of humanitarian assistance is poorly regulated, with the exception of international organizations, humanitarian organizations are essentially self-mandating (Slim, H. 2002a) and, except towards their donors, humanitarian organizations have no formal responsibilities and are hardly accountable (Davis, A. 2001, 7).

Ethically humanitarian organizations are accountable to recipients but in practice the later have very limited possibilities of applying pressure or even sanctions. However a system of commitment to voluntary charters and codes of conduct has emerged (Leader, N. 2000, 3). Noteworthy initiatives are the Sphere Project, the Madrid Declaration (ECHO 1999, 76), the Humanitarian Accountability Project (Callamard, A. 2003, 35) as well as the Active Learning Network on Accountability and Performance (ALNAP). Adherence to codes of conduct (ECHO 2003, 2) may be a condition for becoming eligible for funding. The introduction of internationally recognized ISO 9001 certification for humanitarian assistance providers has also been proposed (Verboom, D.B. 2002, 38).

However voluntary codes are not legally binding and non-compliance has no immediate negative consequences. As an alternative a voluntary international accreditation system has also been recommended (Stockton, N. 2001, 15) where an independent body would monitor compliance with defined standards. Personal accreditation of humanitarian workers and establishing an international disaster response law with internationally agreed standards has also been suggested (Hilhorst, D. 2001, 22).

In order to carry out their mandate in an impartial and neutral way, humanitarian organizations must maintain their independence from any donors as well as economic, military

and political actors (ECHO 2003, 9). The Sphere Project stresses the importance of formulating and implementing strategies and assistance programmes without being influenced by political interests of donors or foreign policies of governments (The Sphere Project 2004, 318). Humanitarian organizations must also avoid being used to gather political, military or economic information for donors. Humanitarian assistance programmes must be driven by needs alone and humanitarian organizations must base decisions on programmes on a sound assessment of the situation alone.

While humanitarian organizations must focus on the needs of recipients in an increasingly violent environment, security and safety of staff must be their first priority. Humanitarian organizations are accountable for humanitarian assistance goods as well as assets and must, as far as possible, prevent diversion, misuse, damage and destruction which not only leads to losses but also to withholding urgently needed goods and services from people in need.

According to article 71 of the First Protocol Additional to the Geneva Conventions, any personnel participating in the provision of humanitarian assistance must not be attacked and must be respected and protected. Medical stocks must never be prevented from operating, attacked, damaged or destroyed and any transport of medical consignments must be protected (ICRC 1999e, 8). According to the Statute of the International Criminal Court direct, intentional attacks against humanitarian workers as well as equipment and infrastructure involved in humanitarian assistance constitute a war crime (Rome Statute Art. 8.2.b (iii)).

If humanitarian organizations above all strive to reduce suffering they must avoid wasting valuable resources (PAHO 2001a, 21) and closely coordinate their assistance programmes with other humanitarian actors. Moreover humanitarian organizations are likely to be denied any funding for providing goods and services which are already being provided by other humanitarian organizations since donors want to maximize the effectiveness of the resources they provide (Minear, L. 1999, p.298).

Finally the scope of many complex political emergencies clearly exceeds the capacity, resources and expertise of any single humanitarian organization. The increasing complexity of humanitarian assistance and developed technologies encourages specialization by humanitarian organizations on certain services. This in turn requires coordination and cooperation with other humanitarian organizations to provide people in need with the whole range of required goods and services.

Humanitarian organizations can also gain mutually by sharing information collected from assessments or sharing storage facilities and transportation resources.

Every humanitarian assistance programme must be preceded by a thorough and detailed assessment of the context, situation and needs of the affected population (Russbach, R., and D. Fink 1994, 7). In parallel domestically and locally available logistics resources need to be assessed (PAHO 2001a, 15).

Humanitarian assistance programmes must be carefully planned in order to be effective and make the best use of the limited resources humanitarian organizations have at their disposal (WHO 1996a, 15).

Many leading humanitarian organizations have committed themselves to the Minimum Standards in humanitarian assistance (The Sphere Project 2004, 19). The "Humanitarian Charter and Minimum Standards in Disaster Response" defines quantifiable and measurable indicators for the areas of water supply and sanitation, nutrition, food aid, shelter and site planning as well as for health services which humanitarian organizations can monitor to determine the quality of their intervention.

The European Community goes further in requiring humanitarian organizations applying for funding to commit themselves to implement humanitarian operations in accordance with the best practices in the sector (ECHO 2003, 9). However these best practices are not specified any further.

As funds are limited and donors demand measurable results, humanitarian organizations must strive to complete humanitarian assistance programmes and achieve their objectives within the planned time frame and budget.

In order to improve their services, humanitarian organizations must monitor and regularly analyse their performance and learn from their past successes as well as mistakes and failures (Larragán, A.A., et al. 1998, 47).

2.4 Context and constraints

The following chapter will describe the environment in and the circumstances under which humanitarian assistance programmes and their supporting logistics services are implemented. An overview of the context and constraints is given in figure 2.3.

Some constraints which restrict, confine, limit and sometimes impede operations, mainly inside the countries where humanitarian assistance is provided, will be pointed out. Logistics managers must understand these constraints in order to be able to overcome them and serve customers effectively and as efficiently as possible.

2.4.1 Humanitarian organizations

By definition international humanitarian organizations do not strive for profits and financial considerations are not a priority in their overall strategy (Larragán, A.A., et al. 1998, 40).

However Drucker claims that, although not-profit-making organizations do not have a "bottom line" they are nevertheless more money-conscious than commercial organizations (Drucker, P.E. 1989, 89).

Humanitarian organizations have no need to compete against each other for the markets and customers they are serving as demand for assistance to people is almost unlimited and by far outweighs supply.

Humanitarian assistance can be considered as "one of the largest unregulated industries in the world" (Buchanan-Smith, M. 2002, 40) which lacks common standards and mechanisms for evaluation (Larragán, A.A. et al. 1998, 42). There are hardly restrictions on establishing humanitarian organizations and raising funds. Although training courses are offered by various organizations, so far humanitarian assistance management is not an acknowledged profession which requires obtaining specific skills or knowledge for qualifying. The criteria for recruiting national and international staff are left to humanitarian organizations.

In many countries state authorities do not exist and recipients, who are usually dependent on humanitarian assistance they receive, can hardly sanction humanitarian organizations for providing poor or even inadequate services.

However since funds are in short supply, donors can exert significant pressure on humanitarian organizations by withholding funds or making funding conditional on compliance with defined criteria for the quality of provided humanitarian assistance.

Whereas commercial organizations are free to choose the markets where they want to offer goods and services, humanitarian organizations must remain impartial towards all conflict

parties at all times (Russbach, R., and D. Fink 1994, 5). Consequently humanitarian organizations may have to provide humanitarian assistance to populations in the territory under control of other conflict parties even if the humanitarian needs of the affected population there are less urgent.

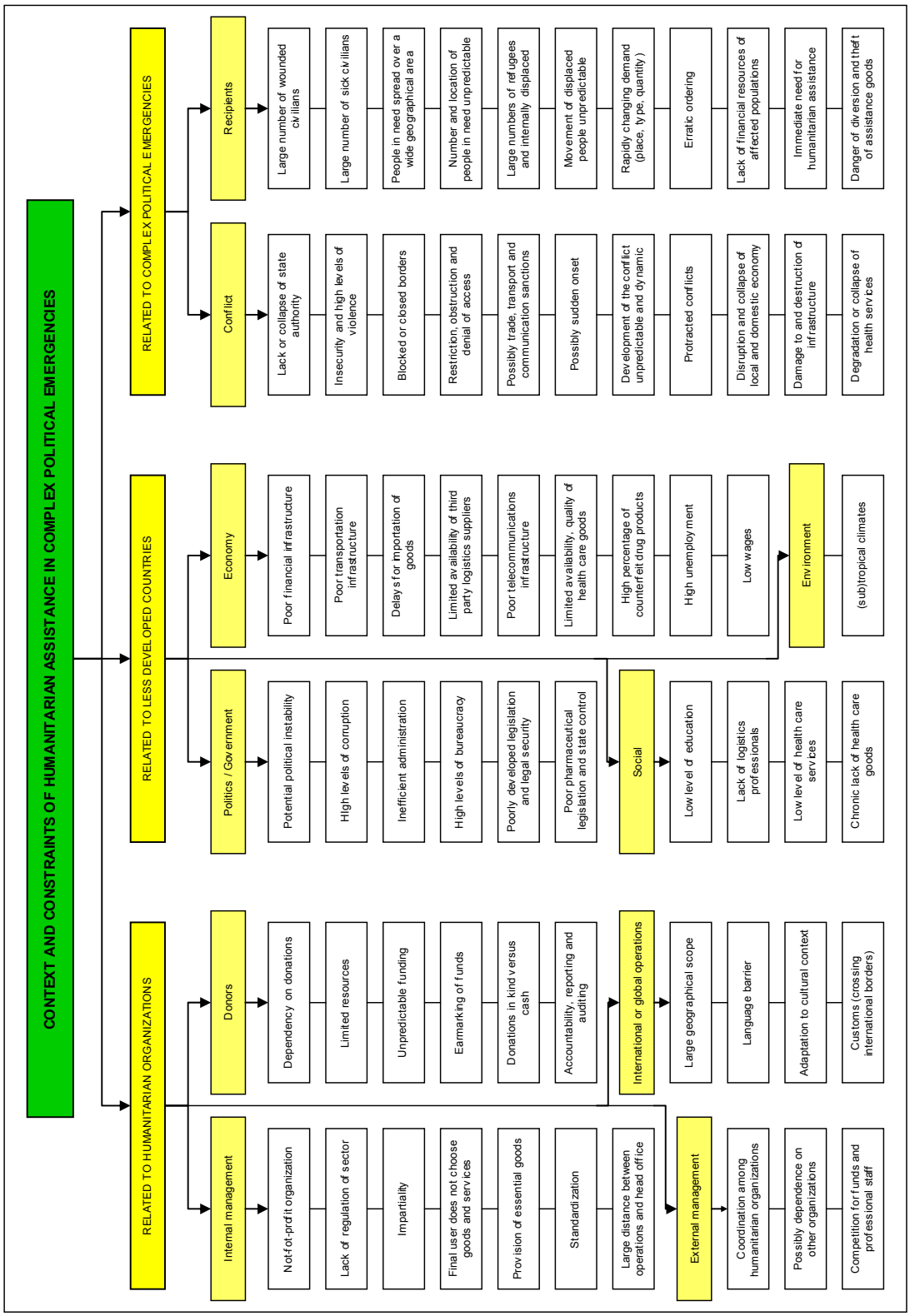

Figure 2.3 Context and constraints of humanitarian assistance

Recipients rarely have the opportunity to choose between different services or a certain service provided by different humanitarian organizations (Larragán, A.A., et al. 1998, 39), such as free treatment at different health care facilities. Likewise health care facilities cannot choose the health care goods they receive. Recipients receive goods and services free of charge which are ultimately paid by the donors of humanitarian organizations and depend on the professionalism of the humanitarian organization to ensure that the most urgent needs are addressed.

Humanitarian organizations are in principle free to decide what kind of services they offer to people in need provided that their donors approve the respective humanitarian assistance programmes. Except in the rare situations where humanitarian organizations have funds at their disposal for which they are not accountable to anyone, ultimately donors decide on the kind of goods and services, the places where they are provided and the number of recipients. Donors will rely, at least to some degree, on the judgement of the humanitarian organizations since the later have more experience and a better insight into humanitarian situations. Donors may also agree to a certain amount of funding for assistance to health care facilities and defined places but leave the design of the humanitarian assistance programme entirely up to the humanitarian organization (Larragán, A.A., et al. 1998, 13). Donors, which lack the expertise and organization for implementation, effectively outsource services, which they are unable to provide themselves, to specialized humanitarian organizations.

Since humanitarian organizations do not compete among each other for market share, want to cover essential needs and have only limited funds at their disposal, they will provide only a limited range of essential goods. The selection of individual goods is based on their suitability, quality and price and there is no purpose in providing a variety of goods, such as different sizes, designs or makes, provided they all serve the same purpose.

The standardization of humanitarian assistance goods as well as equipment used for implementing humanitarian assistance programmes is a cornerstone of efficient logistics management (WHO 1992c, 13) and is a means for improving the quality of services (Perrin, P. 2002, 25). The idea dates back more than a century (Van Meerdervoort, P. 1885, 99) and is reflected in elaborate standard item catalogues. Standardization allows identifying the most suitable items (Lonergan, E. 2003, 90), ensuring compatibility among them, allows identifying potential suppliers in advance as well as limiting and minimizing the overall number of items logistics services need to provide. Since standardization allows reducing the number of different items, forecasting accuracy is increased through risk pooling (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 345).

For health care goods, standardization of items is also a consequence of using standard treatment protocols which allow health care workers with limited medical training to provide adequate treatment for the most common medical conditions (Antequera, M.G., and M.M. Suárez-Varela 1999, 608). The standardization of diagnostic and therapeutic procedures is of particular importance in the emergency phase of humanitarian assistance (Perrin, P. 1996, 205) where decisions need to be taken quickly and assistance must not be delayed by selection and sourcing of suitable items.

Determining the needs of assisted populations together with the standardization of health care goods allows developing tailor-made stock lists for assisted health care facilities such as clinics and hospitals which greatly facilitate the task of forecasting demand and greatly reduces the complexity of required logistics services in general.

Head offices of international humanitarian organizations, often located in developed countries, and managers of humanitarian assistance programmes, usually working in less developed countries, are often separated by large physical and sometimes cultural distances

(Larragán, A.A., et al. 1998, 40). Communications between programme managers in the field, often in remote areas with no or poor telecommunications infrastructure, can be difficult and slow. Consequently even major decisions might have to be taken in the field quickly without the possibility of waiting for advice from or approval by the head office. Conversely it may be impossible for head offices to inform or instruct managers in the field without some delay. At least for operational decisions, humanitarian organizations must therefore adopt a decentralized management structure (Larragán, A.A., et al. 1998, 41).

Most humanitarian organizations do not generate any income through their activities and therefore depend entirely on funds provided by private and institutional donors (Larragán, A.A., et al. 1998, 58).

Although humanitarian organizations can plan ahead, implementation of humanitarian assistance programmes is always subject to obtaining sufficient funds on time. Donors may attach conditions such as utilizing funds for specific programmes, specific groups of recipients, using funds in a specific geographical area or country and spending the money by a certain deadline.

Since funds are scarce, humanitarian organizations rarely have a choice between donors and can hardly afford to turn down an offer for funding because they do not agree with the donor's terms.

Dependency on donations therefore limits the flexibility of humanitarian organizations and can also delay their response to new and suddenly emerging crises.

Although humanitarian organizations compete for funds (Larragán, A.A., et al. 1998, 97), major international humanitarian organizations often launch inter-agency consolidated appeals which allow coordination among the appealing humanitarian organizations, among donors as well as between these two parties.

Humanitarian organizations are constrained by their own capacity as well as by limited material and financial resources which are at their disposal (Forman, S., and A. Stoddard 2002). Consequently they have to limit the number of people they can assist as well as the scope and quality of services they can afford to provide. In order to maximize goods and services provided to recipients, resources must be utilized as efficiently as possible (WHO 1996a, 3) and overheads must be kept as low as possible.

Funding of humanitarian assistance programmes is often inconsistent, unpredictable and erratic, some programmes are under-funded while others are over-funded (Van Brabant, K. 2002, 20). Donor decisions are at times determined by factors which are not directly related to the needs of affected people, such as political considerations, as well as outside the influence of humanitarian organizations.

Variations in government budgets for humanitarian assistance may not be related to changes in the needs of people affected by complex political emergencies (Oloruntoba, R., and R. Gray 2003, 6). Availability of private funds may correspond to ". . . fashion or to emotional, impulsive, or superficial responses" (Larragán, A.A., et al. 1998, 40). The response may also depend on the geographical proximity between donors and people affected by complex political emergencies (Oxfam 2000, 6). The intensity of media coverage, which does not necessarily correspond to the extent of complex political emergencies and the needs of people (Russbach, R., and D. Fink 1994), can also influence donor behaviour. On the one hand humanitarian organizations may face severe shortages for "forgotten conflicts" and on the other hand may have more funds at their disposal for certain humanitarian assistance programmes than required.

Donor decision may be based on short-term political considerations (Oloruntoba, R., and R. Gray 2003, 26) and the unpredictability of funding makes long- and even mid-term planning very difficult.

Another difficulty humanitarian organizations commonly face is the practice of "earmarking" funds (Forte, G.B. 1994, 6) where donors provide funds only for a specific programme and sometimes for a narrowly defined range of goods. The use of funds according to the terms prescribed by the donor may lead to a mismatch between offered and most urgently needed goods. Donors may be inclined to provide goods and services which receive more media coverage and which are perceived as priorities by donors (Larragán, A.A., et al. 1998, 32).

Earmarking prevents humanitarian organizations from providing other goods or services to the affected populations or from using the funds to cover more urgent needs in other crises. The consequence is a high probability of inefficient allocation (Larragán, A.A., et al. 1998, 31) where funds are not spent according to the priorities of recipients. Selling of food for cash by recipients, which allows people in need to purchase other urgently needed goods and services, is common.

Similar problems are caused by donations in "kind" rather than "cash". Donations of goods limit the flexibility of humanitarian organizations for responding to actual and most urgent needs. These donations may also incur significant transportation costs and prevent purchase near to the affected area which allows reducing transportation costs as well as response time. Donated goods may also be unsuitable for the context such as drug products suited for the epidemiology of developed countries rather than populations affected by complex political emergencies in less developed countries. More than half of all drug products donated to Bosnia and Herzegovina between 1992 and 1996 were inappropriate and 17,000 metric tonnes of unwanted drug products accumulated, which cost USD 34 million to dispose of properly (Berckmans, P., et al. 1997, 3).

Humanitarian organizations are accountable to their donors and must provide reports on the impact of their humanitarian assistance programmes as well as the use of funds. While donors can audit financial records and purchasing procedures, verifying the distribution of goods or the quality of services in the field is far more difficult (Larragán, A.A., et al. 1998, 58). Only donors which have the necessary expertise, staff and means at their disposal can audit the implementation of humanitarian assistance programmes and obtain independent information from recipients. Other donors must rely on the trustworthiness of the humanitarian organization they are funding.

In complex political emergencies, where the host government or authorities do not take charge, coordination among humanitarian organizations, which is necessary to maximize overall utilization of funds, can also impede and delay planning. As no formal coordination mechanisms have been established, activities of other humanitarian organizations must be explored and integrated into the planning before humanitarian assistance programmes can be finalized. Planning of health services requires close coordination to avoid duplications and ensuring that all essential needs are covered for all people in need (Perrin, P. 1996, 433).

Especially in acute emergencies coordination between dozens of humanitarian organizations can be hampered by lack of information sharing as well as incompatible communication systems (Burkle, F. 1999, 424).

Planning by one humanitarian organization may be further complicated by changes in programmes of other humanitarian organizations or their inability to obtain the necessary funds, which requires the former having to cover the needs at short notice.

Humanitarian organizations which lack the necessary expertise or funding to provide the whole range of essential services may depend on other humanitarian organizations. For example it is only sensible to provide health services if supply of safe water and food is assured. Small humanitarian organizations may depend on larger ones who outsource and pay for certain services.

While humanitarian organizations usually do not need to compete for customers they do compete for funding as well as for staff. Humanitarian workers not only need to be professionally qualified, they should also have experience in humanitarian assistance, be multilingual, be flexible, able to work under high stress and willing to take the risk of working in conflict areas. Human resources are particularly scarce where humanitarian organizations rely on volunteers or offer low remunerations (Larragán, A.A., et al. 1998, 39). The often high turnover of staff results in lack of institutional memory (Weinberg, J., and St. Simmonds 1995, 1663).

According to a survey among humanitarian organizations only 45% of logisticians possessed any formal qualification in logistics, transport or related areas (Oloruntoba, R., and R. Gray 2003, 4).

The potential geographic scope of humanitarian assistance programmes is vast (Larragán, A.A., et al. 1998, 40) and implementing humanitarian assistance programmes in several countries around the world requires complex management of global supply networks (Oloruntoba, R., and R. Gray 2003, 5).

Working internationally requires working in several different languages. In countries where languages commonly used internationally, for example, English, Spanish, French or Portuguese, are spoken staff with the required language skills can be recruited internationally. However in countries where languages which are rarely studied as foreign languages or various dialects are common, international staff will often require the help of translators for communicating. This is not only time-consuming but can lead to misunderstandings.

International humanitarian workers also need to adapt their conduct as well as assistance programmes to the regional, national and local culture and consider the difference in cultural perceptions and interpretations of behaviour, assistance and provided humanitarian assistance goods (Benoist, J., B. Piquard, and E. Voutira 1998, 2).

Where goods and services are not purchased domestically, crossing international borders increases the complexity of logistics operations (Oloruntoba, R., and R. Gray 2003, 5) and compliance with national laws and regulations can cause significant delays. Importation of some types of goods such as telecommunication equipment and drug products are often subject to stringent regulations and require prior registration and approval.

2.4.2 Less developed countries

Most armed conflicts take place in less developed countries (Mack, A. (ed.) 2005, 35), almost all deaths attributable to conflicts occur in less developed countries (Denny, Ch. 2005, 151) and needs for humanitarian assistance will be greatest in the least developed areas and countries (European Commission 2006, 5).

Some key indicators in high income or developed countries (DC), less developed countries (LDC) and least developed countries (LLDC) which are relevant for further analysis are presented in table 2.2 the data sources are presented in appendix A. The table shows that most averages for less developed countries which were affected by complex political emergencies in 2009 are worse than averages of less developed countries in general. Likewise

least developed countries affected by complex political emergencies show poorer ratings for most of the indicators than least developed countries which are not affected.

No.	Indicator	Number of countries for which data is available	Scale	Developed countries	LDC	LDC affected by CPE	LLDC	LLDC affected by CPE
A	**Education**							
1	Adult literacy rate	158	0 - 100%	99%	89%	85%	59%	56%
2	Enrolment in secondary education	174	0 - 100%	103%	82%	74%	37%	30%
3	Enrolment in tertiary education	137	0 - 100%	62%	32%	31%	4%	4%
B	**Health**							
4	Human Development Index	182	0 - 1	0.93	0.77	0.75	0.51	0.47
5	Health expenditure per capita	191	USD	2,003	285	237	68	17
6	Public health expenditure as percentage of total government expenditure	191	0 - 100%	15.0%	10.0%	8.9%	10.1%	6.6%
7	Number of people per physician	192	- - -	230	700	892	5,799	6,512
8	Number of people per nurse	192	- - -	93	325	530	1,335	2,310
9	Number of people per health professional	192	- - -	50	161	174	534	687
10	Annual per capita expenditure for drug products	181	USD	223	40	22	5	6
11	Access to essential drug products (estimate)	183	0 - 100%	0.96	0.72	0.74	0.54	0.50
12	Hospital beds per 1,000 people	182	- - -	5.63	3.06	2.14	1.16	0.61
C	**Technology**							
13	Main (fixed) telephone lines per 100 inhabitants	225	0 - 100	47.2	21.4	13.5	2.3	1.2
14	Mobile cellular phone subscribers per 100 inhabitants	221	0 - 100	108.3	80.2	73.0	26.7	15.8
15	Population covered by mobile cellular network	209	0 - 100%	87%	73%	87%	48%	39%
16	Internet subscribers per 100 inhabitants 2008	190	0 - 100	26.7	7.6	4.8	0.7	0.2
17	Internet users per 100 inhabitants 2008	216	0 - 100	60.1	26.3	19.3	4.4	2.8
18	Broadband subscribers per 100 inhabitants 2008	187	0 - 100	23.7	6.6	2.8	0.4	0.1
19	Personal computers per 100 people	172	- - -	48.6	12.5	11.7	2.0	2.3
20	Percentage of households with personal computers	158	0 - 100%	67%	25%	22%	4%	3%
D	**Infrastructure**							
21	Motor vehicles per 1,000 people	157	- - -	531	164	82	18	14
22	Road density (km / km^2)	79	- - -	280	109	119	6	7
23	Percentage of paved roads	64	0 - 100%	77	63	56	18	16
24	Air passengers carried (millions per year)	177	- - -	38.8	7.8	15.7	0.3	0.7
25	Air transport, cargo (million ton-km)	134	- - -	2,588	745	818	25	69
E	**Economy**							
26	Trade and transport infrastructure	154	1 - 5	3.48	2.53	2.58	2.01	1.98
27	Customs clearance efficiency	154	1 - 5	3.32	2.45	2.45	2.16	2.20
28	Timeliness of shipments	154	1 - 5	3.96	3.37	3.40	2.94	2.93
29	Logistics competence	154	1 - 5	3.48	2.67	2.74	2.21	2.18
30	Logistics Performance Index	154	1 - 5	3.52	2.78	2.81	2.38	2.34
31	GDP per capita	183	USD	32,362	11,255	8,851	2,164	1,249
F	**Governance**							
32	Rule of law	209	- 2.5 to 2.5	1.18	-0.14	-0.55	-0.78	-1.44
33	Regulatory quality	207	- 2.5 to 2.5	1.27	-0.10	-0.29	-0.93	-1.36
34	Government effectiveness	209	- 2.5 to 2.5	1.19	-0.09	-0.37	-0.92	-1.36
35	Political stability and absence of violence/terrorism	209	- 2.5 to 2.5	0.80	-0.06	-1.38	-0.60	-2.08
36	Corruption Perception Index	179	0 to 10	6.73	3.68	3.01	2.52	1.79
37	Control of corruption	207	- 2.5 to 2.5	1.19	-0.14	-0.55	-0.73	-1.29
	Total number of countries = 237			**60**	**128**		**49**	
	Total number of CPE = 24					**15** (11,7%)		**9** (18,4%)

Table 2.2 Comparison of indicators in developed and less developed countries

Consequently the constraints already encountered in less and least developed countries are even further compounded by complex political emergencies.

The lack of democratic traditions and structures in less developed countries is conducive to the collapse of state authorities, disintegration of states and the emergence of authoritarian rulers and (military) dictatorships.

The uncertainty about political developments makes mid- and long-term planning for humanitarian organizations difficult. Imminent political destabilization poses particular problems where humanitarian organizations establish structures and services in less developed countries for supporting neighbouring countries suffering from complex political emergencies.

While corruption is an international problem, it is more widespread and pronounced in poor countries (see table 2.2), can jeopardize the humanitarian organization's credibility and lead to security threats (Mayhew, B. 2004, 65).

When confronted with obvious corrupt practices of commercial businesses and state authorities, humanitarian organizations are faced with a dilemma. On the one hand they are bound by their ethical standards and code of conduct as well as the obligation to accurately account for all of their expenditures. On the other hand corruption in combination with weak judicial systems can cause significant delays in importing goods or obtaining various permits and paying "charges" or "fees" may be unavoidable (Mayhew, B. 2004, 65). In countries where corruption is widespread and part of everyday life, there is also a danger that tendering or recruitment of staff is tainted by corrupt practices.

Inefficient administration can cause significant delays for, among other things, obtaining visas and travel permits, registration of vehicles and aircraft, importation of goods, obtaining licences for operating (medical) stores and warehouses or tax exemptions.

Apart from the problems these delays are likely to cause, humanitarian organizations must also devote valuable resources to the follow-up of administrative procedures.

Even in countries which are not plagued by inefficient administration, high levels of bureaucracy which require submitting a multitude of documents, obtaining various approvals and signatures and involve a multitude of government authorities, are likely to cause significant delays for obtaining various permits.

Humanitarian organizations must take great care to comply with their code of conduct and follow rules and regulations meticulously. Even minor violations may not only have legal consequences but could be used by the authorities as a pretext to hamper humanitarian organizations which are critical about the authorities.

International logistics and supply chain management requires considering the national legal system and government regulations (Kummer, S., and H.-J. Schramm 2004, 77). Poorly developed legislation (see table 2.2) and especially poor legal security pose significant risks for concluding contracts and agreements. Enforcing contracts and indemnities may be literally impossible or require years of litigation. In addition high levels of corruption bear the risk of perversion of justice. Parties to contracts, especially suppliers of goods or services, may be tempted to take advantage of these circumstances and default on their contractual obligations.

Poorly developed pharmaceutical legislation and a domestic pharmaceutical market which is poorly controlled by state authorities facilitate importation of health care goods by humanitarian organizations. On the other hand protection of the domestic markets from counterfeit and substandard health care goods, both from domestic production as well as importation, will be low (WHO 1996d, 118).

Counterfeiting of drug products and other health care goods is a global public health problem which affects developed but predominantly less developed countries (WHO 2006e).

An estimated 1% of drug products in developed countries and between 10% and 30% in less developed countries are substandard or counterfeit (WHO 2006e).

Production of counterfeit drug products is encouraged where national drug regulatory authorities do not carry out the recommended regular inspections of manufacturing facilities (WHO 1992d, 17). According to the World Health Organization, national drug regulatory authorities should only permit importation of drug products which are licensed in the country of importation although waiving this requirement in emergency situations is recommended (WHO 1996d, 187).

A poorly developed financial infrastructure (McClintock, A. 1995, 21) requires settlement of financial transactions in cash rather than by check or bank transfer. This may include paying a large number of staff or purchasing large amounts of goods with cash. In countries with weak currencies and high levels of inflation the physical transfer of large amounts of cash can pose significant security risks (Mayhew, B. 2004, 76). Moreover cash in domestic currencies might depreciate very quickly or may be devalued and must be spent quickly. Changing of money may be subject to legal restrictions, for example officially a privilege of state banks.

In less developed countries infrastructure in terms of transportation networks, warehousing facilities and distribution systems is generally insufficient (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 327).

Management and provision of logistics services is often hampered by poor transportation infrastructures (Oloruntoba, R., and R. Gray 2003, 25) in less developed countries such as limited numbers and capacities of seaports and international airports. Rail networks are often poorly developed and services irregular and unreliable. Road networks are often poorly developed (see table 2.2) and maintained which limits the size and pay load of heavy vehicles, significantly reduces vehicle speeds and increases the risk of accidents. Especially deliveries to final recipients may require the use of all-terrain vehicles.

Transport may also be hampered or blocked by poorly maintained or impassable bridges. Rivers without bridges which are usually passable at shallow places may be impassable during certain seasons. Weight limits of bridges may even require carrying goods across a bridge and loading onto another vehicle on the other side.

Poorly constructed and maintained roads may turn into mud during the rainy season and become impassable. In countries with severe winters, road transport may be interrupted by unavailability of equipment for removing snow as well as by avalanches.

The airline industry is less developed (see table 2.2) and airports and airstrips may be poorly maintained or information on their condition unavailable.

Importation of goods may be hampered by limited capacities of seaports, airports and border crossing points due to lack of handling equipment and lack of staff. Difficulties for importation can be compounded by high levels of bureaucracy and corruption. In some countries the queuing of trucks for several days at borders is the rule rather than the exception.

This situation can quickly worsen when a large number of humanitarian organizations strain already limited infrastructure with the request to import large quantities of goods and equipment at short notice.

In many less developed countries warehouses and storage facilities may be unavailable (Lambert, R.S., and J.R. Stock 1993, 337) while services for port handling and road transport are usually offered by commercial companies.

Telecommunications networks are poorly developed (see table 2.2), often limited to the main cities and domestic as well as international connections can be unreliable. The use of computers is not as widespread as in developed countries (see table 2.2) and Internet and data communication networks (see table 2.2) are usually not widely available. The environment of less developed countries generally does not allow supporting advanced information technology such as bar coding or EDI (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 328).

Under these constraints information systems which require real time exchange of data such as EDI (Electronic Data Interchange) are not affordable. Especially in remote areas humanitarian organizations have to substitute any lack of telecommunications infrastructure by their own networks. In the absence of reliable landlines, voice and data communications will require the use of radio or satellite communications. Since maintaining satellite connections permanently may be prohibitively expensive, data exchange is restricted to regular up- and downloads.

The less developed economy as well as lower expenditure on health care (see table 2.2) limits the demand and therefore availability and quality of health care goods. Health care goods will often not be available domestically (PAHO 1983, VII) since their manufacturing requires expertise as well as investment in sophisticated equipment, which is mostly limited to advanced economies. Worldwide over 90% of drug products are manufactured in a few developed countries with two-thirds of drug products (in terms of value) manufactured by companies headquartered in only five countries (Creese, A., N. Gasmann, and M. Mariko 2004, 3). Most of the drug products available in less developed countries are imported (Menkes, D.B. 1997, 1557). Importers may offer a wide range of products but will not keep them in stock and rather import them only upon receipt of firm orders.

Since consumers are unable to check the composition and contents of drug products and drug testing requires sophisticated laboratories, counterfeit drug products are difficult to detect (WHO 1999a, 35). Counterfeit drug products may be mislabelled with respect to the identity of their contents and/or the source, be sold in fake packaging or contain little, the wrong or no active pharmaceutical ingredient or even toxic substances (Forzley, M. 2006, 2). The decrease or absence of therapeutic, diagnostic or prophylactic value of counterfeit drug products can cause death, disability and injury (Forzley, M. 2006, 6).

Lack of legislation or enforcement of existing legislation, weak or absent national drug regulatory authorities, corruption, scarcity of drug products and high prices (WHO 1999a, 15f.) as well as potentially high profit margins are conducive to trade in counterfeit drug products from domestic production as well as through international trade.

In many less developed countries purchasing of drug products does not require the prescription of health care professionals and the possibility of self-medication creates a large and lucrative market.

The relatively high value of single use medical devices, such as syringes and various catheters, and the difficulty of determining the quality and especially sterility also open a lucrative market. For example the illegal re-processing and re-packaging of used syringes for resale (Cheng, M. 2003, V). Moreover regulatory controls for single medical devices and health care equipment are scarce in less developed countries (Cheng, M. 2003, V).

Because of high unemployment rates, labour is generally readily available. At the same time well educated and highly qualified staff, such as health care or logistics professionals, is likely to be scarce as staff will seek better employment conditions and career opportunities abroad.

High unemployment, low wages and very limited social benefits encourage employment of labour rather than investing in equipment and automation and may justify manually loading and unloading lorries or aircraft.

High levels of illiteracy (see table 2.2) and low levels of education in general imply difficulties in employing qualified and well trained staff, especially logistics professionals (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 328). While education levels tend to be higher in urban areas, recruiting literate and numerate staff with foreign language skills may be difficult outside urban areas. Moreover finding staff with good computer skills may also prove difficult.

In many countries where humanitarian organizations provide assistance, the practice of logistics is not developed (Oloruntoba, R., and R. Gray 2003, 5) and recruitment of experienced logistics professionals may be difficult.

Health care services are poorly developed, often chronically under-resourced, concentrated in urban areas and offer a limited range of specialist services (see table 2.2). The number of health professionals is low (see table 2.2) and populations in rural areas often have to rely on health care workers with limited professional training.

Although health care goods are usually readily available in the market, due to financial constraints of governments and authorities, shortages in health care facilities are common. In 2000 the populations of middle-income countries, which account for half the world's population, consumed only 10% of worldwide production of drug products and the populations of low-income countries, which account for 36% of the world's population, purchased less than 1% of worldwide production (Creese, A., N. Gasmann, and M. Mariko 2004, 33). A quarter of the world's population (1.7 billion people) and half of the population in Africa do not have access to essential drug products (Creese, A., N. Gasmann, and M. Mariko 2004, 61).

Logistical support to health care facilities in less developed countries is neglected and poorly planned. Storage facilities are often inadequate and poorly managed and poor distribution management results in delays, spoilage and losses of critical supplies (Tarimo, E., and E.G. Webster 1997, 33). Patients or relatives are often obliged to purchase necessary drug products and equipment in the market and provide them to the respective health professionals for treatment or surgical operations.

High temperatures and humidity in (sub)tropical countries require special measures to protect drug products from degradation and spoilage.

2.4.3 Complex political emergencies

Humanitarian organizations are faced with "uncountable constraints" (Russbach, R., and D. Fink 1994, 1) in armed conflicts and delivery of humanitarian assistance in armed conflicts is difficult (Weinberg, J., and St. Simmonds 1995, 1663).

Complex political emergencies are characterized by high degrees of instability (Larragán, A.A. et al. 1998, 40) which are caused by collapsed, contested or seriously weakened states (Gundel, J. 1999, 4).

Even where formal state authorities may still exist, they are unable to exercise power or control over the state territory. This void is filled by a multitude of (illegitimate) actors such as paramilitaries, separatists, insurgents, rebels, vigilantes, militias, mercenaries, warlords, irregular fighters and criminal gangs.

These actors have disparate interests (Larragán, A.A. et al. 1998, 40) and are virtually uncontrollable (Trintignac, F. (ed.) 1999). Where access is not free, humanitarian organizations

have to negotiate access to each territory with the respective actors which exert actual control (Ebersole, J.M. 1995, 19).

Since state authorities are weak or even absent they cannot fulfil their responsibility of coordinating humanitarian assistance efforts. Moreover weakened state authorities, their remnants or other conflict parties will divert any available resources to the armed conflict and may not be able or willing to provide for the population.

The inability of any state authority to exert control over their territory leads to the breakdown of the rule of law, the absence of any effective regulatory framework (Leader, N. 2000, 10) and therefore leads to the lack of legal security for humanitarian organizations.

State authorities can no longer be held accountable for breaches of international (humanitarian) law. Humanitarian organizations can also not rely on any intervention, protection or assistance in case of violations of laws such as theft, looting or damage to property. Contractual agreements, for example renting of warehouses, purchasing of goods or employment of staff, are concluded at the risk of humanitarian organizations since breaches cannot be prosecuted.

As a consequence of the breakdown of legitimate government institutions (Milwood, D. (ed.) 1996), immigration authorities cease their services, customs authorities are no longer controlling and administering importation of goods and national drug regulatory authorities no longer control the importation, storage or distribution of health care products.

The lack of commercial regulations often results in the development of "war economies" (OECD 1999, 7) which engage in activities which would be illegal under normal circumstances. Since control of wealth is often one of the causes of conflicts, war economies can prolong conflicts.

Regardless of whether the actors exerting control are legitimate or not, humanitarian organizations depend on their permission for entering their territory and on their consent for carrying out humanitarian assistance programmes.

Crime and banditry, encouraged by the absence or weakness of state authorities, as well as the conflict itself cause insecurity and high levels of violence (Burkle, F. 1999, 422). The insecurity poses risks for the general population, recipients, humanitarian workers (Larragán, A.A., et al. 1998, 40) as well as humanitarian assistance goods and assets. Within a country or even a region the level of insecurity may differ significantly. While some areas may be relatively peaceful others can be affected by violent conflict at the same time (OECD 1997, 11).

Despite their protection under international humanitarian law (Bruderlein, C., and J. Leaning 1999, 430), increasingly civilians and their livelihoods are not only indirectly affected by the conflict but are becoming direct targets (OECD 1999, 7). Woman, children and health care facilities are deliberately and indiscriminately attacked (Burkle, F. 1999, 425). Where civilians become part of the conflict, humanitarian workers providing assistance to them can no longer rely on being considered as impartial (Makinlay, J. (ed.) 1996, 20) and are also being deliberately targeted (Krähenbühl, P. 2004, 505). Moreover differentiating between combatants and civilians is becoming more and more difficult (OECD 1999, 7) and combatants may benefit from humanitarian assistance provided to civilians.

Before the end of the Cold War, security of humanitarian workers was no major concern. Despite their protection under international humanitarian law, violence against humanitarian organizations and their staff have since become a daily routine (Schneider, M. 2003, 138). Threats against the safety and security of United Nations personnel have escalated at an

unprecedented rate during the 1990s (United Nations General Assembly A/57/300, 2002). In nearly all conflicts humanitarian workers have fallen victim to threats, injuries, kidnapping, robberies, sexual assaults and 350 humanitarian workers from the United Nations and Red Cross movement alone have been murdered between 1992 and 2001 (Schneider, M. 2003, 139). The concern over the growing number of deaths and injuries from deliberate attacks on humanitarian workers has led to establishing the Convention on the Safety of United Nations and Associated Personnel (UN General Assembly Resolution 49/59, 1994).

Humanitarian workers may become victims of various crimes such as threats, harassment, illegal arrests, robberies, abductions, physical abuse or injuries (UN Security Council Resolution 1502, 2003) while humanitarian assistance goods and assets may be looted, confiscated, stolen or vandalized. Humanitarian organizations may also be affected by conflict related dangers such as indiscriminate attacks, ambushes, threats from various types of fire arms, a wide range of explosive devices such as anti-personnel mines, grenades, improvised explosive devices and car bombs, shelling with mortars, artillery and rockets as well as aerial bombs (Roberts, D.L. 2005, 41).

International borders may be closed either by the conflict parties themselves or by neighbouring states which want to prevent combatants or displaced populations from entering their territory.

In these situations humanitarian organizations will have to negotiate passage of humanitarian assistance goods, humanitarian workers and evacuated civilians with all parties in control of the respective territories or use alternative access routes.

Humanitarian organizations need to obtain consent and cooperation of the parties in control to gain access to the conflict area and to the people in need (The Sphere Project 2004, 13), an indispensable condition for providing humanitarian assistance.

Despite obligations under international humanitarian law, access is often hindered (Russbach, R., and D. Fink 1994, 8) and frequently even denied (Trintignac, F. (ed.) 1999).

According to Art. 70 of the First Protocol Additional to the Geneva Conventions, parties to the conflict must allow and even facilitate humanitarian assistance and withholding of humanitarian assistance can constitute a war crime (Rottensteiner, Ch. 1999, 580). Conflict parties must allow free passage of humanitarian assistance goods to territories under control of the adverse party (Geneva Convention IV, Art. 23) but have the right to search consignments and regulate their passage (Geneva Convention IV, Art. 59).

Access of humanitarian organizations in general as well as provision of humanitarian assistance goods might be restricted, obstructed or denied directly (Bruderlein, C., and J. Leaning 199, 431) by physical means such as road blocks, mining roads and bridges, by threats to use force or by military means such as direct attacks. Besides conflict parties may resort to more subtle means (Rottensteiner, Ch. 1999, 559-560) such as denying humanitarian workers visas or travel permits, granting staff access but being unable to guarantee their security, denying the use of telecommunication equipment essential for safety and security of staff or imposing unacceptable conditions such as demanding fees and customs duties or determining the beneficiaries. Provision of humanitarian assistance can be delayed by requesting additional documentation and permits for staff or consignments, lengthy inspections of consignments, possibly requiring vehicles to be completely unloaded as well as threatening or carrying out confiscations. Authorities may refuse or delay providing security escorts or deny over flight and landing permissions for aircraft.

During armed conflicts authorities often deliberately restrict people's movements by imposing curfews, enforcing roadblocks and travel restrictions and closing borders

(Slim, H., and A. Bonwick 2005, 26). Since in most cases humanitarian assistance cannot be physically provided to each recipient, access of people to locations where goods or services are provided are of equal importance.

Access to health care facilities can be impeded for several reasons (Perrin, P. 1996, 322). Great distances and unavailability of means of transportation cause physical or geographical inaccessibility while lack of financial resources may make available treatment unaffordable. Increased demand for health services during crises may lead to social inaccessibility where disadvantaged groups are denied access. Discrimination against groups because of their political affiliations, ethnicity, religion or support of a conflict party may make health care facilities politically inaccessible. Finally safe access to health services may be blocked by warfare (Guha-Sapir, D., and W. van Panhuis 2002, 19) or by destruction of transportation routes (Perrin, P. 1996, 319). People may also be too afraid to seek health care services from facilities even if they are accessible (Slim, H., and A. Bonwick 2005, 26).

Humanitarian organizations may negotiate cease-fires to allow safe passage of humanitarian assistance goods or access of people in need to distribution points or health care facilities (OECD 1997, 15).

Economic sanctions are among the measures the Security Council can take under Chapter VII of the United Nations Charter to maintain or restore international peace and security (Gasser, H.-P. 1996, 872). Transportation sanctions which interrupt road and rail links as well as sea and air transportation may hamper access to critical health care goods (Bessler, M., R. Garfield, G. Mc Hugh 2004, 20). Vital voice and data transmission to suppliers outside the conflict area may be hampered by interrupted communication links (Gasser, H.-P. 1996, 879) and trade sanctions may reduce variety and availability of health care goods in the domestic market. Obtaining approval for importation permissions for humanitarian assistance goods from the United Nations Security Council can take months (Forte, G.B. 1994, 6).

Obtaining exemptions from sanctions according to international humanitarian law (Minear, L. et al. 1998, 55) and complying with sanction committee procedures can delay shipments. Items such as telecommunication equipment or vehicles which could be diverted and misused by conflict parties will be particularly scrutinized.

Armed conflicts and the resulting complex political emergencies may erupt suddenly (Ballance, S. (ed.) 2005, 1), even if their causes go back years or even decades. On the other hand complex political emergencies may develop slowly, alternate between relative peace and extreme violence (Slim, H. 1997) or show seasonal patterns.

Conflicts and the resulting complex political emergencies are unpredictable and dynamic processes (OECD 1997, 11). Situations and front lines often change rapidly and unexpectedly (Domestici-Met, M.-J. et al. 1998, 50). In long lasting conflicts fairly stable situations may suddenly exacerbate, creating urgent needs for humanitarian assistance, and recede again (OECD 1999, 7). In cases where military preparations indicate imminent warfare or when a conflict party gives an ultimatum, the onset of hostilities may be quite predictable.

Complex political emergencies are often protracted, lasting many years and even decades and have therefore been called "permanent emergencies" (Slim, H. 1997).

Insecurity, possibly trade sanctions, domination of trade by conflict parties as well as displacement discourage economic activities and disrupt trade of essential goods or even cause the collapse of local and domestic economies. Health care goods will become scarce and transportation may be hampered by fuel shortages.

Lack of state authorities and a deteriorating economic situation will lead to a neglect of the infrastructure and its maintenance. Besides civilian structures such as airports, ports, railway stations and railways, main roads, bridges and tunnels are often primary targets (OECD 1999, 7) or are inadvertently damaged during warfare. In extreme cases conflict parties may pursue a scorched earth policy (Bunjes, R.A. et al. 1998, 7) and try to destroy as much infrastructure as possible. The targeting of power and transformer stations as well as fuel depots can cause the collapse of the energy supply system.

Damage or destruction of telephone networks or radio stations, which are often the first targets in a conflict (Collier, P. et al. 2003, 14), can cause the rapid collapse of the telecommunications infrastructure. The increased centralization of domestic and global public telecommunication networks has increased their vulnerability (Klenk, J.S. 1997, 44).

The lack of state authorities, decrease of state revenue and lack of foreign currency will lead to a general lack of financial means and weaken national health systems (Perrin, P. 1996, 324). Health expenditure is usually drastically reduced in conflicts although demand for health services increases (Kalipeni, E., and J. Oppong 1998, 1645). Armed conflict directly affects all contributors to health and increases the risk of disease, injury and death (Ghobarah, H.A., P. Huth, and B. Russett 2004, 871).

Unpaid health professionals will be forced to seek alternatives for earning a living (Guha-Sapir, D., and W. van Panhuis 2002, 19) and are often the first to leave the country (Ballance, S. (ed.) 2005, 12). The degradation or suspension of national education systems as well as the departure or killing of professionals (Mackinlay, J. (ed.) 1996, 18) cause acute shortages of health staff and cause further deterioration of health services.

Already fragile and under-resourced health care facilities may be looted, damaged or destroyed by inadvertent bombing or shelling as well as by deliberate attacks (Guha-Sapir, D., and W. van Panhuis 2002, 19). These problems are compounded by the interruption of distribution systems for supplying health care facilities, the loss, damage or destruction of equipment and the lack of drug products and other health care goods (Ockwell, R. 1994, 72). Armed conflicts cause deterioration of health services which are often already inappropriate even before the conflict (Macrae, J., A.B. Zwi, and L. Gilson 1996, 1095).

Preventive, curative as well as rehabilitation services can be affected and deteriorate. Preventive care will be affected by a reduction of immunization coverage which increases the risk of epidemics (Guha-Sapir, D., and W. van Panhuis 2002, 20) as well as by disruption of prenatal care which increases infant and maternal mortality (Kalipeni, E., and J. Oppong 1998, 1638). The suspension of measures and programmes for controlling vectors also increases the incidence of communicable diseases (Perrin, P. 1996, 154).

The percentage of civilians among the casualties increased from 5% during the First World War to 50% during the Second World War (Beristain, C.M., and G. Donà 1998, 4). During the cold war civilians accounted for by far the greatest number of casualties through direct or indirect effects of armed conflicts (Mackinlay, J. (ed.) 1996, 13). The repeated claim that 90% of people killed directly or indirectly by armed conflicts has been described as completely unfounded (Mack, A. (ed.) 2005, 75). However in protracted conflicts in poor countries the indirect effects of armed conflicts account for the vast majority of deaths und in some conflicts more than 90% of victims were civilians (Lacina, B., and N.P. Gleditsch 2005, 159).

This dramatic increase is not an inadvertent side effect but rather the result of disregard and blatant violations of international humanitarian law, where civilians are being deliberately targeted and attacked (Schneider, M. 2003, 139). The distinction between combatants and non-combatants, the very foundation on which international humanitarian law rests, is being eroded (Leader, N. 2000, 2) and civilians have become the objective and focus of armed

conflicts (ECHO 1999, 80). Among the civilians, children and woman are most vulnerable and account for the great majority of the civilian victims (Bunjes, R.A. et al. 1998, 4).

Machetes, fire arms, varies types of mines and grenades, shelling, bombs, incendiary devices and as well as chemical weapons cause (gun shot) wounds, traumatic amputations, crush injuries, burns and poisoning which in turn result in psychological trauma, injuries, permanent disabilities, mutilation and death (Perrin, P. 1996, 224). Tripling the number of deaths provides an indication of the number of injured combatants and non-combatants in armed conflicts (Russbach, R., and D. Fink 1994, 3).

Civilians do not only suffer from direct violence of warfare but are also affected indirectly by deterioration of their nutritional status, lack of safe water, poor sanitary conditions, displacement and overcrowding as well as deterioration of health services (Perrin, P. 1996, 396). Mortality rates among refugees which have newly arrived in a neighbouring country have been reported to be up to 12 times as high as normal rates (Ghobarah, H.A., P. Huth, and B. Russett 2004, 872). Consequently complex political emergencies need to be recognized as public health disasters (Burkle, F. 1999, 422) which require a public health response.

Although counter-intuitive, with the exception of genocide, the great majority of deaths in armed conflicts can be attributed to indirect causes rather than direct violence and ironically the safest place in contemporary conflicts may be the army (Slim, H. 1997). An analysis of nine major armed conflicts in sub-Saharan Africa found that battle-deaths accounted for as little as 2% and on average for 6 - 8% of deaths while the majority of deaths were caused by disease and malnutrition (Mack, A. (ed.) 2005, 127).

The combination of increased prevalence caused by poor nutritional status, deterioration of preventive services and impaired access to curative health services and the increased seriousness of medical conditions caused by delayed treatment result in an overall increased mortality (Perrin, P. 1996, 192).

With maternal and child health often already precarious in peace times (Bunjes, R.A. et al. 1998, 5), children, (pregnant) woman and the elderly are most vulnerable to the indirect effects of armed conflicts (Guha-Sapir, D., and W. van Panhuis 2002, 17). The highest mortality rates are found among children under five years of age affected by armed conflict (Zwi, A. et al. 2006, 1886).

Another reason for the increase in the number of sick people, which would be treated and would recover in the absence of the armed conflict, is the degradation or collapse of health services (Sondorp, E., and A.B. Zwi 2002, 310). Compared to peace time demand, conflict related injuries increase the overall demand for health services (Perrin, P. 1996, 321).

Even health care facilities which have not been adversely affected by the armed conflict may be overwhelmed with injured patients as well as by the need to serve a population which has suddenly and significantly increased due to the arrival of displaced people in the community (Perrin, P. 1996, 324). Moreover providing displaced populations but not the host population with humanitarian assistance can cause diversion and conflict.

Compared to peace times the extent of health needs of displaced populations in complex political emergencies increases two- to threefold (Perrin, P. 1996, 301). The main cause for mortality among displaced populations is the spectacularly high rate of infectious diseases (Guha-Sapir, D., and W. van Panhuis 2002, 19). The negative impact on public health persists up to ten years after hostilities cease (Mack, A. (ed.) 2005, 131) and the increase of infant mortality persist almost at the same level during the five years after the armed conflict ends (Collier, P. et al. 2003, 24). In the aftermath of armed conflicts health services will be allocated

less resources, they are used less efficiently and damaged health care facilities may take years to restore (Ghobarah, H.A., P. Huth, and B. Russett, 872). One study estimates that twice as many deaths were caused by the aftermath of conflicts from previous years than through direct and immediate effects of armed conflicts in 1999 (Ghobarah, H.A., P. Huth, and B. Russett, 870).

Overcrowding, lack of food and safe water, poor sanitary conditions as well as a decrease in immunization coverage and lack of health services are conducive to the spread of infectious diseases (Perrin, P. 1996, 127). However except for measles and cholera, epidemics are rare (Simmonds, St., P. Vaughan, and S. W. Gunn (ed.) 1986, 36).

The most frequent infectious diseases among displaced populations are measles, diarrhoeal diseases, acute respiratory infections and malaria (Hanquet, G. (ed.) 1997, 41). Together with malnutrition these diseases account for up to 95% of deaths among displaced populations (Hanquet, G. (ed.) 1997, 41).

According to the World Health Organization up to 30% of the almost one million annual deaths from Malaria in Africa occur in countries affect by humanitarian emergencies (WHO 2000c, 1) and malaria often kills more people than the direct effects of armed conflicts.

Complex political emergencies often affect entire countries or large regions and sometimes even spread to neighbouring countries by drawing them into the conflict or by displacement of populations across international borders (Mack, A. (ed.) 2005, 132). Even if an armed conflict does not spread, public health in neighbouring countries is adversely affected and deteriorates mainly due to an increase of infectious diseases (Ghobarah, H.A., P. Huth, and B. Russett 2004, 880).

Since patients will only visit a health care facility if it is within a reasonable distance of their home (Perrin, P. 1996, 318), a fairly large number of health care facilities must be maintained in order to provide health services for the entire population.

The unpredictability of the conflict implies that the number as well as location of people in need is difficult to anticipate. Military attacks can suddenly increase the number of wounded and the disruption of water supplies can increase the prevalence of infectious diseases. The (deliberate) damage or destruction of health care facilities (Slim, H., and A. Bonwick 2005, 26) and the breakdown of health care systems (Ballance, S. (ed.) 2005, 1) can create an immediate need for substitution. The lifting of military blockades and sieges, which deprive the civilian population of health services, can suddenly create large and urgent needs for humanitarian assistance.

Complex political emergencies often lead to displacement of large populations (Guha-Sapir, D., and W. van Panhuis 2002, 17) which try to escape from violence and persecution or which are no longer able to sustain their livelihoods at home. The number of people, speed of displacement and the direction they flee in may be unpredictable as they depend on the development of the conflict.

Populations may also move to places where they expect to have better access to humanitarian assistance such as distribution of food or household goods. Patients, who can (no longer) afford paying for health services, may seek free treatment offered by humanitarian organizations elsewhere (Perrin, P. 1996, 319).

For several reasons mentioned above, demand for health care goods will change with the unpredictable developments of the conflict, prevalence of medical conditions as well as movements of populations. The need for humanitarian assistance will also depend on changing capacities of health care facilities.

The place of need, the type as well as the quantities of required health care goods can change quickly and unpredictably.

A sudden increase in demand for health care goods may be caused by an influx of wounded patients, seasonal increases of diseases and epidemics, emergence of diseases which are not endemic or changes in treatment protocols.

Even where demand for health care goods is fairly steady, irregular and unsystematic ordering, miscalculations as well as damage, destruction or unanticipated expiry of stocks can cause irregular and erratic ordering. Health care facilities may also make large requests to take advantage of free donations rather than basing requests on actual demand. The breakdown of (poorly maintained) health care equipment may cause a sudden, unexpected and urgent order for its replacement.

Changes in assistance programmes can also cause sudden changes in demand for example by extending assistance to other departments or services within a health care facility, increasing the number of assisted health care facilities or extending assistance to health care facilities in other cities or areas.

Demand may be particularly erratic where health care facilities already receive (irregular) support and humanitarian organizations only fill gaps when shortages occur.

Due to the general economic decline or collapse, loss of income as well as displacement, people may no longer be able to pay for health services. Humanitarian organizations may have to assist health care facilities which are no longer able to recover costs from patients.

In many complex political emergencies humanitarian assistance must be provided immediately (Larragán, A.A. et al. 1998, 40) in order to save lives and prevent outbreaks of infectious diseases.

Since health care goods are not useful for everyone and less coveted by the conflict parties, they are less prone to diversion and theft than for example food, vehicles or fuel. Nevertheless health care goods may be diverted by combatants for their own use. Health care professionals, often underpaid or not paid for a long time, may steal goods either for use in their private practice or to make money.

Diversion and theft cause unexpected increases in demand, may deprive patients of health care goods and lead to allocation of resources to individuals for which the assistance was not intended.

2.4.4 Characteristics of health care goods

The different characteristics of health care goods are a major consideration for logistics and supply chain management (Rushton, A., J. Oxley, and Ph. Croucher 2000, 91) and have important implications for their purchasing, packaging, handling, storage, transportation and distribution.

Relevant physical characteristics are weight, volume and physical state. Liquid dosage forms such as infusions and disinfectants or x-ray supplies are heavy and have high densities. Other dosage forms such as pressurized containers, for example inhalers, may be subject to restrictions for air transportation. Various single use medical devices as well as instruments are sharp or pointed and require special care during handling. Many dressing materials, such as gauze or cotton, are light but bulky while furniture, for example operating tables, and some equipment, such as autoclaves or x-ray machines, are bulky and heavy.

Some chemical characteristics are important for storage and transport, especially by air. Some liquids used for laboratory diagnostics, which often contain alcohol, are flammable and disinfectants may be corrosive.

Injectable drug products and some other dosage forms as well as injection material, catheters, drains and surgical gloves are sterilized after manufacturing and require enclosure in special packaging until opened for use. All drug products and sterilized products have limited shelf lives and must be used before expiry.

Some drug products, diagnostic tests, sutures and health care equipment can have significant values.

Finally drug products which can be abused or are precursors of addictive drugs are subject to the Single Convention on Narcotic Drugs (1961), the Convention on Psychotropic Substances (1971) or the United Nations Convention against illicit Traffic in Narcotic Drugs and Psychotropic Substances (1988) as well as to special regulations at national level. Importation of internationally controlled drug products requires obtaining an import authorization from the competent authorities which is then submitted to the competent authority of the exporting countries for obtaining an export authorization (WHO 1996d, 193).

2.5 Material assistance framework

One important element in designing and implementing health care programmes is deciding on the kind, frequency, scope and volume of material assistance. While development of strategies and policies are the responsibilities of health programme managers, logistics managers can contribute by assessing and explaining the logistical advantages and disadvantages of different strategies.

Close cooperation with health programme managers allows logistics managers to plan and design the required logistics services to meet the needs of assisted health professionals and health care facilities.

The framework in figure 2.4 attempts to link different assistance strategies with suitable logistics strategies.

Not every humanitarian emergency warrants the intervention of humanitarian organizations in general or a specific humanitarian organization in particular. For example humanitarian organizations specializing on complex political emergencies will not intervene in case of natural disasters. Secondly the situation must be covered the mandate of the respective organization.

Needs for material assistance may be covered by health care systems in the country, governments may be able to provide additionally required resources or other assistance such as training of health professionals may be needed. If their capacities are not sufficient, the intervention of other humanitarian organizations may be sufficient already.

If the need for material assistance is in principle identified, the affected target populations (A) such as civilians, wounded and sick (ICRC 2008, 11) or refugees and internally displaced populations need to be determined.

As a next step the geographical areas such as regions, provinces or districts in need of humanitarian assistance need to be determined.

Within the selected areas the health care services (C) such as first aid and medical evacuation, primary health care, hospital care and rehabilitation (ICRC 2004, 690) as well as the respective health care facilities requiring assistance need to be identified.

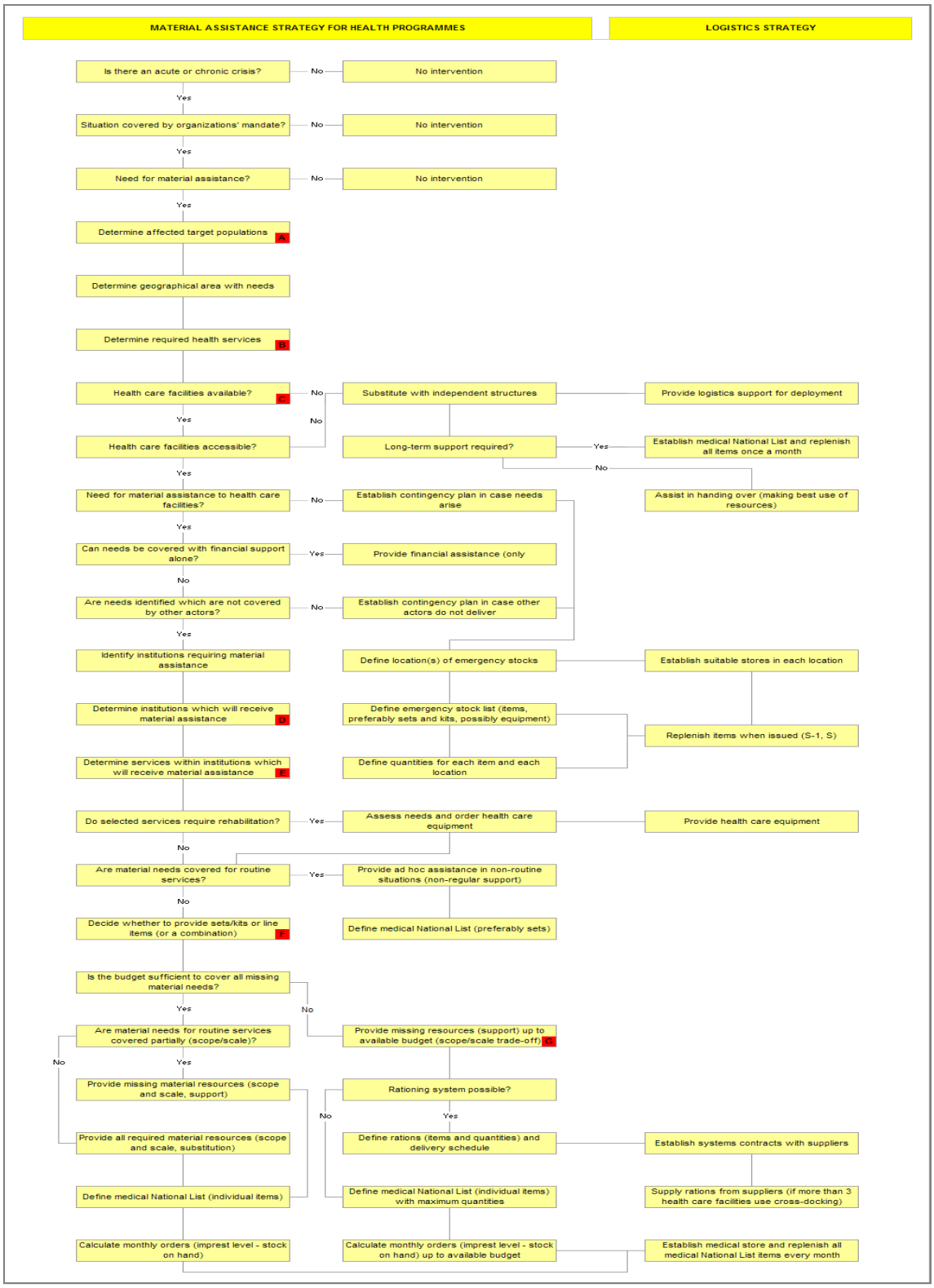

Figure 2.4 Assistance - Logistics strategy framework

If no health care facilities are available or existing structures are not accessible for people in need, setting up independent structures provided by the humanitarian organization can be considered (substitution). For example the International Federation of Red Cross and Red Crescent Societies has developed Emergency Response Units for basic health care and a

complete referral hospital which can be deployed within a few days. These are self-sufficient for weeks or months but require logistics support during deployment. For long-term deployment the replenishment of these health care facilities has to be planned from the time of deployment.

In some cases providing financial support for purchasing material resources in the country may be sufficient to cover existing needs.

Even if health care facilities are not (yet) in need of material assistance, health programme managers and logisticians need to establish contingency plans for the case that the demand for health services increases and exceeds existing capacities.

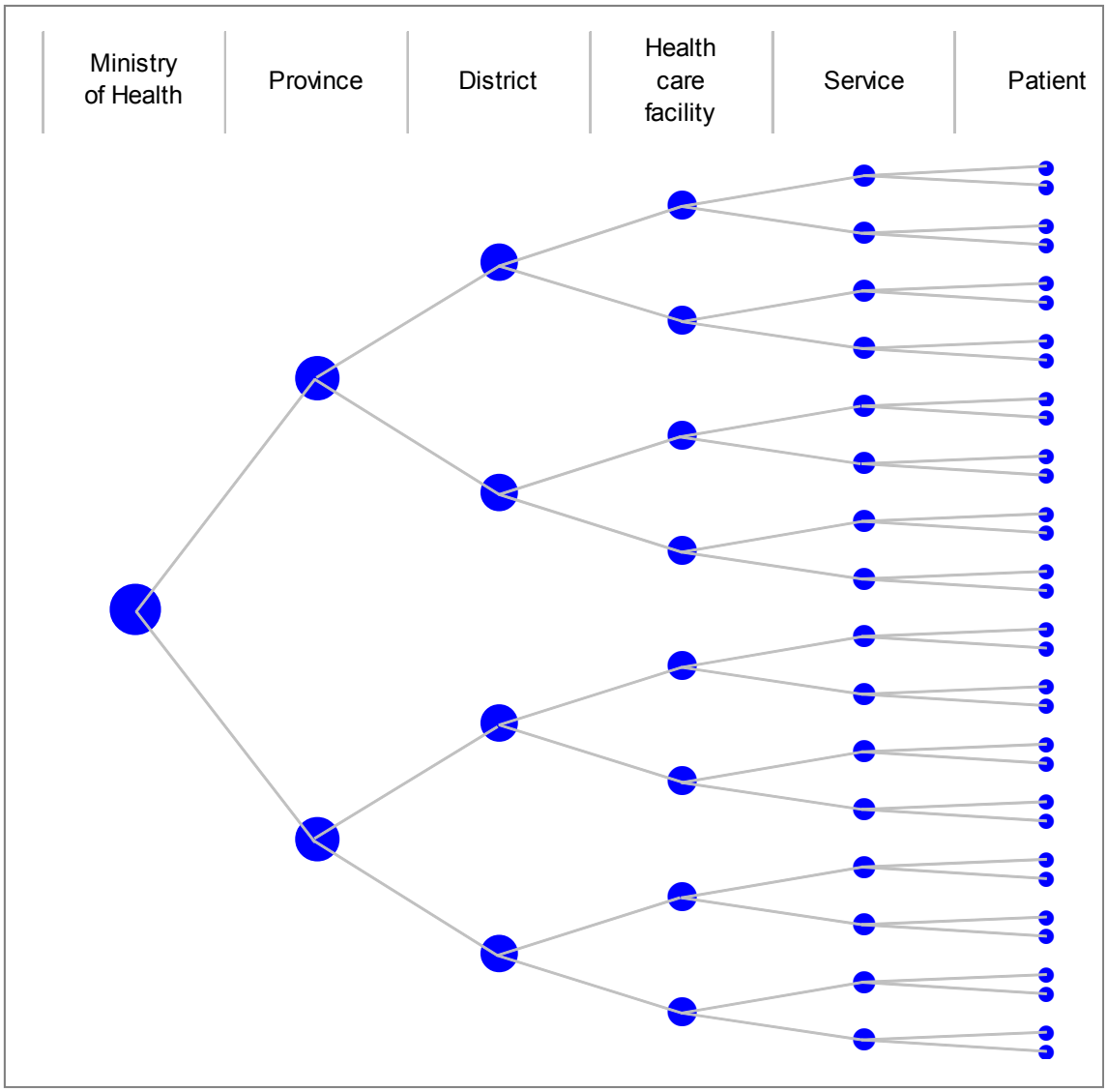

Figure 2.5 Stages of supply networks of the domestic health system

The (sudden) departure of another humanitarian organization or (sudden) suspension of their health care programmes may be another reason that needs may suddenly arise or increase and likewise requires developing contingency plans. If a general need for material assistance is confirmed, the stage of the domestic supply network of the health system (D) at which support is provided needs to be determined (see figure 2.5). Material assistance could be provided directly to the Ministry of Health, at the provincial or district level or directly to

health care facilities. In the last case specific health care facilities such as first aid posts, clinics, vaccination centres or hospitals need to be identified. Depending on the constraints, available resources and priorities a number of specific health care facilities will be selected for assistance.

As a next step the services (E) within large health care facilities such as outpatient departments, emergency and elective surgery, internal medicine (including chronic and infectious diseases) departments, clinical support services (laboratory and blood transfusion, diagnostic imaging etc.) as well as ancillary services (pharmacy, laundry, water and power supply) need to be determined.

The next important step is considering whether these health care facilities require any kind of rehabilitation as this will require providing health care equipment and possibly construction and installation works.

If needs for providing routine health services are covered, ad hoc assistance may be needed to cover increases in the demand for health services such as large movements of populations or situations of mass casualties.

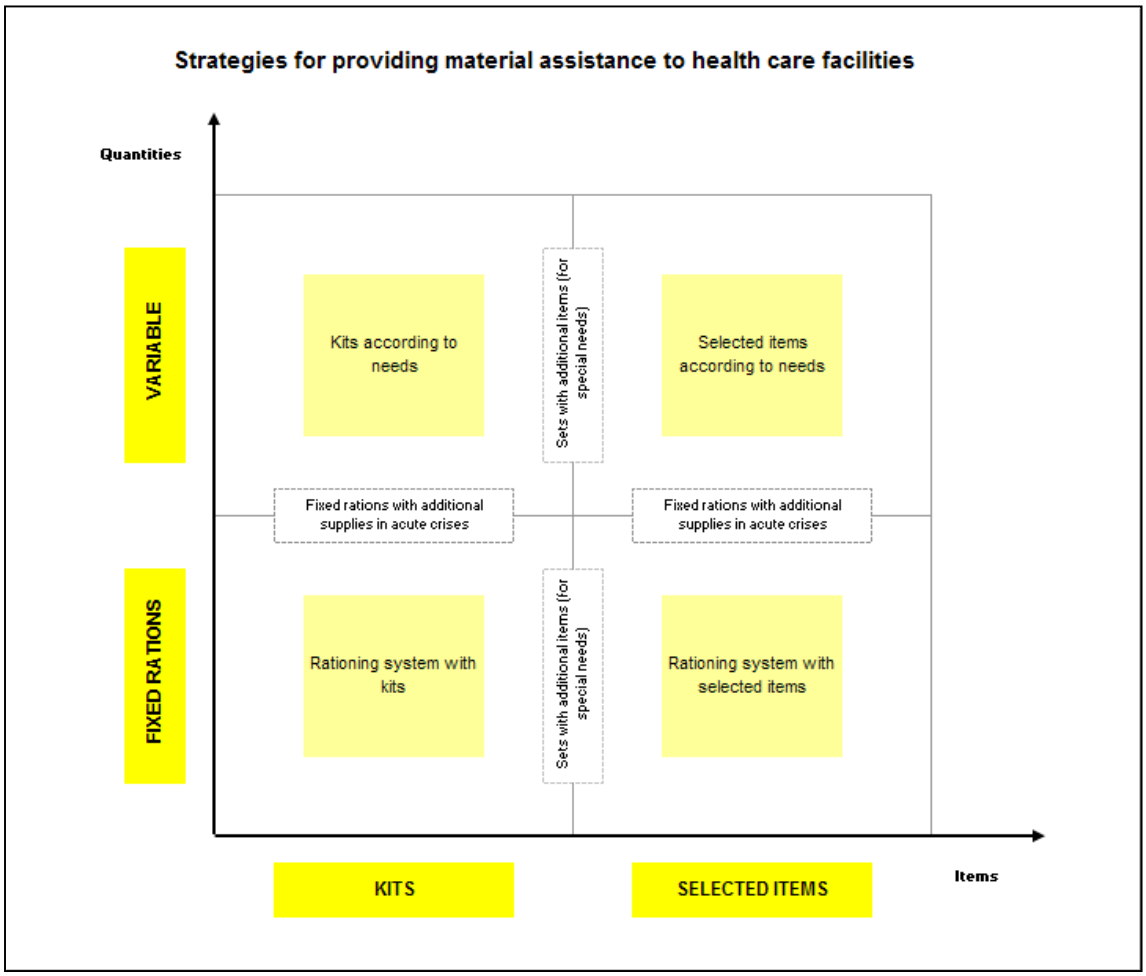

Figure 2.6 Strategies for providing material assistance to health care facilities

The decision on whether to assist with individual items or prepacked kits (F) has very significant implications on the complexity of required logistics services. The logistically least complex and most efficient strategy (see figure 2.6) is the provision of a specific number of

predetermined types of kits at regular intervals. This rationing system allows to accurately forecasts needs but is inflexible.

Material assistance can be more adapted to actual needs by providing the number and type of kits requested by assisted health care facilities and (occasionally) supplementing kits with individual items not included in the kits or required in larger quantities.

Where kits are not suitable or part of the required health care goods are provided from other sources, selected items can be regularly provided in fixed quantities (rationing system).

Finally, the greatest flexibility for assisted health care facilities which requires the greatest complexity for logistics services is enabled by providing individual items in individually required quantities.

A rationing system of providing kits or items allows establishing system contracts as well as scheduled deliveries from suppliers, international or regional distribution centres. Therefore determining the material assistance strategy has an immediate and significant effect on the required supply network. Figure 2.4 points out that setting up medical distribution centres and stores is not always necessary. If the financial and logistical resources are not sufficient to cover all missing material needs, the scope and scale (G) of the selected items must be determined (see figure 2.7). Assisted health care facilities and health programme managers must consider the trade-off between providing only a limited proportion of the full range of essential items or providing the full quantities of a limited range of essential items.

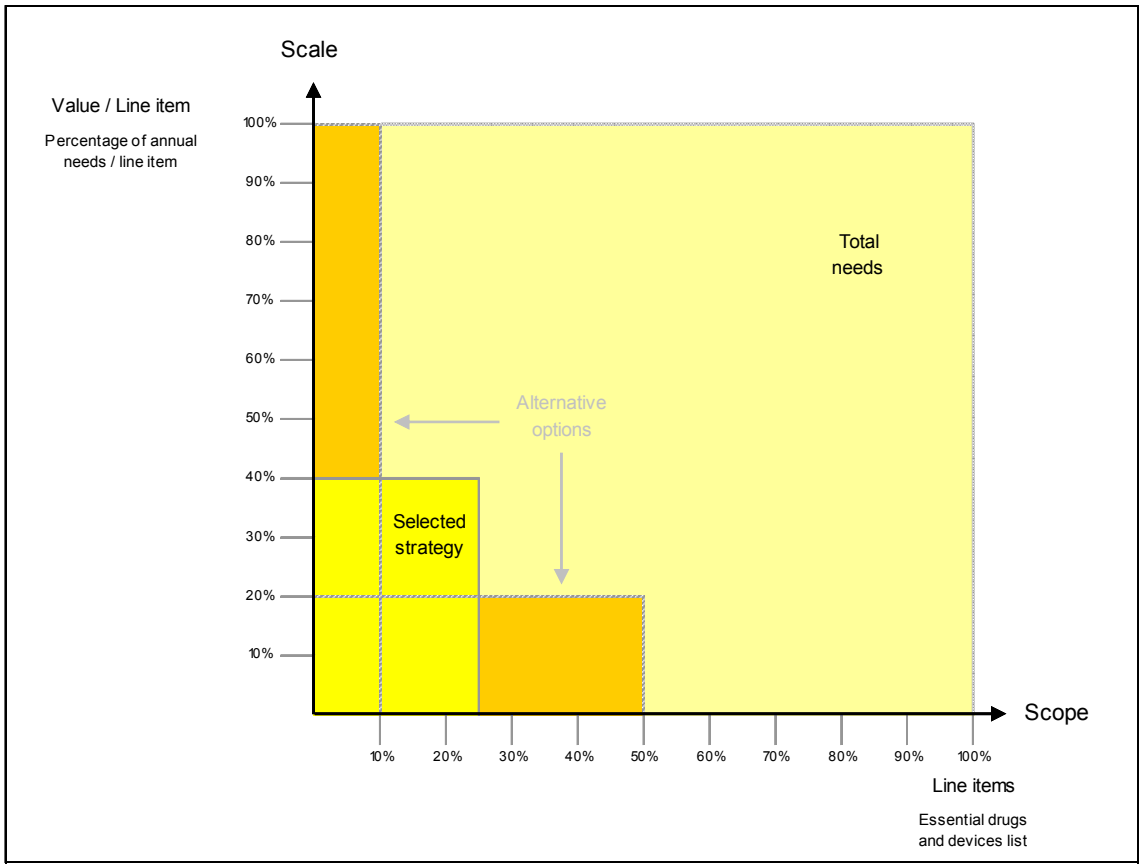

Figure 2.7 Scope and scale of provided items

Except for situations where assisted health care facilities can be served with kits alone, establishing a national standard list is indispensable.

3 HUMAN RESOURCES MANAGEMENT

Any organization depends on qualified, competent and motivated staff for achieving its objectives. Even in emergencies, careful attention must be paid to staff and staff management in order to ensure effective and efficient supply chain management.

This chapter will be concerned with management of human resources in the field rather than at head offices. It is based on the assumption that a human resources manager or administrator will be in charge of staff administration. However logistics managers need to have some basic knowledge about and competences in human resources management.

Competent and motivated staff are the key to effective and efficient supply chain management.

3.1 Human resources strategy

The human resources strategy and all relevant policies defined by the human resources department for the entire organization will equally apply to the logistics department.

In order to be efficient, organizations must have a clear structure. Every staff member must be assigned her/his responsibility and know who s/he reports to. Logistics staff will usually be divided into functional departments such as purchasing, warehousing and transportation etc.

The organization structure must be clear, transparent and laid down in a formal organization chart.

The organization chart is a graphic representation of the organization structure, its reporting lines and hierarchy. It lists all job titles and names of staff members and shows to whom they are subordinate. Each staff member should have only one superior and managers should not have too many subordinates.

Staff members and responsibilities which are not clearly assigned to a department will inevitably lead to inefficiencies, misunderstandings and conflicts.

The logistics department will be integrated into the overall organization at a site, in the respective country as well as in the global structure.

Organization charts must be updated whenever changes occur, should have a title, be dated and signed by the manager in charge.

3.2 Human resources capacities

For each department the required skills and qualifications as well as the total number of staff need to be determined.

The number of staff which are needed to provide the required services will depend on the size and nature of the assistance programme, the size, the number of locations where services are required and the scope of required services.

Sufficient staff should be available for providing the required services as well as a capacity for coping with unexpected demands and requests. On the other hand staff incurs costs and employment of every staff member must be justified.

A surplus of staff must be considered for compensating annual leave, sick leave and training.

3.2.1 Qualifications

Staff need to have a variety of ability and skills. Logistics operations require a wide range of formal qualifications such as drivers, mechanics, workshop managers, warehouse managers, storekeepers, pharmacists, clerks and purchasers.

Most staff will also need to be literate and numerate and many positions require good computer skills.

Staff should also be motivated, eager to learn, flexible, willing to work hard and willing to work overtime when needed. They should also be able to communicate, cooperate and work well in a team.

Staff also need to be committed, reliable, punctual, accurate, honest, mature and work consistently. They need to have the ability of organizing their work, setting priorities and working independently.

Some positions may require good analytical skills or the ability to write reports.

Managers will also have to have good communication skills, be able to motivate people and delegate work.

The personality and informal skills are difficult to assess during a short interview but may be more important than formal skills. A highly motivated staff member without any formal skills may be far better qualified for the position as a storekeeper than an applicant presenting several diplomas but being inflexible and showing little interest.

3.2.2 Recruitment

Recruitment of staff is critically important and should be carried out with great care. Many staff members will work in the humanitarian organization for many years. If they are not properly qualified, skilled or motivated, this may have a negative impact for many years.

Managers should formally request employment of a staff member from the human resources manager or the administrator together with a job description and a list of required qualifications.

The recruitment process must be structured and fair to prevent favouritism. Jobs will usually be very coveted and naturally employed staff will try to introduce family members or friends into the organization.

For each vacant position a detailed and formal job announcement should be issued and posted on the notice board. Word of mouth will help to spread information about the vacancy quickly. Job vacancies can also posted at offices of other humanitarian organizations or in newspapers. Staff employed in the humanitarian organization already in another function at the same or another site should also be eligible for applying.

All applicants should be in good health and a medical examination may be required.

The vacancy notice should state the minimum age, required qualifications, language skills, management and personal skills. It should outline the location of the post, the responsibilities, working hours, type of contract (permanent, temporary) and offered salary. Finally a contact address, a list of documents required for applying and the closing date for application should be mentioned.

All received job applications should be reviewed by the human resources manager or administrator together with the manager who will be responsible for the new staff member.

All applicants which fulfil the requirements should be invited for a job interview with the human resources manager as well as the manager of the respective department. Different kinds of tests for assessing various technical skills may be conducted.

In preparation of the job interview, the documents submitted by the individual applicant should be studied. Before the interview all participants should introduce each other and the human resources manager should briefly outline how the interview will be conducted. S/he should briefly present the humanitarian organization and outline the duties and responsibilities of the offered position.

During interviews a number of issues need to be discussed and assessed (see table 3.1).

- Personal background such as age, place of living, marital status and health status.
- Ethnicity, religion, affiliation with groups, clans or political parties.
- Educational background and training.
- Previous professional experience.
- Technical qualifications (certificates, diplomas, degrees).
- Current employment.
- Motivation and reason for applying for the position.

Table 3.1 Issues for assessing applicants

The human resources manager should outline the terms of employment such as salary, social benefits etc.

Throughout the interview the general behaviour, manner and social skills of the applicant should also be assessed. If the interview is not held in the native language, the language skills should be assessed.

The applicant must have the opportunity to ask questions and inquire into any issues of her/his interest.

The suitability of each candidate should be assessed without any bias. However if tensions between different groups, nationalities, religions or ethnicity exists, humanitarian organizations will have to carefully balance the composition of their work force. It can lead to discontent and be dangerous, if humanitarian organizations are perceived as favouring certain groups, religions, nationalities or ethnicities.

The final decision on the most suitable applicant should be made by the human resources manager together with the manager of the respective department.

The successful candidate should be informed and the human resources manager should ascertain that s/he is still interested in the position under the offered conditions. All unsuccessful candidates should be informed.

3.2.3 Employment

All permanently employed staff must receive written contracts which is a mutual commitment and defines the obligations of the employer as well as the employee. Any contract must comply with national legislation such as labour laws as well as local rules and regulations. Contracts may be issued in the local language, an international language or bilingual.

The contract should state the name, date of birth and address of the employee, position and job title, working place, beginning an duration of contract, monthly salary and any benefits to which the employee is entitled. This may include food allowances, free transport, accommodation and free health care. The contract must state if money is being withheld for taxes or social security.

The salary and other benefits will be based on a salary scale as well as the qualifications and previous professional experience of the employee. In order to attract professional, qualified and competent staff, the humanitarian organizations will have to offer reasonable salaries which are comparable to salaries which can be earned in the public sector and private businesses. Humanitarian organizations may be competing for the most qualified staff which results in increasing salaries beyond the local averages.

Paying salaries which are higher than the national or local average may tarnish the image and create envy, make it difficult for staff to adjust to lower salaries when leaving their job and make it difficult to hand over a programme to local authorities or other humanitarian organizations.

Salaries should only be increased according to a clear and transparent policy and be predictable to avoid any favouritism and discontent among staff. Salaries will usually be increased to compensate loss of purchasing power caused by inflation.

Humanitarian organizations will be obliged to pay social security contributions according to national law. In addition, or if no laws exist or are enforced, humanitarian organizations may cover, completely or partially, expenses for health care of staff and immediate dependants. This includes cost for medication, medical consultations at doctors, laboratory tests as well as hospitalization in case of illness or accident. Paid maternity leave as well as payments in case of permanent disability and death may also be granted.

The contract of employment should make a reference to the staff regulations which state the working hours, entitlement for annual leave, health care coverage, social benefits, reasons for dismissal etc. The employee must receive a copy of the staff regulations and confirm their acceptance with his signature. The contract may include a plea of discretion to treat any work related information as confidential. The contract must be signed both by the employee as well as the employer.

At the beginning of employment the employer may request a probation or trial period.

Staff may receive permanent contracts, contracts for a limited period of time (for example for a certain programme) or be employed as daily workers.

As far as possible no temporary workers should be employed for working in stores and warehouses since it increases the risk of pilfering and theft.

3.2.4 Personal files

Upon employment a staff file must be opened for every employee. It should contain a copy of a national identification document, personal history form, curriculum vitae, a photograph, copies of diplomas, certificates etc., any other documents submitted during the application process as well as a copy of the contract of employment.

The personal file should be regularly updated with any information or documents regarding the employee such as birth certificates of children, marriage certificate, medical certificates, job descriptions, changes of position, promotions, salary increases, appraisals, training, warnings as well as salary sheets.

All personal files must be considered as strictly confidential and must be kept locked in an office. Only the human resources manager, direct superior as well as the staff member her/himself should have access.

The personal file must be transparent to the staff member and only documents known to and signed by her/him should be included.

3.2.5 Staff regulations

Staff regulations govern work relations and outline duties and responsibilities of the employer as well as the employee. Staff regulations must be dated, signed by the human resources manager and given to all staff upon employment.

Staff regulations should clearly state obligations and rights concerning a number of issues (see table 3.2).

- Working hours and schedules.
- Overtime regulations.
- Holidays, vacation and annual leave.
- Regulations concerning sick leave.
- Maternity leave.
- Health care benefits (payment of consultations, hospitalization, cost of medication).
- Pension and insurance benefits.
- Benefits granted to direct dependants of the employee.
- Work clothes.
- Free transport.
- Free meals.
- Free accommodation.
- Appraisals and evaluations.
- Disciplinary measures and dismissal.

Table 3.2 Issues covered by staff regulations

3.2.6 Job description

Upon employment every staff member must receive a detailed job description which outlines her/his duties and responsibilities in detail (see table 3.3). It is the responsibility of the manager to explicitly state what s/he expects from every employee. The job description must be signed by the employee and s/he must receive a copy. It must be updated whenever the responsibilities of the employee change. The job description is also an important tool for holding staff responsible for shortcomings and appraising the performance of the employee.

Job descriptions are an indispensable management tool which allow managers to ensure that all tasks are assigned to a staff member. All staff members must know their responsibilities and tasks which are not their responsibility.

The job description is also the basis for determining the required qualifications and skills for a position and a valuable tool for orientation of new staff members.

Every job description should include the job title, the superior to whom s/he is reporting, required qualifications as well as a summary of the main responsibilities. A detailed task by

task description of the work to be performed is at the centre of the job description. The nature of each task, how and how often it should be carried out as well as any required reporting should be stated. Job descriptions must be specific and concise.

In addition to the job description certain staff members may receive standard operating procedures for certain tasks.

Standard operating procedures give detailed instructions how to carry out certain tasks and describe the sequence of tasks and activities. They state the material and equipment to be used as well as any required documentation or reporting. For example the procedures from receipt of a consignment until put-away may be described.

- Managing logistics staff.
- Training logistics staff.
- Ensuring safety of staff, assets, goods and facilities.
- Carrying out logistics assessments.
- Preparedness planning.
- Managing standard item catalogues.
- Assuring high quality of products.
- Providing specifications of health care goods to customers.
- Carrying out market assessments and sourcing products.
- Purchasing health care goods.
- Strategic planning of supply networks.
- Setting up and managing stores and warehouses.
- Collaborative planning with programme managers.
- Demand analysis and forecasting.
- Inventory control and stock replenishment.
- Receipt, storage and dispatch of health care goods.
- Transportation of health care goods.
- Tracking of consignments.
- Importation and exportation of consignments.
- Managing vehicle fleets.
- Establishing customer service plans.
- Filling customer orders.
- Providing updated order status information.
- Reverse logistics.
- Maintaining accurate records.
- Preparing reports for donors.
- Measuring performance.
- Closing down logistics operations.

Table 3.3 Responsibilities of logistics staff

3.2.7 Staff and career development

The primary objective of humanitarian organizations is to employ qualified and competent staff. However, human resources managers should also consider training and promoting staff within the organization to be able to fill vacancies for higher positions within the organization. Compared to newly recruited staff, staff members from within the organization have good

knowledge of the organization and its management and will have accumulated experience in their area of expertise. They therefore require less training and can work more efficiently than newly recruited staff.

Promoting staff within the organization also has the advantage that the performance of staff members, their competencies and honesty have been observed over a long period of time. They can therefore be assessed better than staff which is only known from references and interviews.

Apart from the own interests, humanitarian organizations should also consider that staff will sooner or later have to find a job in the public or private sector. Providing training will increase their career prospects once the humanitarian organization terminates its programmes.

3.2.8 Training

Training can be provided internally or externally in form of on-the-job training, seminars, formal courses, workshops, lectures, discussions or conferences and may be short- or long-term. Other means are providing staff with educational material such as books or videos.

Training can improve professional and technical knowledge and skills, social competencies, management or communication skills.

All staff should receive on-the-job training from their supervisors to refresh and improve their knowledge and skills. Humanitarian organizations may also organize internal training sessions for example for staff management, improvement of driving skills, language or computer courses. In some cases individual staff members may attend training by other organizations or institutions for example for warehouse management, purchasing or quality assurance. Humanitarian organizations may also grant financial contributions to staff members who enrol in courses, private, public or academic institutions privately but which are expected to benefit the humanitarian organization.

Ideally a training plan should be devised for each staff member rather than sending staff to courses on an ad hoc basis. This plan should be bases on an assessment of training needs and guided by the intended career development.

Training may also be initiated when new technologies, equipment or software is introduced. Another reason may be that staff with the required skills cannot be found in the job market.

Training should be specific and have clear objectives.

Training can be an important source of staff motivation since it improves the prospects of finding a better (paying) job especially after humanitarian organizations have terminated their programmes.

NOHA post-graduate Diploma in Humanitarian Assistance

This training is organized by a network of universities in Belgium, Spain, France, Germany, Ireland, Italy and Sweden and supported by ECHO.

The programme starts with intensive course followed by a basic course offered at all universities which includes courses on geopolitics, International Law, anthropology, epidemiology, ethics as well as management and logistics. Students can then select and specialise in one of the core topics. The course is concluded by a secondment to humanitarian non-governmental or international organization.

Successful training depends on the motivation and interest of staff and should take the educational background of staff into account.

The financial resources which are invested by the humanitarian organization must be in proportion to the improvement of performance which can be expected.

3.2.9 Staff visibility

All staff should be issued with an identity card which facilitates access control and allows staff identifying themselves when working outside their offices.

Depending on the security situation, wearing of badges, caps or jackets with the symbol of the humanitarian organization may be used to increase visibility of staff and afford them a certain degree of protection, especially during field trips, distributions etc.

3.2.10 Stress

Occupational stress in humanitarian workers can be caused by a variety of factors (see table 3.4).

- Personal problems.
- Difficult living conditions, lack of privacy, lack of rest and recreation.
- Conflicts at the workplace (interpersonal conflicts, lack of supervision, poor management, lack of resources, professional disagreement etc.).
- Overwork and exhaustion.
- Isolation.
- Lack of security.
- Critical incidents (combat situations, assaults, hostage taking etc.).
- Witnessing suffering of people and possibly atrocities.

Table 3.4 Factors which can cause stress

Stress can be caused by a single event or be cumulative.

Continuous stress is unhealthy both physically and psychologically and reduces the efficiency of staff. Stress can manifest itself in poor concentration, fatigue, anxiety, depression, irritability and insomnia and lead to exhaustion and substance abuse. A particularly traumatic experience can lead to a post-traumatic stress disorder (PTSD).

Stressed staff can become a security risk to themselves as well as others.

Staff working under difficult and sometimes extreme conditions must be carefully recruited not least in view of their ability and capacity to cope with stress. Staff should be assigned to very stressful and difficult tasks only for a limited period of time.

Except in acute emergencies staff should have regular working schedules and sufficient time for rest and recreation. Staff should be economical with their resources and know when they need to take a break. Working and living conditions should be adequate, staff should eat properly and regularly and get enough sleep.

Personal contacts with family members and friends should be facilitated and staff should have the possibility to receive mail and parcels.

Staff must be qualified for and capable of carrying out assigned tasks and should be supervised properly. Managers should have the ability to listen to their staff, take their problems seriously, assist them and should have the skills to resolve personal conflicts.

Managers must make sure that staff can cope with the assigned workload. If managers notice that staff is working long hours and is getting exhausted, more staff should be (temporarily) employed. Difficult situations or difficult takes should be rotated among different staff members or tackled by the whole team. Staff should be able to take holidays.

Conscientious and rigorous security management will be reassuring to all staff.

Managers should be alert, detect signs of stress as early as possible and take measures immediately.

Staff members should have the possibility to talk to a person they trust. Managers should provide support and if necessary assign staff to less stressful tasks and grant leave. Staff members may be relocated to other places or terminate their mission early.

In case staff were exposed to critical incidents they should be debriefed by a psychologist or a staff member who is specifically trained for this procedure.

3.3 Human resources administration

3.3.1 Briefing and staff orientation

New employees should receive a briefing and detailed staff orientation. New staff members should be introduced to the various departments and their colleagues.

They should receive a detailed briefing on safety and security regulations and training, for example for using fire-fighting equipment, where necessary.

They should be acquainted with communications equipment, information systems, record keeping and any equipment or machines they need for carrying out their job

The briefing should be structured and carried out according to a schedule.

3.3.2 Motivation

Humanitarian organizations must expect staff to work professionally and conscientiously. However supervisors must be aware that the primary concern of staff members, who may be living under very difficult circumstances, are the safety and well-being of their families. Under these circumstances it may be difficult to ask staff to work hard and work overtime.

Staff will, among others, be motivated by the salary and other benefits they receive. However, even if the paid salary corresponds to an average salary in the country, it may only be sufficient to barely support a family. With high unemployment, a staff member may have to support a large number of people. The purchasing value of the salary may be eroded by rapid inflation. Consequently staff may have to take on a second job and be tired at work.

Staff should identify with the objectives of the humanitarian organization and also be motivated by the assistance and services they are rendering to their people.

In general staff will also be motivated by the possibility to participate in decision making processes and having a feeling of accomplishment and satisfaction in their work. Wherever possible, but at least in matters directly related to their work, staff should be consulted and be involved in decisions.

Supervisors should respect the work which is being accomplished and acknowledge good performance.

Respecting the experience and knowledge of staff and asking them for advice can be a source of motivation.

Staff are further motivated by the prospect of being promoted, assuming higher responsibilities and better pay as well as being assigned to a more attractive post, for example in the capital. This motivation will greatly depend on a transparent and fair procedure for promotion. Any favouritism and discrimination will undermine the motivation to learn, improve skills and perform well in order to be promoted.

Staff should be compensated for any extra work or hardship.

Staff may be motivated to work hard if additional bonuses are paid for excellent performance. However it is very difficult to objectively assess the performance of staff members and the assignment of bonuses to certain staff members may be highly contentious which in turn can be de-motivating.

The possibility to learn and increase skills and abilities can also be an important motivation. Staff may be given free language courses, computer training or training to enhance their professional skills. Such training may be helpful for them to find a job once the humanitarian organization terminates its programmes.

Depending on the reputation of the humanitarian organization, the prospect of being able to mention employment in the curriculum vitae as well as receiving a certificate may be a significant motivation as it enhances the chances of future employment in the public or private sector.

Motivating staff does not only improve their performance but also helps retain the most qualified and competent staff members which will have more opportunities of finding more attractive jobs than less competent staff members.

3.3.3 Supervision

Sound supervision is essential for ensuring effective and efficient performance of subordinates and maintaining discipline. All staff should understand the hierarchy of the organization and know who their supervisor is. Staff members must know exactly what is expected from them. They must receive the means and support by their superiors necessary for completing their tasks.

Supervisors should take interest in the work of their staff and have the ability to motivate staff. Staff must receive immediate feedback on their work performance and be supported in improving their performance if necessary. Minor lapses in performance should be kept in perspective while recklessness, negligence or theft should be dealt with firmly.

Supervisors should be open-minded to ideas and staff should be encouraged to express their opinion but should have enough discipline to accept the decision of their supervisor.

Supervisors should be capable of delegating work and effectively organising and coordinating work. Staff should be guided and supported but at the same time be allowed to work without any undue interference.

An important task of supervisors is to maintain harmony within the time and help to resolve personal conflicts.

If mistakes occur, supervisors should first determine the cause and support and train staff to avoid any recurrence.

In case staff members do not perform satisfactorily or commit offences, supervisor should apply appropriate disciplinary measure which may include verbal and written warnings, dismissal and criminal action.

3.3.4 Attendance

Staff attendance should be monitored by the respective supervisors on a daily basis.

3.3.5 Reporting

All staff should receive clear instructions concerning verbal and written reports.

3.3.6 Meetings

Formal and informal meetings are useful for gathering and exchanging ideas and information, planning work, discussing problems and resolving conflicts.

In order to be effective and efficient, formal meetings need to be planned carefully. The number of people must be small enough to allow everyone to contribute within a reasonably long meeting. All participants should be clear about the objective of the meeting and an agenda should be agreed upon by all participants and circulated in advance. This allows the participants to prepare themselves and consult documents and references if necessary. The date and time of meetings should be announced well in advance so all participants can prepare themselves and adjust their working schedule. Meetings should commence at the predetermined time at a selected place and last for a predetermined length of time.

A designated person should chair and conduct the meeting according to the agenda. The chairperson should introduce the topics of the agenda, clarify points, ensure that discussions remain to the point, summarize and keep time. All participants should be able to see each other during the meeting and have the opportunity to express their ideas and views. Important discussions and decision should be summarized by the chairperson at the end of the meeting and documented in minutes of meeting.

Meetings may be scheduled regularly in a team or department or be requested by one of the team members.

3.3.7 Staff appraisal

Supervisors should give regular feedback to staff on their performance. In addition a formal appraisal should be carried out on a regular basis, for example annually.

Poor performance may be caused by lack of motivation but may be just as well caused by lack of knowledge, lack of required skills or organizational obstacles such as lack of means (office equipment, computers etc.), lack of time or lack of authority. Supervisors can cause poor performance simply because staff responsibilities are not clearly defined in their job descriptions or responsibilities of two staff members are not clearly separated.

Formal appraisals are a management tool which help to motivate staff, assist in decisions concerning promotions as well as determine salary levels and bonuses.

New staff members should be informed who will appraise them at the time of employment. The contents of appraisals should not come as a surprise to staff members since they should continuously receive feedback from their superiors. Any work-related problems or conflicts should be discussed when they arise.

Every humanitarian organization will design its own standard appraisal form which usually considers the aspects listed in table 3.5.

- Appearance.
- General behaviour and manners.
- Communication skills (verbal, writing).
- Social skills, behaviour towards colleagues and team spirit.
- Flexibility and adaptability.
- Commitment, motivation and initiative.
- Reliability and consistency.
- Accuracy of work, punctuality.
- Discipline and respect for rules and procedures.
- Careful use of material and financial resources.
- Ability to work independently.
- Analytical and problem solving skills.
- Compliance with safety and security rules.
- Staff management skills.

Table 3.5 Issues covered by staff appraisals

In addition, based on the job description, the nature of tasks carried out as well as the performance should be assessed.

As far as possible appraisal should be objective and reflect facts rather than subjective opinions. Assumptions and references to the private life should be avoided.

Appraisals should point out the strengths and weaknesses of staff members and may indicate possible career developments.

All appraisals should be presented to the respective staff member and discussed with her/him. Staff members need to sign the appraisals to acknowledge that they have read it and should have the possibility of appealing if they disagree with the appraisal.

3.3.8 Terminating employment

Contracts of employment may be cancelled by the employee or the employer who must give advance notice according to the contract.

Contracts may be terminated at the end of the agreed contractual period. Employees may also have to be dismissed when assistance programmes are scaled down or closed, sites are evacuated or because employees do not fulfil their contractual obligations or have committed a serious offence. The dismissal must be well founded to ensure fairness and avoid litigation. In any case applicable national laws, rules and regulations must be observed and a qualified lawyer may be consulted for advice.

Employees should be informed by the human resources managers and presented with the reasons for terminating the contract. Giving advance notice will allow the employee to search for another job. Depending on the contract, the employee may receive a severance pay.

Terminating contracts is unpleasant for both sides and should be managed with great sensitivity. In less developed countries and even more in complex political emergencies, a whole family may be losing their livelihood without the prospect of finding a different source of income.

Employees must return working clothes, identification cards, keys, hand-held radios etc. which they have received when beginning their contract.

Employees should receive a formal document certifying the position they held and the time period during which they worked for the humanitarian organization.

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4 INFORMATION MANAGEMENT

4.1 Information systems strategy

The timely flow of accurate information through the entire supply network is an indispensable prerequisite for managing the flow of goods as well as efficient supply chain management in general. The flow of information mainly depends on an efficient and reliable communication system, which is also vital to ensure security of staff.

- Identifying data source.
- Data storage.
- Data distribution.
- Data processing (generating information).
- Data analysis.
- Reporting.
- Decision making.

Table 4.1 Use of data in an organizations

Health care goods available in a distribution centre are without value if the information on customer orders cannot be received and treated. Moreover effective and reliable communications are indispensable for ensuring the security and safety of staff in the field. Likewise information management is vital especially during the emergency phase (Moody, F. 2001, 16).

Management in general and managing the flow of goods in a supply network in particular requires collecting, processing and transmitting large amounts of data. According to Long information systems are the most important factor for logistics services in humanitarian assistance in the context of emergencies (Long, D. 1997, 27). The easier information can flow across the supply network, the more responsive logistics services can be to changing demand (Gattorna, J. 1998, 277).

Humanitarian organizations first need to decide whether or rather where and to what degree to use manual records rather than electronic data storage and processing. Manual records do not allow data processing and electronic transmission but are reliable and do not depend on sophisticated equipment or reliable power supplies. Moreover computer systems are useless without competent staff to run them (Quick, J.D. (ed.) 1997, 741).

Where computer systems are used, a strategic decision needs to be made concerning the sophistication and complexity of hardware as well as software. Even running a simple server requires a trained technician for installation and maintenance. Electronic equipment is prone to theft as well as to damage by high humidity, dust as well as power fluctuations.

If computer systems are used, the level and means of integration arises, using stand alone workstations or connecting them to networks. Permanently connecting computer systems worldwide can be prohibitively expensive. However work stations can be integrated into a network at a particular site and connected to other sites through periodic transmission of data packages.

Humanitarian organizations also need to decide whether to use simple software applications such as spreadsheets or use logistics applications for purchasing, order management, inventory control, warehouse management, vehicle fleet management or distribution management. Commercial logistics applications are expensive, complex and depend on

reliable computer systems as well as efficient data transmission and are poorly adapted to the context of humanitarian assistance. Alternatively humanitarian organizations which can afford the investment can develop their own software or customize available commercial products.

A further strategic decision is whether to develop and implement worldwide tracking systems (Harrison, A., and R. van Hoek 2002, 247) for consignments or instead to use a (small package) carrier who offers this service.

Whether manual or electronic information systems are used, humanitarian organizations must ensure that each batch of health care goods can be traced worldwide in order to allow immediate retrieval of stocks at distribution centres or customers in case a quality defect requires a batch recall.

Various software applications have been developed to suit the needs of humanitarian organizations. However these concentrate on tracking donated goods from their arrival until their final distribution in order to provide accurate donor reports and often do not provide features for inventory control and stock replenishment. For example the Pan American Health Organization (PAHO) has developed the Humanitarian Supply Management System (SUMA) which allows registering, identifying, sorting and classifying donations, prioritizes distributions according to known needs and allows preparation of detailed reports during disasters (Tomasini, R.M., and L.N. Van Wassenhove 2004, 440).

Figure 4.1 Computer network server

4.2 Information systems and applications

In principle the supply network for health care goods can be managed using only manual records, as long as the number of regularly supplied items and the number of customers is fairly small. However the efficiency can be increased and repetitive and time consuming manual work can be avoided by using information systems.

Long contends that "Information systems are arguably the single most important factor in determining the success of an emergency logistical operations" (Long, D. 1997, 27), but also states that "In disaster relief, the non-computerized aspects of the information flow play a much more important role" (Long, D. 1997, 28).

Before the decision to introduce computers to an organization or to a specific site, office or warehouse is made, its consequences and implications should be carefully considered. Today computers are so widespread that often the decision "is not whether but rather how and how much to computerise" (Quick, J.D. (ed.) 1997, 728).

Computers can speed up complex tasks, can improve accuracy and automate repetitive tasks provided that staff are adequately trained (WHO 1997a, 16). If computers are used efficiently, they can save costs, increase the efficiency of supply chain management and improve services. However they can also waste money, decrease efficiency and distract staff from important work as well as from improving services by other means (Quick, J.D. (ed.) 1997, 728).

Before computer systems are introduced, management must carefully determine what purposes they are intended for, whether they are really needed and whether they will increase efficiency compared to a manual information system. If a decision is made in favour of implementing computer systems, a specialist should determine what equipment will allow and facilitate efficient supply chain management.

In any case computer technology should be seen as a tool to facilitate work and improve efficiency but cannot replace efficient procedures (WHO 1997a, 16). Technology cannot replace proper management of manual records and good management within the organization in general.

Computers cannot replace good management.

If computer technology is introduced, a reliable and continuous power supply must be ensured, funds for purchasing equipment as well as maintenance, support and training must be available and skilled staff must be available or trained. Procedures and documents must be in place in all departments for all work carried out.

Computers allow storing, processing, manipulating and analysing a great amount of data (text, numbers, graphics, pictures) which also can be automatically presented in graphs. Computers can quickly perform, or even automate, repetitive and tedious tasks as well as carry out complex and time consuming analysis. The accuracy of data is increased by avoiding human error in calculations, the possibility to crosscheck data and spell checks.

Data and files can be accessed very quickly and can easily be copied and transmitted by electronic mail. Printouts are better legible than handwriting. Computers allow the timely distribution of information and simultaneous access by several persons.

Computers are a very flexible tool and a great number of software applications are available for almost any purpose.

Computer systems can quickly provide updated information for decision making and can help streamlining administrative processes. They also allow logistics operation which would be difficult to perform with only a manual information system.

Although computers have become ubiquitous, even in the remotest places, they also have disadvantages (see table 4.2) which need to be considered carefully. Despite their increasing power and features, computers are not intelligent and cannot identify problems or make decisions, although they can assist in these processes.

Computers and accessories are expensive equipment which require capital investment and which are prone to theft and damage. The hardware and software of computers need to be carefully maintained and technicians need to be available in case of technical problems. Although the purchase price may be the most prominent, computer (systems) continuously require financial resources for maintenance, repairs, support, upgrading and training. Funds, which may be more efficiently used for a different purpose.

Computers require a reliable power supply which is not always available and may therefore require installation of backup generator sets which are expensive to purchase and maintain.

Damage to computers or storage devices may lead to loss of important data and require significant time for restoring. Great amounts of data can be accidentally erased. Especially if no backup system is in place and logisticians are dependent on computers, their failure may seriously disrupt logistics services.

Viruses can be a nuisance only or cause serious damage to hardware as well as software and result in the loss of all data. Therefore all computers and computer networks must be protected by regularly updated antivirus software (WHO 1997a, 16).

In order to ensure continuity of logistics services, a backup system which allows running all operations in case of computer failure should be in place. Data backups should allow replacing damaged equipment after downloading all necessary files. Manual records such as stock cards and customer orders, should allow to continue work until computer systems are restored. In any case total dependency on computers should be avoided.

Computers require skilled and trained staff. Logistics staff must be computer literate and be trained in any applications which are used. Unskilled staff may be wasting time in managing hardware and software while neglecting other important work.

One danger of more complex spreadsheet and database applications, is that calculations and results are trusted blindly. An undetected "bug" or a simple flawed formula can produce wrong results which may not be detected immediately.

There is a danger that time is wasted in designing attractive forms with pictures and graphs, where a simple photocopy may fulfil the same purpose.

Advantages	Disadvantages / Risks
• Allow storing, processing, manipulating and analysing large amounts of data. • Data and files can be easily copied and transmitted. • Accessibility of data and files by several users (simultaneously). •	• Expensive (hardware as well as software). • Requires a continuous and reliable power supply. • Require maintenance. • Sophisticated equipment is prone to damage. • Valuable and prone to theft. • Requires skilled staff and training. • Danger of data loss through damage of storage devices. • Requires making regular backups. • Computer "crashes" and "lockups". • Blind trust in calculations.

Table 4.2 Advantages and disadvantages of computers

Before selecting computer equipment, management should clearly define what functions the equipment should be able to perform, where it will be used and by whom. One important

consideration is whether links are needed between workstations at a site or even between sites. This will allow selecting appropriate hardware as well as balancing the sophistication of equipment and their costs. In emergencies it must be possible to set up equipment and be operational very quickly.

Computer technology has advanced so quickly, that even a third generation model will generally be sufficient for running basic applications in the field. In any case it is essential to first consider the software to ensure that the hardware can support it.

Desktop computers are cheaper and more powerful while notebook computers are smaller and mobile. Any new computer equipment must be compatible with already existing equipment. Standardizing equipment within the organization allows using any equipment in different locations and exchanging accessories and replacement parts. Computers can be used as stand-alone systems or they can be linked in local-area networks.

Computers should be simple, flexible, reliable, robust and easy to maintain. Replacement parts and maintenance should be available on the spot or at least in the country where logistics services are provided. Computers should be built in modules so that damaged parts can easily be exchanged and replaced. This also allows upgrading equipment for example with more advanced storage devices without having to change the basic equipment. The power supply should correspond to the mains electricity supply used in the country, or additional transformers are needed.

Standards for computer equipment within an organization should be determined by a specialist. Standardization reduces costs and allows transferring equipment or equipment parts to other workstation. Importantly, it allows using equipment in another place when a programme is closed.

Using computers requires technicians for regular maintenance and carrying out repairs. Especially if programmes are planned to be handed over to local organizations, local resources for maintenance, support and training should be preferred.

Computer hardware can malfunction or be damaged by improper use, attempts by untrained staff to make repairs, frequent switching on and off, humidity, dust, static electricity, extreme temperatures as well as spilled liquids. Unchanged images which are displayed for a long time can be "burnt" into the screen. This can be prevented by using screen savers or automatically switching off the screen if the computer is not being used. Power supplies, voltage regulators and uninterrupted power supplies also need to be maintained regularly.

As far as possible computers and printers should be operated in rooms which are protected from dust and they should be protected by plastic or cloth covers when not in use. In regions with extremely high temperatures air-conditioning might be needed. If there is a danger of power fluctuations, every computer must be protected by a voltage regulator or a surge protector. In addition wherever power cuts are frequent, uninterrupted power supplies (UPS) must be installed for all desktop computers. Otherwise work will be lost whenever a power failure occurs. Car batteries with chargers and inverters can also provide a safe and reliable power supply.

A regular supply of CD-ROMs and other storage media, printer cartridges, paper for printers and cleaning material must be ensured.

Skilled staff is also needed for providing technical support to staff in running applications, debugging applications and restoring systems in case of faults. Hardware needs to be regularly checked for any viruses. Some software requires regular updating by a specialist. Regular services can be provided by specialists within the organization or contracted to a competent and reliable supplier or service provider.

In order to protect computers from viruses, any data storage device (USB-keys) should be checked before downloading data. Computers connected in a network need to be checked regularly to avoid viruses being distributed through the network. Only stand-alone computers or computers with carefully configured firewalls should be connected to the Internet to avoid viruses spreading quickly through the network. No sensitive data should be stored on computers connected to the Internet. This avoids loss of data if the hard disk is damaged or requires reformatting. If network computers are connected to the Internet, they must be protected by regularly updated anti-virus software. Anti-virus software must be updated regularly, for example every month, as new viruses are constantly being created.

- Carefully consider what software is needed.
- Standardise hard- and software throughout the organization.
- Protect equipment from excessive dust and humidity.
- Protect computers, monitors, key boards and printers with plastic or cloth covers when they are not in use.
- Protect equipment from excessive heat by using air-conditioning.
- Protect hardware from theft.
- Use screen savers or set the screen to be automatically switched off when not in use.
- Protect computers with voltage regulators and uninterrupted power supplies (UPS).
- Make sure all staff using computers are trained.
- Establish a routine for regularly making backups of all essential files.
- Establish rules who is allowed to use computers and who has access to data.
- Do not eat and drink while working at computers.
- Ensure that only skilled specialists carry out any repairs.
- Move computers only when they are switched off.
- Only use reliable and constant power supplies.
- Make operating manuals available to all staff using computers

Table 4.3 Advice on using computers

Computers are valuable and coveted for private use or sale. They must therefore be protected from theft. Equipment can be fastened to furniture with looks and cables. Rooms where computers are used should always be kept locked when no staff is present. Notebook computers must be individually assigned to individuals who are responsible for their safety.

Computers may be coveted for private use, especially in countries where they are not widely available. Therefore their use should be restricted to authorized staff for professional reasons. Hardware and software can be protected by passwords which are given only to authorized staff.

". . . computers are useless without competent staff to run them. Recruitment and training are key to maintaining good computer services . . ." (Quick, J.D. (ed.) 1997, 741). There should always be more than one staff member who can operate a computer or specific applications to ensure continuity of operations when staff members change their position, are absent or leave the organization. When computers are newly introduced into an organization or a site, training of staff will be the biggest problem (WHO 1990b, 6). All staff using computers should be trained in the use of the hardware as well as the software.

Workstations should be properly equipped and designed, especially when staff are spending the majority of their time at a computer. They should be furnished with a comfortable chair which is adjustable in its height. Rooms in which computers are used should be properly lit to reduce the strain monitors cause on the eyes.

Figure 4.2 Computer equipment

4.2.1 Software applications

A large number of software applications are available (see table 4.4). Operating systems are necessary to run computers, regardless of what applications are being used.

General purpose software include word processing, spreadsheet, database and presentation software. They are usually sold in packages or "suites" together with the computers and often include organizers, calculators and other small applications. They are simple to use, not restricted to any specific purpose and can be used very flexibly. Unlike custom made software, their features can be used and combined in any way. This software is used for day-to-day work and usually satisfy the needs of most office work. Computer literate staff will require little training for general purpose software, which can be very powerful if used with skill. Compared to special applications, this software is cheap and upgrades are available at low cost.

Communication software are necessary for accessing the Internet and receiving and sending messages. Multimedia programmes allow manipulating sound, pictures and movies. Utility programmes include anti-virus and backup software, applications for file management and backup of files, data compression and data recovery as well as various software for checking and optimization of the hardware.

Special software is, among others, available for project management, accounting, drug management and logistics. Commercial software for various logistics applications are available as standard applications or custom made (bespoke) software. Finally management information

systems try to integrate all information needs of an organization into one application which can be accessed by all staff.

- Operating systems.
- General purpose software: word processing, spreadsheets, presentation software, databases.
- Special purpose software: logistics, accounting.
- Utility programmes: anti-virus software, backup software.
- Multimedia software (audio, video).
- Browsers and electronic mail software for the Internet.
- Management information systems.

Table 4.4 Types of computer software

When purchasing software it is important to consider the language used by national staff. In some countries Arabic or Asiatic languages will be used and require the respective character sets and keyboards. Accounting, finance and logistics software in general should be able to handle several currencies.

Especially in emergencies and setting up new logistics services and medical warehouses, software should be immediately useable without requiring configuration.

Software should be easy to install and allow exchange of data and files with other applications. The availability and cost of software updates and upgrades should be considered when purchasing software. Software should be user-friendly and compatible with other programmes are at least allow exchange of data.

Word processing software applications allow manipulating text as well as creating simple tables and graphs. They are mainly used for correspondence, designing forms and compiling reports, including tables and graphs.

Spreadsheets are designed to store, manipulate, process and analyse large amounts of data and prepare graphic presentations. Worksheets are divided into rows and columns which create a matrix and which allow entering data in each cell. Spreadsheets are mainly designed for processing numbers but they usually allow a limited number of manipulations with text and dates as well.

Spreadsheets offer a great number of mathematical and statistical functions as well as analysis tools. Despite their simplicity, spreadsheet applications have become very powerful.

Spreadsheets are useful for designing forms and reports, inventory control and forecasting, financial calculations (budgets) and simple simulations (what-if-analysis).

Spreadsheets are more flexible than databases and allow a greater variety of analysis. Although different spreadsheets can be linked, in principle all information is contained in a single file and spreadsheets are therefore less complex than databases. Unlike databases, spreadsheets allow viewing and manipulating several sets of data simultaneously.

Simple presentations are a useful tool for reporting, presentations during meetings as well as for training. Text as well as graphics and pictures can be presented like a slide show which is commented by the presenter.

Databases are designed to store, manipulate, process and analyse a large number of sets of data very quickly. They can be used for customer records, inventory control, equipment records, maintenance schedules etc. Many commercial software applications are in fact sophisticated database applications.

By entering attributes, text or numbers, of a set of data in individual fields, a record is created for each data set. All records together constitute the database file. Creating special fields allows selecting data entries from a predetermined menu which can reduce the time needed for entries as well as data accuracy.

After all data sets have been entered, reports can be created. Data entries can be automatically checked for consistency according to selected criteria. Usually sets of data can be downloaded from other applications (for example spreadsheets), other database applications or other computers.

Attributes from different data sets can be compared and analysed. A simple application would be the names and addresses of customers or vehicle data. The database can be quickly searched for any attribute or data sets with certain attributes. A set of records can be quickly found, for example all customers in a certain country or vehicles older than five years. Specific records can be quickly retrieved and records can be quickly sorted according to one or more criteria.

Databases have less mathematical and statistical functions for analysing data and are less flexible since reports need to be created rather than entering formulas directly into the worksheet like in a spreadsheet application.

Special software allows manipulating and combining several databases at a higher level and create very sophisticated applications. One disadvantage of more complex databases is that their sophistication requires skilled operators and often a database administrator to continuously maintain and backup the database.

Databases can be designed to restrict access and to trace the user who has entered an individual set of data by assigning passwords to every user.

4.2.2 Logistics applications

A large variety of software applications are available for all areas of supply chain management, either as standard applications or custom made (bespoke) software (see table 4.5). Standard applications are cheaper but require some degree of adaptation and customization by the user before implementation. Bespoke software takes considerable time to develop and is far more expensive than standard software but is tailored to the specific needs of the organization and allows inclusion of any required feature. A further disadvantage is that it has to be tested and "debugged" while standard software is known to work.

While some degree of adaptation and customization is usually possible, standard applications are less flexible than general purpose software and features cannot be added. Compared to general purpose software, the e advantage of standard applications is that individuals cannot make unauthorized changes. Software for special applications is usually far more expensive than general purpose software and often requires regular payment of licence fees.

Logistics applications are available for managing a single or several sites simultaneously.

Expensive and complex software applications may not be justified for small medical warehouses, establishing temporary logistics services or use in places where there is a high risk that offices and stores might have to be abandoned because of security.

Software applications which combine several features, for example order management, warehouse management, purchasing and accounting are also available.

Finance and accounting	Budgeting. Logistics costing.
Purchasing software	Item database. Supplier database. Supplier performance. Management of tenders. Managing purchasing documents (contracts, invoices). Viewing order status information. Preparing reports.
Order management	Receipt of orders. Order acknowledgment. Reports on backorders. Reports on customer service levels
Inventory control	Demand analysis and forecasting. Reports on stock issues. Calculating order-up-to-levels, order quantities and reorder dates.
Warehouse management	Storage place allocation. Scheduling of order picking. Generating picking lists. Preparing packing lists. Scheduling loading of vehicles. Reports on stock on hand. Reports on stockouts. Reports on expiring stock.
Vehicle fleet management	Vehicle register. Fleet licences. Insurances. Maintenance scheduling. Service history. Cost analysis. Utilization. Workshop management. Workshop cost analysis. Fuel consumption analysis. Stock management for replacement parts.
Distribution management	Scheduling.

Table 4.5 Logistics software applications

While spreadsheets are sufficient for simple bookkeeping, finance and accounting software can be used for costing various logistics services and preparing budgets and financial reports.

Purchasing software provides a detailed item database, supplier database, allows preparing documents such as tenders and purchase contracts and monitoring supplier performance.

Software can also register and track customer orders, continuously update the order status and ensure that eventually all orders are filled.

Inventory control software is used for calculating and monitoring monthly demand, forecasting and calculating replenishment orders.

Warehouse management software allows optimizing the use of warehouse space, increases accuracy of records and facilitates issuing of documents. Customer service is improved by providing updated stock positions and warning of pending stockouts. Commercial software usually includes features such as use of bar code scanners or radio tags. Because of the complexity and lack of security such investments are usually not justified.

Fleet management software ensures that all legal requirements (licences, insurances etc.) are fulfilled and vehicles are regularly maintained and roadworthy. Fuel consumption can be monitored and the cost of vehicle use can be calculated.

Software applications can also assist in project management such as setting up a new medical warehouse. It allows establishing a schedule and organizing and tracking a large number of tasks. Bottle-necks can be determined and resources can be reallocated accordingly.

4.2.3 Management information systems

Management information systems try to integrate and coordinate all the functions of features of various software applications into a single application and centralize all data. A central database manages all data and information and allows all departments to have access to accurate and updated information simultaneously. Such systems can manage all processes in an organization such as human resources, finances and accounting, purchasing, order management, warehouse and fleet management as well as performance measurement and provide information for any level of decision making.

Such systems are expensive, complex, require customization before implementation, considerable time and resources for implementation and regular maintenance by specialists. They may be justified for head offices of large organizations but are in general too sophisticated and complex for use in the field.

A special form is the drug management information system (DMIS) which integrates all software needs for selection, purchasing, distribution and use of drugs.

4.2.4 Examples of applications developed for humanitarian organizations

Some larger humanitarian organizations have developed special information systems, tailored to their needs and the environment in which they work.

The United Nations head office in New York administers the United Nations International Emergency Network (UNIENET), which supports UN agencies with databases containing contact lists and equipment stockpiles (Long, D. 1997, 28).

The World Food Programme (WFP) in Rome, Italy, administers the International Food Aid Information System (INTERFAIS) which provides information on ports and less developed regions of the world (Long, D. 1997, 28).

EPI-Info has become the standard application for statistical epidemiological analysis for health professionals working in humanitarian assistance. This application is developed and distributed at low cost by the World Health Organization (WHO) and the Centre for Disease

Control and Prevention (CDC). It includes a database, allows various statistical analysis and allows analysing data from surveys.

Management Sciences for Health (MSH) has developed an application for drug quantification. Based on demand data, morbidity data and standard treatment schedules, forecasts for drugs are calculated.

4.2.5 Other information systems

The Internet allows exchanging electronic messages as well as transmission of data files and pictures. It is becoming more and more accessible in less developed countries and the cost of base stations connected via satellite are becoming affordable. The Internet is also a rich source of information. Most suppliers provide information and specifications of their products. The WHO library catalogue can be accessed through the Internet and a great number of excellent documents and reports can be downloaded free of charge.

Digital imagery has become widespread due to the decreasing cost of high quality digital cameras and the possibility to transmit images by electronic mail. Digital images are useful for making assessments of logistics or health infrastructure or for illustrating reports. They are also very useful for making pictures of equipment or spare parts for which specifications are not known and can be sent to purchasers and suppliers for identifying items and their manufacturers.

Bar code systems which are standard in almost all logistics service providers in developed countries are slowly being replaced by RFID (radio frequency identification) tags. Although bar code scanners are fairly cheap, the technology is still fairly sophisticated. The implementation may be justified in large logistics centres. However in the field the application is expensive and in case of a fault of hardware or software support is unlikely to be available. Moreover implementation of bar code technology requires that all suppliers and logistics services throughout the supply network use the same standard. Implementation of bar code technology only makes sense if the humanitarian organization is using a standard logistics and warehouse software which allows downloading data from bar code scanners.

Global positioning system (GPS) devices have become very small and cheap and are now even included in some mobile phones. They allow determining the position anywhere in the world very accurately and are especially useful for vehicles travelling in remote areas. They can be very useful for travelling in areas for which accurate road maps are not available. They allow reporting the position in absence of landmarks and milestones along roads. They also allow recording and retracing a journey to remote places as well as to direct vehicles or aircraft in case of urgent need for help. GPS should be considered especially for increasing the security of staff travelling in vehicles or convoys in remote areas.

4.3 Information systems administration

4.3.1 Data sources and collection

Data represents real-world data (Quick, J.D. (ed.) 1997, 714) and can be seen as the basic material from which information is made. Data in itself is often meaningless and of little value before it is processed and aggregated into information, "In other words, information is processed data that contains sufficient context to make it meaningful" (Quick, J.D. (ed.) 1997, 714). "Data are raw numbers or other findings which, by themselves, are of limited value to decision makers. Information, on the other hand, is the result of organising, processing, and

interpreting data, thus transforming the findings into facts that are useful to decision makers" (MSH 1997, 11). For example the weight or volume of health care goods shipped from a medical warehouse has little meaning until it is related to the time period, the number of customers, the geographical area covered etc.

Data from within or outside of an organization needs to be created, collected, stored, assimilated, transmitted and distributed for further processing and interpretation.

Data can be constant or changing infrequently, such as the number of staff or total storage area of a medical store or changing frequently such as the quantities of ordered health care goods.

In principle data can be quantitative or qualitative. Quantitative data is measurable with a certain accuracy, for example the number of items in stock or the price of purchased goods. Qualitative data is not measurable accurately but is determined subjectively. For example rating the packaging of health care goods as conforming or non-conforming or appraising the performance of an employee.

Accuracy of data is vital especially when it is used to make important decisions. Information derived from data cannot be more accurate than the data used. For example if demand data from the medical store is inaccurate, the forecast of demand will also be inaccurate. Physical measurements can only be performed with a certain degree of accuracy for example when measuring the weight or volume of a parcel. Any collection of data is prone to error. Depending on the data accuracy which is required, collected data must be checked and crosschecked before being processed any further.

Garbage in - garbage out.

Data can be generated by and originate from a variety of sources and from different levels of the supply network.

Data can be derived and collected from manual records, electronic records, reports, people, references (manuals, operating instructions, databases), counts, assessments, measuring devices (clocks, odometer etc.) or sampling and from a range of sources (see table 4.6).

Collection of data should be assigned to individuals who are also responsible for ensuring their accuracy.

Data items can be collected individually such as the distance a vehicle has travelled during an individual trip or aggregately, such as the number of kilometres travelled per month. Data can be aggregated in different periods of time, usually days, weeks, months, quarterly or years.

Data may be available immediately or only after a certain delay, for example financial data which has to be processed by accounting before it is available.

Data can be collected by considering all items in question or by measuring a sample. For example the number of staff can be counted or the total warehouse surface can be measured. On the other hand during inspection of a consignment, often only a sample can be checked for estimating the number of confirming items.

Data can be collected constantly or whenever changes occur, such as the stock position of an item in the medical store. Data can also be updated on a regular basis such as weekly, monthly or annually.

Wherever possible existing data sources should be used before repeating the collecting of data. Within the organization data collection should be organized and coordinated in a way that avoids duplication and parallel collection of data.

Warehouse and stores management	Warehouse surface
Inventory control	Demand data Stock levels Backorders Stock on order
Customer service	Customer record Order
Quality management	Quality control records
Product selection	Product data Prices
Purchasing	Supplier record
Warehouse operations	Bin cards Stock cards Physical stock count Expiry dates Packing lists Waybills
Transportation	Distance travelled Fuel consumption Number and weight of consignments Transportation costs
Distribution management	Transportation records Vehicle data (mileage, fuel consumption etc.)

Table 4.6 Data sources

Before data is collected, careful consideration should be given to its future use. Data should only be collected if it is really needed for monitoring or decision making. There is a tendency to collect and process data simply because it is readily available. If the data is needed, careful consideration should be given to the question whether time and resources needed for collecting this data is proportionate to its importance. Only data which is really needed and useful should be created and collected in the first place. Another important consideration is whether the data can be collected on time for making certain decisions. For example data on stock levels is needed at the time a replenishment order is calculated.

During data collection a trade-off between the resources invested into data collection and data accuracy must be made. More accurate data often requires more time for collection but may not significantly change any decisions. Consequently an estimate may be just as good.

Usually more time is used when starting collection of new data than after data collection has become a routine.

The data collection system in an organization should consider compatibility within this organization. For example the same units of measurement and the same time periods should be used. Otherwise somebody may be measuring the volume of transported goods in cubic feet per week while someone else will measure the same parameter in cubic metres per month. Especially for financial calculations an agreement must found, which currency and which exchange rates are being used for data collection.

Data must also be collected consistently to allow comparison over a longer period of time.

Electronic data is usually much faster to process and manipulate than manual data. However collecting and entering data into an electronic record may require considerable time and resources and not always be worthwhile. Careful consideration should be given to whether collected data is entered directly into an information system or first collected manually and later entered into the information system. Any processing, copying and transfer of data is a potential source of error. On the other hand manual data collection has the great advantage that a hardcopy backup is available in case the information system is not working or electronic data is lost.

If a coding system is used, for example for health care goods, it must be ensured that the same codes are used throughout the entire organization. Otherwise data cannot be collected accurately or requires time-consuming checking to consolidate different coding systems.

Regularly used data can be collected by standardized reports. These ensure that all necessary data is collected on time in the correct format. Reports should state the origin of the data, the time of data collection and the person responsible for compiling the report. This allows tracing the origin of the raw data in case doubts on their accuracy arise during processing.

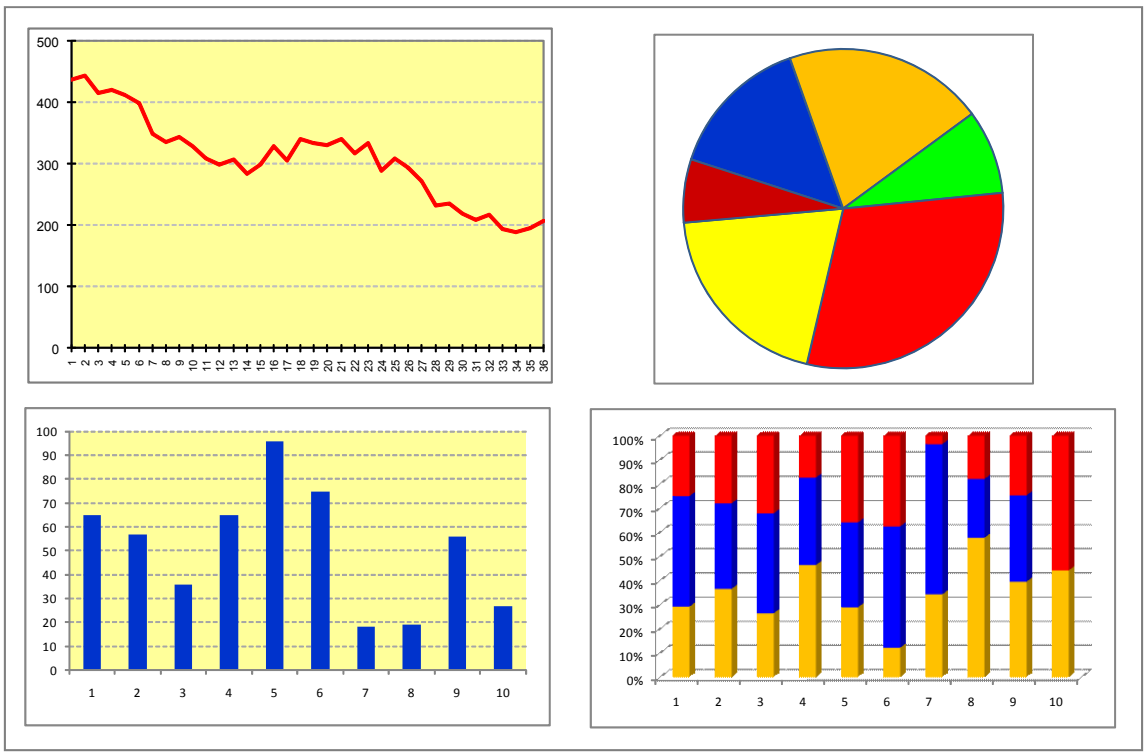

Figure 4.3 Examples of different graphs for presenting information

4.3.2 Generating information

Collected raw data is aggregated and processed to produce information which is needed in the organization. New information can be combined with previously generated information for example to present long-term developments or with information from other medical stores for comparison.

Organizations should avoid collecting data and producing information which nobody really needs or uses.

The need for information should determine what data is collected and not vice versa.

Information must be produced consistently to allow long-term comparison and detection of trends over time where this is necessary.

Generation of information from raw data must be reliable and consistent. The same set of raw data must always generate the same information.

Information which is generated from the raw data can be presented in form of tables, graphs or written reports. Simple graphs often greatly facilitate interpretation of information.

Once information is generated from the raw data, it needs to be analysed and interpreted. People who are using information should have access to detailed information on how the information was generated. Any information needs to be reviewed critically and checked for figures which seem improbable or odd.

4.3.3 Flow and distribution of information

To ensure that information is available by the people who need it and use it for making decisions, information must be distributed within a location, between locations as well as between different organizations. Duplication of distribution of information as well as lack of distribution should be avoided.

While it is important to ensure that important information is distributed quickly and efficiently it is also important to avoid unnecessary distribution of information. Especially when electronic mail systems are available and transmission of messages is very easy, there is a danger that unnecessary information is distributed.

Especially information which is personal or related to security, must be handled carefully to ensure that it is only distributed to persons who are authorized to have access to it. This is especially important when information is distributed outside the organization, for example to suppliers or journalists. A simple message informing about the blockage of a road, a damaged bridge or the closure of an airstrip can be militarily sensitive information.

Information must be distributed efficiently and in a timely fashion to allow timely decisions. Especially information between different locations must be forwarded quickly. Often filling of orders is delayed simply because orders are processed and approved by different people and retained at each stage. Ideally, all data will be shared in real-time. In some cases information needs to be distributed only in certain intervals, such as monthly reports, rather than in real time.

If supply chain management in general should be efficient, information must be forwarded and distributed as quickly as possible. It is also vital to ensure that information is not distorted during its transmission for example by making errors in copying. Usually a trade-off between cost and speed of transmission of information needs to be made. For example transmission of a hardcopy by mail is far cheaper but slower and less reliable than by satellite fax.

Slow and unreliable transmission of information can lead to the sub-optimization of the supply network and waste of resources. For example it may take just as long to receive orders from various destinations than to pick, pack and ship consignments from the logistics centre in a neighbouring country.

It is vital to ensure that information flows equally fast in all directions of an organization. There is sometimes a tendency to consider information flowing up the hierarchy more important than vice versa.

Wherever possible information available in an electronic format should be transmitted electronically. This allows the receiver to read and process the information electronically rather than having to convert information into an electronic format manually. One humanitarian organization generated medical orders by using a spread sheet application. The orders were printed or sent as electronic files. But because the information system used at the logistics centres was not able to download these spread sheets, all orders had to be printed and entered into the information system item by item manually.

Information can be distributed physically by sending copies to various people or locations. If computer workstations are linked by a local-area network (LAN) files and databases can be shared, several people can simultaneously access the information without the need for physical distribution. A very efficient means of distributing information is the Internet. It allows anybody with access to the Internet to have instant access to a large volume of data, for example item catalogues or information about humanitarian organizations. Making as much information as possible accessible centrally avoids the same information being multiplied and stored in several places. Centralising information in a database also avoids that different people within an organization are using differing or wrong data.

If hardcopies are used for distributing information by mail, it must be clear who is in charge for processing and how the mail is processed. Otherwise there is a danger that mail is lost but its loss is not noticed. Consequently a customer may be waiting for the delivery of an order which has not been processed.

Especially in places where the infrastructure is poor or has collapsed, information should be distributed electronically wherever possible. Postal services often do not exist (McClintock, A. 1995, 21) or are inefficient and sending mail with vehicles or aircraft is often time consuming and not entirely reliable. Especially documents which require original signatures will have to be sent as hardcopies.

Whenever information is distributed, the format of the information needed by the recipient should be considered. Whenever possible s/he should receive information in a format which can easily be converted and does not require processing.

While humanitarian organizations have defined standards for distribution of information within their organizations, communication between humanitarian organizations in the field is not always efficient. Long writes that ". . . the lack of inter-organizational coordination is becoming a major impediment as institutional rivalries takes priority over logistical efficiencies. A universal information system would benefit a large number of agencies, but no agency thus far has been willing to accept the leadership responsibility and development costs" (Long, D. 1997, 29).

4.3.4 Record keeping and data storage

Collected data and information usually needs to be stored for a certain period of time. This allows checking data in case doubts on their accuracy arise. Especially when data is processed

electronically, a hardcopy ensures that the data is not lost if the electronic record is lost or the information system fails. Therefore, wherever possible, raw data should be recorded manually before being entered into an electronic record.

Some records, such as stock cards or vehicle log books, need to be updated regularly while other records, such as the register of suppliers, is only updated when changes occur.

The system of record keeping within an organization should be consistent to ensure that all necessary data and information is recorded while no unnecessary data and information is accumulated.

Record sheets should be carefully designed to ensure that all necessary data is recorded and unnecessary data is avoided. Record sheets should not be changed frequently since otherwise the available data will change and make long-term comparison difficult.

The responsibility for maintaining and updating records should be clearly assigned to one person or one department who feels responsible and can be held accountable. All records should have a clear reference to the time, location and type of data which is recorded. For some records, for example bin cards, the person responsible for updating the record needs to sign for every entry.

An efficient record-keeping system allows retrieving all necessary data quickly and presents the data in a format which allows efficient processing.

For every type of record the time it needs to be kept should be defined. Bin cards and stock cards for example should be kept for at least one year in case of an audit while any kind of contract should be kept for several years for legal purposes.

If data and information is maintained only in electronic records, regular printouts of essential data and information should be made and kept as a hardcopy.

If data is collected and stored by electronic means, careful consideration should be given to a backup system. Manual records have the great advantage that they do not depend on the functioning of the information system and are not as vulnerable to loss as electronic records. If records are kept only in an electronic format, a parallel manual system may be justified for important data. Alternatively important data can be printed on a regular basis and kept as a hardcopy. For security reasons, backups may be stored in another location or even send abroad on a regular basis.

Data on computers are most often stored on magnetic media, such as hard disks or on CD-ROMs and DVDs. These media can be damaged (see table 4.7) by physical forces, moisture, dust as well as high-voltage electrical spikes (Quick, J.D. (ed.) 1997, 742). Spinning hard disks can be damaged by sudden physical movements. CD-ROMs can be damaged by scratching the surface or cracking.

- Dust.
- Humidity, moisture.
- Excessive heat and cold.
- Voltage fluctuations.
- Physical damage (vibration, dropping etc.).
- Connections to inappropriate power supply.
- Sudden movement of spinning hard disks.

Table 4.7 Possible causes for damage of storage media

Hard disks may be stolen together with computers, which have a high value and are coveted by thieves. The complete loss of data may also be caused by viruses which can infect storage media.

Consequently it is vital to maintain and regularly update backups of all important files (see table 4.8). Backup of important files should be made whenever they are modified or at least daily. In addition a backup of all important files should be made on a regular basis, for example weekly or monthly. If computers are connected in a network, a central backup of all clients can be created. If large databases are used, a detailed backup plan must be established and carried out automatically or by the system administrator, usually on a daily basis. If computers are used stand-alone, every user must regularly make backups.

- Internal documents (procedures, rules, policies, security plan, contracts, minutes of meeting etc.).
- Programme documents (plan of action, budgets, reports etc.).
- Contacts (addresses, telephone numbers, emails, radio call signs etc.).
- Staff management (organization chart, staff records, minutes of meetings etc.).
- Item specifications, standard item catalogues.
- Quality assurance policy and documentation.
- Supplier files.
- Tender documents.
- Purchase contract files (with all associated documents).
- Customer order files.
- Demand records, forecasts and stock replenishment calculations.
- Warehouse records (stock records, temperature record, records on destruction of goods).
- Importation and exportation files.
- Documents on logistics performance.
- Reports for logistics, programme mangers and donors.

Table 4.8 Overview of documents and records which need to be maintained

If the offices where computers are being used is not considered as safe and there is a danger of fire, theft or conflict related damages, a second backup should be kept in a safe place.

Data and information which needs to be audited, must be available as a hardcopy. Electronic records can often be changed without being able to trace the person who made the change. Important manual records must always be signed. In more sophisticated management information systems it may be possible to trace any data entry or change by requiring entering of a password before making any change.

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5 COMMUNICATION MANAGEMENT

5.1 Communication management strategy

Effective and efficient communication is indispensable for professional supply chain management, as for enabling any humanitarian assistance programme. The efficient flow of goods and services is directly dependent on the fast and efficient flow of information. "Everyone involved in disaster, aid and allied voluntary services is aware of the huge waste and nuisance caused by poor communications in the field. Time is wasted driving around looking for staff and equipment. The rapid deployment of the right equipment in the right place at the right time is impossible" (Wood, M. 1996, 1).

Telecommunication is governed by national and international laws and closely related to national sovereignty of the host country (PAHO 2001a, 163). The distinction between information such as conditions of transportation infrastructure or presence of armed forces and military intelligence is fine (Mayhew, B. 2004, 23). Use of communication and information systems in conflict areas is highly sensitive as it may raise suspicion of gathering and communicating information which could benefit the adversary (Bickley, S. 2003, 75). Consequently importation and use of equipment is highly regulated and humanitarian organizations must obtain permission for importation as well as licences for operating equipment (Bickley, S. 2003, 88).

Establishing independent communication networks is a strategically important decision as it requires significant investment in telecommunication equipment, qualified staff for installing and maintaining networks as well as in training humanitarian workers.

Communication and information systems should be simple since non-specialist humanitarian workers need to be able to use them. Above all, communication and information systems need to be effective and reliable.

An important strategic decision is whether to rely on existing domestic infrastructure or to establish independent communication networks. The later are expensive to establish and maintain but avoid dependency on public networks which may be overloaded, disrupted, shut down by authorities or armed forces any time or may be damaged or destroyed in the course of armed conflicts.

Reliable communications are even more important in humanitarian assistance as safety and security of staff, goods, assets and facilities are of primary importance. Communications are of particular importance when staff, vehicles, vessels or aircraft are moving or under attack as well as for medical emergencies.

Reliable communication, transmission of data, exchange of information, placing of orders and transmitting information on movement of goods is imperative for any humanitarian assistance programme (PAHO 2001a, 163). The communication network must link means of transportation such as vehicles, distribution centres (PAHO 2001a, 123), authorities, suppliers, ports, customers as well as other humanitarian organizations. Telecommunication resources are essential for the security of humanitarian workers (UN General Assembly Resolution 58/122, 2004) in general as well as for notifying authorities and tracking of convoys in particular.

In areas where public communication infrastructure is not reliable, humanitarian organizations need to establish their own communication network (Ockwell, R. A. 1994, 425). Even where public communication networks are available, humanitarian organizations need to at least establish a rudimentary backup system in case the public network is disrupted

(Bickley, S. 2003, 76). Especially during acute crises, telecommunication infrastructure is particularly prone to becoming overloaded, being damaged or simply purposely disabled by conflict parties (Mayhew, B. 2004, 31).

In particular complete dependency on mobile phone networks should be avoided (Mayhew, B. 2004, 31). Where humanitarian organizations are left to their own devices, they should establish a primary communication network (for example radio network) as well as a backup system (for example satellite communication) in case the former one fails (Mayhew, B. 2004, 31).

Where data communication infrastructure is unavailable, the ideal of real time exchange of data across the supply network (Govil, M., and J.M. Proth 2002, 65) is usually unaffordable with satellite communication systems and exceeds available capacities with radio communication networks. Moreover the vulnerability to the disruption of communication networks increases with the sophistication of communication systems (Lambert, R.S., and J.R. Stock 1993, 518). A compromise is storing information in mailboxes and regularly transmitting consolidated information through the network. Humanitarian organizations need to decide what amount of resources they are willing to commit and what frequency of data exchange they want to achieve.

Where national and international telephone and data transmission networks are unavailable or unreliable, apart from using mail, humanitarian organizations can resort to establishing their own high frequency (HF) and very high frequency (VHF) radio networks (Mayhew, B. 2004, 97) for telex, teleprinter over radio (TOR) or packet radio. Installing satellite communication systems allows transmission of voice, fax as well as transmission of electronic data and use of electronic mail. These systems can be installed and dismantled quickly and also used as mobile devices for vehicles or ships. Despite the availability and ease of using satellite communication, the high cost favours the use of high frequency radio telecommunication for voice, email, text and data transmission (Klenk, J.S. 1997, 47).

The Internet is not considered as a reliable option in emergency situations as it usually depends on public telecommunication networks and is vulnerable to the disruption of switch stations and satellite links (Klenk, J.S. 1997, 49).

Installation, operation and maintenance of telecommunication networks require professional technicians. However logisticians are so heavily dependent on telecommunications that they must have a basic understanding of the technical possibilities, their advantages, disadvantages and limitations.

With the rapid expansion of mobile phone networks as well as the Internet in developed countries, reliable telecommunications infrastructure is often taken for granted. "The ease of communication in a developed city is seductive, so much do we take it for granted that it becomes like the wallpaper in the office (no cheating, do you remember the pattern?)" (Wood, M. 1996, 1). However in less developed countries, telecommunications are often less developed and may have been damaged during the conflict, especially since telecommunication installations are also considered as military targets.

Communication is necessary with other logistics staff, offices, vehicles, aircraft, vessels, warehouses, workshops, customs, ports, airports, commercial suppliers at the same site as well as in other domestic locations or abroad and indispensable for coordination of logistics operations (see table 5.1). Communications is also necessary with beneficiaries, aid workers, assisted health care facilities and programme managers, other humanitarian organizations as well as local and central, civil and military authorities.

A large variety of data and information may require transmission. Transmitted information can consist of speech or voice, written or printed text, reports, documents (for customs, invoices, orders etc.), tables, graphs, maps, pictures, figures, images, photographs, sound or video and in principle be transmitted from person to person, by mail or by telecommunication equipment. In telemedicine applications, data from diagnostic equipment such as electrocardiographs, pulse oximeters, sphygmomanometer or electronic stethoscopes need to be transmitted.

A) Geographically

- Internationally.
- Countries in the region, neighbouring countries.
- Within countries.
- Within sites.
- Within departments.

B) Institutionally

- Within humanitarian organization.
- With donors.
- With other humanitarian organizations.
- With government institution and authorities.
- With commercial suppliers (of goods and services).
- With public media.
- Private communications.

C) Hierarchically

- Head office.
- Management at country level.
- Programme managers.
- With other logistics departments.
- Within department.

Table 5.1 Communication needs in humanitarian assistance

Telecommunications may be needed for a large number of different reasons. Person to person communication may not be possible because of the distance between people or the time needed to travel to each other, especially in rural and remote areas. Transmission of messages only by mail is often too slow, may be unreliable and impossible because of poor security. The availability of telecommunications reduces the need for travel, wear and tear on vehicles, reduces costs and saves time (Quick, J.D. (ed.) 1997, 326). Mail bridges the distance between people who want to communicate with each other and telecommunications in addition significantly reduces the time needed for transmission and allows real-time communication at a distance.

Communications is vital for people who have suffered an accident, are under attack or face a medical emergency. They need to be able to quickly call for competent help, transmit their location and provide details about their situation and the help they need.

Humanitarian aid workers and logisticians need to communicate for transmitting information concerning security, orders, humanitarian assistance programmes and administrative matters as well as for keeping personal contact. For humanitarian workers in remote places, speaking to colleagues and friends from time to time can be important for providing encouragement, reducing the feeling isolation and improving their well-being.

A large variety of means of communications are used (see table 5.2). Communication takes place during personal conversations, formal as well as informal meetings. Written messages, documents, images etc. can be transmitted by public or private mail services, internal mail systems or a courier. Fixed and mobile radio and telephone equipment, both terrestrial or satellite based, can be used for transmission of voice as well as text and images.

Planning of networks as well as selection, installation, operation, maintenance and repair of any telecommunication equipment must be carried out be skilled specialists who are also needed for training non-specialist users.

All equipment must be strictly standardized worldwide within the humanitarian organization. Standardization facilitates purchasing, licensing, maintenance, training, purchase of spare parts and reducing purchase costs. It also provides the necessary flexibility for moving equipment to other locations when programmes are closed down. Standardization between humanitarian organizations is difficult. However equipment should allow some communication, even if it is only one common radio frequency. This is important to facilitate communications in general as well as for emergencies where assistance is required or evacuations need to be coordinated.

Means of communication	Text	Voice	Data files	Images	Video
Mail (postal service, internal mail)	●	●	●	●	●
Morse code	●				
Telex	●				
Teleprinter over radio	●				
Packet radio	●		●		
PACTOR	●		●		
Satellite packet radio	●		●		
Facsimille (Fax)	●				
Electronic mail	●		●	●	●
Radio transceivers		●			
Field telephony		●			
Private wires and private telephone networks		●			
Public telephone networks		●			
Public land mobile network	●	●		●	
Satellite telephony		●			
Voice of Internet Protocol (VoIP) telephony	●	●	●	●	●

Table 5.2 Overview of means of communication

A number of general considerations apply to all types of telecommunication equipment. When choosing telecommunication equipment, a trade-off between costs and speed, capacity and reliability has to be made. Shortwave radio equipment is cheaper than satellite telephones but the quality of reception can be poor during part of the day. Real-time telecommunications will generally be more expensive than systems which work with delays such as mailboxes which are regularly transmitted. Less urgent communications should use cheaper and slower means of telecommunication. "Technology can do wonderful things for us but at a price. You must ask how much money you want to spend . . ." (Wood, M. 1996, 203).

A reliable global radio network requires several frequencies and powerful transmitters which are expensive. An alternative is using satellite telephones for urgent calls and data transmission while using radio communications for lower priority communications which can

be delayed when the reception is poor (Wood, M. 1996, 64). Mail boxes can store low priority messages and automatically transmit them when the quality of reception is sufficient.

Telecommunication equipment should be affordable and fulfil the technical requirements in terms of range, capacity for data transmission as well type of data which needs to be transmitted (voice, text, images etc.). The operation in the country where it is used in must be legal and licences should be easy to obtain. Replacement parts, maintenance, repair services and training must be available. Equipment should be reliable, robust, easy to install and easy to use. Mobile equipment should be light.

Another fundamental consideration is whether telecommunication equipment should be fixed, mobile or portable. Fixed installations are usually more powerful and cheaper compared to mobile equipment. However fixed installations require time for installation, their use is limited to one place and they cannot be quickly dismantled in case of an evacuation. Especially for vehicles, vessels or aircraft mobile equipment is indispensable. Fixed telecommunication equipment must be installed professionally and in a way that the installation will last, even during emergencies. Otherwise it will constantly require modifications.

Never rely on a single communication system, especially when working in a dangerous environment.

Humanitarian organizations should never rely and be dependent on a single telecommunication system. Wherever possible a backup which works independently of the primary telecommunications system should be available. "Never trust techno-wizzgadgets. If you are really serious about reliable communications, then always have a back up plan, preferably a simpler system, to fall back upon if your flagship sinks" (Wood, M. 1996, 180 f.). For example in a city with a functional public telephone networks, an independent radio network should be available as a backup in case the telephone network fails or is deliberately closed down. Communication networks may be damaged during fighting or the power supply may be cut.

Available telecommunications infrastructure may be overloaded, disrupted, deliberately shut down by the authorities or destroyed. Existing infrastructure may fail or shut down because of a power failure.

When setting up radio networks, humanitarian organizations must decide which language should be used in general to allow all receiving stations to follow the communications. The language should be adapted to the country in which the network is set up but must also allow expatriate staff to communicate. The standard language for written messages and documents also needs to be decided upon. One important consideration when selecting languages is ensuring that the humanitarian organization remains transparent.

Civilian and military authorities will always be concerned that radio networks may be misused to the advantage of other conflict parties. They may therefore restrict the languages which can be used on the network so they can monitor communications. Allegations of misuse of telecommunication equipment can lead to loss of licences or even confiscation. Therefore humanitarian organizations must control who uses their equipment and ensure that no political or military information is transmitted. If humanitarian organizations make their telecommunication equipment available to other humanitarian organizations they must also prevent misuse. Moreover they should make agreements for sharing costs as offering satellite telephones free of charge can quickly lead to huge expenses. "If people borrow your communications facilities then make sure you know who they are, how much they owe you

and how and when they will pay. This goes for your own people too, Satcomms is highly intoxicating, you must tell your client when he has had enough and close the bar!" (Wood, M. 1996, 6).

Humanitarian workers must be aware that using telecommunication equipment is very sensitive, especially in places under conflict. They must therefore always make sure that they adhere to laws and regulations and obtain all necessary permits for importing, installing and operating telecommunication equipment. Humanitarian workers must be aware that they have no right to use telecommunication equipment without permission and should not take its use for granted. The revocation of licences or confiscation of telecommunication equipment may immediately lead to the need for evacuation of all staff and termination of humanitarian assistance programmes since telecommunication equipment is indispensable to assure safety and security of staff.

Telecommunication equipment is always coveted and prone to being misused and stolen. After all the same technology is used by conflict parties. Humanitarian organizations must therefore take great care to protect their equipment, especially portable and mobile devices. Theft is not only a financial loss but humanitarian organizations may quickly be blamed of being partial if stolen telecommunication equipment is found in the hands of adversaries.

The better the telecommunication system the greater the temptation to use it, for more or less urgent needs. Humanitarian organizations must therefore set controls in place which will prevent unnecessary or nonessential use of equipment. Communications, especially when using satellite equipment, should be limited to professional matters and not be misused for chatting.

The last two decades have seen a rapid development of telecommunications technology, especially with the proliferation of mobile phone networks and the advent of the Internet. Several system of low Earth orbit satellites (LEOS) which allow global satellite communications with hand-held mobile phones are being developed and costs can be expected to fall. These will also allow access to the Internet from small portable devices in the near future.

However the increased sophisticated will also lead to an increased vulnerability. Satellite and Internet connections will depend on a small number of links which can fail. Unlike analogue systems, digital and computerized systems are vulnerable to viruses and deliberate attempts to shut down networks. Therefore conventional systems which work independently from outside services are unlikely to become obsolete soon.

Immediate availability or the rapid establishment of communication and information systems throughout the supply network is essential and must be the priority during the initial emergency phase.

In order to ensure that communication systems are reliable, humanitarian organizations must establish and maintain their own networks during the emergency phase. Public networks can be used as soon as they are restored and reliable while at least a rudimentary backup system with own means should be maintained.

Information systems must be simple during the emergency in order to be operational immediately. Manual records can be used without being dependent on reliable power supplies and sophisticated computer equipment as well as manual records should be maintained in any case as a backup system. If computers are used, simple standalone systems with software which does not require maintenance by a qualified technician should be preferred. When reliable support services can be provided to humanitarian workers, more complex and sophisticated information systems with greater functions can be implemented.

During the initial emergency phase the main objective is to quickly establish effective and reliable communication systems, such as satellite communications, even if their cost is high.

While humanitarian organizations can rely on more cost-efficient commercial and public communication systems in less developed countries as well as outside the crisis area, independent and reliable communication systems are needed near and inside the crisis area. Here reliability and effectiveness are more important than providing complex functions.

In order to ensure reliability, sustainability and consistency, information systems of low complexity and sophistication should be used inside the crisis area. Outside however, more complex information systems can be used or established which allow providing additional services and improving efficiency of supply chain management. For the same reasons, communication systems outside the crisis area can be integrated, linking different sites and services of humanitarian organizations.

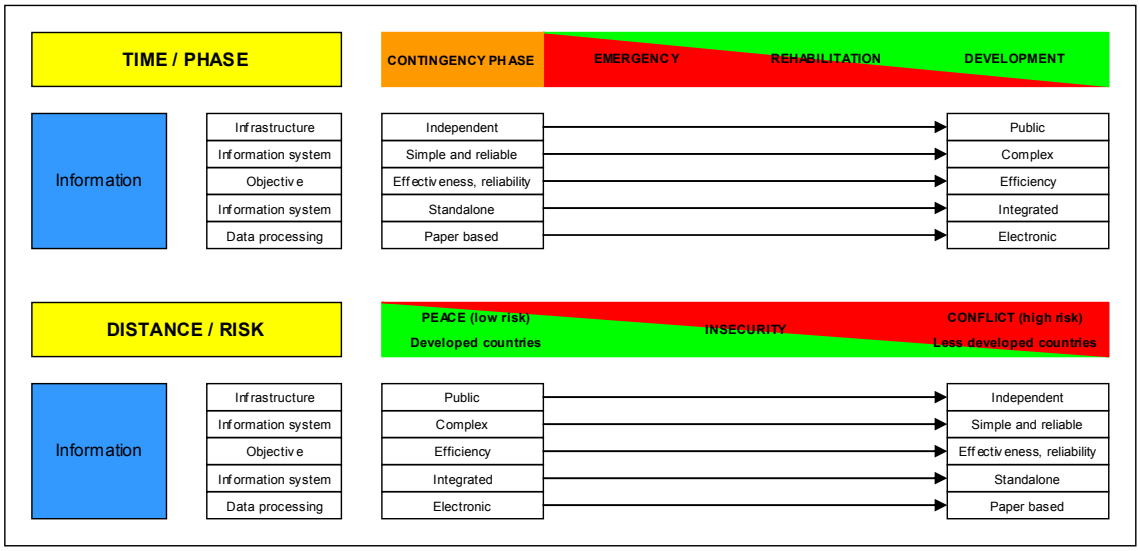

Figure 5.1 Communication management strategy

5.2 Communication systems and networks

5.2.1 Text communication

Text consists of letters of the alphabet as well as numbers. These can be transmitted physically by mail or be electronic means such as telex, packet radio, fax or electronic mail.

Especially when humanitarian organizations work in several countries and a language is used at the head office which is not commonly used throughout the world, a policy is needed what languages are used in which countries for all messages. This ensures that a maximum number of staff have access to all information.

Text communication has several advantages (see table. 5.3) for the sender. Messages can be sent at any time convenient to the sender and without regard of different time zones or different office hours, for example of suppliers. During office hours in the field, head offices may be closed and vice versa. In Islamic countries Friday is usually a public holiday while in Europe for example it is Sunday. Even if offices are open, the addressee might be absent but will receive the message as soon as s/he returns. If the office of the receiver is closed the message can be received provided the equipment is not switched off.

The sender of a message has the advantage that s/he can carefully draft a message with a logical structure, check records and references and make sure the message is consistent, coherent and complete before it is sent. Everyone has had the experience of making a satellite phone call and thinking of various issues which should have been discussed as soon as s/he puts down the receiver. Moreover the sender can attach other information such as tables, graphs, images or pictures which cannot be transmitted during a radio or telephone conversation and are difficult to explain. Unlike radio or telephone conversations, the receiver can carefully consider her/his answer.

If messages are sent by mail, original documents, pictures, brochures, samples, data carriers (CD-ROMs, DVDs), tapes or video cassettes can be attached. Especially for official documents (purchase contracts, lease of a warehouse, licences, passports etc.) hard copies will have to be sent for legal reasons, even if the information was already transmitted, for example by fax. This may also be the case for orders for goods with a high value which require original signatures from programme managers.

Written messages allow addressing several people at different locations simultaneously. They also have the advantage that they avoid problems of poor communications such as misunderstandings on radios or satellite phones when reception is poor.

Text messages also have several advantages for the receiver. Unlike in real-time communications, the receiver does not have to be available at the time the message is sent (Wood, M. 1996, 10 f.). Messages can remain in a physical or electronic mail box or be printed as a fax even if the office is closed. Unlike radio equipment, the receiver does not have to permanently monitor the telecommunication equipment, can leave it unattended and can leave her/his office at any time, although receivers must ensure that telecommunication equipment is switched on at all times.

Receivers who will usually receive a multitude of messages by different means, can postpone checking their mail if more urgent work needs to be done without constantly being interrupted by radio or phone calls. Messages can be compiled in physical or electronic mail boxes and treated at regular intervals.

The receivers have the advantage that they will receive a message which is well structured.

Another advantage is that the receiver of a written message has time to check records and consult with others before preparing an answer. This time is often not available in real-time communications.

The lack of language skills can lead to misunderstandings during voice communications. Receivers with limited language skills have more time to study a written message and can ask for advice from other people for translation (Wood, M. 1996, 12).

Both the sender and receiver have the advantage of having identical and accurate hard copies of the message. The sender, and other people who are referring to the document, know the content of the message exactly. The message can be filed and used as future reference. Even if notes are taken during radio or telephone conversations, they are unlikely to be identical for the sender and receiver and few people will take the time to actually document (all) conversations.

Generally speaking it is cheaper to transmit the same message in text form than by voice.

However, text messages also have disadvantages for the sender (see table 5.3). Since, unlike during a radio or telephone conversation the sender does not receive an answer from the receiver immediately, s/he cannot be absolutely sure that the addressee has actually received the message and when the message arrived. The message could have been lost or sent to the

wrong destination by mistake. Log books and exchange of information on received and transmitted should allow determining if messages were lost but this will not be known immediately.

Writing messages takes more time than a conversation by voice, especially for people who are not able to touch-type. Moreover the sender is not able to receive immediate feedback. It may require an exchange of several messages and therefore hours or even days, until a problem or issue can be resolved, depending on the delay until messages are answered.

Written messages cannot convey as much information and emotion as a personal conversation. Written messages are usually accessible to many people and the sender might be reluctant to express what s/he really thinks. In a private conversation on a telephone you can be more frank without having to worry to embarrass the receiver towards others. A personal conversation by voice can also be more reassuring than a written message.

When messages are transmitted electronically it may be difficult to ensure their confidentiality especially when fax or packet radio is used. Electronic mail may allow restricting access only to selected individuals.

Text messages also have several disadvantages for the sender as well as the receiver. Electronic transmission of text requires some additional hardware like a MODEM, and telephones and radio networks will be more commonly available than fax machines or packet radio. This constraint may limit the ability of transmitting messages especially outside the humanitarian organization, for example with suppliers or authorities and also limit the use in mobile and portable communication devices.

Notebook computers which can be used for packet radio or electronic mail are sensitive equipment which are prone to break down and require a reliable power supply. If notebooks are used for mobile applications they must be rugged and reliable. In comparison a broken telephone is more easy to repair or replace if a public telephone network is available.

A further disadvantage of electronic transmission of text is that a printer is necessary if the message should be available as a hard copy. While electronic messages can be read from the screen, the message cannot be received at all if the fax machine is not working. Printers need to be available, regularly maintained and require regular replacement of toner cartridges, printer ribbons etc.

Pure text messages, such as a telex, do not allow transmitting graphical information such as diagrams, graphs, images or pictures. If graphical information can be transmitted and printed, a large data volume will be needed for transmission, printing may take a significant time (as on a fax machine), the quality may be very poor and if colour is important, sophisticated colour printers will be needed.

Text messages should be clear and concise. It is important to explicitly make clear what the sender is expecting from receiver.

Regardless of what system for transmission of messages (mail or electronic transmission) is used, a log book of all sent and received messages must be kept. This log book must include the sender, receiver, date, time, contents of the message and when and where a message was forwarded to. Electronic mail systems will generate this log automatically. The log book should include the time the receiver has confirmed receipt of the message. Log books must be checked regularly to ensure that receipt of all messages was confirmed and that messages were forwarded if necessary. With some electronic systems the receiver will send a report of all received messages to all senders. They can compare these reports with their own records for detecting any messages which may have not arrived, accidentally may not have been sent accidentally or were lost.

Advantages

- Receiver does not need to be available at the time the message is sent.
- Messages can be sent any time, regardless of office hours, time zones and presence of receivers.
- Sender has time to carefully draft the message and ensure that it is consistent, coherent and complete.
- Possibility of attaching tables, graphs and images which cannot be conveyed in conversations.
- Original documents, brochures, samples, data carriers, tapes, video cassettes can be sent by mail.
- Several people can be addressed simultaneously and copies can be sent to different destinations.
- The receiver does not have to interrupt her/his work and can check message whenever convenient.
- There is no need to permanently attend the telecommunication equipment.
- Receivers receive clear and well structured messages.
- The receiver has sufficient time to study received messages and to translate them if necessary.
- The receiver has time to prepare an answer.
- Both sender and receiver have identical and accurate hard copies of the message.
- Hard copies are available for filing and future reference.
- Transmission of text messages is generally cheaper than transmission by telephone.

Disadvantages

- The sender cannot be sure that transmission was successful and has arrived at the intended destination.
- Writing messages is more time consuming than communication by voice.
- The sender cannot receive immediate feedback.
- Except if special precautions are taken, it is difficult to maintain confidentiality of written messages.
- Except for mail, transmission requires additional hardware such as fax machines, MODEMS, printers and possibly notebook computers.
- The possibility of transmitting written messages to mobile or even portable devices is limited.
- Depending on the system, transmission of images and graphical information may not be possible.

Table 5.3 Advantages and disadvantages of text communication

Echo tests can be used for determining the time it takes from sending a message until it is actually received. The sender usually does not know exactly when her/his message was received and cannot determine the efficiency of the communication system. A message is sent asking the receiver to return a message at what time the message was received. This allows determining whether the system is working satisfactorily or needs to be improved.

Stations with which there is little traffic should be contacted on a regular basis to ensure that all systems are working and ready in case of an emergency.

5.2.1.1 Mail

Despite the increasing sophistication of telecommunication, public mail and private messenger services are still very useful means of communication.

In some countries a public mail system may be in operation. However it is often not very reliable. An alternative is the use of private mail or commercial courier services. If neither is available, messages can be sent by internal mail which is transported by travelling staff, drivers or pilots.

Mail services have several advantages and disadvantages (see table 5.4). Mail services are cheap compared to telecommunication equipment. Usually vehicles or aircraft are travelling between the destinations where humanitarian organizations are working (anyway) and transmission of mail does not incur additional costs.

Apart from the physical transport, no telecommunication equipment such as computers, radios or telephones are required. Mail is the only system that only requires a pen and paper to write a message.

One of the main advantages of mail is that it allows transmission of any kind of written or printed material, graphs, images, maps, books, brochures, catalogues as well as data carriers (CDs, DVDs), audio cassettes, video cassettes etc. In addition samples of materials or equipment can be sent with orders or for quality control, as well as specimen for medical laboratory analysis. The sender does not have to worry about the length of messages or the data volume in terms of transmission costs.

The main disadvantage is the low speed. Physical transport of mail can take several days, especially between head offices and the field. Moreover transmission of mail may be delayed for days where there is no daily transportation to the destination.

Mail is also not entirely reliable. Mail can be lost or sent to the wrong destination. Vehicles may not be able to travel to the destination because of poor security and aircraft may not be allowed or able to land.

To ensure that mail is not lost or the loss is detected, every message must be carefully recorded. A list of the contents of the mail bag is transmitted to every destination which can compare it with the received mail and report any discrepancies. This also applies to single messages handed over to truck drivers for example.

Advantages

- Cheaper than communications by telephone.
- No communications equipment required.
- No limitations on length or data volume of documents in terms of transmission costs.
- Availability of visible record.
- Possibility of transmission of written or printed material.
- Possibility of sending small quantities of goods (documents, data carriers, samples etc.).

Disadvantages

- Low speed.
- Dependence on public services or transportation resources.
- Limited geographic coverage (especially in the periphery of a country).
- Unreliability and liability to interruptions.
- Possible delay by sending or delivering mail to the wrong destination.
- Requires physical transportation (which is subject to security constraints).

Table 5.4 Advantages and disadvantages of postal services

5.2.1.2 Morse code

Contemporary humanitarian aid workers may wonder how humanitarian organizations managed to operate in the early days with Morse code being their only means of communication apart from mail.

The use has greatly diminished but radio operators are still able to understand this international standard. The main advantage is that, especially when the quality of radio transmission is poor or there is interference, it may still be possible to distinguish the dots and dashes, where the reception is too poor for communication by voice (Corbett, J.R.G. 1988 , 99).

Morse code requires special equipment for sending messages and is a slow means of communication.

5.2.1.3 Telex

Telex has been widely replaced by fax machines. It does not use the public telephone network and requires its own communication network which is not widely available. It also only allows transmission of text and numbers. Messages are exchanged by one telex machine dialling the number of the other before transmitting the message.

5.2.1.4 Teleprinter over radio

Among the many radio data systems, TOR and packet radio are most commonly used (Wood, M. 1996, 180).

Teleprinter Over Radio (TOR), also known as Simplex Teleprinter over Radio (SITOR) or Amateur Microprocessor Teledata over Radio (AMTOR), is a packet radio system that works over HF radio (Wood, M. 1996, 184).

TOR is similar to but less sophisticated than packet radio which is explained in detail later. The sender connects to the receiving station by typing the call sign into a keyboard. As soon as the connection is established, the sender can type any text which is transmitted in real-time to the receiving terminal and printed or displayed on a screen. In the automatic repeat request mode (ARQ) three characters are sent together with some check information at a time and receipt is confirmed by the receiving terminal before the next data packet is transmitted. If an error has occurred during transmission, the last packet is repeated. This will ensure that the message is transmitted accurately even if the connection is poor. However this mode only works if the message is being transmitted only to a single station at a time.

One advantage of TOR is that radio equipment can be left unattended and does not require a full-time radio operator. As for packet radio, mailboxes are available for TOR. Teleprinter over radio will still work when connections are too poor to transmit and read speech (Wood, M. 1996, 47).

A disadvantage, compared to PACTOR, is that only letters of the alphabet, numbers and a few punctuation symbols rather than the full ASCII code can be transmitted. Consequently text files from standard word processor can only be transmitted after filtering out characters which are not supported by the system.

5.2.1.5 Packet radio

The packet radio system allows transmission of text by HF, VHF or UHF radio. The system converts text data into data "packets" of up to 256 characters to which it attaches the address of the sender, the receiver as well as any stations in between which may be used for relaying the message. A terminal (keyboard with printer) or a computer is connected to the microphone or headphone socket of the radio by an interface called a Terminal Node Controller (TNC) which switches the transmitter on and off automatically.

Connection to another station is made by typing the call sign into the keyboard. Once the connection is established, any entered text is transmitted in real-time to the other station where it appears on the screen or the printer. In addition to the text, each packet also contains control codes and error checking information. The data packet will be retransmitted until the

receiving station has confirmed that it has been received correctly. Messages can be received and stored even if no operator is present.

This system allows transmitting messages or even communicating directly ("chatting") with another station. Although "chatting" is far slower than communication by voice, packet radio can still be used when communication by voice is very poor since the data packets are repeated if the called station has not received them correctly, data transmission requires a lower signal to noise ratio than speech and can still be used when the connection is too poor to transmit voice. This can also be seen as a disadvantage as text is redundant and the message may well be understandable even if individual characters were not transmitted correctly. However the packet radio will repeat transmission of data packets until the message is error free.

The limited range of radio equipment can be overcome by so called digipeating (digital repeating) where the data packets are forwarded by intermediate relay stations (digipeaters) until they arrive at their final destination. This in principle allows worldwide communication provided that the routing and radio stations are known.

Packet radios can also operate mailboxes. A station, which is permanently switched on, has a reliable power supply and a long range, is designated as the mail box and receives and stores messages. Mobile units or stations which do not operate permanently can connect to the mail box and retrieve messages which they were not able to receive because they were switched off or because mobile stations were out of reach or the transmission route via digipeaters was changed. They are also able to send messages to the mail box which are designated to stations which are currently not switched on.

Packet radio also allows using bulletin boards which are available at a designated station. Other stations can connect to the bulletin board, read the contents of the bulletin boards and download the full text of messages of their interest.

Packet radio is cheap and reliable. Most humanitarian organization will install an independent radio network anyway since public telephone networks, if available, are not reliable and do not allow communication with vehicles and portable radios. Therefore packet radio can be installed with little additional equipment. However packet radio does require additional terminals or computers which increases the overall cost compared to radio communications for voice only. The computer also makes the system more vulnerable to failure.

All stations exchanging messages by packet radio must regularly check the radio links by contacting the radio operator.

5.2.1.6 PACTOR

PACTOR is a further development and combination of PACket radio and amTOR (Zavazava, C. 2005, 55) and is the favourite system used by humanitarian organizations.

PACTOR allows transmission of the whole ASCII character set, including upper and lower case letters and symbols on the computer keyboard. This also allows transmitting computer files, for example text files generated by word processing software. This allows preparing the text message on any computer, copy it to a data carrier and transmitting it to the PACTOR terminal. Moreover electronic mail files, spreadsheets and even software can be transmitted and received.

Provided that no fees have to be paid for licences, electronic mail via PACTOR is cheaper than using telephone lines or other data services and PACTOR is faster than TOR. A further

advantage is that PACTOR allows transmission at a far higher rate than TOR. Advanced error correction systems increase the chances that a message arrives without errors (Wood, M. 1996, 185).

Although message can only be received if PACTOR equipment is available, people not belonging to the humanitarian organization, for example journalists or civilian or military authorities can "listen in" and read messages. Consequently aid workers should be aware that PACTOR is not a private means of communication and the same precautions as during voice communications are necessary.

5.2.1.7 Satellite packet radio

Volunteers in Technical Assistance (VITA) have developed the "Satellife" system especially for humanitarian organizations.

A packet radio system including a mailbox and digipeater aboard a Low Earth Orbiting Satellite (LEO) orbits the earth four times a day. Messages can be typed into the TNC which are automatically transmitted to the satellite when it passes the next time. At the same times messages are downloaded from the satellite. The packet radio is connected to the Internet and allows sending and receiving messages without the need for the packet radio equipment. This system requires special equipment but the service itself is free of charge.

A disadvantage is that communication with the satellite is only possible during certain times of the day and then only for a limited time. This restricts the data volume which can be transmitted.

5.2.1.8 Facsimile (Fax)

A facsimile (fax) machine scans and converts a black and white picture into electronic signals which is transmitted over a telephone line or a radio channel through a MODEM, converted back to a picture printed at the receiving station (Corbett, J.R.G. 1988, 99). The MODEM (MOdulator/DEModulator) converts the data to a audio signal which can be transmitted through a telephone line or a radio channel and demodulates incoming tones and converts them back into a data format.

Unlike TELEX, fax uses public or satellite phone lines. Some fax machines automatically print the time and date of receipt as well as the telephone number of the sender on the message.

Unlike Telex or PACTOR, fax machines are able of transmitting graphical information such as pictures, diagrams or maps. In addition handwriting in any language, including for example Arabic, can be transmitted. The formatting of the original document is maintained while it is lost when TELEX or PACTOR is used. This is essential, especially when documents such as bills of lading, purchase contracts, certificates or copies of passports are transmitted.

The advantage of fax machines is that they can simply be connected to existing telephone lines without any additional equipment or the need for a technician.

Fax machines can be left unattended although staff must ensure that sufficient paper is available to receive faxes and make sure that the power supply will not be interrupted.

Fax machines are so wide spread in offices, commercial businesses as well as private homes, that messages can be sent worldwide without either the sender nor the receiver requiring additional equipment. In the field fax machines can be connected to satellite telephones and be called from anywhere in the world.

The receiving fax machine will confirm complete receipt of the data and the sender will immediately be notified if any error has occurred during transmission.

Some fax machines can also be used as a photocopier, scanner and printer which can be connected to a computer.

A computer with a fax MODEM can be used instead of a fax machine. However this has the disadvantage that the computer needs to be permanently connected to the telephone system and cannot be used for any other purpose while receiving a fax and a printer is still needed if a hard copy is needed.

The disadvantage of fax is that fax machines as well as a regular supply of special paper or printer cartridges are needed and fax machines require a constant power supply. Faxes tend to be less legible than the original and can be difficult to read if the original includes colour. Text with dark backgrounds may be difficult to read. Unlike electronic mail, fax messages cannot be downloaded to a computer for further processing which may require retyping of text.

Before sending a fax, each page should be numbered consecutively as well as marked with the total number of pages, for example "5/12" (page 5 from a total of 12 pages). This allows the recipient to know whether all pages were received.

Transmission of text with unnecessary information such as frames, backgrounds or pictures which are not needed, should be avoided as it reduces the speed of transmission and increases costs.

Fax machines should be robust, reliable and set up in a dry place with no draught, since otherwise received faxes will be blown away.

5.2.1.9 Electronic mail

Electronic mail can be sent by Telex, Teleprinter Over Radio, packet radio or over the Internet. Users who have access to the Internet do not require any separate hardware and can communicate worldwide with any user with access to the Internet. Provided the telephone network is working, the capacity for sending data is superior to packet radio and files of several MB (megabyte) can be transmitted.

Recipients do not need to attend the telecommunication equipment as messages are stored in mail boxes and can be retrieved whenever it is convenient for the recipient. Received messages can be forwarded, stored, copied and printed for future reference. Depending on the system used, the format of text including fonts and colours is maintained and it is possible to print documents in the original format. In addition computer files (text files, spreadsheets, images, software etc.) can be attached to messages (electronic file transfer). Messages can easily be sent to a large number of recipients simultaneously.

One disadvantage is that an urgent message may not be read immediately as the recipient is not aware of its arrival. However some electronic mail system automatically alert recipients when new mail arrives.

Unlike packet radio, electronic mail is dependent on public telephone network and other infrastructure such as servers. It is possible to feed electronic mail from packet radio into the Internet and receive answers if the infrastructure is available (Stern, D., n.d., 1). This system is far cheaper than using satellite telephones. The World Food Programme (WFP) has developed the portable Deep field mailing system (DFMS) which allows transmitting data such as spreadsheets, memos and even digital pictures by HF radio.

The Internet is also vulnerable to viruses. The Internet or other data carrier services can also be accessed through satellite telephones although equipment and services are fairly expensive. In order to reduce costs, outgoing messages can be collected and send as a data packet in regular intervals for example every four hours.

5.2.2 Radio networks

Various types of radio equipment are very commonly used by humanitarian organizations for voice as well as data transmission. Most commonly terrestrial radio networks are installed although satellites (LEOS) can also be used for transmission.

Radio networks have several advantages and disadvantages (see table 5.5). Radio networks can operate independently of any infrastructure, provided they have their own power supply and can transmit information over long ranges. Unlike public telephone services they do not depend on service providers and the functioning of telephone lines and telephone exchanges. In complex political emergencies the telephone infrastructure may be damaged or be deliberately switched off.

Therefore radio networks can be set up anywhere, even in very remote places. The equipment is fairly expensive but can be moved to other programmes. Transmission itself is free of charge regardless of the distance of the station which is being called.

Any number of people can receive transmissions from a station simultaneously, provided they are within the range of the sending station. This open channel system allows distributing information efficiently, quickly and in real-time to a large number of people which is especially valuable in emergencies. All concerned people can keep updated on "what is going on". If telephones were used, the information would have to be passed to each person separately. "By the way, this apparently annoying side effect of simplex, that all stations can hear everything said, is actually a great bonus. If you keep an ear open to what is going on, it is like having a rolling briefing constantly going on. In fact, sometimes someone may just say something to no one in particular just so that everyone can be informed, and understand the whole situation by the time they are called personally for comment. This is one reason why police, fire and ambulance services don't use mobile phones though they could easily afford them" (Wood, M. 1996, 151).

Unlike telephones, radio transceivers can also be installed in vehicles, aircraft, ships and portable equipment can be carried around. Apart from voice, with some additional equipment, data can also be transmitted. The use of radio equipment requires some training but is simple and easy to learn.

Despite the many advantages, radio networks also have some disadvantages. Unlike telephones, radio base stations require skilled and trained operators. The quality of reception depends on the prevailing atmospheric conditions. Reception may also be impaired in certain locations. A special concern is that areas or stretches of roads my lie in a radio "shadow" in which radios cannot reach any other station even in case of an emergency.

Unlike telephones, the sender and receiver cannot talk simultaneously. And a channel that is used for a conversation between two stations cannot be used by any another user. This requires discipline of all users who must wait until the channel is free rather than interrupting.

Except if equipped with a selective call function is used, the sending station cannot selectively call a particular other station. Rather all stations must permanently listen to their radios and respond to calls which concern them. This also means that radios must be

permanently attended. Radios can be a nuisance, especially when many conversations are held and somebody is trying to concentrate on her/his work.

Importation of radio equipment as well as operating radio networks requires permission and licences from the authorities in the country where it is set up and operated.

Anyone, private people, journalists or authorities, can listen to any conversation. Radio conversations are therefore never "private".

Radio equipment is coveted as it is valuable, can be used for military purposes and is therefore prone to theft and looting (Taux, J.-D. 1996, 353).

Advantages
• Independence from public communication systems and service providers.
• Long range.
• Installation independent from available infrastructure.
• Can be set up in remote areas and places.
• Immediate and direct access between stations.
• No cost for transmissions themselves.
• Many people can participate in communications at the same time.
• Radio transceivers can be carried around and installed in vehicles, ships, aircraft etc.
Disadvantages
• Requires skilled and trained radio operators.
• Quality of reception dependant on atmospheric conditions.
• Areas or stretches of roads may lie in a radio "shadow".
• Sender and receiver cannot talk simultaneously.
• Any channel can only be used by one sender at time.
• Generally, senders cannot selectively call a certain station or receiver.
• All stations must be permanently attended in order not to "miss" a call.
• Monitoring radio communications all day can be a nuisance.
• Importation of radio equipment and operating of networks requires permission and licences.
• Radio communications are never "private".
• Radio equipment is prone to theft.

Table 5.5 Advantages and disadvantages of radio communications

5.2.2.1 Planning of radio networks

Radio networks may be necessary because other telecommunication infrastructure such as telephones are not available or unreliable. Even if a public telephone service is available a radio network may be needed in case the telephone network fails as well as for communicating with vehicles etc. In any case a reliable means of communication is indispensable for efficient supply chain management in general and for safety and security reasons in particular.

Radio networks need to be planned and set up by a specialist. Planning requires field experience to ensure that installation is not unnecessarily delayed by missing or incompatible equipment or missing tools. Humanitarian organizations need to determine where radio communications are needed and what range they should cover. In principle all offices and premises (warehouses, workshops, residences etc.) as well as vehicles, vessels and aircraft etc.

and perhaps ports, airports and border posts need to be connected. A technician can then plan where base stations are necessary and which areas or places can be covered by mobile or portable equipment. As far as possible at least base stations should be able to communicate with each other without the need for relaying messages. A further consideration is communications with other humanitarian organizations which is generally useful for coordination as well as for security.

In order to avoid theft in case of the need to evacuate, fixed stations should only be installed in secure places as they cannot be quickly dismantled in case of an emergency.

If a radio network is necessary, the first consideration is whether radio communications are permitted in the concerned area. Before installation, licences and permits for importation must be obtained. This may require presenting documentation of the equipment. Lack of documentation and licences could lead to confiscation of the equipment upon arrival. If no civil authorities exist, military authorities may regulate the use of radio equipment.

One important consideration is whether radio equipment and its operation is affordable and a detailed cost estimate must be made for purchasing equipment. Capital costs include purchase cost of equipment (transceivers, aerials, microphones, headphones etc.), cost of accessories (batteries, battery chargers, voltage regulators, uninterrupted power supplies, generator sets, solar panels etc.), cost for tools and testing equipment, cost of transportation, importation, obtaining licences as well as installation. Recurring costs include costs for operating and maintaining the radio network as well as licence fees. A set of essential spare parts should be purchased together with any equipment.

Suppliers must provide operating, maintenance, service and perhaps training manuals, preferably in a language understood in the destination country, as well as spare part catalogues. Equipment must be packed in a waterproof manner, in shock absorbent material and shipped in wooden boxes to reduce the risk of theft.

If radio equipment is carried by passengers, they will have to carry copies of importation permits with them and may have to pay duties or present exemption certificates when entering the country.

Many humanitarian organization have standard equipment kits with all necessary accessories and tools packed, which can be shipped immediately. This is especially useful in emergencies.

Finally an important question is whether a radio operator needs to be employed and trained. A full time radio operator will be needed if sophisticated equipment is installed, the station handles are large number of messages which need to be relayed and if the radio must be permanently attended for security reasons. If there is little traffic and there are no security concerns, the transceiver can also be installed in an office.

5.2.2.2 Installation of radio networks

Humanitarian usually install private radio networks. Amateur or CB radio networks may be in place. However they require that each user holds a licence. While this can be expected from radio technicians, humanitarian aid workers usually do not hold such licences.

"Private" network means that the humanitarian organization owns all fixed and mobile stations which means that communications are free of charge (Wood, M. 1996, 63). However operating of private networks requires a licence as well as allocation of frequencies which takes time which is not available during emergencies. Competition for frequencies is fierce and frequencies may have to be shared with other users. For communicating between countries,

licences are needed in both countries and for ensuring reliable global communications, channels in many bands will be needed.

Large humanitarian organizations like the United Nations or the Red Cross have frequencies permanently assigned to them. They therefore only require a licence for operation in the country they are working in.

Radio networks must be installed by professional technicians. Humanitarian organizations either have their own specialists or can outsource installation. Even in an emergency they must be properly planned and installed so that they will function better and longer and not require future modifications. Radio equipment that is not installed properly is also prone to be damaged.

Radio rooms should be accommodated in a separate room of a building and there must be a place for setting up aerials which is not obstructed by trees or buildings, as far as possible within 25 metres of the transceiver. Fixed stations can be installed in offices, warehouses etc.

Mobile stations can be installed in vehicles, boats etc. Some transceivers allow being used as base or mobile stations (Corbett, J.R.G. 1988, 68).

Base stations and repeaters can be installed in one or two hours while setting up taller aerials and more complex radio networks may take several hours.

5.2.2.3 Aerials

Aerials emit radio waves which travel to another aerial where they are captured and conducted to the receiver. Hand-held radios have small aerials attached to them but can also be connected to external aerials with the correct connection cable. "I want to stress here that the secret is in the position of the aerial, mostly its height, and not the power of the transmitter or anything else. A perfectly ordinary hand-held connected to the aerial by an extension lead is just as good a base station as a more elaborate set up" (Wood, M. 1996, 158).

In order to increase the range, an external aerial can be installed and permanently connected to the transceiver. These base stations will increase the quality and range of transmission, the aerial will also be in the correct position but the radios are no longer mobile. Setting up these permanent installations takes time and they should be made by a professional radio technician. Where two hand-held radios cannot communicate because they are out of range, they will often be in good contact with the base station which can relay messages.

Aerials must resonate at the frequency used and their length must therefore correspond to the wavelength of the radio wave. For HF radios this would require quite long aerials. And because the frequency may need to be changed to improve reception, different lengths of aerials would be needed (Wood, M. 1996, 49). In practice this problem is solved by installing ATUs (aerial tuning units) which, to some degree, allow adjusting an aerial of fixed length to the radio frequency which is used. For example a long piece of wire can be tuned from 1.5 to 30 MHz (Corbett, J.R.G. 1988, 16). ATUs can also be integrated in the transceiver.

Aerials are installed at the highest possible point of buildings, tress, poles or masts or at the point with the clearest view towards the place you want to communicate with. As far as possible they should be located within 25 metres of the transceiver.

They must be installed by a competent technician according to the instruction manuals provided by the manufacturer.

Anchor points must be able to support the weight of the aerial. Aerials, wires and ropes which are used to hold them should not rub against adjacent walls or overhanging roofs when

swinging in strong winds. Steel or aluminium masts will require guy wires which are fixed to the ground around them and prevent the mast from tipping over while timber poles should be set in the ground and be self-supporting.

Aerials should not be set up parallel to electric power lines or long pieces of metal wire and should not be suspended above a tin roof (Corbett, J.R.G. 1988, 61). There should be 20 metres of clear ground in front of the aerial in the direction the radio waves should be emitted.

Static electricity can build up in aerials and cause electric shocks when connected equipment is touched. In this case the aerial should be earthed when it is not in use (Corbett, J.R.G. 1988, 60).

A range of different aerials are in use (see figure 5.2 for some examples).

Dipole aerials are simple, cheap, easy to set up and the most commonly used HF aerials (Corbett, J.R.G. 1988, 13). Dipoles are wires of 10-30 metres length which are hung from trees or buildings or set up as an inverted V aerial which requires a central support. The length of the wire can be adjusted to the frequency used simply by winding up or unwinding the wire. This type of aerial is very convenient for mobile installations as it can be set up quickly. Some dipoles are designed in a way that they can be used for two different frequencies (Corbett, J.R.G. 1988, 16).

Most energy is received by and transmitted from dipole aerials perpendicular to the direction of the aerial (that is at a right angle to the wire) and less effective in the directions parallel to aerials (Corbett, J.R.G. 1988, 14).

The higher the dipole aerial is suspended vertically above the ground, the flatter the angle up to the ionosphere. Therefore if the aerial is used for short ranges, it should be suspended only about 1/4 of the wavelength above the ground which will result in emission of radio waves in a steep angle. Ideally two dipoles will be suspended at different heights for different ranges. However in practice installation at the required height (for example 20 metres) will not be practical as it would require special support towers and the dipole is installed as high as possible.

Inverted V aerials are special dipoles which are supported in the middle and both sides slope down to about two metres above the ground. The advantage is that this aerial transmits in most directions and is therefore suitable for covering the whole area around the aerial. Since part of the waves are horizontally polarized and part are vertically polarized, the receiving aerial can be horizontal or vertical.

Vertical aerials (or verticals) are straight poles which are installed vertically on the ground or on the top of buildings and usually are prevented from falling over by guy ropes. These aerials are compact and require little space horizontally. Short verticals can also be used for mobile aerials which are installed on car bumpers.

Vertical aerials transmit radio waves horizontally in all directions and at low vertical angles (flat angles to the ground).

Beams look like huge television antennas. The power of beams is mainly emitted parallel to the beams and the direction can be fixed or changed by a rotator driven by an electric motor to point in the direction the transmission is required.

Beams are preferable if the direction of the station which is usually being called is known since its concentrates the power in one direction. If mobile stations are contacted it is better to use 'inverted V' aerials.

For practical reasons mobile aerials are usually vertical. It is usually not possible for the aerial to have the length of a quarter wavelength (for example at 5 MHz this would require a 15 metre long aerial). Therefore aerials are about 2-3 metres long and tuned to the used frequency by ATUs or pre-tuned by coils in the aerial.

In helical whip aerials a wire is twisted around and sealed in fibreglass.

A multi-dipole consist of several individual dipoles of different lengths for different frequencies which are set up in parallel but require less space than several single dipole aerials.

Broadband aerials can be erected horizontally or in an inverted V and contain special circuits which allow to be tuned to different frequencies for example from 3 to 30 MHz.

Different types of aerials have different advantages, some are more suitable for short range, some for long range. Therefore different aerials can be installed and the transceiver connected to the aerial which allows the best communications. In any case one of the aerials should be of a simple wire type as a backup since it can easily be repaired (Wood, M. 1996, 52).

Figure 5.2 Example of radio aerials

5.2.2.4 Transceivers

Radio equipment needs to be able to transmit and receive radio signals. In practice both functions are combined in one device, the transceiver, an abbreviation for transmitter-receiver. These are about the size of a shoe-box, weigh approximately 5 kilograms and can normally not receive and transmit simultaneously (Wood, M. 1996, 45).

A great variety of different transceivers with different levels of sophistication are available. In any case it is important that the radio operators can use the equipment and understands all controls. The more sophisticated the equipment, the more difficult it will be to find

maintenance and repair services locally or domestically. "You should aim for the simplest transceiver that will satisfy your needs" (Corbett, J.R.G. 1988, 44). The frequency and the aerial are more important than the make and model of the radio. However the transceiver should be reliable, easy to maintain and easy to use by lay(wo)man.

Like all radio equipment, transceivers should be standardized within the humanitarian organization to facilitate purchase, servicing, maintenance and repair. Since radio equipment is expensive, future availability or at least availability of spare parts must be ensured, even if suppliers no longer manufacture these models.

Transceivers should be easy to dismantle for servicing and repair. Equipment containing components which can be unplugged and replaced facilitates locating faults and allows exchange of components even with limited knowledge of radio equipment. Transceivers should also be easy to modify like for adding or changing frequencies.

Suppliers must provide operating, training, service and detailed technical manuals which allow a radio technician to carry out repairs.

Apart from the radio operators, humanitarian workers will usually not be skilled in using radios. Transceivers should therefore be simple to use.

Transceivers must have the option of being powered by mains electricity (usually 110 or 220-240 V AC) or batteries (usually 12 V DC). Each power supply will require a separate power unit and it should be easy to change between them, ideally by a switch or changing plugs rather than soldering wires. Having the power supply unit built into the transceiver eliminates the need for cables, plugs and external power supplies which can wear, be damaged and lead to failure of the equipment. Great care must be taken not to accidentally connect equipment intended for 12 V power supply to a mains electricity supply. Batteries should be installed as close to the transceiver as possible.

In order to protect transceivers from damage by lightening they should always be disconnected from the aerial when they are not used. Aerials can then be connected to earth or left unconnected to anything ("floating") but should be at least 30 cm away from the transceiver.

Since lightening striking solar panels can be conducted to the battery and the transceiver, solar panels should be disconnected from the battery when they are not in use (Corbett, J.R.G. 1988, 66).

Lightening is likely to be conducted through lightening arrestors which are installed at the highest point of the building and earthed to the ground with a good conductor, rather than through the aerial or other equipment (Corbett, J.R.G. 1988, 60). Special lightening arrestors which are connected to the coaxial cable between the aerial and the transceiver also provide some degree of protection but disconnection provides the best protection. Lightening can damage or destroy expensive equipment and can injure people operating radio equipment.

Simple transceivers can be tuned to a small number of fixed frequencies. More sophisticated and synthesized equipment allows tuning the transceiver to any frequency, for example from 2 to 30 MHz (Corbett, J.R.G. 1988, 20). In any case the possible need to add more frequencies in the future should be considered.

Transceivers must allow to be tuned to the frequencies which the humanitarian organization is authorized to use and should be able to communicate with aircraft, vessels and vehicles which may be using different equipment.

It may be useful to include certain frequencies for receiving only which allows listening to communications but not to transmit.

Figure 5.3 Arrestor (lightening protection)

"Attaching" the signal onto the carrier wave is called modulation and can be accomplished in different ways. The most common mode is SSB (single side band) since it allows to fit more channels on a band than other systems. At the receiving station the radio signal is processed by a demodulator which extracts the signal from the carrier wave which is then heard from the speaker.

The range a transceiver can emit radio signals is, among others, determined by the transmitter and its power. The greater the power the longer the range. However with increasing range the likelihood of interference with other stations using the same frequency increases and it is important not to "blast over" other stations.

Microphones are an indispensable part of the radio system. They are delicate, heavily used and prone to wear or break if used carelessly. Hand-held or fist microphones are moved and used a lot and therefore wear and break. The connection cables may be accidentally overstretched and microphones may be left dangling on their cable or be dropped. Since the transceiver cannot be used without the microphone it is worthwhile to purchase a product of high quality which is reliable and will last. When hand-held microphones are not in use, they should be placed in a clip which is attached to the desk or dashboard of a car. These clips must not be attached to the transceiver as the screw can damage components inside the radio.

Desk microphones are usually left in the same position or even fastened to the desk, the switch is the only moving part, and they are therefore less likely to fail than hand-held microphones. Whatever microphone is used, a spare piece of equipment should also be available.

Another alternative is a handset which looks like a telephone receiver but has a switch for transmitting. The advantage is that the speaker is near to the ear providing clear sound and

the microphone is automatically placed in the correct position for speaking. For persons who need to look around or have their hands free during speaking such as during driving or flying, a boom microphones which is positioned in front of the mouth can be used.

Earphones or headphones can be useful when the signal is weak or reception is poor.

Although transceivers differ, some basic controls will be needed in any case.

The transceiver is switched on and off with the ON/OFF switch and the power light, usually red, will indicate when the transceiver is switched on. The VOLUME or AUDIO control allows adjusting the loudness of the sound from loudspeakers or earphones. The VOLUME control knob might double as the ON/OFF switch. Because this knob has to be turned all the way every time the radio is switched off, it is often the first piece to wear. If a separate ON/OFF switch is used, the volume control can in principle remain in the same position permanently.

CLARIFIERs allow adjusting the pitch of the voice coming from the loudspeaker to the preference of the listener.

In most transceivers different channels can be selected by a rotary multi-position switch (CHANNEL selector) for transceivers with a few fixed frequencies or by entering the frequency in a number pad.

The SQUELCH control switches the loudspeaker off whenever no transmission is received. This allows keeping the transceiver switched on but avoiding having to continuously hear noises, hisses and crackles. Without a SQUELCH control there is a danger that someone who is annoyed of hearing the radio crackling constantly will simply turn down the volume so low that calls, when they eventually occur, are not heard anymore. However if the SQUELCH control is set too high it may not only block out the noise but any transmission. The SQUELCH should be switched off when the transceiver is switched on, and only be switched on after the correct channel, volume etc. have been selected.

The RF GAIN or ATTENUATION allows adjusting the amplification of the incoming signal in the transceiver. If the RF GAIN is set too high, the signal from a nearby or strong station can sound distorted. On the other hand if the control is set too low a weak signal may not be heard (Corbett, J.R.G. 1988, 77).

The USB control allows using the channel 3 kHz above the selected frequency while LSB uses the channel 3 kHz below the channel frequency. This feature allows stations to use the same frequency simultaneously without interference or switch to the other sideband if there is too much interference (Corbett, J.R.G. 1988, 22).

A red or orange TRANSMIT light will usually light up whenever the transceiver is transmitting.

Transceivers can be used as hand-held devices, mobile stations or fixed stations (base stations) which have several advantages and disadvantages (see table 5.6). Installation of a fixed station, which are usually attended permanently, allows setting up a large and powerful aerial. The office or premises such as a warehouse may not be an ideal place to set up a base station. However obviously it would not be practical to have to walk or travel to a base station every time you want to use the radio and a compromise between the ideal spot and accessibility to staff will have to be made (Wood, M. 1996, 161). An alternative is a "remote controlled" base station where the aerial is set up in a place ideal for the aerial for example on the top of a high building or a hill, while the transceiver and controls are set up in a place convenient for the staff and both are connected by cables such as a telephone line. However since the aerial is placed outside the premises where the transceiver is used, security of the aerial site as well as the connecting cable must be ensured.

The term "base station" refers to the way the radio equipment is used and not related to the type of equipment that is used. A hand-held connected to a permanently installed external aerial is considered as a base station.

Fixed stations have the advantage that there is more time to carefully select the best available site for setting up the aerial and larger aerials can be used. More powerful transmitters can be used which increases the range. Another big advantage is that the equipment will work at any time as the aerial is fixed and the equipment is permanently installed.

One disadvantage is that equipment is more expensive and the whole set-up is not mobile. If the installation needs to be moved it requires considerable time for dismantling as well as a qualified technician for installation at another site. In case of an evacuation there will not be enough time to dismantle the equipment which may consequently be lost or destroyed, although the transceiver and computers can be quickly disconnected and salvaged.

Advantages

- More time for carefully selecting the best available site.
- Allows installation of larger aerials.
- Allows installation of more powerful equipment.
- Greater range.
- Works any time and is reliable.

Disadvantages

- More expensive.
- Not mobile.
- Requires significant time for dismantling and moving to another place.
- Cannot be dismantled quickly in case of an evacuation.
- May not be able to receive from a weaker station although the other station can receive signals.

Table 5.6 Advantages and disadvantages of fixed radio stations

As mobile and stationary are opposites, "mobile stations" are a contradiction in themselves and "the reason for this odd name is that the licence for a radio transmitter is called in law a Radio communications Station licence, so legally at least you have a mobile radio station" (Wood, M. 1996, 107). The equipment is permanently mounted in a vehicle, usually below the dashboard and can be operated while driving. The transceiver should be installed in a place that is protected from direct sunlight and which allows operation by the driver as well as the passenger. The transceiver should be mounted in a way that it can easily be fitted and removed. A clip must be fitted near the transceiver to hold a fist or hand microphone. VHF or HF equipment or both can be installed.

Mobile stations have several advantages and disadvantages (see table 5.7). The weight of the equipment and aerial is not a limiting factor and therefore fairly large aerials with a greater gain can be used. Moreover the car battery is available as a power supply and therefore allows using aerials with a large gain. Depending on the topography of the area between the mobile and the other station, ranges of up to 50 km for a VHF radio are possible. Aerials can either be fasted to the bumper or be mounted on the roof of the vehicle.

A "Magmount" aerial can be placed in the centre of the roof of a vehicle and is held in place by a powerful magnet. Unlike other aerials which are permanently mounted on the vehicle, this aerial can quickly be attached or detached. It can be connected to a hand-held radio with a feeder cable through the window which can then be used as a mobile station but also has the

flexibility of being disconnected and used as a portable hand-held radio. One of the disadvantages is that the transceiver and radio can easily be removed from vehicles if a permanent installation is not advisable because of poor security.

Advantages

- Can be used in moving vehicles, boats etc.
- More powerful than portable units.
- Allow use of fairly large aerials compared to portable units.

Disadvantages

- Equipment cannot be as powerful as in fixed stations.
- Requires expertise for installation of the aerial, transceiver as well as the power supply.
- Less secure than fixed stations.
- Equipment will be lost in case of theft of the vehicle.
- Reception depends on location of vehicles and topography between the vehicle and the other station.

Table 5.7 Advantages and disadvantages of mobile radio stations

A transportable transceiver is intended for being moved but for placing on a table and using at a fixed place rather than as a mobile station. They are intended for use "on the move" and temporary installation of external aerials. They are more powerful than portable and mobile units but can be installed and dismantled faster than base stations.

Transportable units have larger batteries, are more powerful and therefore have a longer range than portable units.

Advantages

- Longer range than mobile stations.
- Can be installed and dismantled faster than base stations.
- Can be quickly dismantled in case of emergencies.

Disadvantages

- Equipment larger and heavier than mobile stations.
- Requires installation (unlike mobile stations).

Table 5.8 Advantages and disadvantages of transportable radio stations

Portable radio sets (hand-held radios) are small enough to be carried around by a person although they may be connected to an external aerial for increasing its range. Hand-held radios are small enough to be held in a hand during reception or transmission and can be clipped onto a belt or carried in a bag when not in use.

The correct term is "radio telephone" (R/T) and used in legislation although it has become obsolete with the advent of mobile phone systems. Often the terms hand-held radio, R/T, R/T set or "Walkie Talkie" which is actually a trademark of the Motorola Corporation are used. Although incorrect, often the term "handset" is used as this actually refers to the receiver of a telephone.

All hand-held radios which are used to communicate must be programmed in the same way by a radio technician to ensure that the frequency of channel 1 on one hand-held radio matches the frequency of channel 1 on all other hand-held radios.

Since only short aerials are practical to use with hand-held radios, the wave length must also be small and the frequency therefore high. Consequently only VHF or UHF is used for hand-held radios. The "rubber duck" is in fact a helical steel aerial protected by a rubber sleeve.

Hand-held radios have the advantage that they can be carried anywhere and people can receive as well as transmit any time. This is good for security of staff and has the advantage that there is no need to go to a base station or a radio room every time you need to communicate. However because of the limited power of the transmitter it may be necessary to change the location, move to a window, leave a building or move to an elevated place to communicate with another hand-held radio.

The disadvantage of portable radio sets is the fairly range of up to 2 kilometres and the need to regularly recharge batteries. Because the person using the hand-held radio is moving around, the quality of communications will very much depend on her/his location. Increasing the power of hand-held radios is limited by the size and weight of the battery which can be conveniently carried.

Hand-held radios can only be powered by a battery and need to be recharged regularly which can take several hours during which the hand-held radio cannot be used. Hand-held radios require very little power for receiving but much more for transmitting. If hand-held radios do not have an indicator for checking the charge of the battery, there is also a danger that the battery is flat when it is urgently needed in an emergency. An alternative is to charge one battery while using the other and exchanging them when the battery is flat.

Another disadvantage is that because of their small size they are easily forgotten, mislaid or stolen. Since they are not fixed they may easily be damaged by being dropped or knocked around. Hand-held radios are coveted because they are valuable and are used by combatants.

Advantages

- Small size and weight allows carrying them around everyone.
- Always available for use, no need to move to a base station or a radio room.
- Can be connected to external aerials when necessary.

Disadvantages

- Small range.
- VHF radios in principle require a line of site with the other station.
- May require changing location, leaving a building or moving to a higher elevation.
- Requires regularly recharging batteries.
- Battery may be flat when the hand-held radio is urgently needed.
- Prone to theft.
- Can easily be damaged by dropping or being knocked around.

Table 5.9 Advantages and disadvantages of portable radio sets

Unlike two-way radios which allow receiving as well as transmitting, scanners allow only receiving radio signals. If several frequencies are used, scanners allow briefly switching to each of them for example for one second. This allows detecting stations calling on a frequency different to the one the transceiver is tuned to. Although stations in a network will usually all be tuned to a certain frequency for contacting each other, a station might need to change the frequency because of the poor quality without being able to notify the station it is trying to call. The disadvantage is that the calling station will have to call for several seconds since the

scanner will take some time to switch through all the frequencies. Scanners may be integrated into transceivers.

5.2.2.5 Automatic repeater systems

Hand-held radios are very convenient but have the disadvantage of a limited range. An alternative to using more powerful hand-held radios or mobile stations is to install automatic repeater systems (Wood, M. 1996, 163 f.) which have ranges of around 50 km. Repeaters (repeaters, relay stations) are fixed stations with an aerial installed at a location with a good range. They receive weak signals (uplink) and instantly retransmit the same signal (downlink) but with a higher yield than the hand-held radio. This allows two hand-held radios to communicate with each other although they may be out of range of each other without a repeater. The only alternative for them would be to use more powerful transmitter or ask a base station to relay the message which would be time consuming.

Since the instant retransmission of the received signal would interfere with the hand-held radio which is transmitting and "jam" it, the repeater must use a different frequency for retransmitting than the frequency of the received signal. This means that hand-held radios need to use a duplex-system which are designed to transmit and receive on different channels and automatically switch between these channels depending on whether they are transmitting or receiving. The two hand-held radios communicating with each other are nevertheless switched to the same channel and do not notice any of this switching.

Such hand-held radios are then unable to communicate without a repeater (Wood, M. 1996, 164). They can therefore not be used if the repeater has not been installed yet, the repeater or its power supply fails, the repeater is stolen or if the hand-held radios are used in another location without a repeater station. Consequently the entire radio communication network is dependent on one piece of equipment. A contingency plan in case of failure must be available and repeaters must be carefully maintained. An alternative is to programme another channel for using in the simplex mode. This channel can then be used for direct communications between hand-held radios in case the repeater fails. Another possible disadvantage of automatic repeater systems is that the authorities may be unwilling to allocate duplex channels.

Another problem arises if the range of the repeater is smaller than the area in which the hand-held radios are being used. One possibility is to install a second repeater to enlarge the area. However as these two repeaters cannot work on the same frequency users of hand-held radios would have to know exactly where the range of one repeater ends and switch to the other frequency. Hand-held radios will need to be programmed to the frequencies of both repeaters and users cannot communicate only with hand-held radios using either repeater at a time.

This problem can be overcome by using a trunked repeater system where both repeaters are linked with a land line. However this requires specially designed hand-held radios which are expensive. Another possibility is that the hand-held radios are designed to automatically scan the strength of signals and automatically switch and tune to the repeater emitting the stronger signal.

Multi-channel "pool" systems operate on different channels and allow different services to use the same repeaters and benefit from the larger range.

An alternative to automatic repeater systems is to use a more powerful base station to relay messages between two hand-held radios which are out of range of each other but both within the range of the base station. The disadvantage is that relaying messages is time consuming.

However the advantage is that the hand-held radios can still communicate directly with each other when they are in each others range and can still be used even if the base station fails.

5.2.2.6 Selective call systems

Another way of avoiding having to listen to crackling and bustling of radios as well as radio calls between other stations is using selective calling systems (Wood, M. 1996, 188 f.) which makes the radio similar to a telephone. Ever radio station is assigned a distinctive call sign. The receiving station only switches on the speakers if it receives its assigned call signal. The sender can call a single station or all stations and a bell or buzzer at the receiving station will alert the person that somebody is trying to call her/him. The sender of the call sign also receives confirmation that the station s/he is calling has been successfully contacted.

The advantage of the selective call system is that staff at a specific fixed or mobile station are alerted that they are being called without having to be disturbed by the radio all day. Of course the transceiver must be switched on all the time and be connected to the aerial.

One disadvantage is that calling codes are assigned to specific transceivers. In order to call a specific person, s/he will always have to carry the same hand-held or listen to the same fixed or mobile transceiver. If the person you want to call happens to be using another transceiver s/he will not be alerted to the call. In case the caller is unable to contact the person s/he wants to contact s/he can activate a group call which will open the speakers of all radios and then call the name of the person s/he wants to contact. The receiver can then inform the sender of her/his current call sign and the conversation can carry on in the selective call mode.

If the person who somebody is trying to call happens to travel in a vehicle and her/his hand-held radio is out of reach of the caller, the mobile station in the vehicle will not react to the call. This person could of course deactivate the selective calling system in the vehicle and listen to all traffic in case s/he is being called. However this would require the caller to name the person s/he wants to contact rather than just activating the selective call system. As only one call sign can be assigned to any transceiver, a person who has more than one function would have to carry two hand-held radios to ensure that s/he is alerted to all calls in any of her/his two functions.

Selective calling system therefore combine some advantages as well as disadvantages of telephones.

5.2.2.7 Radio rooms

Efficient and proper operation of a radio network is just as important as installing the correct equipment. Operators must be competent, the network must be controlled and the efficient and accurate handling of outgoing and incoming messages ensured.

A radio network usually consists of several base stations and portable units (see figure 5.8) which may be unattended at times. Especially for security reasons, at least one station must be permanently attended, listen and answer to all calls and be able organize help if an emergency occurs. One station, which is normally at the head office must monitor and control the network and all other stations must have the discipline to follow its instructions.

In addition this station can relay messages to stations which are currently not listening or by other means such as telephone. These stations can also relay messages between two stations which are out of each other's reach but both within the reach of the base station. Another important function is tracking and recording the position of vehicles and aircraft. In case of an emergency at least the last location and direction will be known. Radio rooms should also

allow a certain degree of privacy for the user. Earphones or headphones can be used to avoid any bystanders following the conversation.

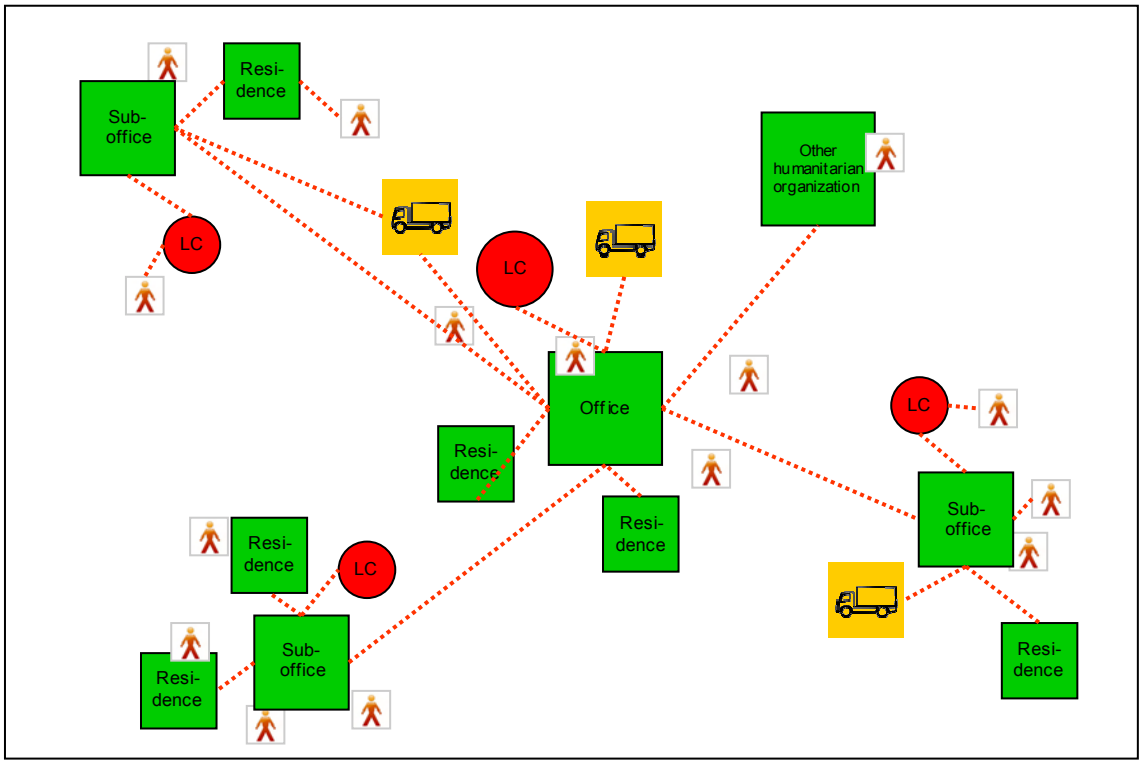

Figure 5.4 Example of a radio network

Radio rooms will usually be set up in the place where the radio has the largest range and the greatest variety of communication means. As radios are usually heavily used it is inconvenient and a nuisance to install the transceiver in an office. It is also important to acknowledge the importance of radio rooms and provide a professional and convenient working environment for radio operators. Radio rooms are noisy and busy places and should therefore be shielded from other noise as far as possible. The door should be kept closed, only people wishing and authorized to use telecommunication equipment should enter and it should not be used for private conversation which will disturb the radio operator.

Radio rooms must be staffed with trained and skilled radio operators who can operate the equipment and know how to react in case of emergencies. Depending on the security situation the radio operator may be required to regularly contact all stations in the network in the morning, during the day and before shutting down in the evening to ensure that everyone is well. Radio rooms will be open at least during the daytime and sometimes during the night as well. Radio operators will also ensure that only authorized staff have access to radio equipment. Before closing a radio room the operator must be sure that all vehicles have safely arrived at their intended destination and all aircraft have safely landed.

Sufficient staff must be trained to ensure that skilled staff is always available in case of absence of her/his colleagues. In order to be prepared for emergencies in principle any humanitarian worker should be able to use the available equipment.

One important function of radio rooms is to accurately and quickly forward messages or pass on received messages to the concerned staff. Radio operators must keep detailed, accurate and up-to-date records on received, transmitted and relayed messages as well as positions of vehicles and aircraft and the names of passengers. Keeping a log book with time, date and

notes of all received and transmitted messages may be a legal requirement by the government granting the licence. Radio operators must regularly check their log books and ensure that all messages have been forwarded. Even if keeping a log book is not required, it is advisable as messages and their details are easily forgotten.

Radio rooms should be installed in the safest available place. They will be indispensable in case of an emergency and especially during shelling and bombing. Ideally they will be located underground. In case they are not installed in a safe place, a contingency plan must be available for emergencies. Either to carry some equipment to a shelter which is furnished with a connection to the aerial or by installing separate equipment in the shelter itself.

As far as possible rooms which echo should be avoided since echoes will increase the background noise and make it more difficult for the receiver to understand voice transmissions. In large radio rooms with several communication devices, sound absorbing screens or hoods can be installed (Corbett, J.R.G. 1988, 54). This also helps to avoid people who are using telecommunication equipment simultaneously disturbing each other.

The equipment should be permanently installed since frequently removing equipment for example to lock it in a secure place during the night, is inconvenient and could easily result in damages to the equipment. Consequently radio rooms must be secured with strong doors and bars on the window to prevent theft of equipment when the radio room is closed.

Installation of a radio rooms requires planning and takes time. However proper installation will increase the reliability of the equipment as well as efficiency of operations. The power supply and transceiver will have to be installed first as they will be needed to adjust the position of the aerial. "Wherever possible unsuitable temporary arrangements, e.g. wiring, should not be fitted because once the transceiver is working this may never be changed. For example the limitation in performance caused by the loss of voltage in a long thin wire being used as a power lead from battery to transceiver may never be discovered. The resulting poor quality of transmissions may well become accepted as normal for that particular location whereas with more careful and proper installation things could be much improved" (Corbett, J.R.G. 1988, 53).

All cables should be properly attached to the walls. They should not be laid across the room since staff can trip and equipment can be damaged. Where applicable equipment should be properly and safely earthed. All cables should be labelled or colour coded in a consistent way. This will help avoiding accidental connection of equipment with the wrong polarity. Plugs may also be labelled or marked to facilitate orientation.

The main equipment should be installed conveniently on a radio desk of suitable height and with sufficient lighting for reading and writing. It should allow the radio operator to have a good overview and easy access to all commonly used equipment and avoid having to rush to and fro. Usually computer equipment for packet radio or electronic mail will also be set up on the radio desk. Equipment that requires cooling, such as large transceivers or computers, should be set up in a way that allows sufficient circulation of air.

If aerial switches to select between different aerials are installed they should be placed near the radio desk. Providing radio operators with a foot switch instead of the "press to talk" switch will allow them to have their hands free for writing, checking records and operating equipment.

An accurate clock should be well visible from the radio desk. If the radio room is communicating with stations in other time zones such as head offices, a second clock with the local time at the head office should be installed. If aircraft are being used, another clock

displaying GMT (Greenwich Mean Time) or UTC (universel temps coordonné) should also be installed.

Since the radio room will serve as a backbone and will use the most powerful equipment of the radio network, it must have a reliable power supply. If the radio room has to shut down, other base stations will not be able to replace all its functions and other base stations will usually have a shorter range.

For short term power failures all equipment should be fitted with a battery backup. This battery should be installed in a safe enclosure near the transceiver since the voltage loss in the connection cable increases with its length. However the battery should be easily accessible for maintenance and checking. This battery should never be removed and used for other purposes such as trying to start a vehicle with a flat battery. In addition a dedicated backup generator set should be available in case the main power supply, whether mains electricity supply or a generator set used for the entire premises, fails. All connections should be permanent and installed properly and safely. An alternative emergency backup is a pedal generator.

A "fail to battery" system will automatically connect the transceiver to the battery if the mains electricity supply or generator set fails. However radio operators must make sure that the batteries are always fully charged. Also equipment itself must be switched off when it is no longer used since disconnecting it from the mains electricity supply will automatically connect it to the battery and the equipment will keep running.

Any equipment connected to mains electricity supply must be protected from power surges by voltage regulators.

5.2.2.8 Maintenance and repair

Radio equipment is sensitive and expensive and should be inspected regularly and be maintained carefully (see table 5.10). Repairs should be carried out immediately by a qualified technicians. Well maintained radio networks are more efficient, less likely to fail and more reliable which is essential to ensure the vital role telecommunication equipment has in maximizing safety and security for staff. Radio equipment is a valuable asset that can be used for many years if it is cared for.

Maintenance should be regularly carried out by competent and qualified technicians according to a systematic schedule. Technicians must be provided with sufficient testing equipment such as multimeters as well as tools and replacement parts. Depending on the size of the network a workshop may be needed. Maintenance can either be carried out by own staff or contracted out to a commercial service provider. The maintenance cost of equipment should be taken into consideration when selecting and purchasing equipment. Even failure of simple parts such as loudspeakers or microphones may stop the entire station from working. And perfectly maintained transceivers and aerials will quickly become useless if the power supply is not properly maintained.

Operating instructions and maintenance manuals should be carefully kept and be available near the equipment.

During installation of a radio network a contingency plan in case of a failure or disruption must be established. It should include alternative backup communication systems as well as instructions who should be contacted and who can carry out repairs.

Equipment failures can be caused by manufacturing defects, poor installation or poor handling and bad operating practices (Corbett, J.R.G. 1988, 88).

Radio technicians should maintain a stock of basic replacement parts in the field. These include switches and controls which are likely to wear, plugs, sockets, connectors, cables, loudspeakers, microphones and electronic components. This will allow quick repairs and avoid delays for ordering replacement parts from abroad. A set of essential replacement parts may be purchased together with the equipment. Depending on the size of the network, replacement equipment such as transceivers or aerials may also be kept in stock.

Transceivers and microphones should be kept clean, the build-up of dust should be prevented and they should be covered when they are not in use.

The acid level of vented batteries must be checked each week and refilled with distilled or rain water if necessary. Metal parts must be regularly cleaned and covered with grease to prevent corrosion. Checking the state of charge of the battery regularly with a voltmeter or hydrometer will allow determining whether batteries are too discharged. When the voltage of the battery is low a transceiver may still be able to receive signals but no longer be able to transmit as this requires more power.

Trees and bushes or other plants should not overgrow or touch aerials and may need to be cut from time to time. Aerials and cables should be checked regularly as well as during high winds and after storms (Corbett, J.R.G. 1988, 79).

Cables should not be allowed to become tangled up or twisted into knots.

- Handle all equipment with care, especially microphones.
- Handle controls carefully and not more than necessary.
- Maintain equipment regularly according to a systematic schedule.
- Repairs should only be carried out by competent and qualified technicians.
- Protect transceivers and microphones from dust.
- Do not cover the transceiver with paper or other objects during operations (this will impair cooling).
- Ensure that all equipment is properly ventilated.
- Regularly check the acid level of batteries.
- Regularly check aerials and remove plants which may be overgrowing them.
- Check aerials during high winds and after storms.
- Always disconnect aerials when thunder is heard or lightening can be seen.
- Unqualified staff should never open radio equipment.
- Prevent tangling of and knots in cables.
- Prevent equipment from power surges.
- Lock radio rooms when nobody is present, especially during the night.
- Ensure that only instructed and authorized staff use radio equipment.
- Keep operating instructions near the radio so they can be consulted if necessary.

Table 5.10 Caring for and maintaining radio equipment

5.2.2.9 Regulations

Use of any telecommunication equipment is subject to national as well as international laws and regulations. It is important to keep in mind that possession and use of telecommunication equipment is very sensitive especially in countries with ongoing conflicts. Host countries have the authority to regulate the use of telecommunication equipment, enforce national as well as international legislation, monitor the use of equipment and ensure that rules and regulations

are respected. In principle licensing of equipment, allocation of frequencies and monitoring of networks should be considered as a service provided by the authorities and they therefore deserve respect. Importation, installation and use of telecommunication equipment should be seen as a privilege rather than a right, even for humanitarian organizations. "In some countries 'radio' is synonymous with 'spy', so possession of one without clearance from the state security services will get you in to a lot of trouble" (Wood, M. 1996, 92). In complex political emergencies, laws and regulations may no longer be valid or enforced. However civilian and military authorities as well as any parties to the conflict will be eager to control the use of telecommunication equipment.

Laws and rules may only be considered as a nuisance and delay of setting up telecommunication equipment and using it. However it should be kept in mind that all users benefit from rules and regulations. If anybody were allowed to set up and operate a radio network, radio communications would become impossible. Likewise poor quality equipment can cause disturbances in operation of radio networks and therefore only "type approved" equipment should be used.

The radio spectrum is a finite resource which needs to be allocated and regulated to optimize its utilization as well as be guarded to avoid misuse. Radio equipment may be used by government departments, emergency services, the military, commercial companies as well as private organizations. Especially in an acute crisis dozens of humanitarian organizations may be setting up networks. Without coordination of frequencies, humanitarian organizations may be interfering or even blocking the channels of other users.

The International Telecommunications Union (ITU) is based in Geneva and sets international standards for telecommunication equipment and procedures. Countries are not bound by their resolutions but many keep them since there is a need for standardization (Wood, M. 1996, 93).

Unless telecommunication equipment is purchased inside the country it must first be imported. Bringing telecommunication equipment into a country without proper documentation, notification of and approval by the authorities is illegal (Wood, M. 1996, 91). Before shipping telecommunication equipment regulations for importation should be known. Information can be obtained from the authorities as well as from other humanitarian organizations. The host country may restrict importation of certain telecommunication equipment. For example it may prohibit radio transceivers which can be tuned to any frequency and permit only equipment with pre-tuned channels. It may also be necessary to obtain a radio licence before the authorities approve importation. Before shipping radio equipment it is necessary to know what frequency bands will be used since this will determine the design of the aerials that can be used.

The importer may be required to pay import taxes, duties and custom charges on the equipment but humanitarian organizations may be exempted. In addition usually an importation licence will be required. In order to avoid delays, payment of large sums for storage of equipment withheld at customs or even confiscation of equipment at the border, all necessary documents should be prepared in advance.

If the telecommunication equipment is expected to be used only for a short time, the humanitarian organization might be able to import equipment into the country with a TIR carnet without paying any dues. However the equipment must be exported as agreed, even if the equipment is broken or has been scraped.

Once the telecommunication equipment is in the destined country, a private mobile radio licence must be applied for from the host government or authorities. The licensing authorities will require specifications of the equipment as well as information on the intended network such as number, location and range of stations.

When applying for frequencies the specifications of available equipment throughout the network should be considered. Additional frequencies may be needed to communicate with aircraft. An expert radio technician should give advice when applying for HF radio channels as frequencies may not allow satisfactory conditions during the whole day (Wood, M. 1996, 176).

The licensing authorities will allocate frequencies as well assign call signs to all stations. Frequencies might have to be shared with other users and may only be used during certain times of the day. The allocated frequencies may not allow satisfactory communications all day and the use of radios may be limited to favourable atmospheric conditions. The licensing authorities may also limit that maximum power of transmitters.

Maintaining a log book and recording all received and sent messages is usually a legal requirement for holding a radio licence. The licensing authority may levy an annual fee.

Once licences are obtained, it should be ensured that other humanitarian organizations, civilian and military authorities are not using the same frequencies and blocking the network. It is almost important to ensure that other networks are not disturbed by technical faults or poor installation.

5.2.3 Radio bands

Different types of radio bands with different ranges are available (see table 5.11).

Type	Frequency	Wavelength	Range	Power
HF	3 - 30 MHz	100 - 10 m	50 - 3,000 km	60-140
VHF	30 - 300 MHz	10 - 1 m	5-50 km	5 -65 W
UHF	300 - 3,000 MHz	1 -0, 1 m	5-50 km	5 - 25 W
CB	27 MHz band	around 11 m	up to 10 km	5-10 W

Table 5.11 Frequencies, wave lengths and ranges of radio bands

For VHF the secret lies in the position and elevation of the aerial, for HF it lies in the frequency.

VHF radio: the secret is in the position of the antenna (mostly its height),

HF radio: the secret is in the frequency.

(Wood, M. 1996, 158 and 177)

Except for very severe rains, the weather has only a minor effect on the quality of HF and VHF communications. However the quality of HF communications depends on the severity of solar activity and different frequencies may have to be used throughout the day to reduce these effects.

5.2.3.1 Short wave (high frequency) band

In principle radio waves, like other electromagnetic waves travel in straight lines between sender and receiver. Consequently radio stations communicating which each need to be in a line of site. However because the earth is curved and there are many obstacles such as

buildings and mountains, a line of site is often not possible. Fortunately the ionosphere which surrounds the earth at a height of between 100 and 200 kilometres above the surface, reflects HF waves which in principle allows global telecommunications. But unfortunately the reflectiveness of the ionosphere depends on the density of electrons which is increased by sun shine. Consequently the reflectivity of the ionosphere increases gradually during dawn, reaches a maximum during midday and decreases again towards the night. In addition the reflectivity of the ionosphere increases with the number of sun spots which has a cycle of 11 years. Moreover the ionosphere is not stable but is constantly changing. Especially during dawn and dusk the ionosphere is changing and radio communications should be avoided during these times, while telecommunications are reasonably stable during day time. Propagation of radio waves can also be impaired by irregular solar flares.

Waves of different frequencies are reflected best at different times of the day and the most suitable frequencies are difficult to predict although software is available for assisting. Therefore it requires a skilled radio technician to find suitable frequencies for ensuring communication throughout the day. Consequently a licence will be needed for at least two different frequencies which lie at least 2 MHz apart. "At any particular time HF radio communication will be about 70% - 80% reliable at any one particular time, with a 1% chance of not working at all, during a particular day" (Wood, M. 1996, 34). In principle higher frequencies should be used during the day than during the night. Other radio operators in the area can give advice and otherwise the most suitable frequencies will be found by trial and error.

The higher the frequency, the less likely it is for the radio wave to be reflected. Shorter distances between stations require using lower frequencies. In principle short distances of 50 to 100 km can be difficult for HF communications although a ground wave may extend to about 20 km around the station.

Advantages

- Allows worldwide communication.
- Flexibility, allows short range as well as long range telecommunications.

Disadvantages

- Quality of signal various throughout the day (dependency on atmospheric conditions).
- Suitable frequencies change throughout the day.
- Requires a skilled radio technician for finding suitable frequencies throughout the day.
- Requires licenses for at least two frequencies.
- Not very user-friendly.
- Short range telecommunications (50 - 100 km) may be difficult.

Table 5.12 Advantages and disadvantages of HF radio

The HF band covers frequencies in the range between 2 to 30 MHz. It has the advantage that it allows short range as well as worldwide communications.

5.2.3.2 VHF band

VHF radio waves in principle require a line of sight between the two communicating stations. However VHF radio waves are reflected by buildings and consequently communications may be possible without a line of sight. Unfortunately the signal weakens with each reflection. As radio waves are emitted perpendicular, aerials must be set up vertically and aerials on vehicles must not be slopped back.

Because propagation of the radio signal depends so much on the topography, it is difficult to predict the range. In any case the strength of the signal decreases with the distance it travels. With a direct line of sight communications may be possible over tens of kilometres but without, the range may drop to a few hundred metres. Apart from the topography the range of a VHF transmitter also depends on its power. However the range of VHF transmitters can be increased by installation of automatic repeater systems. In any case, wherever possible, aerials should be placed on the highest available point (roof) and outside of buildings. As the earth is curved, the maximum length of line of site depends on the height of the transceivers above the ground and can be estimated as shown in figure 5.5 (Zavazava, C. 2005, 83).

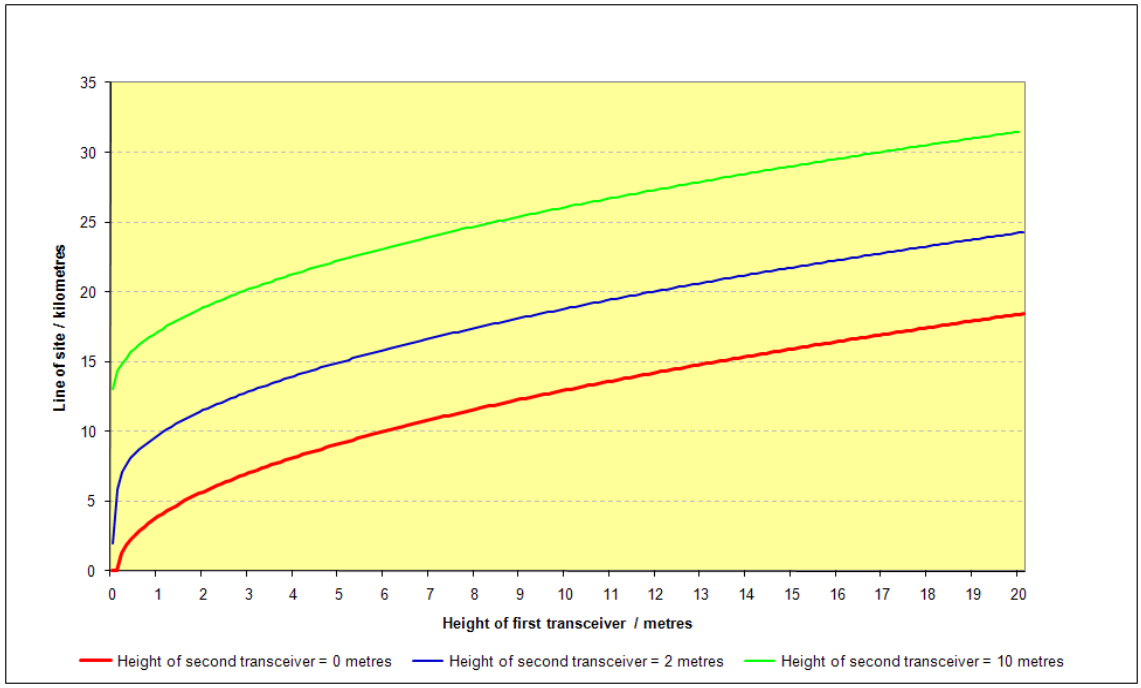

Figure 5.5 Relation between height and line of site

Certain locations may be "dead spots" which do not allow any radio communications at all. This can be dangerous when the security is poor since it may be impossible to call for help in such a "dead spot".

Advantages

- Not dependent on the reflectivity of the ionosphere.
- User friendly.
- Radio waves are reflected by buildings.

Disadvantages

- Limited range.

Table 5.13 Advantages and disadvantages of VHF radio

The vicinity of overhead wires and pylons should be avoided as they can emit radiation and interfere with radio communications.

If VHF transceivers are used without external aerials, the range will significantly drop when using them inside buildings. If communications is unsatisfactory placing the transceiver near a window will usually help.

5.2.3.3 UHF band

The range of UHF transceivers is even shorter than VHF. However UHF radio waves are reflected off buildings even better than VHF radio waves, are more reliable in built up areas and are therefore preferred for hand-held radios (Wood, M. 1996, 44).

5.2.3.4 Civil broadcast (CB)

The citizen band is authorized by the government of many, but not all, countries, subject to certain rules and intended only for local communications. There is no international standard but it usually operates around 27 MHz. In principle any private citizen can obtain a licence against an annual fee and set up a radio transmitter (Wood, M. 1996, 171). Since no exam is required for obtaining a licence discipline on citizen band is notoriously poor. Transmitter power is limited to about 5 - 10 watts and the range extends to less than 10 km.

However the citizen band is not allowed in all countries and it may be illegal to use this equipment.

Citizen band radios are cheap and may be an economic solution for communications for example within a small city or large hospital compound.

5.2.3.5 Amateur radio band

Amateur radio, or Ham radio, is regulated by a set of international laws and allows private citizens to operate radio stations for recreation (Wood, M. 1996, 173). In many countries a large network exists and the range of communications can be extended by repeaters. Frequencies are allocated in the UHF, VHF as well as HF band which allow local as well as global telecommunications.

Unlike citizen band, radio amateurs must sit an exam to obtain their licence and they may loose their exam if they violate rules. Consequently discipline is usually better.

The international laws which regulate frequencies result in a standardization which facilitates communications with other (humanitarian) organizations. A further advantage is that there is no need to wait for allocation of frequencies and the network can be used immediately.

The main disadvantage is that the use the amateur radio band is strictly forbidden for any person who does not hold a licence. Consequently all humanitarian workers would have to obtain a licence or licensed radio amateurs would be needed to operate all equipment. However under certain conditions this strict rules may be waived allowing amateur radio operators to transmit messages of third parties.

Moreover no humanitarian organization has the right to "appropriate" a channel and interfering with communications of other radio amateurs or even blocking the channel.

Amateur radio can be used for transmission of speech as well as data.

As the range of transmitters is quite limited, the amateur radio network is designed for transmission of messages from one station to another which is time consuming and prone to errors and misunderstandings.

5.2.4 Telephony

In principle telephone networks have the advantage (see table 5.14) that humanitarian organizations do not need install, maintain and operate an independent network or to obtain a permission. Except for satellite telephones, the technology is easily available in most countries. Provided the telephone network is functioning, it can be used immediately without the need for installation. This is a great advantage in acute emergencies. Unlike radio networks, the existing telephone network covers the entire world and telephony has an unlimited range.

Telephones are simple to use and do not require training of staff. The quality of telecommunications does not depend on atmospheric conditions and remains stable throughout the day. Any two telephones can be connected to each other without interfering with the communications of any other users of the network.

One of the main advantages of telephones, compared to radio telephony, is that they operate in "duplex" mode. This means that both participants can send and receive simultaneously (Wood, M. 1996, 9). Telephony allows private and confidential conversations and once the connection has been established there is no danger of interference, blocking or jamming by other stations.

Telephony also has several disadvantages. It depends on an infrastructure such as landlines, telephone exchanges or satellites which are not under the control of humanitarian organizations. "Technological and commercial pressures are causing more centralisation of critical network elements, leading to their vulnerability in times of crisis" (Wood, M. 1996, 3).

Telephone networks may be of poor quality to start with, break down because of lack of maintenance, shut down because of lack of power or be intentionally disrupted. Often telephone networks are closed down at the beginning of a coup d'état. Even the quality of satellite telephone connections may be poor and impaired by echoes delays of transmission.

Since only two stations can talk to each other, it is cumbersome and time consuming to distribute information to a large number of stations since they have to be called one by one.

Although the international telephone network is very developed no land lines may be available in the area or at the site where they are needed.

Especially in emergencies, when communications are most important, public telephone networks may be overloaded. A public telephone network is designed to connect about 5% of the telephones at any time (Wood, M. 1996, 2).

Unlike radio telephony, charges for telephony are levied for each minute they are used. Especially international calls and use of satellite telephones are expensive. Consequently there will be a pressure to quickly terminate conversations which may prevent sufficiently detailed conversations.

The caller must know the telephone of the person s/he would like to contact. Moreover (except for cellular phones) a telephone number is assigned to a location not a person. Therefore even if the number is correct, the person might not be present and the caller may not know where the person is s/he wants to call and what telephone s/he is near.

Compared to text communications, telephones are inefficient for communicating specific technical information, data, tables, figures and abstract contents (Wood, M. 1996, 9). Telephone conversations produce no record which can be filed.

Advantages

- Quality of connection does not depend on atmospheric conditions or topography of the area.
- Allows "duplex" mode (both participants can talk at the same time).
- Simple to use.
- Commonly used technology which anyone can handle.
- Does not require installation, maintenance and operation of an independent network.
- Telephones for terrestrial telephony are cheap and available in most countries.
- Vastly developed international telephone network is available.
- No limit on the range of telecommunications.
- Allows private and confidential conversations.
- Once the communication has been established, it cannot be blocked or "jammed".
- A telephone conversation between two stations does not interfere with communications of other stations.

Disadvantages

- Dependency on infrastructure (land lines and telephone exchanges or satellites).
- Dependency on public services (switch boards, land lines etc.).
- May be unavailable in remote areas and places.
- May be unreliable.
- Allows (in principle) only two stations to communicate at any time.
- In emergencies, when communications is most crucial, telephone exchanges may be overloaded.
- No record of communication (compared to text messages).

Table 5.14 Advantages and disadvantages of telephony

Like other real-time communications, telephony has the disadvantage that the recipient has to be interrupted although s/he may have more urgent work to do. Calling from a different time zone may limit the periods during which the telephone can be used unless in real emergencies. Records, data or other information may not be available for responding to questions immediately.

5.2.4.1 Field telephony

Field telephony is only practical over short ranges up to a maximum of 100 kilometres, to connect building, offices or two sites (for example warehouses and offices) which are near to each other. Rugged field telephones are connected by permanent wires which are laid out during installation. Lines must be carefully laid down and tied securely over paths and roads to avoid tripping people and damage to the line. On the other hand it should note take too much time for removing the line. Lines must not be laid over power lines since a person touching the line may be electrocuted (Wood, M. 1996, 143). Holes may have to be drilled to pass lines through doors and windows.

Temporary cabling is used for initial installations with the objective to quickly connect the telephones with a minimum of effort. Wires can be laid on the ground provided that they do not cross paths and roads. This can later be replaced by semi-permanent or permanent cabling where the lines are laid out in a safe way and fixed.

Field telephones may appear outdated and old fashioned but do have several advantages (see table 5.15). The telephones are rugged, reliable and designed to be used outside. The technology is simple and field telephones are easy to install, maintain and repair. Field telephones are self contained, do not depend on any infrastructure and do not require any licence.

Except for a battery to power the microphone, field telephones do not require any power supply.

Since the network is private there is no danger of interference or overloading and conversations are totally private. Unlike VHF or UHF hand-held radios, communications are not impaired but obstacles or adverse topography. Field telephones will work anywhere and are far cheaper than hand-held radios.

One of the main disadvantages is that, unlike VHF or UHF hand-held radios, installation requires connecting all telephones by wire ("cabling") which is laborious and unsuitable for use "on the move". The range as well as the number of possible connections is limited.

Cables may be coveted and stolen.

Advantages

- Independent of existing infrastructure.
- No call charges.
- Equipment is cheap, rugged and reliable.
- Simple technology.
- Simple installation, maintenance and repair.
- Depending on the design, it can operate without a mains electricity supply or battery power supply.
- Does not require any licence or allocation of frequencies.

Disadvantages

- Takes time to install.
- Limited range and limited number of possible participants.

Table 5.15 Advantages and disadvantages of field telephony

5.2.4.2 Private wires and private telephone networks

Private wires may be used because the public telephone network is not working, not reliable, overloaded or in order to reduce costs. A local telephone line is diverted at two points and used to connect two sites where field telephones are installed. This line is then no longer available to the public telephone system and reserved exclusively for use by the humanitarian organization who will pay a fee for using this private line.

Provided such private lines are available, the installation can be set up quickly. Private wires should be considered for more permanent installations and have the advantage that reeling out a long line like for field telephony is not necessary.

Private lines cannot be blocked by public traffic and will not be affected by the failure of public telephone exchanges. The charge will depend on the length of the private wire but there are no call charges.

A further development is the installation of a private automatic exchange (PAX). It takes around half a day to install a dozen telephones. This allows calling any telephone which is connected but on the other hand it is not possible to connect to the public telephone system. Finally in a private automatic branch exchange (PABX or PBX), a private automatic exchange is also connected to the public telephone system (Wood, M. 1996, 145). Cordless PBX systems have a range of around 500 metres, allow staff to freely move around and reduce the time needed for wiring and setting up telephones. However their use requires obtaining a licence,

installation of a base station in every floor of a building and the system is more expensive than VHF or UHF hand-held radios (Wood, M. 1996, 147).

The main disadvantages are that private wires depend on the availability of a spare public telephone line, the private wire can connect only two distinct sites and the outside connection to the public telephone system is not possible. This system is therefore only suitable for mid- to long-term installations.

For installation of a private automatic exchange all telephones have to be connected to the exchange and cannot be connected directly to each other like in the field telephone system. If the exchange or its power supply fails, none of the connected telephones will work.

5.2.4.3 Public telephone networks

If public telephone networks are available, reliable and connect all sites it will be an ideal means of communication. Its use does not require purchase or import of any equipment. No installation is necessary and the network can be used immediately. Everyone is familiar with using telephones, most offices, authorities and suppliers will be connected and fax machines or electronic mail systems can be connected. Call charges will be cheap compared to installation and maintenance of an independent radio or telephone network.

A major disadvantage is that the humanitarian organization is fully dependent. The telephone exchange or its power supply may fail, the network may be overloaded in emergencies or the telephone system may be shut down in the course of the conflict.

Even if public telephone networks are in place they may be unreliable and of poor quality. Offices or other sites may not be connected to the system.

5.2.4.4 Public land mobile networks

". . . when asked what they would really wish for, nearly all aid workers rock their head to one side, sigh, and confess that they want a mobile phone" (Wood, M. 1996, 194).

Over the last decade mobile telephone systems have mushroomed in developed and many less developed countries. Public land mobile networks which are also known as cellular phone systems or public mobile phone systems are easy to use, require no training, the telephones are portable and require nearly no maintenance. Most systems also offer a short message service (SMS).

The Global System for Mobile Communications (GSM) is an international standard which allows using GSM mobile telephones in many countries. International roaming allows finding the mobile telephone with a specific number anywhere in the world and connect the caller.

Despite the convenience of mobile phones, sophisticated computer equipment, networks, base stations and microwave links are needed for operation. They are expensive to install, vulnerable to technical failures and power failures. In case of emergencies no power may be available. In many countries where humanitarian organizations are working no networks have been installed. If networks are available they are usually installed only in urban areas. Since their capacity is limited they may be overloaded in emergencies.

Operation of the network requires a company to operate it and sell licences. Call charges may be significantly higher than for public telephone exchanges especially for international calls. The local standard may not allow using imported mobile phones and new equipment may have to be purchased in every country. GSM or international roaming may not be implemented in the respective country.

Compared to radio telephony one significant disadvantage of mobile phones is that it can connect to only one other telephone at a time. Consequently distributing message among for example a dozen people is time consuming. This is the reason why the police of fire brigades use radio telephony although they could afford mobile phones.

5.2.4.5 Satellite telephony

In the past decade satellite telephony, while still expensive, has become affordable. It has become a standard piece of equipment where public telephone exchanges are not available and a permanent communication facility is needed for safety and security reasons.

Meanwhile even hand-held mobile satellite telephones systems such as IRIDIUM, THURAYA, GLOBALSTAR etc. which cover most of the world are becoming available and affordable.

Unlike public telephone exchanges, satellite telephony uses equipment in space. Mobile or portable telephones connect directly to satellites which relay signals to other satellite phone terminals or feed them into public telephone exchanges through land earth stations.

Systems such as COMSAT or INMARSAT use geostationary satellites which have a fixed position relative to the earth at heights of about 33,000 kilometres and require aerials to be directed at them.

Low Earth Orbit Satellites (LEOS) have a much lower orbit, around 300-800 km, than geostationary satellite and must be in constant movement relative to the earth in order to counter the earth's gravity and maintain their orbit. Consequently several LEOS are needed to provide global coverage. Since their distance to the earth is smaller, less powerful aerials can be used. Mobile telephones automatically connect to the nearest available satellite and their aerials do not need to be pointed in a specific direction.

Currently the only global and most widely used satellite system is the International Mobile Satellite Organization's system (INMARSAT) which was originally intended for use by ships and uses four geostationary satellites. The satellite terminals have the size of a briefcase and small dish aerials which can be disassembled for transport. The aerial is directed toward the satellite and is permanently installed outside of a building while the telephone itself is installed inside. The satellite telephones are in principle intended for use at a fixed location but are portable and can be quickly disassembled and set up in another location.

Satellite telephony is independent of any local infrastructure such as telephone lines or telephone exchanges which mail fail, lack power or be shut down by the authorities. Satellite terminals allow voice as well as fax and data transmission. The terminals and aerials are portable and can be installed quickly. Although the equipment is expensive it can be used anywhere in the world and therefore be moved to another site once assistance programmes are terminated in one place.

Although satellite telephones are valuable they are less prone to theft than radio equipment since the owner will terminate his subscription as soon as s/he notices the theft and the terminal will be unusable.

One main disadvantage of satellite telephones is that importation and use requires a permission by the government or competent authorities. Significant customs duties may be imposed for importation of equipment. As, unlike with public telephone exchanges, they cannot control and monitor traffic they may be reluctant to grant licences. Obtaining a licence may take several weeks which makes immediate installation during the onset of crises impossible. Licences may also require payment of high annual fees. Even if a licence is granted, it may be revoked by the authorities or when power changes.

While satellite telephones are independent from local communications infrastructure they are completely dependent on sophisticated satellites, electronics and earth stations run by the operator.

Satellite telephones as well as charges for calls are expensive. Staff may be tempted to use them like conventional telephones and run up high bills. Call charges are independent of the distance and no difference is made whether a nearby city or another continent is called.

Geostationary satellites require permanent installation of fairly bulky aerials. Except for portable satellite phones, most mobile systems cannot be used in moving vehicles.

Advantages

- Independence from local and domestic infrastructure.
- Allows voice, fax and data transmission.
- Mobile terminals and aerials can be installed quickly.

Disadvantages

- Expensive (equipment and transmission costs).
- Importation and use of equipment requires permission from the authorities.
- Dependence on sophisticated satellites, electronics and earth stations run by operators.
- Call charges are independent of distance.

Table 5.16 Advantages and disadvantages of satellite telephony

Currently four different Inmarsat systems, standards A, B, C and M, are in operation.

Inmarsat A provides good quality of communications, is reliable, easy to use and has all the functionality of a common telephone. Any equipment that can be connected to a conventional telephone such as a fax machine or modem for data transmission and electronic mail can be connected. The mobile earth station (MES) can be connected to several users of a field telephone system by a switch board. This allows users to call from their offices rather than having to go to the satellite terminal (Wood, M. 1996, 29).

Inmarsat-A equipment is expensive and the call charges are high. It cannot be used on the move and requires a mains electricity supply or generator set to power it.

Inmarsat-B is the digital version of Inmarsat-A. It has all the functionality but is more efficient and therefore provides the same services at lower call charges.

Inmarsat-C is cheap, very reliable, smaller and lighter than other systems, can be powered by batteries for days and in some models the aerial is built into the lid of the case. This system can also be installed in vehicles if a non-directional aerial is used and can be powered by a vehicle battery. The main disadvantage is that it allows only text communication but no transmission of voice or images and the system is dependent on the availability and functioning of a (notebook) computer. Messages can be prepared off-line on a notebook and then sent by the terminal.

Inmarsat-M provides the full functionality of a telephone but has lower call charges than Inmarsat-A. It is also more compact and only has the size of a briefcase. It can be used for fax transmission, although it is slower than Inmarsat-A and some versions can be used in moving vehicles.

Regional satellite systems use a single satellite which only allows communication within the limited "footprint" rather than global coverage. The advantage is that call charges are significantly lower.

Mobile hand-held satellite telephones are being offered by different companies and are becoming affordable for some humanitarian organizations.

Because the satellites orbit the earth at only about 300 km, the aerials of the telephones are much smaller than for telephones using geostationary satellites. However since the footprint of each satellite is much smaller than for geostationary satellites, many more satellites (12 - 84) are needed for global coverage. Since the satellites orbit the earth about every one and a half hours, they loose contact with telephones after a few minutes and have to "hand over" ongoing calls to other satellites.

Mobile satellite phones may require clear site to the sky and may not work in buildings.

Dual standard telephones, such as Thuraya, are also available. They allow connecting to the standard GSM network and can be used like conventional mobile phones but automatically switch to satellite communications if the user is an area not covered by GSM or the public land mobile network fails or has been destroyed. Some equipment also provides GPS and SMS.

Satellite dispatcher systems work like automatic repeater stations for VHF radios but offer a much larger range. Except for a fixed monthly fee, no charges would be incurred for individual radio calls.

The satellite dish must be pointed at and have an unobstructed view of the respective satellite. Heavy rains may impair reception and winds can displace or disorient satellite dishes.

Installation of mobile terminals takes 10-15 minutes while installation of a VSATs (very small aperture terminal) takes a few hours, depending on its complexity.

Figure 5.6 Satellite antennas

5.2.5 Power supply systems

"Despite the glamour of the satellite dish and the laptop personal communicator, they are all 'so-much-junk' without electrical power" (Wood, M. 1996, 65).

Any telecommunication equipment, radio or telephone, requires a reliable and continuous power supply. Failure of the power supply is just as dangerous in an emergency as failure of the telecommunication equipment itself.

The power supply system comprises all equipment which is needed to provide power. This includes generator sets, batteries, battery chargers, power supply units, inverters and voltage regulators (Wood, M. 1996, 70).

Possible sources of electric power are mains electricity supply, generator sets, solar panels and wind turbines. Some radios can be powered by pedal generators.

Regardless of what primary source is used, in case of its failure a backup must be available, even if the primary source is considered as reliable. Batteries will allow bridging temporary power failures while a generator set, for example, will be needed in case of a lasting failure of the mains electricity supply.

In order to avoid damage of equipment, injury of staff and to allow efficient operations of telecommunication equipment, the power supply systems must be set up and connected properly by a qualified technician. Unprofessional installation can cause fires as well as electrocution of staff.

5.2.5.1 Mains electricity supply

If a mains electricity supply is available it will be the first choice as a primary source. It does not require purchasing and installing of expensive equipment such as generator sets.

The mains electricity supply may be unreliable, overloaded, available only during certain times of the day or completely irregular. Power failures are usually unpredictable and occur without any notice or warning. Reliance on the mains electricity supply creates a complete dependency on the local infrastructure. Electric power plants, transformers and power lines may be targeted and damaged or destroyed during military operations.

Before equipment is connected the nominal voltage of the mains electricity supply must be known. However the actual voltage may be lower or higher. Fluctuations of the voltage about its nominal value can be considerable. Low voltage will lead to equipment failure which could lead to loss of data when computers are connected. Power surges can damage any kind of equipment and can cause damage to or destroy expensive equipment such as computers or telecommunication equipment.

Equipment can be protected against voltage fluctuations by voltage regulators, which are commonly called "stabilizers". The voltage of the mains electricity supply is continuously measured and transformed accordingly by a transformer if it differs from the required output voltage. This equipment must respond quickly to changes of voltage, for example in 1/50 of a second. Voltage regulators are expensive and heavy and will therefore be reserved to sensitive and expensive equipment.

Another problem with the failure of mains electricity supplies is that vital telecommunications may be suddenly interrupted and data may be lost when computers suddenly lose power. Some equipment may lose its setting and need to be reconfigured after a power failure. This can be avoided by interposing an uninterrupted power supply (UPS) between the mains electricity supply and the equipment. Uninterruptible power supplies combine a battery charger, battery and inverter. The battery is constantly charged and provides electricity without interruption if the mains electricity supply fails. The inverter converts the 12 volt direct current from the battery to 220 volt alternating current. The battery will allow continued use of equipment for a few hours and shut equipment down correctly before the battery is completely discharged. The time gained by operating equipment from the battery allows connecting an alternative power source such as a generator set or restore mains electricity power.

Uninterrupted power supply systems are expensive and heavy and may need to be protected from power surges by a voltage regulator.

5.2.5.2 Generator sets

Generator sets (often incorrectly called "generator") consist of a petrol or diesel powered engine (sometimes called "prime mover") which drives a generator which in turn produces an electric current. Generators can be dynamos which produce only direct current or, more commonly, alternators which produce alternating currents, usually of 110 or 220 volts. Generators can be cooled by air or water and can be fitted with soundproofing. Small generator sets are usually portable while larger models are intended for permanent installation.

Running generator sets allows providing a regular, constant and reliable electricity supply. It is dependent on the availability of fuel which can be stored at the site where the generator set is used to hedge again shortages in supply. Generator sets can be used in places where the mains electricity supply is unreliable or not available at all. Portable generator sets will provide between 100 and 3,000 watts (Wood, M. 1996, 77).

Generator sets are expensive, heavy to transport and require installation by a competent and skilled technician. They are noisy and require a reliable supply of fuel of reasonable quality. A shortage of fuel can cause an unreasonable price increase. Generator sets are valuable and coveted and therefore prone to theft and looting.

In some places a generator sets may already be in operation for example at a warehouse compound or a hospital. Before connecting any equipment the voltage and its stability should be checked carefully. It is also necessary to inquire how reliable the generator set is working, during how many hours of the day it is run, whether it is regularly maintained and whether the fuel supply is reliable.

The main consideration for selecting a generator set is its rating, the average continuous electric power it will supply, which is usually expressed in watts or kVA which are equal. The rating of generator sets is affected by the altitude where they are set up and the ambient temperature in which they operate. For every 100 metres above sea level as well as for every 5.5° C (above + 20° C) generator sets should be de-rated by 1° of their power.

Since devices and chargers may require more power than the average stated in the technical specifications, the rating of a generator set should be approximately 50% larger than the sum of total electricity consumption of all connected equipment at any time. Otherwise the generator sets could quickly become overloaded.

The cheapest solution is to purchase and operate a single generator set which can provide sufficient electric power. However this means there is a single power source and if the only generator set fails there is no backup.

To ensure continuity of the power supply two generator sets, each capable of carrying the entire load, can be set up which is called "standby redundancy strategy" (Wood, M. 1996, 78). One generator set is run and if it fails the other generator set is used.

However this means that the cost for providing a certain amount of power is doubled. The alternative is "load splitting" where two generator sets, each with half the required rating, are set up and run simultaneously. This is still more expensive than one larger generator set but cheaper than two larger pieces. In case one of them fails, all nonessential equipment can be disconnected until it is repaired and the power supply of vital telecommunication equipment

can be maintained. If both generator sets fail simultaneously there is a chance that they fail for different reasons and parts can be exchange to repair one of them, provided they are identical.

Generator sets should be fitted with governors to ensure frequency stability near the nominal 50 or 60 Hz. Otherwise the engine will tend to turn faster when the load is low, turn slower when the load is high and deviate from the required frequency. The governor will counteract this by reducing or increasing the throttle accordingly (Wood, M. 1996, 81).

Small generator sets have a small tank built in which can be refilled from a Jerry can. Larger generator sets will require installation of a fuel tank which is regularly refilled.

In principle generator sets can be run on petrol or diesel. The advantage of diesel is that it can be stored quite safely in Jerry cans or metal drums. Since diesel is commonly used for trucks it is likely to be available in places providing logistics services. Diesel engines are more reliable and less prone to failure since they do not require an ignition system.

Petrol generator sets are usually cheaper and lighter but slightly less reliable than diesel generator sets. Unlike diesel which creates less fumes, petrol cannot be transported in aircraft which will cause problems in places which can be supplied only by air.

Installation of generator sets of more than 3 kilowatt and its wiring should be supervised by a competent technician.

Generator sets are noisy and produce exhaust fumes. Therefore they must be set up in a place with the least possible disturbance to offices and radio rooms. This can be achieved by placing them at a distance as well as behind walls which will shield noise. However generator sets must not be entirely enclosed or installed in closed rooms since lack of ventilation will lead to overheating of the generator set and prevent removal of exhaust fumes (Wood, M. 1996, 85).

The capacity of generator sets is planned for a certain number of consumers and a certain load. Once a generator set is installed there is a danger that various less essential equipment will be connected and overload the generator set. This will trip or blow the circuit breaker or fuse on the generator set and shut off the power. Overloading a generator set can also cause a fire. Therefore a technician should have an eye on planned and unplanned connections of consumers.

Two generator sets must never be connected together but rather the loads must be connected separately to each generator set. Generator sets must also never be connected to the mains electricity supply.

A technician or staff member must be trained to switch the generator set on and off. If generator sets are not run day and night, they should be always switched off at the same time which is announced to everyone and in addition a warning should be given to everyone a few minutes before switching them off. This allows everyone to save her/his data and disconnect sensitive equipment. When generator sets are switched there is always a danger that some mistakes are made which could lead to a power surge which cannot be compensated by a voltage regulator. A warning should also be given before switching between two generator sets or between a generator set and mains electricity supply.

One staff member must be responsible for regularly checking that the generator set has enough fuel. If the generator set runs out of fuel it will stop and sucked in air will have to be removed from the system. Fuel must be carefully filter to prevent dust or sand from entering the engine. Fuel consumption should be monitored for estimating needs and ordering on time.

Like with mains electricity supply, voltage regulators should be used for all sensitive equipment such as telecommunication equipment or computers. If the generator sets is

producing direct current the rectification may not be sufficient to produce a smooth current. Therefore DC devices should only be connected through a battery or voltage regulator for further smoothing.

Generator sets must be regularly serviced by a qualified technician according to the recommendations set out by the manufacturer.

Figure 5.7 Generator sets

5.2.5.3 Solar panels

Solar panels allow generating small amounts of electric energy from direct solar radiation as well as reflected diffuse light. Solar panels do not require any fuel and are therefore cheap to operate.

However solar panels are expensive and require sophisticated equipment for charging batteries. The amount of produced energy depends on the geographic location, strength of solar radiation and the weather. Even under good conditions energy can only be produced during the day. In order to provide a continuous electricity supply for telecommunication equipment a battery for storing energy during the night or poor weather is necessary (Wood, M. 1996, 89). Solar panels are easily damaged and need to be maintained carefully.

The installation should be planned by a specialist who can calculate the surface required to provide sufficient electric energy for the devices which should be powered. An average of solar radiation of different areas can be found in ISOHEL maps.

Individual solar panels produce around 0.5 volt and need to be combined to produce the require voltage. The amount of current produced is proportional to the surface of the solar panels. Only about 10% of the radiation is converted into electric current.

Installation, connection to the battery and maintenance must be carried out by a competent technician. Near the equator panels can be installed horizontally while they must be set up at an angle elsewhere to maximize efficiency. Shade on the solar panels by buildings, trees or other objects throughout the day must be avoided. Solar panels can be fastened to a frame placed on the ground provided they are secure and protected from theft. If solar panels are fixed on roofs they must be protected by lightening arrestors. Solar panels should be accessible for cleaning and maintenance.

Solar panels need be checked and cleaned regularly. Since solar panels can provide only a fairly limited amount of electric energy great care should be taken that no other batteries are

connected and the installed battery is only used for essential equipment (Corbett, J.R.G. 1988, 68).

5.2.5.4 Wind turbines

Alternative energy sources can be considered if the availability of fuel supplies is not ensured or not reliable. Wind turbines are quiet, require little maintenance and are fairly cheap. They can only be used in places with regular and reasonable strong wind. Wind turbines are only suitable for devices which require fairly little electricity. As there will always be times where there is no wind, the wind turbine should be connected to a battery charger and battery (Wood, M. 1996, 88).

5.2.5.5 Batteries

Batteries themselves are not a sufficient and sustainable source of electricity. However they are needed to provide electricity during failure of the electricity source (mains electricity supply, generator set, solar panel etc.) or when the primary source is not providing electricity. For example where generator sets are only running for a few hours of the day. Batteries therefore provide a continuous electricity supply and ensure that telecommunication equipment can be used around the clock. Batteries also temporarily allow providing higher currents, for example during transmission, which could not be provided for example by solar panels.

Batteries are heavy, expensive and contain substances hazardous to the environment. Therefore only rechargeable, or secondary, batteries are practical for use. Solid nickel cadmium battery packs are commonly used for hand-held radio transceivers or portable telephones, computers and uninterrupted power supplies. Chargers supplied with the equipment should be used for safety, reducing charging time and increasing the lifetime of batteries. They usually allow recharging in one or two hours.

For larger equipment, 12 volt lead acid batteries have become a standard which can be used to power most equipment directly or be used with an inverter. Lead acid batteries can be sealed or vented, like the type commonly found in vehicles. If they are properly maintained and not discharged too much they can be recharged approximately a thousand times (Corbett, J.R.G. 1988, 25). Some devices will automatically disconnect the battery if the voltage drops, for example, below 11 volt.

Vehicles batteries are fairly cheap and available in most places. Most logistics services will use some sort of vehicle and therefore have a source for purchasing and servicing vehicle batteries. Batteries provide a smooth output which allows proper performance of equipment. A typical car battery can store around 60 ampere hours (Ah).

If the primary power source fails, vehicle batteries can be charged in a vehicle which are usually available.

Power banks are portable batteries with a carry bag which often have built in battery chargers and regulators.

Nickel/cadmium batteries should only be recharged with chargers provided by the manufacturer of the equipment. These ensure that the batteries can be recharged as quickly as possible, prevent overcharging and damage to batteries as well as maximize life expectancy. Trickle chargers recharge batteries slowly and steadily over several hours but must be disconnected when the battery is full to prevent damage. If nickel-cadmium batteries are not used for some time, they should nevertheless be recharged regularly to avoid damage.

When 12 volt batteries are used their voltage decreases to around 11 volt when about 90% of the power has been consumed and increases to around 12.6 volt when charging is completed (Corbett, J.R.G. 1988, 24). The voltage of the charger must exceed the voltage of the battery by at least one volt. Measuring the voltage of the battery allows estimating the state of charge. Another commonly used and inexpensive method is measuring the specific gravity of the acid with a hydrometer, which is proportional to the state of charge.

Lead acid batteries can be charged indefinitely without being damaged. Lead acid batteries designed for float charging can be left permanently connected to the mains electricity supply or a generator set. This will ensure that the battery always is fully charged and will provide a maximum of energy if the primary power supply fails.

Especially sealed for life batteries should not be charged above the voltage stated by the manufacturer.

Lead acid batteries should not be completely discharged and left discharged since this will significantly reduce their life expectancy.

If no other electric power source is available, lead acid batteries can be recharged by placing them in a vehicle. However this is not very efficient, consumes a lot of fuel, is noisy and produces exhaust fumes. If the battery is completely discharged the vehicle will not start.

If batteries are used as backup power supply a "fail to battery unit" can be installed (Corbett, J.R.G. 1988, 41). This will automatically connect the device to the standby battery as soon as the mains electricity supply fails. An alternative is connecting the device directly to the battery which is continuously charged. If the primary electricity supply fails, the battery will continue to provide power.

Batteries must be set up safely and connected properly to devices and mains electricity supplies by a competent technician. Special care must be taken not to accidentally connect cables to the opposite polarity since this can severely damage equipment. The positive and negative terminal as well as all cables and electrical sockets should be colour coded. Usually red and black cables are used but unfortunately no universal standard exists. If batteries are used to power radio equipment a reverse polarity protection should be installed. This will prevent damage to the equipment if the positive and negative terminal from the battery are accidentally connected to the negative and positive lead of the transceiver respectively.

Cables must be connected to batteries with proper connectors and not with clips which are unsuitable for permanent installations.

Lead acid batteries should be placed in a plastic tray or on a solid piece of timber to prevent acid from overflowing onto the floor (Corbett, J.R.G. 1988, 59).

Vented batteries release hydrogen and therefore must be set up in a ventilated place. These batteries must be accessible to allow regular checking of acid levels.

Operators should not smoke or use open fire such as candles near vented lead acid batteries since they release small quantities of explosive hydrogen during charging.

If the battery is charged directly from the mains electricity supply or a generator set, faults can cause power surges which can damage connected devices. This can be prevented by using voltage regulators.

Operators should keep in mind that satellite equipment and fax machines may quickly drain batteries. Equipment which requires 220 V alternating current supply and is connected to a battery by an inverter, will also quickly exhaust the battery (Wood, M. 1996, 74).

Sealed for life lead acid batteries are completely closed and do not require any maintenance.

The acid level of lead acid batteries must be checked regularly and topped up with distilled water if necessary. The state of charge should be regularly checked with a voltmeter or a hydrometer to prevent overcharging as well as complete discharge. Care must be taken to prevent injuries from the acid.

All metal parts of lead acid batteries should be covered with a layer of anticorrosive grease.

5.3 Communication systems operations

5.3.1 Use of radios

Humanitarian aid workers are usually not radio technicians or radio amateurs and therefore must be trained in the effective use of radio equipment and operations without disturbing other users. All users should be aware that radio equipment is expensive, indispensable in emergencies and must therefore use it with care. Unqualified staff should never open radio equipment such as transceivers or try to carry out repairs on any part of the installation.

Radio equipment should never be used when lightening can be seen and thunder heard since lightening can damage equipment and injure the operator (Corbett, J.R.G. 1988, 76). The aerial should be disconnected from the transceiver and connected to earth or the cable placed at least 30 cm away from the transceiver.

Never use radios when lightening can be seen and thunder heard.

Immediately disconnect the aerial from the transceiver.

Some transceivers may take 5 to 10 minutes to "warm up" before they can be used. Transceivers should not be covered with paper or other objects since this will impair free air circulation which is essential for cooling. In order to avoid damage from spills, no food or drinks should be consumed near radio equipment.

Before leaving with a vehicle the radio equipment must be checked by calling the base station and inquiring about the quality of reception. If vehicles are equipped with HF as well as VHF radios, both must be checked. It could be dangerous to learn that the equipment is not working only when you need to call for help in an emergency. Any fault should be immediately reported to the radio technician and the fleet manager must be informed not to use the vehicle until the radio set is repaired.

Hand-held radios also need to be checked if they have not been used regularly. However if the user is regularly sending and receiving calls, s/he can be sure that the equipment is working and does not need to check it.

Unless a selective call system is used, transceivers will not "ring" to alert that the station is being called, and the transceiver will therefore have to be switched on and attended permanently.

Before calling another station, any necessary records, documents or references should be prepared to avoid having to interrupt the conversation to rush back to the office. Paper and pen should always be at hand for taking notes.

Before making a call the user must make sure the radio is switched on, the volume is not turned off and deactivate the selective call system if necessary. The appropriate channel needs

to be selected and the USB-LSB control should be set to USB by default. A list with the allocated channels or frequencies and their purpose should be placed next to the receiver.

Except in an emergency, before starting a contact it is important to listen to the radio for a few seconds to make sure that the channel is free. If someone else is talking, it is mandatory to wait for the conversation to be completed. This is especially important when transmitting from a powerful station as it is possible to "blast through" with a more powerful radio but interrupting the transmission of the weaker radio without noticing.

To start a contact it is necessary to alert the other station by transmitting the call sign of the station which is being called as well as the call sign of the calling station. It is good practice to repeat the call sign twice since the first time may only be sufficient for getting attention of the radio operator but s/he might not have understood the call sign the first time. It should be kept in mind that the caller of a more powerful station may be able to transmit her/his message to a less powerful station but not be able to receive the answer. The station which is being called may also be temporarily unattended. The quality of connections between moving vehicles and base stations will naturally change depending on the topography as well as the distance. If the other station does not immediately answer, the call should be repeated. If there is still no answer the caller should wait a few minutes and call again but refrain from incessant calls which will block the channel for other users. The receiving station might require the sender to "stand by" to call the person s/he wants to talk with to the radio.

Most radio systems operate in simplex mode which allows only one station to transmit at a time. Consequently the caller and sender must take turns in speaking and cannot speak at the same time. Before speaking into the microphone, the caller must press the "Press to talk" (PTT) button or activate the foot switch and not release it until s/he has finished talking. It is also important to release this button immediately after finishing talking since otherwise the radio cannot receive any answer.

Once the other station has answered ("this is [call sign], go ahead, over"), both participants may want to switch to another channel. This allows keeping one channel free only for calling other stations, especially when several channels are available for communicating simultaneously. Operators should not hold the microphone to close to their mouth, speak clearly and reasonably slow but resist the instinctive temptation to raise the voice or shout if the quality of the connection is poor (Corbett, J.R.G. 1988, 78).

It is important to be aware that radio communications are by no means "private". Anybody within the radio network or outside (authorities, journalists, civilian and military authorities) can listen to the conversation. Therefore it is important not to transmit any confidential information. Information related to logistics can often be of importance to the conflict parties and may be considered as "military information".

Radio conversations are never private.

"I want to tell you right now, that in most cases, ordinary language is quite good enough" (Wood, M. 1996, 151). However there are a few words or phrases which have a special meaning and should be understood by all users such as "over", "out" or "stand by".

A few simple but important rules need to be followed by everyone (see table 5.11). Communications should be clear, concise and limited to essential matters. Effusive greetings and chit chatting must be avoided especially when the network is busy. The sender should consider what s/he wants to communicate in advance and avoid pauses since the receiver may mistakenly think the sender has finished her/his message. Especially when the quality of reception is poor, the sender should make breaks to allow the receiving station to confirm that

it has understood the message. Otherwise the sender might be speaking for minutes although the receiving station could not understand anything and the sender will have to repeat the entire message.

If reception is poor the receiver should repeat the message back to the sender who should in turn confirm that the message was received correctly or repeat the message, especially when transmitting names, addresses or numbers. If the receiver has not understood ("copied") the message s/he should make this clear by saying "negative copy". It also helps to spell words using the phonetic alphabet. "Negative" should be preferred to "no" and "affirmative" to "yes" since the short words are difficult to understand when reception is poor.

Even if separate frequencies have been allocated, stations operating on the other sideband or adjacent channels can cause interference. A nearby station can cause interference even if it is using a completely different frequency. Interference may also be caused by stations using more powerful transceivers simply "to be heard" rather than increasing their range.

Because only one person can speak at a time, s/he or he must indicate when s/he has finished talking by saying "over to you" (or "over" for short) before releasing the press to talk button. Simply stopping transmission can cause misunderstandings as the receiver will not know whether the sender has finished or reception has been interrupted. Before responding the receiver can confirm that s/he has understood the message by saying "well copied".

If more than two people are participating in a conversation, the last person to speak should make clear who is expected to talk next. Alternatively the radio operator at the main radio station will note all the people who are waiting and call them one by one.

Phonetic alphabet

A	Alpha	H	Hotel	O	Oscar	V	Victor
B	Bravo	I	India	P	Papa	W	Whiskey
C	Charlie	J	Juliet	Q	Quebec	X	X-ray
D	Delta	K	Kilo	R	Romeo	Y	Yankee
E	Echo	L	Lima	S	Sierra	Z	Zulu
F	Foxtrot	M	Mike	T	Tango		
G	Golf	N	November	U	Uniform		

Table 5.17 Phonetic alphabet (Corbett, J.R.G. 1988, 85)

When the sender wants to end the conversation s/he should make this clear to the receiver by saying "out", "signing off" or "going clear". This is also an indication for others who are waiting to use the channel that the conversation is finished and they can now take their turn.

Contacting other humanitarian organizations can be tricky since their radios may be programmed differently. However usually a common channel will be agreed upon (even if the channel number may differ between humanitarian organizations) which allows contacting other organizations. In any case the radio room should keep a record of all frequencies of humanitarian organizations working in the area. Especially in emergencies humanitarian organizations must be able to warn and assist each other and coordinate evacuations if necessary. If organizations use different radio systems for example one VHF and the other UHF they will not be able to communicate with each other.

- Prepare yourself for calls.
- Listen to the respective channel before starting any transmission.
- Never interrupt ongoing communications (except in emergencies).
- Do not hold the microphone too close to your mouth.
- Do not raise your voice during transmissions, even if reception is poor.
- Begin transmission with call the sign of the station being called followed by the call sign of the calling station.
- Wait for a reply before transmitting any further information.
- Speak clearly.
- Use plain language and avoid using codes.
- Use the phonetic alphabet for call signs, stations identifications and, where necessary, spelling words.
- Keep transmission as concise and short as possible.
- Avoid pauses in transmissions.
- Make breaks during transmissions to allow the receiving station to confirm reception.
- Request receiver to "read back" messages if reception is poor.
- End any transmission with "over" whenever a reply is expected..
- End transmission with "out" if no reply is expected.

Table 5.18 Basic rules for transmissions in radio networks

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6 RISK MANAGEMENT

Before starting any humanitarian assistance, programme managers will have to assess the security situation and potential risks. Logistics managers will not be deciding on whether a specific programme should be started, but like all managers in humanitarian assistance, they carry great responsibilities.

For logistics managers security and safety of staff, assets and facilities must be of primary concern and a constant preoccupation. Like other managers in humanitarian assistance, logistics managers will be in charge of staff and responsible for their security and safety. In addition vehicles, aircraft and convoys are exposed to special risks which need to be managed. Logistics managers will usually be responsible for humanitarian assistance good, logistical assets and facilities. Their damage or loss is not only a financial loss but may endanger the continuation of supplying humanitarian assistance altogether.

Despite the importance of providing goods and services to beneficiary, the concern for the security and safety of staff must be the overriding consideration. Although some degree of risk will often be inevitable, especially in complex political emergencies, the risks and potential benefits of logistics services must always be carefully weighed up.

This chapter will mainly deal with security and safety of staff while security of warehouses, vehicles etc. will be dealt with in more detail in the respective chapters.

6.1 Risk management strategy

Like all humanitarian workers, logistics staff face a large number of potential threats (see table 6.1). Security risks can be due to criminality, banditry or the armed conflict (IFRC 1996, 2). The greatest danger is probably caused by deliberate targeting of humanitarian organizations (Greenaway, S., and A.J. Harris 1998, 6).

The possible impact of security incidents as well as the possibility or probability of it to actually occur need to be considered.

The border between crime, banditry and conflict related threats may be fluent. The break down of law and order is often conducive to criminality for purely personal gain and criminality and banditry can escalate into a civil war. Food may be stolen by individuals, armed gangs or looted by parties to the conflict.

Security incidents may cause material and financial losses or cause psychological or physical harm. Physical harm may be aggravated by the lack of medical care and the impossibility to evacuate victims for medical treatment.

Humanitarian workers may be exposed to security risks during attacks on specific targets such as a village or town or during indiscriminate attacks such as aerial bombing, but without targeting the humanitarian organization. But increasingly, humanitarian workers are also being deliberately targeted. "We are targets. It is a reality today that aid agencies and their staff have become targets, not just caught in the cross fire" (IFRC 1996, 2). "Increasingly, civilians and those who try to protect and assist them are seen as legitimate targets for extortion, harassment, rape, and brutality" (Sheik, M. et al. 2000, 166).

The primary responsibility for ensuring the security of humanitarian organizations and all of their staff lies with the host government or the authorities which are in power. In conflicts, humanitarian workers are protected under the Geneva Conventions like all non-combatants, more specifically under the first Additional Protocol. Specific protection and security may also

be afforded by bilateral agreements such as Headquarters agreements used by the Red Cross movement (Greenaway, S., and A.J. Harris 1998, 27). "In the event of armed conflict, the States party to the Geneva Conventions have a general obligation under the provisions of the Fourth Convention (in particular Articles 55 and 61 to 63) to ensure adequate security conditions for humanitarian workers" (ICRC 1997, 12).

a) Criminality

Threats
- Verbal abuse.
- Slander.
- Defamation.
- Verbal threats.
- Written threats.
- Harassment.
- Blackmailing.
- Extortion.
- Bomb threats.

Offences against property
- Theft.
- Burglary.
- Robbery, mugging.
- Arson.
- Vandalism.
- Sabotage.

Physical harm
- Physical abuse.
- Mistreatment.
- Beating.
- Physical assault.
- Sexual assault.
- Torture.
- Murder.

b) Armed banditry
- Hold-ups.
- Abduction.
- Kidnapping.
- Hijacking.
- Carjacking.

c) Conflict related risks

Peaceful protests
- Strikes.
- Crowds.
- Protests.
- Demonstrations
- Blockades.
- Sit-in.
- Occupation.

Lawlessness
- Unlawful arrest and detention.
- Expropriation.
- Confiscation.
- Expulsion.
- Riots.
- Looting.

Forms of attack
- Ambush.
- Indiscriminate attack.
- Attacking a specific target.
- Targeting individuals.

Shooting
- Small arms.
- Rifles.
- Automatic guns.
- Snipers.
- Execution.

Explosive devices
- Anti-personnel mines.
- Anti-tank mines.
- Booby-traps.
- Hand grenades.
- Grenades.
- Rocket propelled grenades.
- Improvised explosive devices.
- Bombs.
- Car bombs.
- Unexploded ordnances.

Artillery (shelling)
- Mortar fire.
- Howitzers.
- Heavy artillery.
- Rockets.
- Anti-aircraft guns.

Aerial bombing
- Bombs (explosives).
- Fragmentation bombs.
- Cluster bombs.
- Incendiary devices (Napalm).

Other weapons
- Chemical.
- Biological.
- Nuclear.

Table 6.1 Types of security risks

However in situations where law and order has broken down it may be impossible to claim security from any particular conflict party.

The statute of the International Criminal Court defines deliberate attacks on humanitarian workers as a war crime (Holloway, R. 2000, 2).

Some situations or activities such as transport of cash or valuable goods or distribution of humanitarian assistance goods will increase existing security risks or create new risks. The

vicinity of military installations should be considered as a high risk area and any kind of aggregation of people such as crowds, demonstrations, political rallies or riots should be avoided.

6.1.1 Crime and banditry

Crimes occur anywhere in the world. However in the situations where law and orders breaks down they may be more common. The proliferation of and easy access to weapons, especially small fire arms, encourages crime. In addition there may be no authorities which are able or willing to prevent crime or assist the victims.

The consequences of crime may be material, psychological or physical. Humanitarian organizations are often considered as wealthy and thieves may steal equipment such as telecommunication equipment and computers. In the absence of banks humanitarian organizations often have to keep large sums of cash for purchasing and paying salaries in their offices which are also coveted. Identity cards and passports may also be attractive. Finally thieves may attempt to steal humanitarian assistance good, especially food. Vehicles, generator sets and fuel are also coveted. If the perpetrators do not have to fear any authorities they may in fact remove everything of value. During looting in Somalia even doors and windows were removed.

Armed individuals or gangs may rob or loot offices, warehouses and residences.

Humanitarian workers may become victims of verbal abuse and be exposed to written or verbal threats or blackmail. Individuals or groups may resort to exerting physical harm by beating, mistreatment, sexual assaults, rape and murder for exerting pressure. Humanitarian workers may also be exposed to unlawful arrests and detention without charge as well as torture by civilian or military authorities.

Banditry can be of purely criminal origin or be carried out by armed groups which may belong to one of the conflict parties. In addition to any kind of crime, bandits may harass or mug humanitarian workers, stage hold-ups and ambushes. Further threats are hijackings, especially of vehicles, abduction, kidnapping and hostage taking.

While crime is not particular to conflict areas, it may be facilitated and its consequences aggravated by the absence of civilian authorities, police and any judicial system.

6.1.2 Conflict related risks

Various threats emanate directly or indirectly from the armed conflict. The border between a peaceful protest, civil unrest and civil war or internal conflict are fluid.

Humanitarian organizations may be exposed to more or less peaceful strikes, protests, sit-ins, occupation, blockades, protests or demonstrations by civilians which can block premises, roads or distribution sites and can deteriorate into violence, wanton destruction and looting. Sabotage and arson pose further threats. Crowds are unpredictable and can be seen as a potential security threat to individual as well as organizations in general.

Parties to the conflict or authorities may expel or expropriate humanitarian organizations and confiscate or loot premises, vehicles and equipment.

Humanitarian workers may be exposed to combat situations either because they are caught up in cross fire, due to a military assault on a village, town or city or by direct and deliberate attacks. People may be harmed by direct hits from weapons or indirectly by downing of aircrafts, collapsing buildings, explosion of fuel depots or rupture of dams.

Shooting from small arms fire, rifles and automatic guns is a very common risk. Snipers intend to hit high-ranking military staff or high value targets within a range of up to 1,000 metres as well as cause fear and panic among their opponents (Roberts, D.L. 1999, 41). Humanitarian workers may also be victims of mock or summary executions.

Another danger, which may persist even when military operations have ceased are various types of explosive devices such as anti-personnel mines, (hand) grenades, booby-traps, improvised explosive devices (IED), (car) bombs and anti-tank mines and unexploded ordnance (ammunition). Even though ordnance has not exploded it may be very unstable and only require a little nudge or to be picked up to explode (Roberts, D.L. 1999, 50).

Anti-personnel mines intend to injure and maim combatants, slow down the approach of opponents and cause fear. They are usually round with a diameter of 6-10 cm and can be made from steel, plastic or timber. They can be activated by pressure (stepping or driving upon), trip wires or set off by remote control. Some anti-personnel mines jump about one metre above ground before detonating and projecting steel fragments which are lethal up to 50 metres around. Directional anti-personnel mines can kill up to a distance of 200 metres.

In order to be effective they are usually laid in groups or mine fields. They can be laid individually by combatants, dropped or randomly scattered by aircraft. They may be visible or buried and can be overgrown by vegetation (Roberts, D.L. 1999, 25). The laying of mines is often unrecorded and they may remain a threat for many decades.

Anti-vehicle and anti-tank mines, which are usually laid in fairly large numbers, are designed to disable heavy vehicles. They can be square or round with diameters of up to 50 centimetres and heights of up to 10 centimetres. Anti-tank mines are detonated by the pressure of vehicles (not necessarily tanks) passing over them and sometimes by tilt rods or trip wires. An anti-tank mine will completely destroy a vehicle and probably kill all persons on boards. To prevent removal they are often booby-trapped or surrounded by anti-personnel mines and usually observed by combatants. Anti-tank mines are often used for ambushes. Even if no combatants are visible approaching anti-tank mines may prompt being shot at (Roberts, D.L. 1999, 25).

They are normally activated by pressure (from 100 kg upwards), but could also explode under a bicycle or even a pedestrian. Other means of detonation are electronic devices (detecting the proximity of a vehicle), tilt rods, or remote control. They sometimes include an impulse counter to prevent them from exploding under the first vehicle that passes over them.

Any, even apparently harmless, object can be booby-trapped to injure or kill any person who touches, moves or manipulates the object for example by picking up an attractive object or moving a door. Booby-traps are laid in public places (roads etc.), in civilian as well as military objects during combat or before retreating.

Any military ordnance such as rifle ammunition, grenades, tank shells or aircraft bombs may fail to explode as intended or have been discarded or left behind by combatants but still be dangerous. All unexploded ordnance are dangerous and must not be touched or moved as this may cause them to explode (Roberts, D.L. 1999, 49)

Improvised explosive devices and bombs can be triggered by a trip wire, a signal through a electric wire, an electronic signal from a transmitter or a timing device which sets them off at a predetermined time. They are often set in pairs. The first explosion may cause harm itself but also draws people to the scene who will then be targeted by the explosion of the second device (Roberts, D.L. 1999, 47).

Grenades are small bombs which are either thrown by hand or fired from a hand-held launcher (rocket-propelled grenade).

Shelling can be caused by mortars (up to 6 km), howitzers (up to 13 km) or heavy artillery (up to 24 km). Rocket-launchers are self-propelled weapons with a range of up to 50 km. Finally anti-aircraft guns which have a range up to almost 10 km can be used against ground targets as well as aircraft.

Except for the anti-aircraft gun, all artillery are "indirect" weapons which can be fired from behind buildings, hills or dug-in positions. Since the trajectory depends on many factors such as air pressure and wind direction, weapons may require adjustment between firing and guiding to the target by an observer which is in direct contact with the person firing the weapon ("observed fire"). Consequently a number of shells may hit the vicinity before the actual target is hit. Another, less accurate, method is the "predicted fire" where the trajectory is computed based on coordinates and other factors such as the direction of the wind (Roberts, D.L. 1999, 39).

Aerial bombs can be dropped from helicopters or fixed-wing aircraft. Because of their speed there is usually little warning. Precision bombing requires highly trained pilots and bombing may therefore often be inaccurate or indiscriminate. Moreover often aircraft will fly at high altitudes to avoid anti-aircraft fire which decreases the precision of their targeting and bombing may be designed to cause terror and panic rather than destroy a specific target. Cluster bombs which scatter hundreds of smaller bomblets are designed to cover an area rather than hit a specific target (Roberts, D.L. 1999, 52).

A city, town or area may come under siege or a convoy may be held up in a hostile environment and not be able to move. Although not directly threatened, staff may not be able to leave and may need to be prepared for a prolonged stay.

Biological weapons usually cause illness after inhaling infectious agents which are dispersed by a weapon. Chemical weapons can occur as solids, liquids or gases and can be inhaled or enter through the skin.

Afghan ICRC employee killed in air raid

Geneva (ICRC) - The International Committee of the Red Cross (ICRC) in Afghanistan is saddened by the tragic death of Mr Abdul Rahim, one of its Afghan national staff, in an air raid close to an ICRC warehouse in Jabul Saraj, some 60 km north of Kabul. The incident occurred on the morning of 26 April. Mr Rahim and another civilian were killed on the spot, and two more people were injured in the raid (ICRC 1999a, 1).

A rebel missile downed a company plane in Angola in 1992. The Russian pilot managed to land safely with his five UN passengers. What he didn’t realise, however, was that he had crash-landed in a minefield. When he got out to inspect the damage, he was killed instantly in an explosion. Another SkyLink pilot had to rescue the survivors with a rope ladder dangling from a helicopter (Gray, J. 1999, 5).

West of Grozny a convoy of five vehicles from the Russian Red Cross came under fire in an area where military operations were in progress, despite being clearly marked with the Red Cross emblem. Two Red Cross workers were killed when a rocket fired from an aircraft hit their truck and another 25 people were killed and 70 injured in nearby vehicles (ICRC 1999c).

In addition to hostage-taking, United Nations system offices and premises are frequently occupied by individuals seeking to draw attention to their cause. UNHCR reported four such incidents in the first quarter of 1999, including the occupation of UNHCR headquarters. There have been incidents of asylum-seekers turning violent; one such incident resulted in the maiming of an office guard. In Afghanistan, UNHCR offices were stormed by mobs eight times during a one-week period as a result of a protest against the United Nations (United Nations General Assembly 2000, 3).

UNICEF reports at least six incidents where staff members were arrested for a variety of reasons, including being in possession of a satellite telephone and walking in proximity to a government office (United Nations General Assembly 2000, 4).

On 7th February 2000, 10 heavily armed men opened fire on an MSF vehicle travelling in the Ogaden desert, killing the driver and wounding the two passengers. The more seriously injured passenger was an MSF logistician. MSF immediately suspended the Deghabur programme and evacuated all staff back to Addis Abeba. This was primarily a health and a water and sanitation program. MSF will also stop its ongoing exploratory mission in Gode where a team was carrying out nutritional and medical surveillance for a famine and measles alert. This is the third time in the past 12 months where humanitarian workers have been targeted in the Ogaden region (MSF 2000, 1).

Unknown gunmen fired at a United Nations aircraft with three UNICEF staff members from both sides during preparation for take-off from Kismayo (Somalia) but it eventually landed safely at its destination airport (UN DPI 2000).

Figure 6.1 Warehouse of humanitarian organization destroyed by aerial bombing

6.1.3 Scope

Although comprehensive and accurate statistics on security incidents, casualties and their long-term trends are not available (Greenaway, S., and A.J. Harris 1998, 4), there is unanimity that the security environment in which humanitarian organizations work has become more dangerous during the past decade and the number of security incidents has increased. However the fact that the number of humanitarian organizations and humanitarian workers has also increased needs to be taken into consideration.

In 2000 the General Assembly of the United Nations deplored ". . . the rise in casualties among national and international humanitarian personnel, as well as the acts of murder and other forms of violence, including abduction, hostage-taking, kidnapping, harassment and illegal arrest and detention, to which United Nations personnel in humanitarian operations and elsewhere are increasingly exposed" (United Nations General Assembly 2000, 1).

"The business of providing humanitarian aid has become increasingly dangerous. In virtually every part of the world, those providing aid to distressed populations have been robbed, beaten, raped, abducted and murdered . . . . While this is not a new problem – relief workers have always confronted dangerous environments – the number, scope, and nature of threats to those engaged in humanitarian assistance have become much more severe in recent years, consistent with the proliferation of internal conflicts" (Greenaway, S., and A.J. Harris 1998, 2).

"Broadly speaking, conditions for aid workers have become less safe over the past decade as figures on injury and death and the sheer number of security incidents show" (ICRC 1997, 4) "However, the growing number of victims among aid workers in recent years has become a major cause for concern" (ICRC 1997, 4). "The problem of security for relief operations has, over recent years, become widespread and pervasive" (Greenaway, S., and A.J. Harris 1998, 4). The UN Security Coordinator noted that, prior to 1992, security was "not a major issue" for the UN and that ". . . it was almost unheard of for a staff member to be killed" (Greenaway, S., and A.J. Harris 1998, 4).

This decrease of security can be in part attributed to the change of the nature of armed conflicts. Many conflicts are internal rather than inter-state and waged by loosely organized armed groups which do not respect international law as would be expected from professionally trained soldiers. Instead of dealing with only two conflict parties, often humanitarian organizations have to deal with several fractioned parties and local militia. ". . . one nowadays often has to negotiate with groups, clans, bandits, militias and weekend fighters" (ICRC 1997, 2).

Apart from the increase of security incidents a worrying development is that the neutrality of humanitarian organizations is often not respected and humanitarian workers are being deliberately targeted although they clearly identified themselves (ICRC 1997, 4). "Humanitarian workers are more and more victims of attacks and the emblem of the Red Cross and Red Crescent no longer always provides the necessary protection" (ICRC 1997, 2). Of 177 murdered United Nations staff the perpetrators were brought to justice only on three occasions (Wren, Ch. S. 2000, 2). "This lack of action may create the impression that United Nations system staff can be attacked with impunity" (United Nations General Assembly 2000, 3).

Between January 1992 and September 2000 a total of 198 civilian United Nations personnel were killed (United Nations General Assembly 2000, 1).

Between January 1994 and September 2000, 240 United Nations staff members were kidnapped or taken hostage for up to several months in 63 separate incidents.

"Over the past eight years, the number of incidents presenting a physical threat to ICRC staff has grown from around 20 per year to more than a hundred (153 last year)" (ICRC 1997, 4).

Sheik, M. et al. undertook a detailed analysis of 382 deaths of humanitarian workers between 1985 and 1998 (Sheik, M. et al. 2000, 166) and confirm that the number of deaths among humanitarian workers has increased. 68% of deaths were caused by intentional violence with weapons, 24% by unintentional violence and accidents and the remaining 8% by other causes such as diseases.

Between 1991 and 1998 a dozen of humanitarian workers have been kidnapped and killed (Greenaway, S., and A.J. Harris 1998, 4).

In 1995 an Italian doctor was murdered in Somalia (Greenaway, S., and A.J. Harris 1998, 4).

In Sudan, four national staff working for Save the Children, Norwegian Peoples Aid and German Agro Action died in three separate war-related incidents in 1995 (Greenaway, S., and A.J. Harris 1998, 4).

In 1995, 70 humanitarian workers were seized or taken hostage by various conflict parties in Sudan.

In 1995, at least 10 national and international staff members died in politically or criminally motivated attacks in Burundi (Greenaway, S., and A.J. Harris 1998, 4).

In October 1995, an American relief worker lost her legs and another was injured in Zaire when their car hit a land mine (Greenaway, S., and A.J. Harris 1998, 4).

In 1996 three ICRC staff were killed in Burundi while conducting relief operations (Greenaway, S., and A.J. Harris 1998, 4).

In December 1996 six humanitarian workers of the ICRC were murdered inside their compound at Novy Atagi in Chechnya.

"Between June 1996 and January 1997, ten members of the ICRC's field staff were killed in Burundi, Chechnya and Cambodia (ICRC 1997, 4).

In January 1997 three members of Médecins du Monde were killed in Rwanda and another humanitarian worker was severely wounded and lost a leg (Greenaway, S., and A.J. Harris 1998, 4).

In November 1997 a French humanitarian worker was killed in Tajikistan during an attempt by security forces to free her and a colleague from their abductors (ICRC 1997, 4).

In September 2000 three UNHCR staff were beaten and hacked to death in their office at Atambua by suspected militia supporters angered over the repatriation of refugees (Wren, Ch. S. 2000, 2).

In the same month a UNHCR staff member in Guinea was murdered and another abducted by robbers (Wren, Ch. S. 2000, 2).

The International Committee of the Red Cross and Red Crescent Societies reported that 77% of deaths were due to intentional violence. In 58% of all cases national staff were affected. Although the exact number of national staff was not available and deaths among national staff were probably underreported, expatriate staff had a 5-6 times higher risk of death than national staff.

Deaths occurred at offices, residences, roadblocks or during carjacking and banditry was found as an important cause of death. "When all violent deaths were considered, however, most victims died in cross fire or in cold blood" (Sheik, M. et al. 2000, 168).

Chronic and acute diseases, some of them preventable, were a frequent cause of non-violent deaths while motor vehicle accidents were a rare cause. Since the average age at death was nearly 40 years, death cannot be attributed to inexperience or poor preparation. However a third of all deaths occur within the first three months of duty which indicates that the risks are not fully appreciated at the beginning of missions.

6.1.4 Causes

The environment in which humanitarian organizations operate in complex political emergencies is naturally dangerous and "collateral damage" will be unavoidable to some degree if humanitarian workers are close to the affected people. However the deliberate targeting of humanitarian organizations does not achieve any direct military advantages and can have a variety of reasons (see table 6.2).

- Crime (in general).
- Economic value of humanitarian assistance good, assets and equipment.
- Suspicion of unequal allocation of assistance.
- Extortion of ransom.
- Looting by desperate populations.
- Revenge by disgruntled employees.
- Collapse of law and order and anarchy.
- Deliberate attacks to disrupt humanitarian activities.
- Attacks to gain media attention.
- Suspicion of support by humanitarian organizations to adversaries.
- Confusion of humanitarian organizations with other actors of the conflict.
- Association of humanitarian organizations with governments perceived as hostile.
- Non-discrimination between political measures (sanctions) and humanitarian assistance.
- Perception that humanitarian organizations are promoting foreign values or creeds.
- Personal grudge of a member of a conflict party against a humanitarian organization.
- Combatants which are under the influence of alcohol or other substances.

Table 6.2 Causes of or circumstances conducive to insecurity

Crime which is inherent in any society is likely to increase when law and order breaks down, weapons are more easily available and the level of poverty and destitution increases.

The value of humanitarian assistance good, equipment, cash and assets which humanitarian organizations manage is often considerable. This attracts individuals, armed gangs as well as conflict parties to steal, rob or loot either for their personal gain or as a resource for continuing their fight. Food is coveted for feeding fighters or selling in the local market. Vehicles, fuel, telecommunication equipment and cash are valuable resources for waging war. Health care goods are attractive since there is generally a lack in less developed countries, they have a high value and high value density. The fight over humanitarian assistance goods may further fuel hostilities between conflict parties.

If humanitarian assistance goods are perceived as not being allocated in an impartial and transparent manner, suspicion, resentment and anger will arise or grow (ICRC 1997, 7).

Hostage taking by individuals or groups may be motivated purely by the expectation of extorting a ransom. Since humanitarian organizations are considered as wealthy, targeting them promises higher profits.

A desperate population may loot a warehouse simply for lack of food. Groups among the population may feel that they are being discriminated against and fear that they are not receiving their fair share.

Humanitarian organizations often employ a considerable number of national staff. A secure and regular salary as well as other benefits is highly coveted. People who unsuccessfully seek employment or have been dismissed may want to take revenge.

Since the end of the cold ware the nature of conflicts has changed and they are now mainly internal and often compounded by ethnic tensions. The weakening or collapse of states and state authorities and the ensuing anarchy is conducive to a general increase in violence, emergence of warlords and networks of organized crime as well as lack of respect for civilians which in turn also affect humanitarian organizations. "There has regrettably been a continuous erosion of respect for the principles and rules of international humanitarian law" (United Nations General Assembly 2000, 11).

The civilian population is often drawn into internal conflicts, blurring the distinction between combatants and civilians. Since humanitarian organizations work in close proximity to the civilian population they are also more likely to be targeted than in the past (ICRC 1997, 5).

Humanitarian organizations may be deliberately attacked to influence or disrupt its activities. Threats or attacks may be aimed at forcing humanitarian organizations to suspend certain programmes or drive them out of an area or even country to prevent them from witnessing abuses of human rights, misappropriation of humanitarian assistance goods and war crimes.

Deliberate attacks may also be undertaken to demonstrate that the authorities are not really in charge and unable to guarantee security in the country.

Threats and attacks may also intend to draw the attention of the media and international actors to a problem and put pressure on them to intervene or provide humanitarian assistance (Greenaway, S., and A.J. Harris 1998, 5).

Humanitarian organizations may also be targeted if they are perceived as not being neutral and favouring one of the conflict parties. Parties to the conflict may try impeding provision of humanitarian assistance to adversaries or areas which they perceive as hostile, especially if the aim of the conflict is to annihilate or drive out a population from an area.

Humanitarian organizations may be directly targeted because they are confused with another humanitarian organization or media organizations which have previously given rise to hostility for whatever reason. Conflict parties may also have difficulties in distinguishing between military forces, peacekeeping forces, United Nations organizations, international organizations and a large number of non-governmental organizations.

The association with a country which does not have a favourable foreign policy towards the actors of the conflict can be perceived as hostility as well.

Parties to the conflict may not distinguish between the political or military objectives of the international community or the United Nations and humanitarian organizations. If policies of the international community or the United Nations (peace keeping interventions, sanctions

etc.) are not approved, hostilities may be directed towards humanitarian organizations in general.

Humanitarian organizations may be threatened or attacked because they are perceived as reflecting or even promoting certain foreign values or creeds.

The local population may directly or indirectly support abusive actions of conflict parties towards humanitarian organizations because they believe they can gain more from these groups than from the humanitarian assistance (Greenaway, S., and A.J. Harris 1998, 11).

Although the conflict parties may accept the presence and work of humanitarian organizations, individual combatants may have a grudge against a humanitarian organization because one of her/his relatives has been dismissed or s/he feels that her group or clan has been discriminated against in a programme or during a distribution.

Combatants may be confused about the different humanitarian organizations and their objectives. They may feel that humanitarian organizations are siding with an adversary or not providing sufficient support to the civilian population of the area under their control. Combatants may lack discipline or be completely out of control of their superiors. A common threat are combatants which are under the influence of alcohol or other drugs. They may be totally unpredictable and behave irrationally.

6.1.5 Consequences

When faced with threats or attacks humanitarian organizations must balance between the anticipated impact of humanitarian assistance programmes and the risks they are willing to take to achieve this objective. Humanitarian organizations who have been looted and are pinned down in their compound will not be able to provide any effective humanitarian assistance. "Programming in conflict will always be a trade-off between such dangers and opportunities" (Slim, H. 1997, 2).

However no humanitarian organization can accept theft and looting or injury and death of their staff. Consequently attacks will usually lead to a reduction of humanitarian assistance activities or even complete withdrawal from an area or the country.

Humanitarian organizations will also not accept to lose control over distributions when humanitarian assistance goods are stolen or looted. If distributions cannot be monitored and carried out in an orderly way, humanitarian organizations will not be able to reach their objectives of providing goods selectively to people who are really in need of them.

Reduction of humanitarian assistance or complete withdrawal can have dire consequences for the population in need which may be left without protection, food aid and health care. “When does the risk to your staff outweigh the dire needs of hundreds of thousands of refugees?” (Wren, Ch. S. 2000, 1). "In situations of extreme risk, relief operations are suspended and humanitarian agencies evacuated – or they never start up at all. The resulting loss of life in the affected population is significant – both from lack of access to relief programmes and from the protection international agencies offer as "witnesses" to deter atrocities" (Greenaway, S., and A.J. Harris 1998, 5).

Misappropriation of humanitarian assistance goods by one of the conflict parties may be perceived as tacit support and will make the humanitarian organization appear biased against the other conflict parties.

6.2 Security plan

Security plans and theirs measures basically have three objectives. They are designed to avert and eliminated, or at least reduce, security risks for example by access control to buildings, avoiding certain areas, suspending convoys on certain routes or not storing goods and assets in a certain place. Secondly they intend to limit the negative impact and consequences of incidents by protective measures such as setting up underground shelters. Finally security measures must limit adverse consequences of security incidents for example by ensuring rapid (medical) evacuation.

Concern for security must be a constant rather than transient preoccupation and start from the very beginning of any humanitarian assistance programme. Humanitarian organizations must be willing to provide the financial resources for security measures such as staff, equipment and infrastructure.

Security coordinators and other managers will be in charge of security. However every individual staff member must take responsibility for her/his security as well as security of her/his colleagues. All staff need to be disciplined, comply with security rules and know how to behave in insecure environments. Consequently good security begins with recruitment of staff. Behaviour in insecure and stressful situations should receive as much consideration as technical and professional skills.

Humanitarian organizations must also be aware that security is indivisible and the safety of every humanitarian organization and every humanitarian worker depends on the conduct of all. A single humanitarian organization or even a single staff member behaving provocatively could jeopardise everyone's safety.

An effective and efficiency response to security threats requires detailed and comprehensive planning. Based on a thorough analysis of the general situation, security environment and expected security threats, a security plan needs to be established. Security plans and rules cannot eliminate the risk of security incidence but can reduce the risk to an acceptable level.

Security must be the concern of all managers and individual staff members. However one staff member should be in charge of overall security. Security regulations must be drawn up and distributed to all staff upon arrival or employment. Staff will also need to receive briefings and regular training, especially how to behave in emergencies.

Security incidents and measures for preparedness must be disseminated among all staff and shared with other humanitarian organizations. Security coordinators of different humanitarian organizations in an area should work closely together to share information and perhaps resources such as aircraft for evacuations.

The security coordinator is in charge for analysing situations, assessing risks, developing a security concept for the country as well as individual locations as well as for crisis management.

The responsibilities of the security coordinator (see table 6.3) may be assigned to a staff member as an additional duty. However wherever significant security risks can be expected these responsibilities should be assigned to a designated full-time security officer (Greenaway, S., and A.J. Harris 1998, 16).

The importance of the security officer having professional experience in the area of security, either in law enforcement or the military, as well as in humanitarian assistance operations cannot be overstated (Greenaway, S., and A.J. Harris 1998, 15).

Every security incident must be reported, taken seriously, recorded and carefully analysed.

- Focal point for all security issues.
- Analysis of the general security situation.
- Assessing potential risks.
- Regularly preparing reports on the security situation.
- Keeping all staff informed about the security situation and security incidents.
- Developing a security concept (preventive and protective measures).
- Developing evacuation plans.
- Carrying out security assessments (residences, offices, warehouses etc.).
- Drawing up and regularly updating a security plan.
- Implementing the security plan.
- Assessing and monitoring compliance of all staff with the security plan.
- Conducting training of staff.
- Keeping contact with relevant authorities and other humanitarian organizations concerning security.
- Advising programme managers on assistance operations.
- Investigating, recording and analysing security incidents.
- Managing security incidents (crisis management).
- Coordinating assistance to victims.

Table 6.3 Responsibilities of the security coordinator

"The primary management tool for security preparedness at any duty station is the country-specific security plan" (United Nations General Assembly 2000, 6).

The security plan is drawn up and regularly updated by the security coordinator and contains all information and instructions concerning prevention of and protection from security threats as well as measures to cope with an incident or crisis.

- Staff member responsible for security and central contact (telephone, radio).
- Communication infrastructure to be used in emergencies.
- Preventive security measures.
- Protective security measures.
- Location of safe places and shelters.
- Evacuation plan.
- List of equipment which must always be ready for security incidents.
- Availability of medical assistance.

Table 6.4 Issues to be considered in a security plan

The security plan should cover all possible contingencies such as attacks on staff, hostage taking, arrest of staff, discovery of explosive devices, combat situations (shooting, shelling etc.), attacks on residences, offices and warehouses etc., medical emergencies, evacuations and civil disturbances. It states adequate measures and the sequence in which they should be taken. The further the security situation deteriorates the further movement of staff and vehicles will be restricted to minimize risks.

Security plans should also list places or situations which carry an increased security risks. This may include markets, places of worship, any places where a large number of people gather and times and days with religious, political or military significance.

The security plan must clearly define the responsibilities of the security coordinator, programme managers, logistics coordinators and medical staff. The lack of a sound security plan could prove disastrous in an emergency.

In the process of defining a security concept and establishing a security plan, all possible contingencies should be thought through, possible actions considered and alternatives weighed. Constraints such as curfews, impassable routes, the inability of aircraft to fly at night or unavailability of a health care facility in the vicinity should be considered and the required human, financial and technical resources for each contingency determined. Details of the security plan may differ from location to location.

Once a security plan has been established, it needs to be communicated to all staff members and certain procedures should be rehearsed regularly. On arrival or upon deployment every staff member must be briefed on the security situation and should receive a copy of the security plan, study it carefully and confirm acknowledgment with her/his signature. Security plans must also be distributed to other offices and sites within the country and to neighbouring countries. Staff members who do not abide by the security plan must be admonished and, depending on the severity of breaches of security, dismissed.

Security plans need to be regularly reviewed in light of new developments of the conflict situation as well as changes in humanitarian assistance programmes.

As part of the security plan, different levels of security may be defined where different levels correspond to a different set of security measures. Different parts of a country or different sites may be in different security levels at the same time.

Phase I - Precautionary: staff members are warned about the security situation in the country or an area.
Phase II - Restricted Movement: as a precaution all personnel remain at home and movement of staff members is restricted.
Phase III - Relocation: international staff are relocated to a specific site or area within the country or abroad which is considered safe and non-essential staff are relocated outside the country.
Phase IV - Programme Suspension: assistance programmes are suspended and except staff involved directly in emergency operations and evacuations, all international staff are relocated outside the country.
Phase V - Evacuation: All remaining internationally recruited staff members are required to leave.
Security measures apply only to international staff unless the security of national staff and their dependants is endangered as direct consequence of their employment by the United Nations Organization.

Table 6.5 United Nations security alert system (United Nations General Assembly 2000, 6)

The level of security must consider the level of threat.

National staff must be kept informed of all developments. If the security situation deteriorates they may be asked to stay at home and not come to work. Finally national staff and their dependants may be evacuated, depending on the policy of the humanitarian organization.

6.2.1 General preventive measures and preparedness

Humanitarian organizations can no longer expect that their reputation, intention to assist people in need, their neutrality and provisions of international humanitarian law will protect them (Greenaway, S., and A.J. Harris 1998, 25).

Avoiding and preventing risks is preferable to protection and coping with security threats. Some general preventative measures apply to any security risk.

- Acceptance of humanitarian organization and their programmes.
- Notification of programmes, movements and activities.
- Identification of staff, vehicles and facilities.
- Information collection and analysis, risk assessment prior to movements and activities.
- Taking any threats and security incidents seriously.
- Risk awareness.
- Compliance of all staff with security rules.
- Avoiding areas with particularly high risks.
- Avoiding areas at certain times where risks can be expected to increase.
- Taking precautions and being prepared for emergencies.

Table 6.6 General preventive security measures and precautions

According to Greenaway and Harris relatively simple precautions would have been sufficient to prevent an number of causalities caused by criminality and banditry and "Unfortunately, in many cases, serious security incidents have resulted from a lack of even basic precautions, awareness and understanding of the threats field workers face" (Greenaway, S., and A.J. Harris 1998, 6).

One important measure for reducing security risks is for humanitarian organizations, their staff and programmes to be accepted by the beneficiaries, general population, authorities and conflict parties. Humanitarian assistance must always be considered as an offer towards beneficiaries and cannot be forced upon anyone. In order to be accepted, being neutral towards all involved conflict parties is vital. If humanitarian organizations feel resentment or even hostility against them they must explain their work and objectives.

At the same time humanitarian organizations must be sensitive to and respectful of the culture, tradition and beliefs of the place they are working in.

The close cooperation and association with the local community and the beneficiaries has been referred to as an "anthropological" approach (Greenaway, S., and A.J. Harris 1998, 11). Humanitarian organizations must take time to introduce themselves and their programmes to local communities, their leaders as well as the beneficiaries, maintain a dialogue and be transparent in their work. This approach is expected to avoid misunderstandings and reduce the risk emanating from individuals or groups within the local community or conflict parties which are supporting them. The local community may deter attacks, inform humanitarian organizations of imminent risks and provide advice and assistance in case of attacks. The close participation of the local community and beneficiary may also contribute to reducing misappropriation and misuse of humanitarian assistance (Greenaway, S., and A.J. Harris 1998, 11).

One important consideration is the nationality and ethnicity of staff. Depending on the situation and the conflict national or international staff may be more at risk. For example in an ethnic conflict a truck driver from either ethnicity may be unable to cross a front-line while a foreign national may be considered as neutral. In other conflicts, hostilities towards foreigners may be overwhelming and national staff may be less at risk. In any case tasks must be assigned to the nationality or ethnicity which are expected to face the least risk. Among international staff often certain nationalities are considered to be linked to certain conflict parties because of their history or foreign politics.

Humanitarian workers should not carry fire arms on them or with them in vehicles since they may be considered as participating in the conflict. If an armed escort or armed guards are necessary they can travel in a separate vehicle. Military-looking clothing, caps, boots and (pocket) knives should also be avoided since they may raise suspicion.

Humanitarian workers must refrain from engaging in illegal activities such as changing money on the black market or buying souvenirs or antiques which are not allowed to be exported.

Depending on the situation and programme, the authorities, local population and beneficiaries should be notified in advance about installation of offices and other facilities and provision of humanitarian assistance good. This will help to avoid resentment and feelings of being discriminated against. Likewise humanitarian organizations must notify authorities of any intended movements of vehicles, boats and aircraft and obtain their consent.

This is especially important during open conflicts where identifiers may not be recognizable when weapons with long ranges, such as aircraft or artillery, are used. The conflict parties must be notified of the coordinates of buildings and the routes and schedules of convoys and flights. Because of the speed at which military aircraft travel, the use of remotely controlled weapons as well as the difficulties of identifying visible markings during the night or poor visibility, notification of all medical flights to all conflict parties is indispensable (Eberlin, Ph. 1988, 507).

Humanitarian organizations who are accepted and provide information on their activities must identify themselves. Otherwise they may be mistaken for another conflict party or another humanitarian organization which is not accepted, and attacked.

Offices, residences, warehouses, workshops and other facilities as well as vehicles, boats or aircraft can be identified visually with stickers, flags or paintings although their visibility greatly depends on weather conditions and they can quickly become invisible during snowing, rainfall or foggy weather. However, even in good weather conditions, the visibility of signs and identifiers must not be overestimated. For example, in clear weather, a red cross flag measuring 5 metres across is barely discernible at a distance of 3 kilometres and a 10 metre flag is no longer recognizable at a distance of 5 kilometres (Cauderay, G.C. 1990, 267). A Red Cross emblem on an ambulance measuring one by one metres was not visible from an aircraft flying at 400 metres above ground during daylight and in ideal weather conditions from a horizontal distance of 1 kilometre. Even a Red Cross emblem placed on a roof and measuring ten by ten metres was barely discernable from an aircraft flying at 1,000 metres height and at a horizontal distance of three kilometres (Cauderay, G.C. 1990, 300).

Depending on the conflict and the means of warfare, visual identification may not be sufficient and additional means of signalling and identification, such as radio, radar, underwater acoustic devices and, to some extent, light signals, are therefore needed.

Signs and emblems on aircraft and hospital ships can be marked with adhesive thermal tapes or special tapes which are visible with thermal imaging cameras (night vision systems).

The International Telecommunications Unit (ITU) has reserved special, standardized and uncoded radio signals for medical transports which are emitted at regular intervals at one or several designated frequencies (Cauderay G.C. 1995, 21).

Hospital ships and medical aircraft may also identify themselves with radar transponder signals (secondary surveillance radar) assigned for the duration of the conflict by the competent authorities such as the regional Air Traffic Control Centres (Cauderay G.C. 1995, 22). Radar signals have the advantage of not being affected by adverse weather, their

independence from lighting conditions as well as the great ranges over which they can be detected.

Ships should be fully illuminated during the night or in conditions of poor daytime visibility. In addition hospital ships and medical aircraft can use one or more all-round blue lights flashing at a rate of 60 to 100 times per minute. Flashing lights on vessels should be placed as high above the hull as possible and should be visible from any direction at a distance of at least 5 kilometres (Cauderay G.C. 1995, 25).

In order to allow identification by submarines, hospital ships can use underwater acoustic transmitters which are towed behind the vessel, emit signals approved by the conflict parties continuously or at set intervals and are detectable by submarines at a range of up to 40 kilometres (Cauderay G.C. 1994, 274).

Humanitarian workers should also be clearly identified with badges, tabards or jackets. Political or religious connotations of symbols as well as colours used on identifiers, for example crosses, should be carefully considered.

However, increasing visibility by using identifiers may reduce the security risks related to the conflict but may increase the risk of being targeted, especially by "ordinary" criminals. While conflict parties may accept movement of a convoy, the clear identification may attract criminals and bandits who do not respect the humanitarian organization. Depending on the situation and the attitude of the authorities as well as the general population, humanitarian organizations must carefully weigh the advantages and disadvantages of identification and may decide to prefer keeping a low profile.

Continuously gathering and analysing information is vital to adapt to the sometimes rapidly changing security situation and anticipate potential risks. Formal and informal sources of information are colleagues, the local population, local authorities, police, military, public transport organizations, other humanitarian organizations and various media sources.

The analysis should allow determining current risks as well as patterns and trends of developments. The analysis attempts to identify groups which could pose a threat (rebels, guerrillas, bandits etc.) and the weapons they use as well as areas or place with an increased security risk.

A site of a hospital or planned distribution may have changed hands over night or the front line may have shifted to cross a previously safe transportation route. All formal and informal sources of information should be utilized. Local inhabitants often have access to important informal information. They understand the local language and traditions much better and are in closer contact to the local community.

The effective and rapid distribution and circulation of updated security information is just as important as the information collection.

The collection of information may be considered as suspicious behaviour and authorities may accuse humanitarian organizations of spying. While this may not be entirely avoidable, information should be collected discreetly and taking photographs in public for example avoided. When humanitarian organizations assess the dynamics of military activities, determine areas with potential military targets and location of front lines, they will inevitably touch on sensitive information.

All available information should be shared with other humanitarian organizations, who may also be a valuable source of vital security information, formally and informally. However they may be reluctant to share information and, especially in acute emergencies, no single organization may be in charge for centralising all relevant information.

All staff must keep being aware of possible security risks. When living and working in insecure areas there is a danger of getting used to security incidents and reducing the sensitivity to potential threats. The security situation can deteriorate very rapidly for example at a checkpoint or in a crowd and even if staff feels safe it must be conscious of the possibility of rapid changes.

It is also important to take any kind of verbal or written threats seriously and report them to the security coordinator. They must analysed to determine who could be behind these threats, why they have been expressed, what objective might be pursued and what preventive and protective measures may be appropriate.

All staff should take interest in their surroundings, carefully observe their environment and register unusual activity or behaviour of combatants, refugees as well as the local population. The local population is likely to be more sensitive to dangerous developments and their behaviour should be taken as an example. If suddenly the market closes and everyone goes home there is probably a good reason. Unusual noises as well as sudden silence can be signs of imminent events. If for any reason staff feel that something strange is happening or are uncomfortable about the situation they should return back even if the risk is not tangible.

When walking or driving in an unknown place or area a guide should be used who knows the area as well as the route. Getting lost or walking or driving astray into a combat area or mined area can be dangerous.

Constantly being alert and considering the possibility of an incident or emergency will allow to be better prepared.

The most elaborate security plan and detailed security rules are only as good as the discipline of staff to comply with them. Everyone must be aware that a single person can jeopardise the security of a whole group by wrong behaviour for example if one vehicle of a convoy passes a checkpoint without stopping or by abusing an armed combatant.

In high risk areas inexperienced staff should be accompanied by more experienced staff who will better avoid risks and react more appropriately in emergencies.

It is vital for all staff newly arriving at a place to immediately be briefed about the security situation. Otherwise staff may expose themselves to severe risks by visiting areas which do not appear dangerous or straying into a minefield.

Regularly updating security information and carefully analysing the security situation allows determining high risk areas or situations. Some areas or places may be more dangerous at certain times of the day, for example during dark, or on certain days, such as religious holidays or during an offensive. Trips should be carefully planned to allow arriving at the destination before dark or a curfew. Sufficient time for unplanned events such as a vehicle breakdown must be taken into consideration. In case the destination cannot be reached on time, safe places for staying overnight should be determined in advance.

In many places it may not be advisable to use public transport.

Wherever possible high risk areas should be avoided altogether or entered during the time where the risk is expected to be at a minimum. Alternative routes can be selected, even if they require a significant detour, aircraft can be used if land routes are not safe or field trips and distributions can be cancelled altogether. In light of a tense security situation certain visits or trips may no longer be indispensable.

Curfews must of course be carefully complied with since humanitarian organizations are not exempted. It is important to keep in mind that combatants are of course nervous and might shoot at people or vehicles in legitimate self defence in case of doubt without any bad intent.

In case movements during curfews are required for example to evacuate sick or wounded, the authorities must be informed. Vehicles should be illuminated and must stop at checkpoints or when requested by combatants.

Even if preparedness and precautions may not reduce the immediate risk they can help to limit harm and damage if they do occur. Humanitarian organizations must have contingency plans and be prepared for medical emergencies, hostage taking, evacuation of staff etc.

Humanitarian organizations must maintain a permanent security service which can be contacted any time for calling for assistance and obtaining security information. This could be a radio room which is in contact with the security coordinator or the security coordinator her/himself.

If kidnapping is a risk, finger prints, pictures as well as a sample of handwriting of all staff should be taken.

Maintaining a good physical condition helps to cope in emergencies.

Whenever leaving residences or the workplace, staff should permanently carry telecommunication equipment, either a VHF radio or a mobile phone with them. All vehicles must be furnished at least with VHF radios and additionally with HF radios for field trips. All staff must know how to use telecommunication equipment and the radio channels or telephone numbers for calling help. The radio room must be informed whenever people leave residences or offices on foot or with a vehicle. For field trips a detailed contact schedule must be left with the radio room. Dead spot or areas where communications are poor (for example in a gorge) should be taken into consideration. The radio room at the expected destination must be informed of the expected arrival time. In case the vehicle does not arrive as expected, a search can be initiated.

A global positioning system allows informing the security coordinator of the exact location of a person or a vehicle.

Whenever walking or driving, staff should know exactly where they are and where they are going as well as be aware of sanctuaries where they can take cover or refuge in case they feel threatened by crime, are followed or chased (Roberts, D.L. 1999, 17). These could be police stations, guarded parking lots, embassies, hotels, guarded houses of acquaintances or just a busy area. Getting lost can be extremely dangerous, especially at dark. If the area is not well known, a guide or at least accurate maps should be available.

Routines, which make potential victims very predictable, should be avoided and the time of departure from home as well as routes to work varied if possible.

Attention should be paid to any signs of surveillance of houses, offices or travelling vehicles since this may be a sign for preparation of an attack. Surveillance in offices and residences can be impeded by using shades, curtains or blinds on all windows. Telephones should be placed away from doors and windows through which they can be observed.

People should never walk alone. Depending on the security situation it may be mandatory for at least two vehicles to travel together. In case of a security incident the second vehicle can call help, provide assistance and evacuate people from the first vehicle if necessary.

Staff should also know what station or person within their own organization as well as in other organizations to contact in case of an emergency. Before leaving a residence or office, telecommunication equipment should be checked and the radio room should be informed of the names and exact destination of any party. This will not prevent security incidents but will allow providing assistance faster in case of an emergency.

Vehicles should be carefully maintained and checked before leaving, especially on field trips. A break down in a high risk area or during dark could be extremely risky. Proper maintenance of vehicles also increases the chance of escaping successfully in case of an attack. Driving in the dark without having checked the fuel and the spare tire is a recipe for trouble.

A complete first aid box should be available in every vehicle and checked regularly to immediately provide assistance in case of injuries caused by vehicle accidents, anti-personnel mines, shooting or shelling. In high risk areas it is useful to carry a foldable stretcher in every vehicle so injured people can be evacuated. In high risk areas people should carry a compression bandage with them which can be used immediately to stop bleeding in case somebody is shot or injured by a mine.

When driving all windows should be kept closed and all doors locked. If driving during dark is inevitable, only well lit roads should be used. The vehicle speed should be adjusted to avoid having to stop at traffic lights since a stationary vehicle is much easier to attack than a moving one.

Humanitarian organizations must be prepared for medical emergencies. Drivers must know the location and shortest routes to hospitals. Hospitals and ambulance services should be contacted to assess their availability and quality of services. Private companies, peacekeeping forces etc. may agree to evacuate staff by helicopter or aircraft when necessary. The accessibility and security of airfields and airports for international emergency services which will repatriate staff in specially equipped jets should be assessed.

In case the security situation deteriorates but evacuation is not possible because of fighting or blocked roads, staff may be confined to their offices or residences for days or weeks. Humanitarian organizations must therefore plan for such a prolonged stay. Apart from their own staff, humanitarian organizations have to be prepared to care for injured or sick people from the local population. It is not uncommon that a large number of people seek refuge in the compound of humanitarian organizations which will require at least water and food.

Functioning and reliable telecommunication equipment is essential for informing and regularly updating other locations and head offices about the situation. Staff will need safe water, food, cooking utensils, emergency lighting, places to sleep and a safe shelter. If possible a generator set to provide electricity for telecommunication equipment and lighting should be set up in a safe place. Material for providing first aid and basic medical care to sick or injured people who cannot be evacuated must be available. Depending on the climate, heaters and fuel may also be necessary. As far as possible one or two vehicles should be protected in a shelter to prevent damage and be available for immediate evacuation as soon as the security situation has improved again.

Insurances for vehicles, assets and buildings will not reduce the risk of security incidents but will limit the financial losses in case property is damaged or lost. However insurance fees may be prohibitively expensive for war zones.

Even if the situation seems calm, humanitarian organizations should always be prepared for an evacuation. The political situation can deteriorate very quickly and front lines can shift unexpectedly very quickly. The security coordinator needs to consider what situation or incident would justify and "trigger" an evacuation.

Humanitarian organizations need to plan where to evacuate and whether by road or by air. Maps should be available which indicate airports and evacuation routes. The travel distance and time to the next safe town, city or border should be known.

If evacuation by air is considered, security coordinators must know whether landing and take-off during dark is possible and permitted by the authorities. Information such as exact

location, altitude, length of runway etc. for pilots which are unfamiliar with the airstrip or airport should be determined and recorded. Equipment must be available for illuminating airstrips during dark either with flares or by vehicles parked besides the airstrips and pointing their head lights in the landing direction.

All staff must have valid travel documents including valid visas and travel permits ready. They should be prepared to pack valuables and essential belongings at short notice.

A plan must be made which staff is less important and should be evacuated first. Plans for leaving somebody in charge of the security of the compound behind should be made.

The evacuation plan should include a list of documents which must not be left behind and be either taken or destroyed. Continuously updating stock positions will allow to assess the loss or damage in case stocks cannot be evacuated and are important for later insurance claims.

Vehicles must be carefully maintained and dedicated and fully equipped vehicles (or boats) must be refuelled daily and always be ready for an evacuation. Vehicles should always be parked in the direction of the entrance to allow a quick departure. Vehicles, boats or aircraft must have sufficient capacity to transport the expected number of passengers.

Contingency stocks of fuel for vehicles and aircraft must be maintained. Drivers for vehicles, including trucks if necessary, should be available. If trucks need to be hired for evacuating equipment and stocks, their availability should be assessed.

Administrators must elaborate a plan for all national staff. They may be evacuated, their contracts maintained or given a severance pay and be dismissed.

6.2.2 Preventing intrusion

The entering of unauthorized people can lead to theft, robbery, looting, physical assaults or kidnapping. All buildings should be guarded by security staff who check all entering visitors and vehicles. Unknown visitors can be asked to remain at the gate until identified by a known staff member. In private residences any unexpected visitors, especially after dark, should raise suspicion.

In countries where carrying weapons is common, these should not be allowed inside offices or warehouses. Some visitors may be moving with body guards. Weapons should be left with the security guard or outside with the companion, driver etc. of the visitor.

General measures to prevent or at least impede intrusion are the use of physical barriers, guards and implementing strict access control. Lighting of premises and installation of alarms will deter intruders as well as allow detecting them earlier. Measures for facilitating escape in case an intrusion could not be prevented, should be taken.

Intrusion can only be prevented effectively if several measures are combined. For examples a perimeter barrier alone will only delay intrusion but not prevent it.

Physical barriers may not prevent intrusion but can deter and delay intruders. Measures to prevent intrusion which are visible will discourage intruders and encourage them to seek another less protected target. Fences and walls protect guards and force vehicles and people to enter at certain places which allows controlling access properly. Walls also provide a certain degree of protection against weapons.

Walls and fences impede intrusion and are also a deterrent since intruders take a greater risk by entering premises which they cannot scout out before. They cannot determine whether guards are patrolling the premises and locate niches for hiding after they have scaled the wall or fence.

Concrete, brick of stone walls should be at least 3 metres, fences at least 2.5 metres high. The difficulty of climbing walls can be increased by half rounded tops, placing chips of broken glass or metal spikes on the top. The effectiveness of barriers can be increased by placing barbed wire or electric fences on top. Fences and walls with protruding tops are also more difficult to climb. In addition fences and walls can be topped by extension arms with barbed wire. Trees near fences or walls should be cut or covered with barbed wire.

Fences should be covered by screens, timber, hedges etc. to prevent intruders from scouting the premises, observing guards etc. The inside of the perimeter should be cleared from objects and brushwood in order to allow guards to observe any intruders and prevent intruders from hiding. Any bushes or trees close to building which might hide intruders should be removed or at least cut back.

Any openings below fences or walls such as drainpipes must be blocked with metal gratings.

Ladders or other devices should be available at the back side of the premises to allow occupants to escape unseen in case of an attack.

The number of gates should be kept to a minimum. Fences and walls must be furnished with robust doors or gates for vehicles and a separate entrance for pedestrians. Spikes or barbed wire should be placed on the top of doors or gates to provide the same degree of protection as fences or walls.

Figure 6.2 Perimeter wall with barbed wire

Frames of exterior doors must be made from metal, stone or solid timber and must be able to resist attacks. Strong hinges will prevent removal and tearing the door out of its frame. Sturdy horizontal and vertical bolts are needed for closing doors and gates. In addition they must be lockable. Locks should be sturdy using bolts with padlocks or crossbar.

The doors should be furnished with spy holes or door viewers which can be closed so guards can check visitors before opening the door or gate.

Gates must be kept closed and locked at all times and only opened by the guards to allow vehicles are visitors, which have been identified before, to enter. Gates which are not permanently manned must be bolted and locked.

Figure 6.3 Main gate with guard building

However keys must be available for leaving the premises in emergencies.

The perimeter of buildings, walls and fences as well as their vicinity should be illuminated in the dark. Illumination increases the risk for intruders to be detected and makes it more difficult for them to hide before or after they have cleared the perimeter barrier. Lighting greatly increases the efficiency of the work of guards. Illumination should be as even as possible and eliminate any dark areas and shadows. The entrance gate as well as the area in front should be illuminated to reveal and identify approaching pedestrians and vehicles.

Neon or halogen lamps as well as light bulbs which are protected from water and moisture, can be fixed on top of polls, on top of walls and fences or on buildings. Light switches, especially for lights fixed on buildings, must be accessible from the outside so guards can switch them on and off without having to enter the building. Lights may also be activated by infrared movement sensor which will switch on the light if the building is approached by a person.

Illumination throughout the night may be nuisance to neighbours which should be considered during planning.

In offices and residences the main entrance should always be illuminated in the dark. Lighting should also be fixed in corridors, staircases and in front of apartment doors.

If the power supply is not reliable, installation of an emergency lighting system should be considered.

Outside doors in buildings must be made from sturdy timber or metal. Solid hinges should be protected by bands. Doors must have strong cylinder locks and can additionally be secured by bolts with padlocks or crossbars. Glass panels in doors must be protected by a metal grating and should be covered with a curtain. Where existing doors are not strong enough, they should be replaced by a metal door. Alternatively an additional metal gate, steel roller shutter or collapsible metal gate with strong padlocks can be fixed in front. Sunken exits must be protected by a lockable metal grating.

Especially doors at residences should be furnished with a spy hole and a security chain.

Keys should never be marked with an address or name to prevent misuse in case they are lost and locks must be changed if a key is lost. Whenever moving into a new building all outside locks and keys should be replaced. Keys should be never left in the lock.

Exterior doors in offices and warehouses should always be kept locked when they are closed. Doors of residences should always be locked.

Window frames should be sturdy and of good quality and all windows must be protected by metal gratings, bars or steel shutters. However there must be a possibility to escape through a window from inside the building in case of a fire.

In residences windows should be permanently covered with curtains to prevent observation, especially in the dark.

Especially after dark, windows should only be left open if they are protected by bars or metal gratings.

Other openings such as ventilation ducts or air-conditioner outlets must also be secured with welded (rather than screwed) metal gratings or bars.

Glass panels fitted to roofs must be secured by metal gratings or bars on the underside to avoid intrusion through the roof.

Offices and especially residences should be furnished with safe rooms, usually bed rooms or bath rooms. These will allow staff to retreat, call for help and stay protected until help arrives, in case intruders have managed to enter the building.

A dedicated room should be fitted with a heavy metal door or strong metal grating which can be secured with a bolt and furnished with telecommunication equipment to call for help in case of an intrusion or attack.

In residences the bed room usually will be fitted as the safe room to prevent surprise attacks during the night. In any case bedrooms must always be locked at night.

Infrared detectors and intrusion alarms fixed to windows and doors can be used. They will alert occupants and guards with a siren or other audible alarm in case of an intrusion or attempted intrusion. This alarm will allow occupants to retreat to a safe room and allow calling for help. Alarms can also be connected to control rooms or the police which will send assistance when needed.

Alarms may cause intruders to panic and become violent. Therefore these alarms should only be used if the building is not occupied or the occupants have the possibility to take refuge in a safe room.

Alarm systems must be reliable and continue to operate even if the mains electricity supply fails or is interrupted by the intruders.

All premises and buildings should be secured by guards around the clock. Private security companies have the advantage that they have experience with security and crime in the area, have an established infrastructure, can provide backup (response unit) in case of an emergency and can provide trained staff. A contract which details the exact responsibilities and duties of guards should be signed.

Alternatively guards can be hired by the humanitarian organization who must then train them and provide them with detailed instructions on their duties. The humanitarian organization must then also set up and maintain their own communications infrastructure and establish a contingency plan in case of an emergency.

Guards should be clearly identifiable by uniforms and badges. They must be provided with suitable clothing, flashlights, whistles or hand-alarms and hand-held radios. Guards must be able to contact the security coordinator or radio room at any time and must be able to contact the police or military in case of an emergency. Hand-held radios are also essential for guards to communicate among each other.

Humanitarian organizations must decide whether guards should bear arms or not depending on their security policy and the overall security situation.

Guards control access of people and vehicles to the premises and patrol premises to detect intruders and fires. The presence of guards itself increases the risk for intruders and acts as a deterrent.

Guards should regularly patrol the entire premises according to a defined plan and time schedule. The routes and timing of the patrols should be varied so they cannot be predicted by intruders. They must check that no objects are leaning against or stacked near walls and fences and ensure that the surroundings are kept clear of objects which intruders could use to hide. They switch on the security lighting during dawn and ensure that all lights are working.

They must check that all gates are closed and locked, check that all external doors are locked, that all windows are closed and ensure that emergency exits are not blocked.

They must regularly check on vehicles parked inside the premises and ensure that the lights are switched off, windows are closed and the doors are locked. Loaded trucks and their seals must be checked.

Guards will also check that all equipment and lights as well as electric or gas heaters in offices are switched off in the evening since they could cause a fire. They will also check that water taps are closed and ensure that hazardous materials are stored properly and securely. They should also check that fire fighting equipment is in place.

Guards, especially during the night, have the tendency to sleep and should therefore be checked by a supervisor or a security patrol. Alternatively they can be given clock watches which requires them to regularly visit certain points on the premises and record the time of their visits. The report can then be printed for checking the guards.

In order for guards to be effective they must be trained and properly instructed. They must receive clear guidelines on what is expected from them and what their duties are.

Guards must be trained in using telecommunication equipment and clock watches. They must be able to use fire fighting equipment and know how to switch off the central gas and electricity supply in case of emergencies.

Guards should received detailed instructions on their duties at the gate as well as the schedule, route and duties of patrols.

They must receive clear and written instructions how to react in case of intrusion, who they must alert and how they can call for assistance. Guards should not try to attack intruders but rather observe them while calling for help.

Guards must be advised to record and report all security incidents or suspicious events.

Access control is an essential part of any security system and should be applied to any building, office, residence or warehouse. The objective is to ensure that only authorized staff and vehicles enter the premises and only through the main entrance. Vehicles of visitors should be parked outside the premises.

Guards should check all people and vehicles before entering. Guards will recognize staff or check identity cards. Any visitor should report at the gate and the guard should call the

concerned staff member to confirm authorization for her/his entry. All visitors should identify themselves and be recorded with their name, time of entry and vehicle number in a log book.

Guards must also check people and vehicles leaving premises to ensure that nothing is stolen. Drivers must present a gate pass which authorizes them to leave with loaded goods.

Guards may also be required to record the name of passengers, destination and mileage of any vehicle that leaves the premises.

6.2.3 Preventive measures against crime and banditry

Areas in cities or the countryside which are notorious for high crime rates must be avoided. Staff should move in groups, whether walking or driving. People standing around in groups and crowds should be avoided especially if there are any signs of violence. Walking near places where people can conceal themselves such as dark doorways should be avoided.

When walking or driving one should always be alert of people or vehicles which may be following. If there is suspicion that a vehicle is following, refuge at a safe place should be sought rather than driving home. Unknown people should never be allowed to enter cars.

When moving in public staff should "dress down" and be as inconspicuous as possible to avoid attracting attention of criminals. As far as possible carrying cash and signs of foreign status and wealth, such as watches, jewellery or conspicuous cars, should be avoided and keys should not be displayed. However some cash should always be carried since frustrated robbers may quickly turn violent. Cash should be divided and carried in different places. Keeping a low profile and behaving quiet and unassuming will reduce the risk of attracting attention of criminals. On the other hand a certain degree of confidence should be displayed.

If there is suspicion that a pedestrian is being followed s/he should cross the street. If the suspicion is confirmed, the pedestrian should ask or call for help and escape to a safe place.

Personal or professional documents should only be carried if this is indispensable. Large sums of cash should not be kept since they are very attractive to thieves and robbers. Some cash however will be necessary which can be kept in concealed safes. Where available cash should be kept in a bank. More frequent deliveries of cash to offices will reduce the loss in case of theft or robbery. By paying part of the staff every week the amount of cash needed at any time can be reduced. Pay days are known and offices or staff having just received their salaries are also attractive targets. Where possible cashless means for transfer of money should be used. In offices documents, cash and valuables should be kept locked in a safe place or safe. In any case some cash should be available to hand over to robbers since they might turn violent if they have to leave empty handed.

A concealed strong-room should be set up to secure valuable items such as telecommunication equipment, computers as well as cash.

Unused rooms should be kept locked at all times and offices, warehouses etc. locked when no staff is present, even if they are left unattended only for a short period of time.

Theft of assets may not be preventable but it can be made more difficult. A generator set which has its wheels removed, is placed on blocks or bolted to a concrete slab is more difficult to remove than a generator set on wheels. Vehicles can be locked in a garage or container. If looting is expected or vehicles have to be left behind unattended, the wheels can be removed, provided that the vehicles are not needed for escaping and evacuating.

Vehicles should only be parked in safe and secured places and should always be kept locked. They should be locked inside a garage or warehouse or at least inside a guarded compound at

night. Car alarms, locks on the steering wheel and other anti-theft devices can make theft more difficult. External aerials may need to be removed and if vehicles have to be parked outside a secured compound they should be emptied as not to attract break ins and theft.

Valuables, equipment and goods should never be left outside buildings especially in warehouses. All goods should be locked inside buildings, especially at night.

In residences names should not be displayed on mail boxes or at the gate. Keys should never carry tags with names or addresses. If it is inevitable to give keys of private residences to other people such as staff members, a separate lock should be used at night for which only the resident has the key. Residents should be able to identify keys in the dark to avoid any delays during opening entrance doors.

Travellers may be particularly exposed as they usually carry money and valuables and may be unfamiliar with the area. Information of the security situation along the route and at the destination should be obtained before leaving. Travellers should leave information on their itinerary as well as the expected arrival time behind. Contact numbers at the destination should always be carried in case assistance is needed. Passport, cash and air line tickets should always be kept on the person and briefcases and luggage should never be left unattended. A set of photocopies of the passport and other documents should be left at home and another set carried separate from the original documents.

As far as possible direct flights should be scheduled to avoid staying overnight in possibly insecure places. Pickup by office staff from the airport in vehicles owned by the humanitarian organization should be arranged to avoid having to travel by taxi.

In hotels rooms near to elevators which avoids having to walk down long corridors should be preferred. The windows should always be kept closed, curtains drawn and doors locked. Vehicles should only be parked in guarded and well-lit areas.

Travellers should be suspicious of individuals which may be posing as security officers or police men and should obtain proper identification.

The ground floor should be avoided but rooms below the 7th floor should be preferred since they are safer in case of a fire.

As far as possible use of public transport should be avoided. If its use cannot be avoided, passengers should know the exact schedule to avoid having to wait for buses or trains. In trains only cars occupied by the driver or conductor should be used.

Moving in groups and clearly identifying staff and vehicles will reduce the risk of being arrested. All staff should ensure that all legally required documents such as visas and permits are obtained and always carry valid identification cards they can present to authorities with them. During work all staff members should carry identity cards with them proving that they are working for a humanitarian organization. Any movements should be announced to the radio room in advance. In case of longer journeys the radio room should be given a contact plan before departure. While this will not prevent arrests it will allow noticing an arrest faster.

When carrying telecommunication equipment or transporting goods which require a permission all relevant documents should be carried.

No passenger in a vehicle should carry weapons.

In general behaving in an unpredictable manner will reduce the risk of ambush, hold-ups, hijacking, hostage taking, kidnapping, carjacking and abduction. Travelling the same route at the same time everyday allows to carefully plan a hijacking or kidnapping. However alternative

routes may not always be available. Travelling with companions and where possible with several vehicles reduces the risk.

Standing or slow moving vehicles are far easier to attack than fast moving vehicles. If a vehicle stops, its doors can be opened to attack passengers. Therefore vehicles should constantly be kept moving. Wherever possible drivers should have free space in front or next to them to escape. A vehicle surrounded by others or blocked by objects on the side are far easier to stop. If someone tries to force a vehicle off the road, the driver should blow the horn and try to attract attention.

Depending on the security situation clearly identifying vehicles may increase or decrease the risk. Where humanitarian organizations are well respected large stickers and flags will increase security. Otherwise using inconspicuous vehicles which are commonly used in the area are preferable.

Whenever travelling in a vehicle the doors should be kept locked. This will prevent assailants from flinging open a door to attack passengers or to hinder the vehicle from moving on.

In buildings strict access control and measures to prevent intrusion should be implemented.

6.2.4 Preventive measures against conflict related risks

In general conflict related security risks can be avoided or reduced by avoiding known conflict areas, especially at times where fighting is expected to intensify. In every group or convoy one experienced staff member should be in charge of the group as well as security measures and coordinate activities in case of an emergency.

Armed combatants must never be allowed to enter vehicles or compounds since humanitarian organizations will be accused of transporting combatants and weapons and they may therefore become a legitimate targets. Especially encountering the other conflict party with an armed combatant in a vehicle is obviously dangerous. However combatants may be very reluctant to part with their weapons. In case a combatant needs to be transported in a vehicle during a medical evacuation s/he should leave her/his weapon with a colleague.

Warnings of military authorities or combatants should always be taken seriously even if the objective only seems to be obstructing provision of humanitarian assistance. Especially updated information on the conflict situation at checkpoints should be carefully considered.

If warning shots are fired pedestrians or vehicles should always turn back immediately.

The vicinity of possible military targets such as barracks, power stations, waterworks, government buildings, bridges and airports should be avoided.

For avoiding combat situations (shooting, shelling), updated information on the security situation should be obtained before travelling even for short distances. Telecommunication equipment must be at hand at all times to allow calling for assistance immediately in an emergency. Places along the routes which provide protection from shooting or shelling should be identified in advance to allow seeking the nearest shelter without delay in case fighting erupts.

The risk of shelling and bombing is an important consideration when selecting buildings for offices, residences or warehouses. The vicinity to potential targets such as military installations, bridges, airports, power plants, main roads etc. which are likely to be attacked should be avoided. Current risks as well as the dynamics of the conflict should be considered.

Places which are known to be exposed to snipers should be avoided.

When travelling in vehicles windows should be kept half-open to allow hearing combat related noises (shooting, explosions) earlier. No radios or music should be played. The doors should not be locked to allow a faster escape if necessary. While vehicles itself may not pose any security risk, vehicle breakdowns in an exposed place may increase the risk of attacks and make it impossible to escape quickly.

Hazardous materials, especially fuel, should not be stored in or near buildings. While this will not prevent attacks it will prevent an explosion or fire in case the building is hit by shells or bombs.

Combatants should be notified about the position of residences, offices and warehouses and provided with exact (GPS) coordinates. Professionally trained soldiers and pilots will mark these places on maps to avoid targeting them. Identification by flags etc. may not be visible from high flying aircraft or in bad weather. Moreover pilots have other things on their mind than looking out for such signs during an attack although signs will help pilots to confirm their briefing (Roberts, D.L. 1999, 53).

The possible threat of mines, booby traps, bombs and improvised explosive devices always needs to be considered. Before travelling or walking in an area, information about known and possible mine fields should be gathered. Humanitarian organizations should keep updated maps with known risk areas which can be consulted before every field trip.

The location of mines is often not available from military sources. However authorities, police, public transport organizations, local people, staff members, drivers, other humanitarian organizations or a mine detection centre may be able to provide information. While travelling, updated information may be available from checkpoints. The location of mine fields may also be marked especially in areas where mine clearing is under way. All staff should be familiar with the means of marking mined areas such as with flags or coloured stones. Even if the location of mines may not be known, local people will be able to advise on routes which are routinely used by vehicles and which have proved to be safe.

In areas where fighting or movement of combatants has recently taken place there is an increased danger of land mines. Passengers should look out for suspicious signs such as surface irregularities, colour contrasts, bumps, freshly turned earth or obstacles in the middle of a track or road. The absence of traffic on a road as well as visible wheel tracks on unpaved roads should arouse suspicion.

When travelling in unfamiliar areas a guide who has a good knowledge of the area and its dangers should be used. Vehicles must always stay on the road and must not drive on the verges or shoulders of roads. If a vehicle needs to turn on a road, it must continue until reaching a safe place which is known not to be mined, for turning. On narrow roads vehicles can give way to oncoming traffic only by making way at safe places where the sides of the roads are known not to be mined. In case of doubt one of the vehicles will have to reverse until a safe place is reached where the vehicles can pass.

The windows of vehicle should be kept open to prevent injury by shattering glass and the driver as well as passengers should wear seat belts. A distance of 150 metres should be kept between cars. This will avoid injury of passengers in vehicles following behind if the first vehicle hits a mine. Vehicles following behind another should drive in the same tracks.

Obstacles on the road may be mined or booby-trapped or be intended to make vehicles leave the road and drive onto a planted mine. Potholes and puddles should be avoided. Roads that were safe the day before may have been mined in the meantime. Therefore driving on a road as the first vehicle in the morning should be avoided.

Paved and tarred roads are safer than dirt roads and should be preferred. New and unknown roads should never be used unless it is certain that they are not mined.

Passengers must also stay on the roads for example when leaving a vehicle for changing a tire.

A safe distance must always be kept to any security forces, military vehicles or military convoys as they may be targets of ambushes, remotely set off explosive devices and bombs.

People should not enter premises which may be mined. When walking in unfamiliar areas a guide should be used who will know the mined areas as well as safe places. Abandoned premises, Abandoned military installations, old front-lines, trenches, buildings, ruins and wreckage and even dead bodies may be mined or booby trapped. Pedestrians should look out for any suspicious signs such as empty crates, boxes, canisters, wires, barbed wired and any unusual equipment. A dead animal may have been killed by a mine. In case a suspicious object or obstacle on a road is found it should never be touched. Passengers or vehicles should turn back and inform de-miners.

Places which are likely to be mined are (former) water points, military objects, checkpoints, roadsides, bridges, borders, front lines and places suitable for ambushes.

Land mines may be displaced by heavy rainfall or water courses and river banks must be considered as risk areas. Sandstorms may also displace mines or bring them to the surface.

Objects on or next to the road, whether they look like a mine or not, should never be approached or touched.

Places or areas which have been cleared of mines are not entirely safe as it is very time-consuming and difficult to clear 100% of the mines.

Planting of bombs and explosive devices in buildings or on premises can be prevented by rigorous access controls and measures to prevent intrusion. Vehicles of visitors should not be allowed to enter the premises and must be parked outside. The parking directly in front of buildings or perimeter walls or fences can be prevented by setting up concrete boulders. All staff should be vigilant and report odd or suspicious objects on the premises.

Staff dealing with receipt and distribution of mail should be trained to detect suspicious mail and parcels. All staff should be alert to people which behave strangely (nervous, frightened) as well as objects which seem to be out of place.

Bomb threats should always be taken seriously, the buildings evacuated and the authorities and police informed.

Keeping corridors, stairways and rooms clean and tidy will reduce the risk of explosive devices being installed undetected. Rooms and cupboards which are not being used should be kept locked. Premises should be kept clear of debris and rubble and should not be allowed to overgrow with vegetation.

6.2.5 General protective measures

Protective measures are designed to prevent or at least reduce the impact and consequences of a security incidence. The main objective is to prevent or at least reduce harm and injury to staff and damage to buildings and assets when risks could not be prevented or measures where not sufficient. Protective measures may be directed against crime, banditry, indiscriminate attacks as well as conflict related threats.

Protective measures should be discreet and never have a military appearance. A balance between effective protection and withdrawal from the community and displaying a "fortress mentality" must be found.

Protective measures can be passive such as blast walls and shelters or active, such as armed escorts.

6.2.6 Protective measures against crime and banditry

The main means of protection during any kind of attack or intrusion is to escape to a safe place and call for assistance.

In a building all occupants should gather and barricade themselves in the safe room or shelter. When walking or travelling in a vehicle escaping to a known safe place may be advisable depending on the situation.

In any case armed attackers or intruders should not be resisted and money, valuables or equipment handed over to them if demanded.

6.2.7 Protective measures against conflict related risks

Active and passive protective measures are designed to prevent or reduce harm and damage in case preventive measures where not able to prevent security incidents.

Even if the humanitarian organization and its programmes are well accepted, preventive measures against indiscriminate attacks must be taken. Moreover targeted artillery or bombing may miss the intended target.

The main objective is preventing harm to people and in the second place preventing damage to equipment, assets and buildings.

Protective measures may make the civil or military authorities suspicious or uneasy as they may think that the humanitarian organization may have some information about an imminent attack the authorities do not know about.

Protection against biological weapons can be provided by gas masks which prevent inhalation of the infective agent or by filtration systems in buildings or shelters. Gas masks as well as special suits are needed for protection against chemical weapons. Humanitarian organizations are unlikely to work in an environment where biological or chemical weapons are used. However some protection will be needed during evacuation.

In combat situations, helmets and protective (flak) jackets offer some degree of protection to staff from (small) fire arms. If such protective equipment is necessary, humanitarian organizations are taking very large risks and their presence must be well justified by the importance of their assistance. Protective equipment may be very coveted by combatants.

Flak jackets are not designed to stop bullets but rather offer a low level protection against blasts, shrapnel, glass splinters etc. for the chest, back and neck and should be used together with helmets (Roberts, D.L. 1999, 89).

Ballistic (bullet-proof) jackets, which can be enhanced by front and back plates, protect against small calibre pistol and rifle rounds and should always be worn together with a helmet. These may be considered for drivers or staff working near or crossing front-lines.

Helmets are usually not designed to stop bullets but will protect the head against blasts and shrapnel. The neck strap must always be tightly fastened to prevent the helmet from flying away during a blast.

Vehicles furnished with light armour can offer limited protection against small arms fire as well as blasts from shells and anti-personnel mines. However armoured vehicles will offer no protection against snipers, high calibre ammunition, mortars, artillery shells or light anti-tank weapons which are widely used in conflicts (Greenaway, S., and A.J. Harris 1998, 18). Armoured vehicles are heavy and may require special training of drivers. For added security armoured vehicles should be used in pairs.

Protective measures should not give a false sense of safety and tempt people to increase the risks they take.

Protective measures for buildings are mainly intended to protect people inside the building during targeted or indiscriminate shooting, shelling, mortar or grenade attacks, bombing or detonation of explosive devices but will also prevent or decrease damage to the building itself. While it is impossible to protect a building from a direct hit, the impact of a bomb or shell exploding near a building can be reduced and injuries to people can be prevented or reduced. However protective measures can provide excellent protection against small arms fire, grenades as well as the effects of blasts.

Window panes or glass panels in doors in the vicinity of an explosion will be shattered by the blast wave of an exploding bomb or shell. Pieces of broken glass flying at high velocity can injure, maim and even kill people inside buildings and damage equipment. People can be protected from these pieces of broken glass by completely covering the inside of the pane with a transparent adhesive plastic or polyester foil which is also called anti-blast film. If transparent foils are not available large stickers can be used (Roberts, D.L. 1999, 84). Placing strips of adhesive tape crosswise on windows does not provide efficient protection.

Other means are long and heavy curtains, mosquito-netting, metal plates (3 mm), wooden shutters or timber planks nailed to the window. However these must be closed at times of high risk and timber will not offer any protection against shrapnel or bullets. Alternatively bricks or sand bags can be stacked in front of the window.

For protection against sporadic small arms fire and fragments 1 cm of steel, 20 cm of concrete, 40 cm of bricks, 75 cm of sand, 90 cm of timber wood or 100 cm of soil are needed. Continuous firing will require doubling the thickness (Roberts, D.L. 1999, 86).

Gratings or metal chain link fences in front of windows and buildings are an efficient protection against grenades. The grenades will either bounce back or explode at a safe distance (Roberts, D.L. 1999, 49).

Safe rooms or safe areas are suitable to protect people during short periods of time from sporadic small arms fire as well as mortar and grenade fragments. Safe rooms should be located inside a building away from external walls, have no windows and no doors directly to the outside. If such a room is not available, any openings towards the outside must be protected by blast walls. Corridors, bathrooms or toilets may be used.

In any case a telecommunications device with an emergency power supply must be available.

Blast walls in front of windows and doors will deflect the blast of an explosion and offer a physical barrier against bullets, shrapnel, debris as well as blasts from artillery or mortar fire. Blast walls can be used for protecting entrances of buildings and shelters, windows, fuel tanks, water tanks, generator sets as well as provide cover for reaching shelters. Offices, residences as well as warehouses should be protected (Roberts, D.L. 1999, 81).

Blast walls are made from sandbags which are supported by timber logs or planks to hold the sand bags in place.

Sandbags should be around 60 - 80 centimetres long, 30 - 40 centimetres wide and are ideally made from jute which should be impregnated to protect it from bacteria and fungi. Smaller sandbags are better than big ones since they are easier to lay properly. Plastic or polythene can be used but they rot when exposed to sun light and can break open. The bags can be filled with pure sand, with one part cement mixed with ten parts of dry earth or one part of cement mixed with six parts of sand a gravel. As the bags absorbs moisture the mixtures solidifies and bags containing cement last longer. Two people can fill around 60 sand bags per hour which is sufficient for approximately two square metres sandbag-wall protection. After filling, the necks or "chokes" of the sandbag are tied with a string (Roberts, D.L. 1999, 76).

If no sand bags are available, other receptacles such as boxes, baskets or oil drums can be filled with sand, earth or rubble. Other alternatives are to use sods, pile up bricks or build a second wall (Roberts, D.L. 1999, 77).

Sandbags should be laid in horizontal layers like bricks overlapping each other which greatly improves the strength of the wall. In the first layer ("headers") the sandbags are placed perpendicular to the wall and in the next layer parallel ("stretchers") to the wall to increase overall strength of the blast wall. The blast walls are built of alternating layers of "headers" and "stretcher" and the joints in adjacent layers must be staggered ("broken joints"). Neither the necks nor the seems should point to the outside to prevent the sandbags from bursting and each bag must be compacted by beating with a shovel or board. Sandbags should be filled only to three-quarters and the tied end tucked in when laying the sandbag (Roberts, D.L. 1999, 78).

Figure 6.4 Sand bags protecting openings of a building

The great advantage of sandbags over concrete protection is that the sand trickles and closes any (bullet) holes (at least if the sand or rubble is dry). On the contrary, repeated hits of the same place of concrete creates a hole and the protection disappears.

In case of an attack by fire arms, artillery or bombing, shelters which can be located in the basement of sound buildings or be purpose built, will protect people for several hours or even

days from heavy weapons such as artillery and bombs. However they usually will not withstand a direct hit.

In principle shelters should be available at all buildings or premises where staff work or live such as offices, residences, workshops and warehouses.

Shelters must allow accommodation of all staff which are usually working at any site. Shelters must be carefully planned and designed properly by a competent engineer to ensure that they provide adequate protection.

Cellars of sound buildings or underground facilities such as garages are by far the best shelters apart from purpose built bunkers. Any windows or entrances leading directly outside must be protected with blast walls. However underground facilities must be safe from water infiltration.

If no basement is available an underground shelter should be constructed either from concrete or by using a ISO shipping container. If an underground facility is not available or cannot be constructed, the windows and doors of a room or building above ground can be reinforced and protected with blast walls.

Alternatively a sandbagged shelter can be constructed above ground by placing timber logs or planks, metal sheets or metal poles across the blast walls and covering the roof with two layers of sandbags. Wherever possible sandbagged shelters should be built next to existing walls. The entrance must be protected by an angled blast wall.

Approximately one square metre surface is needed per person for short stays and two square metres for longer (overnight) stays. The larger and higher a shelter, the weaker it is. The size should therefore be calculated to accommodate all people who will need protection but not more. Building (unnecessary) large shelters is time-consuming and can be expensive.

The shelter must be very near the building where staff is working since it is pointless to have to run across an unprotected area during shelling to reach the shelter. Ideally the shelter will be located in the basement of the building so that staff does not need to leave the building when running to the shelter. If the building has no cellar, the shelter should be located in the adjacent building. Short distances between a building and a shelter can be protected by blast walls. These can be low since people can crawl to the shelter.

Wherever possible shelters should have two entrances to provide an exit in case one of the entrances becomes blocked by rubble during an attack.

Shelters must be furnished with some essential equipment and items since people might be forced to stay for considerable time.

A reliable means of telecommunication such as a radio or telephone is essential to inform other people of the attack and call for help. These can be permanently installed in the shelter or a connection to the aerial can be installed in the shelter to which a portable radio is connected which is taken to the shelter. A backup aerial should be available in case the aerial is destroyed during the attack. A charged battery must be available to power telecommunication equipment. A connection to an existing generator set should be installed and a small generator set with a stock of fuel can also be installed in the shelter as a backup. Emergency lighting and, depending on the climate, heaters should be available (Roberts, D.L. 1999, 84).

Bottled drinking water and some water for basic hygiene, food, torches, candles, blankets, sleeping mats and a chemical toilet should be available. Some basic furniture such as chairs and tables may be useful. If possible the shelter should be connected to kitchen facilities and a toilet.

Tools for digging out buried people such as pickaxes and shovels as well as a medical kit and a fire extinguisher should be available.

All people who may be using the shelter must be briefed on its location, entrances and available equipment. Everyone must know where the key for the shelter can be found. A simple short phrase such as "air attack" should be agreed upon which allows to quickly warn all people without lengthy explanations.

Air-raid shelters are built underground, constructed from reinforced concrete or can be installed in the cellar of a building and need to be planned by a professional engineer. They will not protect against a direct hit but provide excellent protection from the effects of blasts (Roberts, D.L. 1999, 52).

Pilots may fly over their target before bombing it. Therefore people should take shelter immediately when a military aircraft appears rather than wait for the second pass during which bombs may be dropped.

Pedestrians cannot protect themselves against the impact of anti-personnel mines. Anti-tank mines are designed to be activated by pressures above 100 kg but may be activated by pedestrians or bicycles. Anti-tank mines may be furnished with an impulse counter and therefore not explode when the first vehicles passes over.

Conventional vehicles cannot be protected against anti-personnel (AP) although installation of ballistic blankets which are sealed directly to the body of the vehicle may offer some limited protection to occupants and reduce the extent of injuries. Anti-tank mines will totally destroy vehicles.

Vehicles should not drive faster than 30 - 50 km/h since it is impossible to escape the blast if a vehicle hits a mine but the consequences of an accident, which inevitable will follow hitting a mine, will be more severe if the vehicle is moving faster.

The driver and all passengers, including those on back seats, should wear safety belts. Earplugs will protect hearing in case of a blast and glasses or sunglasses protect the eyes from splinters of shattered glass.

Armed protection against attacks by criminals or combatants is at least controversial among humanitarian organizations. "Clearly, it is the physical protection of humanitarian operations which raises the most controversy among relief agencies" (Greenaway, S., and A.J. Harris 1998, 22). There is a broad consensus that the use of armed escorts is to be avoided as they tarnish the image of humanitarian organizations, pose problems of liability in case the use of force results in harm and may increase the likelihood of being attacked (ECHO 2004, 74).

Humanitarian organizations will usually prohibit their staff from bearing arms or keeping arms at home for personal protection. However if individuals do bear arms they must comply with national legislation and regulations. Arms can deter criminals but might also provoke intruders to be more violent or use their own arms. The use of fire arms for example against intruders may result in criminal charges and civil claims.

People can be protected by armed body guards, buildings by armed security guards and convoys by armed escorts. Armed guards may be hired from private security companies, be provided by the police, the military or peacekeeping forces.

If at all, armed protection should only be used as a last resort and need to be considered very carefully. Humanitarian organizations are usually considered as "soft targets" and armed protection is a means of "target hardening".

Armed guards may be used to protect staff, offices, warehouses, air ports, convoys and distribution sites or only be used during evacuations.

Armed guards may act as a deterrent to attacks by criminals or combatants. However they may also raise suspicion and make the humanitarian organization a "legitimate" target in the eyes of the attackers.

Use of armed force could be seen as giving up neutrality and impartiality and taking sides with one of the conflict parties, especially if police forces or the military are used for protection. "Almost all agencies will resist collaboration with armed units, fearing association will undermine the key tenets of impartiality and neutrality which, in their view, affords them access to contested areas" (Greenaway, S., and A.J. Harris 1998, 11). Humanitarian organizations which are associated with the police force or military may be indirectly held responsible for their acts and conduct (ICRC 1997, 3).

Linking provision of humanitarian assistance with armed force may make humanitarian organizations suspicious in general. The actual use of fire arms appears to be incompatible with the ethics of humanitarian organizations. While use of armed protection as a deterrent can be considered, humanitarian organizations must not be drawn into the conflict itself.

The implications of using armed protection for other humanitarian organizations must also be considered.

If body guards or armed security guards are used a strict code of conduct must be agreed upon.

In any case the use of armed protection must not have detrimental effects or even endanger the beneficiaries and the short- as well as long-term consequences for beneficiaries should be considered. Armed protection may allow carrying out some distributions but jeopardizes the assistance programme in the long-term (ICRC 1997, 5). Armed protection should only be used as a last resort, when the lives of beneficiaries are at stake and no other humanitarian organization can provide assistance.

While it will be impossible to provide humanitarian assistance against the will of any of the conflict parties even with armed protection, use of this deterrent may be considered against pure criminality and banditry (Greenaway, S., and A.J. Harris 1998, 21). "Remember that there should be no risk of confrontation between the escort and the actual parties to the conflict or organized armed groups which control part of the area through which the humanitarian convoy has to travel" (ICRC 1997, 6).

In any case the use of armed protection must be approved by the civilian or military authorities which are in charge.

Armed guards should use separate vehicles which are not marked with identifiers of the humanitarian organization.

Weapons must only be used in self-defence to save lives of people if the convoy comes under attack and the response must respect the principle of proportionality.

6.3 Coping with security threats

If preventive and protective measures where not sufficient, staff must be trained and be able to cope with the security risks and its consequences.

As soon as possible after a security incident occurs, a short report should be given to the security coordinator or radio room which also serves as an immediate warning to other colleagues. This report should include the names of the people involved, the location and time

of the incident, a short description of what happened, whether (medical) assistance is required and what immediate measures the affected people intend to take.

After the security incident a detailed written report should be submitted to the security coordinator for documentation and analysis. This report should include the date and time of the incident, the location, the type of mission during which the incident occurred, the names of all involved people, the armed groups involved and whether any injuries occurred. A short summary of the events before the incident, a description of the incident itself as well as the measures taken following the incident should follow. Any damages to vehicles, equipment, assets or buildings should be listed. Some reflections on what lessons can be learnt by the people involved as well as other people reading the report should be included. The security coordinator should carefully study all incident reports and if necessary review the security plan to prevent future incidents or at least help reduce their likelihood.

6.3.1 Crime and banditry

The overriding concern is saving lives and preventing injury and harm. People should never take risks to protect valuables, assets or facilities.

People who are being robbed should try to remain calm, should not offer physical resistance and follow instructions of the assailants. If possible victims should draw the attention of bystanders by shouting or blowing the horn of a vehicle when they feel they are being attacked. Learning a few phrases in the local language to call for help may be useful. Money, valuables and assets such as vehicles should be handed over without offering resistance. Sudden gestures and movements should be avoided and the hands should be kept visible at all times. Assailants should not be looked into the face since they may fear that the victim is trying to memorize their faces for future identification. Assailants may be very nervous and resort to violence if they feel threatened or attacked.

No physical resistance to looting should be offered but, as far as possible, at least damage to the infrastructure by vandalism or arson should be prevented.

After an attack the security coordinator as well as the police should be informed about the incident. If necessary medical assistance must be provided to victims quickly. A police report may be needed for filing an insurance claim.

Another group of risks are kidnapping, abduction and hostage taking. Whether to offer immediate resistance or try to escape during the kidnapping itself is an individual decision and will depend on the situation. However resistance is extremely risky as the kidnappers may resort to violence and the hostage may be injured. Hostages may be tied up, blindfolded and possibly drugged.

The prime objective of the kidnapping victim is to survive. The first hour of a kidnapping is the most dangerous as the kidnappers are very nervous. Being kidnapped is a shocking and devastating experience but hostages should accept the situation and try to remain calm and composed. The dominance and superiority of the kidnappers will cause feelings of helplessness and humiliation. Hostages should be co-operative, follow instructions by the kidnappers, keep a low profile and not try to escape. If hostages are sure that they can escape successfully they may take the risk but must be aware that hostage takers may severely punish hostages if they are not successful (UNSECOORD 1998, 23). It is the responsibility of the security coordinator and the humanitarian organization, in collaboration with the authorities, to secure the release.

The anxiety is greatest during the first hours of the kidnapping but feelings of helplessness, humiliation and depression will remain throughout the hostage taking although hostages

usually adapt to the situation and some kind of routine will set in. Immediately after the kidnapping not knowing what will happen causes fear. The kidnappers will try to disorient their hostages by keeping them in a windowless room and taking away watches.

Hostages should not argue, arouse hostility, antagonize or even threaten the kidnappers or engage in discussions of political or religious subjects and only speak when they are addressed by the kidnappers. Hostages should try to talk to their kidnappers provided it does not make them more nervous. However hostages should try to find mutual interests, establish communications with the kidnappers and ask for things they need. The kidnappers should view their hostage as a person which is worthy of compassion. At the same time hostages should not be servile and should try to gain the sympathy of their captors. Hostages might develop a positive attitude towards their captors and a negative attitude towards the outside which is known as the Stockholm Syndrome (UNSECOORD 1998, 23).

Hostages should try to memorize clues concerning the kidnappers and the place they are held which could be helpful for later police investigations but not give any indication to the kidnappers even if they might have recognized them.

Hostages need to eat and drink, even if they lose their appetite, should try to establish a daily routine, groom themselves and exercise daily.

If possible kidnappers should be convinced to inform the authorities of the situation and condition of the hostage.

Hostages should not try to escape. It is the responsibility of the humanitarian organization and the authorities to negotiate a release. Hostages should try to avoid feelings of hopelessness, keep in mind that people are looking for them and trying to negotiate their release even if the kidnappers might try to convince the hostages that they have been forgotten. Nevertheless hostages should prepare themselves mentally for a long ordeal. Hostages must also keep in mind that kidnappers need the hostages, alive, to achieve their objective. Hostages should also not try to threaten kidnappers by pointing out criminal persecution for example.

The time of release is a period of high risk since the kidnappers will be very nervous. Therefore hostages should pay close attention to instructions the kidnappers give, stay alert and not make any sudden or unexpected moves.

In case of a rescue attempt by the police or the military, hostages should drop to the floor, seek cover and be ready to identify themselves.

In case of a carjacking no resistance should be offered. However the carjackers should be persuaded to allow removal of identifiers such as flags and stickers as well as radio equipment.

In an airline hijacking, passengers should remain calm and composed, follow the instructions of the hijackers, respond to questions simply and try to get rid of anything that may irritate or provoke the hijackers. Passengers on window or centre seats are less visible to the hijackers and less vulnerable to gunfire (UNSECOORD 1998, 25). The passport should be covered with a case to make the nationality less obvious in case hijackers collect all passports.

Hostages should appear to be uninterested in the situation since inquisitive passengers may be considered as a threat. However passengers should also not appear sullen since this depersonalizes them in the eyes of the hijackers. Passengers should not say or do anything that may arouse the interest of the hijackers. Passengers should not let the hijackers know in case they speak their language but rather listen which may allow obtaining information on what the hijackers are planning. Passengers who try to resist hijackers are at greater risk than

those remaining passive. If the hijacking continues for more than a day, passengers should try to do some exercises in their seats (UNSECOORD 1998, 25).

In case of a rescue attempt all passengers slide down in their seats as far as possible or get on the floor and cover head and arms with a pillow to avoid injuries.

6.3.2 Conflict related threats

Reactions of the local population, which may have years of experience in the conflict, should be carefully observed and followed in case of shooting or shelling.

The behaviour in case of shooting depends on the circumstances, the distance from which firing is heard as well as the behaviour of other people which are present and may have more experience with this kind of situation. The direction from which the shooting is coming and whether it is moving closer or further away should be determined.

If the shooting is away far enough, pedestrians and vehicles should stop and return to a safe place. If the shooting is close cover, should be sought as quickly as possible, preferably by lying flat on the ground behind a wall, solid object or at least a rise in the ground.

In a building shelter should be taken near the centre of the building, putting at least two walls between the danger and oneself, or in the shelter. In any case people must stay away from windows.

The behaviour in case of being targeted by a sniper is different than from behaviour in case of random shooting or coming into a crossfire because the objective of snipers is to kill people.

If a vehicle comes under fire from a sniper, the driver should never stop but rather accelerate and drive on at the highest possible speed since it is far more difficult to hit a moving than a stationary target (Roberts, D.L. 1999, 42). Reversing or turning around should be avoided since it will slow down the vehicle and make it an easy target.

If the driver has been shot or the vehicle is immobilized, the passengers must dive for cover off the road. People should try to find cover in a ditch or behind solid objects such as stones but at least put the vehicle between themselves and the sniper. If no physical protection is available people should at least try to disguise their location by hiding behind objects even if they do not offer physical protection since the sniper needs to be able to see the target to aim at it.

Since the sniper might have noted the position where a person has taken cover and just be waiting for her/him to emerge again, people should not be tempted to pop up their head and look around but must either not move until help is available or crawl a few metres to another place without behind seen by the sniper to disguise their location.

In case of an ambush, in principle vehicles should stop and occupants and pedestrians should seek cover. However if people are sure that they are being targeted it is advisable to try to escape to a safe place.

In other group of conflict related risks are mines, booby traps, improvised explosive and bombs. When a person steps on an anti-personnel mine, try to keep calm, talk to the victim, advise on how to deal with the wound and call for immediate help. Helpers should not rush towards the victims since usually many mines are laid and placed in a way to injure or kill rescuers. The victim should be evacuated by a single person who must carefully retrace the path and steps of the victim and should mark the path s/he has taken in order to be able to retreat safely. If the path the victim has taken is not visible, the arrival of de-miners and rescuers should be waited for.

If a vehicle hits an anti-personnel mine the car should be stopped but the occupants must not jump out of the car since they may step on further mines. Occupants should call and wait for help. If no help can be expected, the vehicle can reverse in its tracks or the occupants can crawl out of the back door of the vehicle and walk back in the wheel tracks to the place the came from.

If anti-personnel mines are detected they must never be touched or moved. Since barely visible trip wires may be attached, they should not even be approached. If an anti-personnel mine is found it is very likely that there are many more around. Therefore pedestrians or vehicles should return to the place they have come from. Vehicles should never attempt to turn around but rather reverse exactly in their tracks.

If an anti-vehicle or anti-tank mine is detected it is likely to be observed and may be part of a planned ambushed. These mines must never be moved or touched and vehicles should immediately turn back.

If the explosion of an improvised explosive device or bomb is witnessed, vehicles should immediately stop and all passengers should take cover. The explosion may be part of an ambush and gun fire and further explosions may follow. The explosion should not be investigated but the vehicle should return as soon as it seems safe.

If bombs or unexploded ordnance is found they must not be touched or moved. If they are blocking the way, vehicles should turn around. Colleagues, authorities and de-miners should be informed of the exact location.

If bombs are found in a building, it should be evacuated. Windows and doors should be left open to vent possible explosions. The electricity and gas mains should be shut off to reduce fire hazards in case of an explosion. De-miners should be called for defusing the bomb.

Another group of risks are artillery fire, rockets, mortars and grenades. Since artillery are "indirect" fire weapons, several rounds may be fired while adjusting the weapon until the intended target is actually hit. Artillery can be fired from considerable distances and is not very precise. The attackers may be invisible since artillery can be fired from behind hills or buildings or dug in positions. Consequently cover must be taken immediately when fire is heard since the next round may hit vehicles and buildings nearby even if the first round hit a target further away. Even if the humanitarian organization is not being directly targeted it may be hit during the "adjusting" procedure of the weapon.

As soon as shelling starts people must seek cover immediately, preferably in a prepared underground shelter.

When driving and shelling starts in the vicinity the vehicle should be stopped immediately and all occupants should seek the hardest available cover away from the direction of the shelling. Road verges and ditches should only be used if it is known that they are not mined. If no protection can be found or the area is mined, people should lie down on the road. If the vehicle seems to be the target people should try to distance themselves from it. Never crawl under cars as they may be targeted and hit.

If the shelling is not very near and there is no protection nearby, the vehicle should quickly drive to the next known safe place where the occupants can seek shelter. However if the shelling seems to be coming closer, cover should be sought immediately.

In case of bombing from the air the nearest shelter must be sought. People should never seek protection underneath a vehicle. Colleagues should be warned and the radio room should inform other offices of events in case outside help is needed.

In case of a state of siege, staff should barricade themselves in the shelter and inform other offices of the situation. Looters should not be resisted but if possible they should be persuaded not to take essential equipment such as telecommunication devices. Another office or the head office should be regularly updated about the situation so they can negotiate free passage or an evacuation.

Alcohol should simply be thrown away as it would be extremely dangerous for someone to get drunk and behave uncontrollably, possibly provoking combatants who are laying siege.

6.3.3 Checkpoints and road blocks

Road blocks or checkpoints are set up by the conflict parties to control movement of people and goods into or inside the conflict area. Checkpoints may be furnished with buildings, sandbagged bunkers and moveable or raisable barriers. Barriers may also simply be placed in a way that makes passing them in a vehicle at high speed impossible. However checkpoints may consist of nothing more than a rope stretched across the road. The surroundings of checkpoints may be mined.

Road blocks may also be set up by bandits who are not linked to the conflict parties and extort tolls from all passing vehicles for their personal gain or rob them at gunpoint. If this is suspected, the vehicle should stop at some distance and some passing vehicles should be observed. Information on the nature of the checkpoint can be obtained from drivers of oncoming vehicles who have just passed the checkpoint. If the checkpoint is found not to be genuine, the vehicle should turn back.

Humanitarian workers travelling in vehicles marked with signs of humanitarian organizations have no special rights, must carefully respect all checkpoints and follow the instructions by the staff guarding the checkpoint. Humanitarian workers must ensure that passengers are not carrying any kind of weapons or other items which may arouse suspicion.

Vehicles must slow down well before the checkpoint and stop at the checkpoint. If combatants fear that the vehicle may not stop, they may consider it as a threat and shoot at it. When approaching a checkpoint in the dark, headlights should be dipped and the interior light switched on to allow guards to inspect the interior of the vehicle. Crossing checkpoints after dark should be avoided but may be necessary.

The volume of transceivers should be turned down and the radio should not be used shortly before or at the checkpoint (at least not without informing checkpoint staff) since this can arouse suspicion. An experienced humanitarian worker should sit in the front of the vehicle, either as a driver or passenger to talk to the combatants manning the checkpoint. An experienced driver who speaks the local language may be best suited for talking to combatants. Any radio or music should be turned off. Any attractive items such as cigarettes should be removed from the dash board and watches and sunglasses etc. should not be displayed.

People in the vehicle should avoid sudden movements, keep their hands visible, take off dark glasses, be polite and identify themselves if requested. The driver should open the window and provide information on purpose as well as destination of the vehicle. Staff should identify themselves properly on request. Where necessary, permits for passing checkpoints and transporting goods should be readily produced. A search of the vehicle should not be resisted but humanitarian workers should be firm if personal belongings or humanitarian assistance goods are being requested. Likewise payment of any kind of "fees", whether in cash or kind, should be refused.

Combatants may be bored, want to chat and humanitarian workers should be prepared to spend some time for talking. A conversation is an opportunity to explain the work of the humanitarian organization and its programmes which helps to build some trust.

Where possible information on the general security situation and the security of the stretch of road ahead should be obtained.

Checkpoints can be very dangerous when soldiers are drunk. There is no purpose in engaging into a discussion with drunk soldiers as it may only be a matter of time until something is said that arouses their anger (Roberts, D.L. 1999, 59).

If a checkpoint appears to be abandoned it may nevertheless be observed and therefore dangerous to cross.

6.3.4 Evacuations

In case the security situations deteriorates to a stage where humanitarian organizations have to suspend their programmes or the risks for staff are no longer acceptable, an evacuation should be carried out. An evacuation may also be necessary if the permission for using telecommunication equipment is withdrawn by the authorities or the authorities or conflict parties order humanitarian organizations to leave. Depending on the situation and available time only staff or equipment and assets will be evacuated.

Before evacuation, safe passage to the airport or for the land route must be negotiated with the conflict parties.

In a partial evacuation essential staff is left behind to continue vital assistance programmes such as provision of food or health care goods as well as provide security for staff, assets and buildings. It may be difficult to persuade staff which are considered as nonessential to leave. On the other hand essential staff may want to leave although their expertise and services are needed. If the security situation deteriorates a complete evacuation will be necessary.

The first priority is to evacuate staff. Depending on the situation humanitarian organizations may evacuate international as well as national staff living in the area. Evacuation only of international staff may pose an ethical dilemma. Humanitarian organizations may agree to evacuate all staff or only staff which may be endangered as a direct consequence of their employment. Alternatively humanitarian organizations may only pay for transport.

If time is available personal documents, cash and at least confidential records (data carriers or documents) should also be taken. If confidential records cannot be taken, their destruction should be considered. In any case any documents or records which could compromise staff must not be left behind.

If possible, sensitive and expensive telecommunication equipment, computers and generator sets should be taken. All vehicles should be taken and, if there is sufficient capacity, the most valuable humanitarian assistance goods can be taken. Alternatively vehicles can be hired locally for transporting humanitarian assistance good.

As far as possible buildings and assets which have to be left behind should be protected. If possible a remaining staff member should be in charge and supervise security guards to protect against theft and looting. If possible the supervisor should regularly provide information on the security situation by radio or telephone. Vehicles, generator sets and humanitarian assistance goods which stay behind should be locked in stores and warehouses. Stocks can also be be distributed or given into the custody of another humanitarian organization which has decided not to leave. Health care goods may be donated to health care facilities in anticipation of an increasing number of casualties. Terminating assistance to health

care facilities in case of an attack on the area or the flare-up of fighting may have severe effects for the patients as demand will increase while supply is cut off.

Identification on buildings and offices (stickers, flags etc.) may be removed if it is expected that vehicles will be looted and buildings will be occupied and used for military purposes. If vehicles are expected to be looted all radio equipment and aerials should be removed. If the humanitarian organization is respected by the conflict parties, the identification may provide some degree of protection.

Administrators must decide whether the contracts of national staff will be maintained, suspended until resumption of programmes or the staff is dismissed. Staff may be given a subsistence allowance or severance payment.

The security coordinator or other staff member must be firmly in charge of the evacuation, all staff must be informed of the situation and receive clear instructions of necessary measures. Despite the anxiety and excitement, the evacuation must be properly planned and carried out in an orderly way.

Staff evacuated by air should take only personal documents and valuables to allow a maximum number of people rather than cargo to be transported.

"NAIROBI, Feb 24 (AFP) - The international aid agency CARE said Thursday it was evacuating staff from south Sudan in line with an ultimatum by authorities there over new rules of operation in the troubled area.

The Sudan Relief and Rehabilitation Association (SRRA), the humanitarian arm of the rebel Sudan People's Liberation Army, has told all non-governmental organizations (NGOs) working there that they must sign a memorandum of understanding (MOU) before next month or leave" (AFP 2000, 1).

"Geneva (ICRC) - The International Committee of the Red Cross (ICRC) withdrew its international staff from Kosovo this afternoon, 29 March. The decision was taken in view of the deteriorating security situation, which prevented the ICRC from pursuing its humanitarian work. The team of 19 expatriates has arrived safely in the Yugoslav capital Belgrade" (ICRC 1999b, 1).

"ICRC (Geneva) - The International Committee of the Red Cross (ICRC) was asked yesterday by a member of the Sierra Leonean Government to leave Freetown for security reasons.

Following this request, an ICRC-chartered helicopter was sent from Conakry to pick up the five remaining expatriate staff, who arrived in the Guinean capital yesterday evening" (ICRC 1999d, 1).

6.4 Safety risks and measures

The main safety risks are natural hazardous (floods, earth quakes etc.), fires, electricity (electrocution), occupational injuries and vehicle accidents.

6.4.1 Natural hazards

Natural hazardous such as bush fires, storms, floods, tidal waves, avalanches, mud slides and earth quakes should especially be taken into consideration when selecting buildings and travelling routes by road.

Natural hazards may endanger staff, cause considerable financial losses due to damage of buildings, equipment and stocks and endanger programmes if stocks are destroyed.

When assessing the suitability of buildings for renting or building sites, information on natural hazards should be collected. Local inhabitants can be asked for information on natural hazards which depend on the season such as the danger of flooding during the rainy seasons.

Wherever possible, buildings which may be exposed to natural hazards should not be used. If it is not possible to find sites which are not prone to natural hazards, for example in an area where earth quakes are very common, engineering measures to reduce the likelihood of damages to buildings must be taken.

In warehouses situated in an area where flooding cannot be excluded, goods must be stored well above the floor level.

6.4.2 Fire

Fires are a permanent danger in offices, residences, warehouses and workshops.

A staff member should be assigned to be in charge of fire safety. S/he should draw up a fire safety plan, train staff and ensure that preventive measures are implemented. For larger buildings or premises a specialist or staff of the fire brigade should be consulted for advice. In any case national legislation and local regulations should be known and respected.

Fires can be caused by electrical faults in wiring or equipment, overheating of equipment or machines, careless handling of open fires (welding, oil heaters), improper storage of flammable goods such as fuel or alcohol as well as acts of war such as shelling.

- Faulty electrical equipment.
- Faulty kerosene or gas refrigerators.
- Unprofessional or faulty electrical installations and wiring.
- Overheating of electric equipment (voltage regulators, air-conditioners, refrigerators, lighting etc.).
- Overheating of machines.
- Careless handling of open fire, for example during welding or handling oil heaters.
- Improper storage of flammable goods (fuel, dangerous goods etc.).
- Smoking.
- Lighting.
- Heaters (electric, oil, fire wood, coal etc.).
- Acts of war (shelling, arson).

Table 6.7 Possible causes of fire

Every possible measure to prevent fires should be taken. Precaution aim at preventing a fire from starting in the first place, preventing its spread and reducing the damage it causes if a fire does break out.

Fire prevention should be given consideration already during setting up medical storage facilities. Non-flammable building materials such as bricks, concrete, stone and steel should be preferred over timber, straw (thatch) or plastic and insulation materials should be non-flammable or at least sandwiched between non-flammable materials.

The interior of the building should be compartmentalized to impede the spreading of fire. The separation of store rooms with fire resistant and ideally self-closing metals door can prevent fires from spreading or at least reduce the speed of spreading. All doors in a building should be kept closed, especially when nobody is present, in order to prevent fires from spreading or at least reduce the speed at which it spreads.

As far as possible storage equipment made from timber should be avoided, for example by using metal rather than timber shelving.

- Use of non-flammable building materials.
- Separation of store rooms with fire resistant metal doors.
- Keeping doors closed.
- Use of non-flammable storage equipment.
- Facilities representing a particular fire hazard accommodated in a separate building.
- Strictly prohibit smoking in stores, warehouses, workshops and near fuel stores.
- Provide ashtrays for offices and residences.
- Electrical installations and wiring must be carried out by a professional electrician.
- All electric circuits must be secured by fuses.
- Electric equipment must comply with safety standards.
- Never connect electric equipment to wall sockets by sticking wires into the plug.
- Safe installation of heating equipment.
- Separate storage of fuels.
- Separate storage of flammable health care goods.
- Avoiding use of open fire.

Table 6.8 Measures to prevent fires

Any facilities such as kitchens, workshops or fuel stores which represent a particular fire hazard should be accommodated in separate buildings.

Smoking should be strictly prohibited in all stores and warehouses as well as in workshop and the vicinity of fuel stores.

In offices and warehouses safe ashtrays should be available and smokers must not use rubbish bins for disposing of ashes as they might set rubbish on fire.

Rubbish bins should be made from metal and special models which prevent spreading of fire if they are set alight are available.

Electrical installations and wiring must be carried out by professional and competent electricians. Electric fuses must be installed in all electric circuits which will cut electricity supply in case the wiring or equipment is overloaded. Repairs must also be carried out by qualified electricians.

All equipment used in offices, residences and warehouses must comply with technical safety standards. Electric equipment should be connect to wall sockets only with proper plugs and never by sticking wires into a plug.

Overloading of circuits or plugs by connecting too many consumers must be avoided.

Plugs must properly fit wall sockets since loose connections can create sparks.

All electric equipment must be switched off when it is not in use and unattended, especially during the night and weekends. If electric equipment is not going to be used for some time, it should be unplugged.

Electric equipment standing on flammable material (wooden floors, carpets) should be placed on metal plates.

Heaters must be installed at a distance from any flammable materials (furniture, carpets, curtains, equipment etc.). Nothing which could catch fire or cause overheating of the equipment must be placed on, directly in front or directly next to heaters.

Gas heaters and stoves must comply with safety standards and be installed and regularly maintained by a professional technician. Gas taps must be closed when the gas is not being used, especially during the night and on weekends.

Bottled gas used for forklift trucks must be stored safely outside the warehouse building and away from any open fire or electrical installations.

Flammable medical gases such as oxygen should be stored separately and outside stores and warehouses.

Fuel for vehicles or heating (coal, oil, fire wood) should be stored separately and outside of buildings.

Flammable goods such as alcohol and other laboratory reagents must be stored separately in metal cupboards.

Open fire such as candles or welding equipment must be used with utmost care.

Smoke detectors will not prevent fires but will alert staff immediately when a fire breaks out and therefore indirectly prevent the fire from spreading. Smoke detectors also provide an early warning to people, especially when they are asleep, allowing them to escape before being harmed.

Smoke detectors must have an autonomous battery supply and be installed at the highest point of a room. They should be installed in basements, corridors, sleeping areas, storerooms and warehouses as well as any area with potential fire hazards. In order to avoid false alarms, smoke detectors should not be installed in kitchens and bathrooms or near fans, air-conditioners or air ducts. In large rooms such as stores and warehouses one smoke detector should be installed for approximately every 50 square metres.

Smoke detectors have to be checked regularly, cleaned, maintained and tested. Smoke detectors will emit an audible signal when the battery is low and requires replacement.

Every alarm should be taken seriously.

In a multi-storey building apartments should be located not higher than the fourth floor if possible and below the eight floor at the most to facilitate escape in case of a fire.

A range of fire preparedness measures need to be considered. Buildings must be designed to allow people to escape and be furnished with fire fighting equipment. Staff and especially security guards must be prepared for a fire and be trained in use of fire fighting equipment. Staff must also be instructed how to prevent fires, how to behave in case of a fire, know the fire point nearest to their working place, know escape routes and assembly areas.

For larger buildings, plans which show the location of emergency exits, escape routes and fire fighting equipment should be displayed in corridors. Fire regulations should be drawn up and displayed next to each fire extinguisher.

Buildings must have emergency exits which must be clearly marked with green "Exit" signboards in the local language. In larger buildings emergency lighting with battery backup should be installed which automatically switches on in case of a power failure and guides people to the nearest emergency exit. If emergency exits are locked to prevent intrusion from the outside, keys must be hung next to the respective emergency exit in a clearly marked box. Alternatively exit doors can be furnished with panic bars which allow opening from the inside but cannot be opened from the outside.

Emergency exits must be easily accessible and never be blocked by equipment, stock or vehicles especially in stores and warehouses.

Where windows are protected with metal gratings or bars against intruders, there must be a possibility of opening at least part of it for escaping to prevent people which cannot reach an emergency exit from being trapped in a room. These escapes can be locked from the inside and a key can be kept next to the window.

Multi-storey buildings up to four floors (3 - 12 metres) must be furnished with escape stairways, fixed, moveable, portable or rope ladders. In higher buildings fixed or foldable ladders should be installed.

Buildings should be accessible for fire-fighting services from all sides and the access must never be blocked by parked vehicles or other objects.

- Furnish buildings with adequate and sufficient fire fighting equipment.
- Training of staff in the use of fire fighting equipment.
- Display of fire regulations next to fire extinguishers.
- Ensure a sufficient number of clearly marked emergency exits.
- Display of plans with escape routes In large buildings.
- Ensure availability of keys on the inside of buildings next to all locked doors.
- Installation of emergency lighting In large buildings.
- Never block escape routes and doors with stocks or materials handling equipment.
- Install escape stairways or ladders for buildings higher than 3 metres.
- Accessibility of buildings from all sides (for fighting fires).

Table 6.9 Fire preparedness measures

A sufficient amount of fire fighting equipment such as fire extinguishers, fire hoses, buckets, hand pumps, sand and fire blankets must be available and installed in prominent, easily accessible and well marked places.

Fire extinguishers are effective in putting out small fires shortly after they have started and prevent them from spreading. 60% of all fires are put out with fire extinguishers.

A	Solid materials (wood, paper, plastic).
B	Flammable liquids (oil, petrol, alcohol).
C	Flammable gases (propane, butane).
D	Fires of electrical origin.

Table 6.10 Classification of fire extinguishers

Fire extinguishers are available in various sizes. Small types (1 - 2 kg) are used in vehicles, medium sizes (5 - 10 kg) which can be hung on hooks and large types (50 kg) which are fixed to trolleys.

Fire extinguishers are classified by the materials they are suited to extinguish.

Multipurpose fire extinguishers such as the ABC type are suitable for different types of fire.

Fire extinguishers can use foam, dry powder or gases (carbon dioxide). The agent cuts off the fire from the oxygen source and extinguishes it.

Fire extinguishers use pressurized gas, for example carbon dioxide, as a propellant. In non-permanent pressure fire extinguishers, the gas is contained in a refillable cartridge which is separated from the agent. The advantage is that these fire extinguishers are easier to service.

Permanent pressure fire extinguisher contain the propellant as well as the agent in a single vessel and must be serviced by a specialist.

Fire extinguishers should be installed in corridors, staircases, near emergency exits, near kitchens, in warehouses and near stores of fuel or flammable liquids and gases and must be easily accessible. In buildings fire extinguishers should be placed near the entrance since fire extinguishers placed inside a room might no longer be accessible in case of a fire. Fire extinguishers should be placed in a way that they are very visible and hung on the wall. Fire extinguishers placed on the floor tend to moved away or be misused for holding open doors. The location of fire extinguishers should be marked with signs to increase visibility.

At least two fire extinguishers on every floor and, for warehouses, approximately one fire extinguisher of 6 kilogram powder (or 10 litres of foam) should be installed for every 50 square metres of building.

All fire extinguishers must be checked and serviced at least once a year. All staff and especially security guards must be aware of the location of fire fighting equipment and must be trained in its use.

Fires require three "ingredients": a combustible material, heat and oxygen. Fire fighting measures are directed at removing the combustible material, reducing the temperature by cooling and cutting off the fire from oxygen.

A fire plan should be elaborated, displayed at every fire point and be known to all staff members.

When a fire is detected or a fire alarm is heard staff should try to remain calm and first of all raise the alarm and, if available, call the fire brigade. The name of the caller, the location, the nature and extent of the fire and information how many people may be endangered should be reported.

The first priority is to prevent harm to people by alerting them so they can evacuate and help people who may be injured or disabled. All doors, and if possible windows, should be closed to impede spreading of the fire. All staff should gather in a predetermined assembly area so their presence can be checked and to ensure that everyone is accounted for. If smoke filled rooms or corridors have to be crossed, people should crawl on the floor to avoid smoke and toxic gases and have better visibility.

Attempts to extinguish the fire with suitable equipment should be made but without endangering any people. Fire extinguishers must be aimed at the base of fire from a distance of 2 - 3 metres. Fires in the open must be approached from the side the wind is blowing. Multiple short bursts are more effective than the emptying fire extinguishers without interruption. Attacking the fire from several sides by different people simultaneously increases the efficiency.

The main gas supply and, especially in case of an electrical fire, the main electricity supply should be cut off immediately.

6.4.3 Electricity

Faulty electrical wiring, installations or equipment can damage or destroy equipment, cause fire and electrocute people which may be lethal.

Safety hazards can be prevented by ensuring that all electrical wiring and installations are made by professional technicians. Electric fuses should ensure that the electricity is cut off as soon as a fault in electrical equipment occurs.

All equipment with metal parts on the outside must be earthed to prevent giving electric shocks if the equipment is faulty and outside parts are connected to the power supply.

Wall sockets must be properly attached to walls and only matching plugs should be used. The direct insertion of cables into the wall socket without a proper plug is dangerous and can cause fires.

Electric circuits and especially extension cables should not be overloaded by attaching too many electric devices.

In order to prevent overheating and fires, electric appliances with high power consumption such as electric heaters or air-conditioners should only be connected to wiring with sufficient capacity.

Before connecting electrical appliances the required voltage should be checked to make sure the mains electricity supply is suitable.

6.4.4 Vehicle accidents and breakdowns

Vehicle accidents are a major concern especially because of the poor road conditions and lack of driving discipline in many less developed countries. All-wheel drive vehicles are heavy, have a high centre of gravity and are more difficult and dangerous to drive.

Traffic accidents can injure or kill people, damage or destroy valuable assets and damage the reputation of the humanitarian organization especially if local inhabitants are injured or even killed. The effects of vehicle accidents can be compounded by the lack of ambulance services and proper medical care.

Vehicles should be carefully maintained and serviced regularly. In any case vehicles must conform to national standards and regulations. Drivers must inspect and check their vehicles every day before starting their duty, especially the oil level, coolant, fuel, brakes, tyres and lights should be checked before every drive. A complete tool kit, especially for changing tyres, must be available. The jacks must be suitable to the type of vehicle. Snow chains should be carried where appropriate. Tool boxes are usually locked to prevent theft. However the driver must check that s/he is carrying the key with her/him before departure.

Every vehicle must carry a first aid kit and the facilities where medical assistance is available should be known to the driver and be part of the route planning.

Employed drivers must be reliable, professional, hold valid driving licences, comply with the national highway code, respect speed limits and adjust their speed to road, traffic and environmental conditions such as visibility. Installation of tachographs allow detecting speeding as well as long distance driving without taking breaks.

Drivers must also ensure that goods are properly loaded and not overloaded. Loads must be prevented from falling off vehicles and moving inside vehicles by securing them by lashing. Staff which learned to drive conventional passenger cars should be trained in driving all-wheel drive vehicles. These are heavier, higher, have a higher centre of gravity and are therefore less stable. A speed limit of 80 km/h for these all-wheel drive vehicles should be respected and passengers must never pressure drivers to speed.

Using all-wheel drive facilities also requires special training. Some vehicles require to turn a knob on each wheel while others have automatic switches.

Every humanitarian worker should be able to change a tyre on a vehicle.

The driver and passengers should always wear seat belts. Use of alcohol and drugs must be strictly prohibited. Drivers must be well rested, daily driving hours must be limited and drivers must regularly take a break.

The vehicle speed must be adapted to the environmental conditions and reduced on poor roads, during rain or snowing. Driving at night should be avoided wherever possible.

In case of a traffic accidents the police or other authorities should be informed immediately. In case a foreigner injures or even kills a national it may not be safe to stop the car since bystanders may become hostile and try to take revenge. In this case the driver should immediately report to the nearest police station or military post.

In case a broken down vehicle has to be abandoned, wherever possible markings and telecommunication equipment should be removed in order to prevent misuse by parties to the conflict.

7 DEVELOPMENT OF A SUPPLY CHAIN MANAGEMENT FRAMEWORK

Supply chain management as well as humanitarian assistance are complex and vast topics which need to be limited (see figure 7.1) in order to fit the scope of this handbook.

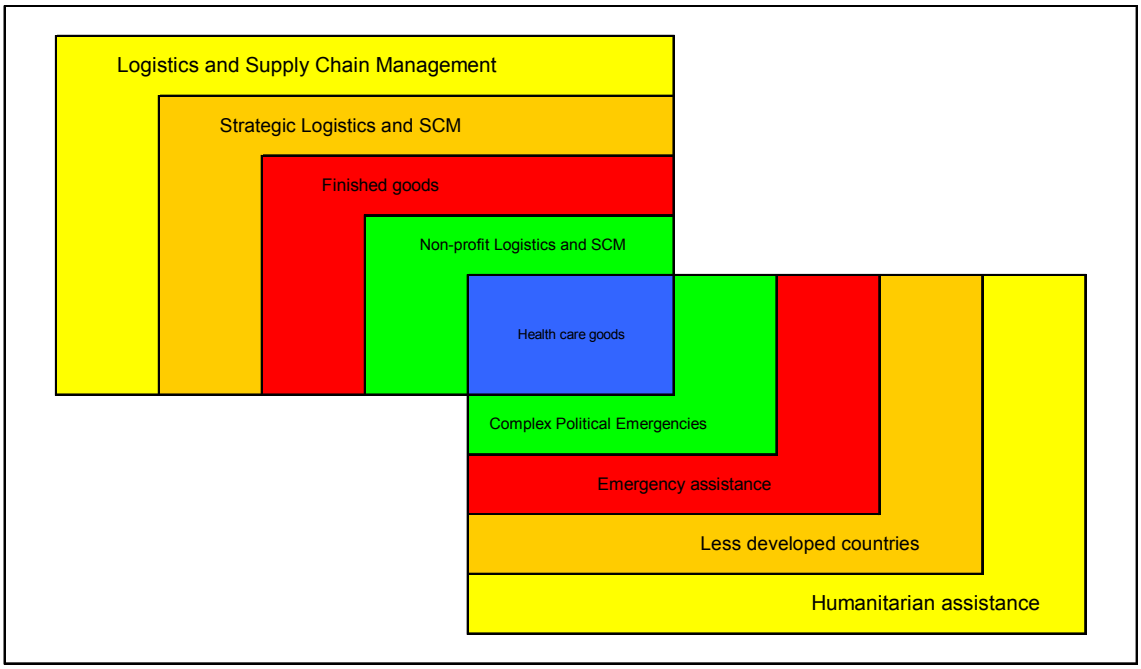

Figure 7.1 Narrowing down of the topic

The topic falls under the management science of logistics and supply chain management. The topic will be limited to the external supply network of humanitarian organizations and therefore focus on management of finished goods rather than on production and manufacturing.

The topic is further narrowed down to logistics and supply chain management in not-profit-making organizations, which humanitarian organizations are by definition. Nevertheless, many concepts of commercial logistics and supply chain management are of interest and applicable to the not-profit-making sector.

Although various concepts, principles and issues of humanitarian assistance are relevant and need to be analysed, this handbook does not deal with developing concepts for humanitarian assistance interventions but deals only with providing the required logistical services and support.

Humanitarian assistance may be provided in developed countries, for example in the aftermath of natural disasters. However since health care logistics concepts for developed countries have already been developed, this handbook will focus on the context of logistics and supply chain management in less developed countries. Developed countries will only be considered to the extent where supply networks span across less developed as well as developed countries.

Since some concepts for logistics management in natural or technological disasters have already been developed, the topic is limited to the problems of logistics and supply chain management in complex political emergencies. The framework will also focus on humanitarian assistance provided during armed conflicts rather than during rehabilitation after armed conflicts or as part of development aid programmes. While supply networks will generally

extend across countries and regions with different degrees of political stability, the framework will focus on the context and situation of political instability and armed conflicts. As a consequence issues of international (humanitarian) law will need to be taken into consideration.

Finally the fields of logistics and supply chain management as well as humanitarian assistance are narrowed down to the core issue of managing health care goods. As in commercial logistics and supply chain management, the characteristics of classes of products must be considered in the development of a supply chain management strategy.

Figure 7.2 Fields related to the topic

While people affected by complex political emergencies require a wide range of goods and services, this handbook will be limited to health care goods and services required for establishing and sustaining health care facilities and services. For example preventive services such as immunization campaigns or Mother and Child Health Care programmes as well as curative services such as treatment of war-wounded, clinical and hospital care. Consequently the framework will have to consider the fields of public health as well as pharmacy. Figure 7.2 illustrates the fields which are relevant for the topic.

Every organization must develop a formal supply chain management strategy in order to avoid wasting resources and realizing the potential of supply chain management (Harrison, A., and R. van Hoek 2002, 210). The use of modern management techniques allows improving the effectiveness and quality of humanitarian assistance (Larragán, A.A., et al. 1998, 1).

According to Christopher (Christopher, M. 2005, 61), logistics strategies should be devised in a sequence of three steps. The objectives of humanitarian organizations, the context in which they work and the constraints they are subject to were discussed in the previous chapter. The logistics and supply chain management objectives will be developed and determined in the following sub-chapters. Finally the supply chain management framework (chapters 8 to 12) will be designed to suit the objectives of humanitarian organizations.

The feasibility, constraints and costs of logistics services must be an integral part of planning humanitarian assistance programmes. Health programme managers need to weigh the potential benefits of assistance programmes against the resources required for different interventions.

However this framework is developed on the premises that once health programme managers have determined their objectives and defined their interventions, logistics managers must provide the required services for enabling and supporting these health care programmes. Logistics managers should be involved in the planning of humanitarian assistance programmes, can point out constraints and present different options for providing services. However humanitarian assistance programmes must be designed according to the needs of assisted populations and the professional expertise of health programme managers rather than according to logistical considerations.

The developed framework will not provide immediate solutions for individual humanitarian assistance programmes and situations. Instead the framework intends to be a decision support system for logistics and supply chain management which can be applied to specific health care programmes of a given humanitarian organization in a specific context. The framework indicates factors which favour certain decisions but does not allow mathematically deducting optimal solutions. Instead, decision making requires considering a multitude of trade-offs between favourable and unfavourable factors in the given context and situation.

7.1 Literature review

In order to position this framework, a brief overview of relevant literature will be given and commented on. Literature which must be considered as non-scientific, such as operational and technical handbooks, is included since it constitutes an important part of available publications and these handbooks are very widely used by humanitarian organizations for training as well as during field operations. Moreover they point out important aspects and problems of logistics management in a context which is very rarely considered in academic literature.

While the areas of commercial logistics and supply chain management have been covered extensively by scientific publications, the literature predominantly refers to developed countries (Shawkey, P., and C. Hart 2003, 132) and hardly considers humanitarian assistance (Oloruntoba, R., and R. Gray 2003, 9).

Several publications deal with health care logistics in less developed countries. The very comprehensive book by Quick, J.D. (ed.) "Managing Drug Supply" (1997) is considered as the standard work and reference for establishing and managing public drug supply systems in less developed countries. Although purchasing, storage and distribution of drug products are

covered extensively, the publication focuses on health economics and policy issues as well as developing national distribution systems for public health services.

Dörner G. (ed., 1992) published guidelines on all aspects of drug selection, purchasing, storage, distribution and transport in less developed countries with a particular emphasis on quality assurance.

A wide range of logistics activities is covered in the handbook by Battersby, A. (1985) which aims at improving logistics management of primary health care programmes.

The World Health Organization (WHO 1997a) has published comprehensive guidelines for quality assurance of drug products which in particular provide recommendations for quality assurance in pharmaceutical supply systems.

Shawkey, P., and C. Hart (2003) develop a framework for the context of less developed countries but only consider supply chain management of reproductive health products in times of peace.

A number of publications cover individual logistics activities such as purchasing and storage of health care goods in the context of less developed countries rather than management of the entire supply networks.

The World Health Organization (1999f) discusses strategic objectives and operational principles of good pharmaceutical procurement for public sector health systems. The World Health Organization (2002c) also published practical guidelines for the procurement of drug products which discusses various different tender methods.

The Appropriate Health Resources and Technologies Action Group (1994) has published practical guidelines for management of small stores with simple means. Their publication covers planning and organization of stores, simple methods of inventory control as well as all procedures from receipt to dispatch of drug products and other health care goods. The World Health Organization (1998a) published a document covering the same topics but focusing on training of staff.

Battersby, A., and A. Garnett (1993) discuss purchasing of drug products, inventory control as well as management of stores at national and regional levels. They also present a method for estimating storage and transport volumes as well as calculating storage requirements and designing warehouses. Similarly Chye, Y.B. (1988), who also compares centralized and decentralized purchasing strategies.

Marshal, A. (1995) describes the difficulties of sourcing and purchasing a large variety of health care and other products for a humanitarian assistance programme in Africa.

A range of publications considers logistics services for different levels of health care or for specific health services. The World Health Organization (1992c) develops recommendations for strengthening logistics support to primary health care (PHC) programmes and stresses the importance of viewing logistics services as an integral part of the overall national health system.

The publication of Pearson, C.A. (1995) on management of hospitals in less developed countries covers operational issues of ordering health care goods as well as management of their storage and distribution at hospital pharmacies.

Compared to other groups of health care goods, a disproportionate large amount of literature is available on management of goods requiring a cold chain. Notably the Expanded Programme on Immunization (EPI) of the World Health Organization has published extensively on technical and operational aspects of providing vaccines to the general population in less

developed countries, for example in WHO (1992b). Laurent, E., and H. Everts (n.d.) discuss storage and transport of vaccines during immunization campaigns.

"EPI Logistics and the cold chain: improving quality" (WHO 1990a) assumes that logistics management of the cold chain is generally well established and discusses methods for monitoring performance and raising the quality of logistics services. The document also deals with technologies for injection, sterilization and refrigeration.

A conference report of the Technical Network for Logistics and Health (WHO 1990c) makes recommendations for improving management, planning supply systems as well as transport of vaccines. It also explores opportunities for integrating logistics management of vaccines into other primary health care logistics services. A further report (WHO 1992b) discusses the development of information systems for demand forecasting as well as inventory control of vaccines, equipment and replacement parts. The following conference report (WHO 1993) discusses measures for improving country-wide distribution strategies and asks whether the "cold chain" could be replaced by a "fast chain". A concept for a global vaccine supply strategy, including trade-offs between international purchase and domestic production, is developed.

Several country studies describe and discuss distribution systems for drug products and give special consideration to national drug policies and legislation, implementation of essential drugs concepts, rational use of drug products as well as quality assurance of drug products. For example in Bangladesh (WHO 1985a), Kenya (WHO 1985b), Papua New Guinea (Brudon-Jakobowicz, P. et al. 1986), Chile (Arango, J.I., P. Carlevaro, and G. Velasquez 1996) as well as Tunisia (Garraoui, A., P. Le Feuvre, and M. Ledoux 1999).

Haak, H., and H.V. Hogerzeil (1991) describe drug supply systems based on ration kits in great depth, analyse possible problems, discuss advantages and disadvantages and present an evaluation of kit programmes based on field studies in several less developed countries.

The World Health Organization (WHO 1992a) presents several country programmes for emergency preparedness and discusses various aspects such as strategic planning and coordination.

Literature on logistics and supply chain management in the context of humanitarian assistance considers predominantly natural and technological disasters.

Tufinkgi, Ph. (2006) provides a detailed theoretical analysis of technological and natural disasters as well as disaster concepts and models. He determines the requirements, objectives and tasks of disaster logistics and points out shortcomings of current disaster logistics management. He makes proposals concerning risk analysis in disasters, for determining logistics support needs, standardization of marking and labelling of humanitarian assistance goods as well as for planning supply networks.

A detailed report based on in depth research of humanitarian organizations, points to the similarities of the state of logistics in humanitarian assistance today with the situation of corporate logistics management 20 years ago (Thomas, A. 2003a, 8). The report analyses the main problems and challenges faced by humanitarian organizations and points to the need of realizing the strategic importance of logistics for disaster management. Fenton, G. (2003) makes the same comparison and points out that some humanitarian organizations still regard logistics services as an expense rather than a strategic management component. He also points out the problems caused by competition among humanitarian organizations and the problems which lack of coordination can cause. In another analysis Thomas, A., and L.R. Kopczak (2005) identify the lack of recognition of the importance of logistics, lack of professional staff, inadequate use of technology, lack of institutional learning and limited collaboration as the core challenges for humanitarian logistics.

The Center on International Cooperation with Lester Salamon and Associates (1999) assesses the preparedness capacities of international humanitarian organizations and stresses the importance of disaster preparedness for a quick and effective emergency response.

The East Africa and Great Lakes Region Inter-Agency Emergency Preparedness & Response Working Group (2004) discusses the potential for inter-agency collaboration of logistics services and has developed a logistics model for optimizing the material flows in humanitarian supply networks.

Forman, S. (1999) discusses the potential for cost savings by well-organized preparedness systems as well as the importance of immediate availability of funding for a quick emergency response of humanitarian organizations.

The European Commission (Larragán, A.A., et al. 1998) has published an academic text which seeks to apply management sciences to humanitarian assistance and devotes a short chapter to logistics which is limited to transportation management.

Several articles discuss specific disaster situations and provide insights into the general challenges and constraints of logistics management.

Cassidy, W.B. (1999) stresses the importance of logistics services in the context of the humanitarian crisis in the Balkans and discusses some of the difficulties humanitarian organizations encountered during providing assistance to refugees. Freudmann (1999) discusses the differences between transportation infrastructure and transportation management outside and inside the conflict area.

Gustavsson, L. (2003) discusses problems caused by lack of adequate information systems. He also points out the lack of professional training, logistics expertise and skills of many humanitarian workers as well as the need to learn from the corporate sector.

Rickard, J. (2003) emphasizes the importance of information flow as well as the need for close coordination and collaborative planning between programme and logistics managers. The same point is stressed in the Field Handbook (OCHA and UNDAC 2000) which devotes a chapter to disasters logistics and includes a detailed checklist for carrying out a logistics assessment.

The importance of involving logistics services early on in disaster response as well as the central role logisticians play in relief efforts in general is also stressed by Thomas, A. (2003b). Similarly Chaikin, D. (2003) points out that logistics management needs to be considered as a key support function and must be incorporated into planning at all stages of humanitarian assistance programmes.

Chomilier, B., R. Samii, and L.N.Van Wassenhove (2003) give an account of logistics management at the International Federation of the Red Cross and Red Crescent Societies in the aftermath of the Gujarat earthquake and point to the importance of standardization as well as establishing frame agreements with suppliers in advance as part of emergency preparedness plans.

The vital role of the freight industry for international humanitarian assistance programmes is pointed out by Lewis, Ch. (1999) who also discusses criteria for selecting different modes of transportation.

McClintock, A. (1995) gives an account of the difficulties and complexities of providing humanitarian assistance goods to refugees in the aftermath of the genocide in Rwanda and emphasis the critical importance of information for logistics management.

Long, D. (1997) describes logistics management during the crisis in Northern Iraq and discusses various differences between the context of logistics management in commercial organizations in developed countries and during a humanitarian crisis in a conflict area. Similarly Gooley, T.B. (1999) describes differences between commercial logistics management and providing logistics services during the Balkan crisis.

Damas, Ph. (1997) describes the logistics strategy of the United Nations Children's Fund (UNICEF) which supplies more than 100 countries from its central Supply Division in Denmark and discusses the implications of using different modes of transportation. The logistics of distributing humanitarian assistance goods to more than one million children for UNICEF in Afghanistan in the immediate aftermath of an armed conflict is described by Molinaro, P., and S. Blanchet (2003).

Loane, G. (1998) points out that success or failure of humanitarian assistance operations are often determined by the effectiveness and efficiency of logistics services and gives an example of the importance of considering the political aspects of conflicts for logistics management in Somalia.

Gray, J. (1999) describes problems a commercial company encountered during providing air transportation services to humanitarian organizations.

Scott-Bowden, P. (2003) explains the function of Augmented Logistics Intervention Teams for Emergencies (ALITE) which develop emergency preparedness plans, manage contingency stocks and provide logistics services to the World Food Programme. ALITE also coordinates activities with other humanitarian organizations and has developed relationships with the commercial sector to improve its logistics capacity and efficiency.

Humanitarian logistics management is often associated with food aid since transportation of often large quantities over great distances is highly visible.

Bigman, D., and I. Weksler (1982) develop a framework as well as a mathematical model for contingency stocks which are established in anticipation of food shortages and famines.

The extensive study and evaluation of "Humanitarian Aid and Effects" (Milwood, D. (ed.) 1996) in response to the conflict in Rwanda devotes a chapter to logistics and compares advantages and disadvantages of airlifts versus overland transport of food. Likewise several United Nations agencies devoted a section to logistics management in their analysis of emergency operations in the Great Lakes area (UNHCR, 1998). The concept of close cooperation of organizations in the United Nations Joint Logistic Centre (UNJLC) and sharing of resources is discussed.

Huart, J.P. (1996) has published a handbook for food aid programmes which elaborates on a wide range of logistics management issues such as carrying out assessments, planning as well as purchasing, storing, transporting and distributing food. A similar publication by the United Nations High Commissioner for Refugees (UNHCR 1989) sets out standards for planning, carrying out, monitoring and controlling logistics operations. The Emergency Field Operations Pocketbook (WFP 2002) covers all aspects of providing food aid including purchase, storage and transport of food. CARE's Food Aid Logistics Operational Handbook (Hale, H. 1999) stresses the importance of supply chain management in guiding managers through all steps of providing food aid from determining food requirements, transportation management, storage, delivery as well as calculating logistics costs.

Bennet, J. (2003) discusses the unexpected consequences of providing genetically modified food and points to the importance of carefully selecting humanitarian assistance goods as well as to the political dimension humanitarian assistance can have. Since overseas donations were

eventually rejected, logistics managers had to change from an international to a regional supply strategy one on very short notice.

Vikki, M. and E. Bratheim (2003) analyse some of the problems encountered in large scale food distributions in Uganda and describe the "lean logistics" approach of several closely cooperating humanitarian organizations.

The management of health care goods provided as humanitarian assistance in the aftermath of natural disasters is discussed in a range of detailed publications.

Part of the publication "Emergency Health Management after Natural Disaster" (PAHO 1981) discusses the issue of emergency preparedness and devotes a chapter to logistics management of health care goods.

A further publication (PAHO 1983) emphasis the importance and priority of establishing a list of essential health care goods.

The Pan American Health Organization (PAHO) has published several books on disaster management with an emphasis on health care logistics management. It discusses, among others, the problems caused by inappropriate donations (PAHO 1999) and alternatives for donating humanitarian assistance good. Carballo, M., and D. Serdarevic (1997) also caution against use of drug donations and point out the advantages of drug kits. They also stress the importance of carrying out a sound assessment before implementing humanitarian assistance programmes and the critical importance of logistics management to sustain health care programmes. Similarly Musy, A., and D. Barras (1990) describes the kit policy of several humanitarian organizations and point out the advantage of being able to respond to disasters quickly.

An in depth discussion of principles of disaster mitigation in health care facilities, which have been struck by natural or technological disaster, was also published by the Pan American Health Organization (PAHO 2000).

The publication "Humanitarian Supply Management and Logistics in the Health Sector" (PAHO 2001a) discusses the assessment of available logistics resources, coordination between actors as well as all logistics activities necessary after natural disasters.

The Pan American Health Organization (PAHO 2001b) has developed a computerized supply management system, called SUMA, which is mainly designed to record and track donated goods from the time of arrival in the country affected by a disaster until final distribution.

Several humanitarian organizations have published technical manuals or practical handbooks which are based on extensive field experience rather than scientific literature. They are intended for field staff, cover a wide range of aspects, principles and procedures for carrying out humanitarian assistance programmes and usually devote a chapter to logistics management.

For example "Assisting in emergencies: a resource handbook for UNICEF field staff" (Ockwell, R. A. 1994), "Handbook for emergencies" (UNHCR 2000), "The Oxfam Handbook of Development and Relief (Eade, D., and W. Suzanne, 1995), the "Handbook for emergency field operations" (WHO 1999e) as well as "Coping with Major Emergencies" (WHO 1996a).

Other humanitarian organizations have published separate handbooks which are dedicated exclusively to logistics management or specific logistics activities. Among these are "Guidelines on logistics and transportation" (CIDA 2000), the "Logistics standards" (IFRC 2000) as well as the "Logistics Field Manual" (ICRC 2004).

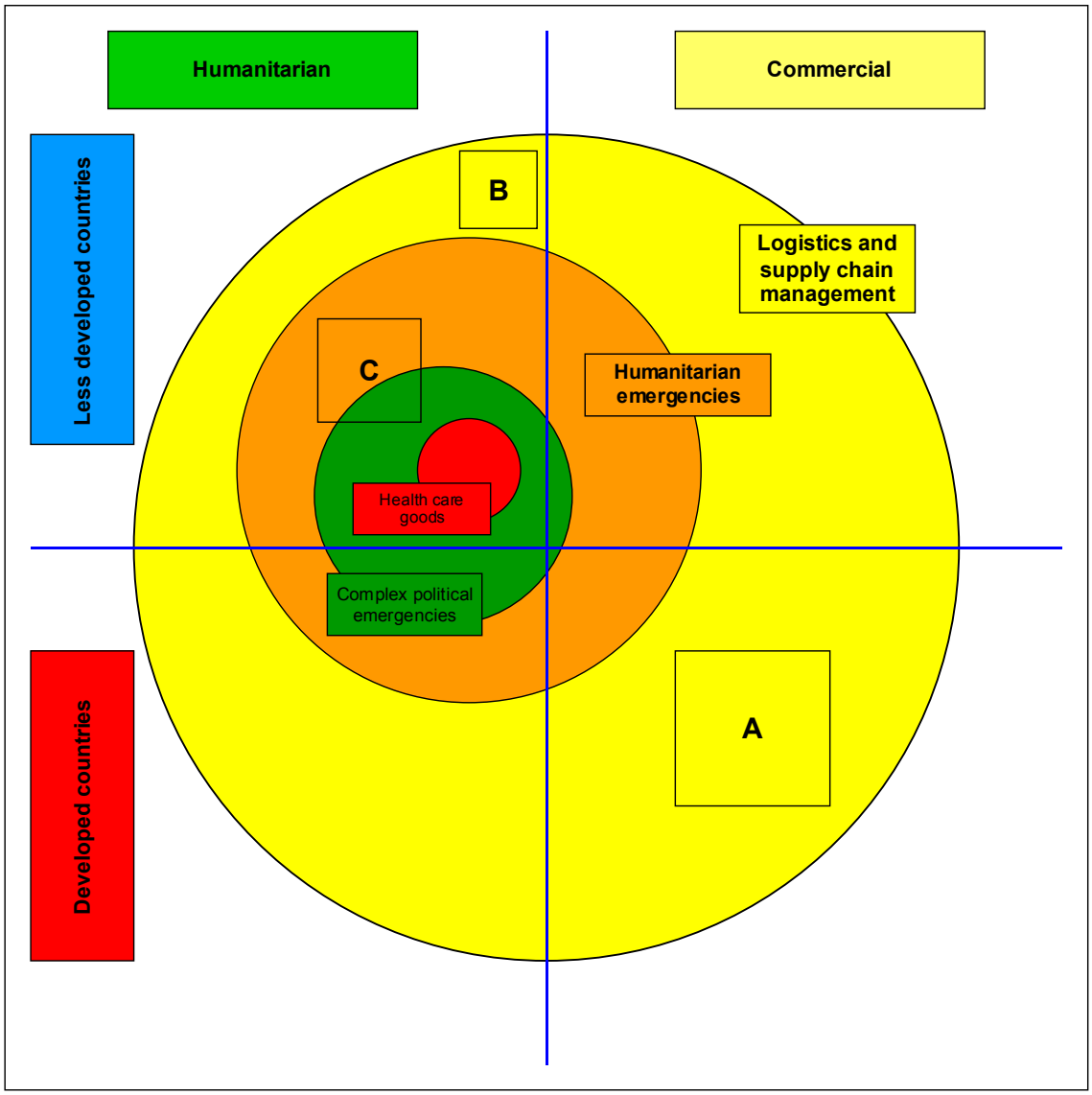

Figure 7.3 Fields of logistics and supply chain management literature

In summary, a very comprehensive body of knowledge has been established for logistics and supply chain management which predominantly pertains to the commercial sector (A in figure 7.3) as well as for various aspects of logistics management of health care goods in less developed countries (B in figure 7.3).

A significant amount of literature has been published on logistics management in humanitarian emergencies after natural and technological disasters (C in figure 7.3) while the implications of complex political emergencies on logistics and supply chain management have not been analysed systematically.

Generally, a striking gap can be noted between academic literature, which rarely considers supply chain management of humanitarian assistance goods and humanitarian organizations, which rarely consider commercial supply chain management concepts which are well established in academic literature.

7.2 Logistics and supply chain management objectives

Logistics services of commercial and humanitarian organizations both pursue the same objective of satisfying customer demand as effectively and efficiently as possible.

The objectives, context and constraints of humanitarian assistance programmes as well as the characteristics of health care goods determine the logistics and supply chain management objectives which need to be achieved in order to enable, support, sustain and complete humanitarian assistance programmes. Excellent logistics management requires linking all logistics activities to the strategic planning of the organization (Schulte, Ch. 1999, 596).

7.2.1 Minimizing safety and security risks

Minimizing safety and security risks for recipients, staff, assets, facilities and humanitarian assistance goods must be the overriding concern in management of humanitarian assistance in general as well as in logistics and supply chain management in particular (UNHCR 2000, 262), even if efficiency is decreased. An overview of the objectives, the context and constraints which imply the need for minimizing safety and security risks is presented in table 7.1.

MINIMIZING SAFETY AND SECURITY RISKS	Continuous risk assessments	Minimize numbers of and carefully select staff	Minimize value of stocks, assets and cash	Locate assets and stocks in most secure places	Decentralization of assets and stocks	Maximize safety of staff, assets and goods	Provide emergency care by own means	Decentralization of distribution	Direct deliveries to recipients	Consider alternative routes and modes of transport	Obtain security clearance before any transport	Caution in dealing with authorities	Caution with commercial transactions
Objectives													
Towards donors													
Openness, transparency and accountability			●	●	●				●				
Towards recipient													
Community													
Security of affected population	●							●					
Management objectives													
Security of staff, assets and stocks	●	●	●		●								
Context and constraints													
Related to humanitarian organizations													
Donors													
Accountability, reporting and auditing			●	●	●								
International or global													
International staff		●											
Less developed countries													
Politics / Government													
Potential political instability	●		●		●								
High levels of corruption												●	
Poorly developed legislation and legal security													●
Economy													
Poor transport infrastructure						●							
Limited availability of third party logistics suppliers					●								
Social													
Low level of health care services							●						
Complex political emergencies													
Armed conflict													
Lack or collapse of state authority	●		●		●							●	●
Insecurity and high levels of violence	●	●	●	●	●		●	●		●	●		
Blocked or closed borders										●			
Unpredictable and dynamic conflict	●		●	●	●					●			
Damage to and destruction of infrastructure						●							
Recipients													
Diversion and theft of assistance goods	●		●	●	●				●		●		
Health care goods													
Characteristics													
High value			●	●	●				●				
Deterioration and damage													
Susceptibility to deterioration and damage			●							●			

Table 7.1 Minimizing safety and security risks

The objectives are to reduce the likelihood of risks occurring as well as to reduce the impact in case the risk could not be avoided (Mayhew, B. 2004, 141).

Safety refers to protection from threats from diseases, accidents and natural disasters while security refers to protection from acts of deliberate human violence (Van Brabant, K. 2000, xiii).

A detailed security plan must be developed for every country and sites where humanitarian organizations are active (UNHCR 2000, 326). Acceptance of humanitarian organizations and their assistance programmes by the community (Mayhew, B. 2004, 10) as well as conflict parties is a key element in reducing security risks.

While humanitarian organizations cannot influence the threats they are exposed to they can reduce their vulnerability for example by protecting buildings from intrusion and they can reduce the impact of security incidents, for example by reducing the number of staff as well as the value of goods and assets at a site (Mayhew, B. 2004, 10).

Information of the government, authorities, the local population as well as the conflict parties about the humanitarian organization, their work in general as well as their programmes is another key element of security management (Mayhew, B. 2004, 21). Moreover being well informed about the development of the political and security situation and sharing information with other actors is indispensable for accurate assessments and analyses (Mayhew, B. 2004, 20). The attitude of staff towards the population, employees, authorities as well as armed forces and their consideration for local customs, traditions and religions (Mayhew, B. 2004, 28) as well as adherence to security measures is one of the most important elements of security management. Staff of humanitarian organizations should not carry any kind of weapons as these are likely to damage their credibility in general as well as efforts to be perceived as neutral and humanitarian (Mayhew, B. 2004, 31).

Damage to and loss of assets and goods will reduce the capacity of humanitarian organizations to provide humanitarian assistance and therefore increase suffering.

The potential political instability, possible collapse of state authority, insecurity, unpredictability of conflicts as well as the constant risk of diversion and theft of humanitarian assistance goods requires regular assessments of the overall security situation. It allows stopping transportation operations and relocating stocks and assets to safer areas if necessary. In order to avoid increasing the risks for recipients, the security situation must be assessed before every delivery of humanitarian assistance goods or provision of services.

Reducing the number of staff carrying out logistics activities reduces the overall risk of staff being harmed. Larger vehicles will require fewer drivers for transporting the same pay load and using powered handling equipment in warehouses will reduce the number of staff exposed to conflict related risks.

Staff members must be carefully selected to reduce the risk of being targeted because of their nationality, ethnicity, religious or political affiliations. At the same time the composition of the workforce of a humanitarian organization in terms nationality, ethnicity and religion must reflect the composition of the population to avoid being perceived as biased (Mayhew, B. 2004, 14).

Keeping the value of cash, stocks and assets such as vehicles to the necessary minimum will reduce the extent of losses in case of theft, robbery, looting or conflict related damages. Reducing stock levels, especially of highly sensitive health care goods, also reduces losses in case of deterioration or damage during storage.

The general insecurity and unpredictability of the conflict requires locating assets and stocks in the safest available place which still allows providing the required services.

Humanitarian organizations are accountable to donors, who ultimately pay for replacing damaged goods or higher insurance premiums. They will question any unreasonable security risks taken by humanitarian organizations and be reluctant to provide further funding if the loss of stocks and assets could have been avoided through more cautious management.

In situations where placing assets and stocks in insecure areas is necessary in order to provide the required level of services to humanitarian assistance programmes, the risk of damage or loss can be spread by decentralization. Decentralization will also reduce the risk of completely disabling logistics services which, besides the financial loss, could seriously affect people in need which suddenly cannot be provided with essential health care goods anymore. The possibility of reducing the risk for humanitarian organizations by outsourcing transportation and storage will often be limited by the availability of third party logistics providers and the difficulty of holding them liable for any damages or losses.

The accident risk, which is increased by the poor quality of roads and airports, must be minimized by careful maintenance of means of transportation. Damage to stocks by fire, water, high and low temperatures must be prevented by taking precautions and carefully maintaining stores and warehouses.

In the absence of any emergency services, humanitarian organizations must provide assistance to their staff in case of accidents or conflict related injuries by their own means and establish evacuation plans (UNHCR 2000, 328). This will often require establishing reliable communication networks independent of national networks especially for transport through insecure areas.

The movements of recipients through insecure areas to central places where humanitarian assistance goods or services are provided as well as the aggregation of large numbers of people increase their overall risk of being affected by the conflict. The aggregation of people generally has an adverse affect on sanitary conditions and increases the risk of outbreaks of communicable diseases. Besides sick or injured people might be unable to travel to health care facilities and therefore be deprived of medical attention.

Consequently humanitarian organizations must try to decentralize their assistance across the affected area as far as possible.

Direct deliveries to health care facilities, rather than donating goods to national or district authorities for further distribution, will decrease the risk of diversion or theft by criminals, parties to the conflict or authorities. Donors will require assurance from humanitarian organizations, rather than intermediaries they do not know, that humanitarian assistance goods have actually arrived at assisted health care facilities.

The general insecurity as well as the possibility of borders or front lines being closed requires considering and planning reasonably safe and secure alternative modes of transportation and transportation routes. Increasing transportation time of sensitive health care goods can lead to deterioration and damage.

In order to reduce the risk of theft and diversion, wherever possible, humanitarian organizations must seek approval from authorities or parties to the conflict for every transportation operation.

Humanitarian organizations must take care to abide by national laws and regulations and not be tempted to pay bribes demanded by authorities which may expose staff to criminal persecution.

Commercial transactions such as purchasing of goods and assets as well as signing contracts for renting warehouses must be carried out with great care as any kind of recourse may be impossible in the absence of law enforcement and judicial systems. Legal advice should be sought before concluding contracts which should be drawn up in great detail. Losses can be reduced by limiting the value of individual contracts as well as avoiding deposits, especially when engaging with unfamiliar business partners.

Consequently goods should only be paid for after receipt and careful inspection and more frequent payments should be agreed upon for rental contracts, since losses can be reduced in case of breach of contract.

7.2.2 Assuring high quality of provided health care goods

The primary objective of humanitarian organizations, to alleviate and reduce suffering, requires high quality health care goods (WHO 1999f, 7). Health care goods of poor quality will use valuable resources but hardly be effective in preventing epidemics, reducing morbidity, mortality and disabilities. An overview of the logistics and supply chain management objectives which need to be fulfilled to ensure provision of high quality health care goods is given in table 7.2.

The not-profit-making sector lacks the regulatory mechanism of demand and supply where dissatisfied customers can sanction poor quality services by changing suppliers (Badelt (ed.) 2002, 613). Since recipients do not have the possibility to choose the goods they receive and usually do not have an alternative source of health care services, humanitarian organizations have an ethical obligation to provide health care goods of high quality. Moreover customers and even health professionals are not always able to assess and determine the quality of health care goods (Broun, D. 1994, 1).

Accountability towards host countries and donors (ECHO 1999, 35), as well as compliance with national legislation in donor and host countries also require providing high quality health care goods.

The high quality of goods must be maintained along the entire supply network from the manufacturer until final distribution to recipients.

In the absence of national drug legislation or effective enforcement by competent national drug regulatory authorities, which would prevent importation as well as domestic production of substandard health care goods (WHO 1996d, 118), humanitarian organizations need to substitute the missing quality assurance system (WHO 2002c, 5).

Analytical laboratory testing of each batch of drug products requires sophisticated laboratories, is expensive (Health Action International 1998, 6) and also requires holding batches in quarantine for the duration of testing which in turn increases lead time. Moreover determining the identity of the active pharmaceutical ingredient does not prove that the content complies with the required specifications (WHO 1999a, 36). Even an appropriate content of active pharmaceutical ingredients does not necessarily prove bioavailability and efficacy of drug products (Dörner, G. (ed.) 1992, 32). Determining the quality of health care goods and their sterility also requires elaborate testing.

The lack of quality assurance measures in the country where humanitarian assistance goods are provided can be substituted by national drug legislation and national drug regulatory authorities of sufficiently high quality in another (developed) country. However some countries apply less stringent regulations to manufacturing of drug products intended exclusively for export (Creese, A., N. Gasmann, and M. Mariko 2004, 99).

Another possibility for substitution is conducting visits and inspections by qualified pharmacists from humanitarian organizations. However these are time consuming and also need to be repeated regularly. In countries where the quality of domestically available health care goods cannot be assured, humanitarian organizations need to purchase in neighbouring countries, in the respective region or even internationally.

ASSURING HIGH QUALITY OF HEALTH CARE GOODS	Substitution of shortcomings of national drug legislation	Global purchasing strategy	Purchase only of high quality health care goods	Protection of goods during transport and storage	Comply with national pharmaceutical legislation	Reduce stock levels as far as possible	Reduce stages of supply chain	Ensure short transport lead times
Objectives								
Towards donors								
Demonstrate concern for people affected by emergencies			●					
Compliance with humanitarian charter and code of conduct			●					
Relevance, effectiveness and (measurable) impact			●					
Towards recipient								
State								
Accountability towards host state and authorities			●					
Compliance with national legislation and regulations					●			
Community								
Prevent epidemics			●					
Reduction of morbidity and mortality			●					
Individuals or health facilities								
Provision of high quality health services			●					
Provision of high quality health care products		●	●					
Prevent and treat medical conditions			●					
Saving and preservation of human lives			●					
Prevent and reduce disabilities			●					
Prevent and alleviate suffering			●					
Management objectives								
Comply with legislation			●					
Comply with code of conduct			●					
Provide at least minimum standards		●	●					
Context and constraints								
Related to humanitarian organizations								
Internal management								
Final user does not chose goods and services			●					
Donors								
Accountability, reporting and auditing			●					
External management								
Competition for funds and professional staff			●					
International or global								
Customs (crossing international borders)					●			
Less developed countries								
Politics / Government								
Inefficient administration	●							
Poor pharmaceutical legislation and state control	●							
Economy								
Limited availability and quality of products	●	●						
High percentage of counterfeit drugs	●							
Environment								
(Sub)tropical climates				●				
Health care goods								
Characteristics								
Sterilized				●		●	●	●
Limited shelf life				●		●	●	●
Deterioration and damage								
Susceptibility to deterioration and damage				●				

Table 7.2 Assuring high quality of health care goods

Although not legally binding, the World Health Organization demands that donated drug products must be comply with quality standards in the recipient as well as donor country (WHO 1999c, 8). Since most major international humanitarian organizations maintain head offices in developed countries with strict pharmaceutical legislation, they must purchase high quality health care goods if they want to comply with the WHO guidelines for drug donations.

The nature of many health care goods, such as limited total shelf-life and susceptibility to damage by heat, as well as the often (sub)tropical climates of countries in which humanitarian assistance is provided, require particular attention. The high quality of health care goods must

be maintained along the entire supply network by preventing deterioration, damage and destruction during handling, transportation and storage.

Since humanitarian organizations must comply with national legislation of countries where humanitarian assistance is provided in general (Mayhew, B. 2004, 22), they must also comply in particular with pharmaceutical legislation and regulations where it is in place.

Compliance with national pharmaceutical legislation is of particular importance when importing goods into a country which may require applying for import permits, submitting certificates of origin and certificates of analysis for each batch.

National drug legislation which should ensure quality, safety and efficacy as well as correct information of drug products (WHO 1988a, 50) may impose a minimum remaining shelf-life upon importation and may even prohibit importation of high quality health care goods because of lack of a marketing authorization in the country.

Any increase in stock levels will reduce turnover and therefore shorten the remaining shelf-life of health care goods. In order to minimize the losses through expiry in stock and ensure a reasonable remaining shelf-life upon distribution to the final recipient, especially in global and multistage supply networks, stock levels must be kept low.

Every stage in the supply network reduces shelf-life by the average duration of storage and increases the risk of expiry of health care goods before they can be distributed. Therefore any stage of the supply network which is not necessary for providing the required services to final recipients should be eliminated.

For the same reasons transportation lead times must be kept to the necessary minimum, especially if the required environmental conditions, for example room temperature, cannot be maintained during transportation.

Avoiding delays at customs by pre-clearing goods will minimize reduction of remaining shelf-life and also reduce the time health care goods are exposed to adverse environmental conditions if ports of entry cannot ensure adequate storage.

7.2.3 Simplicity and reduction of complexity

While most commercial organizations try to provide a wide range of products and varieties in order to please as many customers as possible, the objective of humanitarian organizations is to provide essential goods and services effectively and efficiently to as many people in need as possible. An overview of the factors which require simplification and reduction of the complexity of logistics and supply chain management are shown in table 7.3.

Limiting the number and variety of items which need to be managed will increase the overall simplicity and efficiency of supply chain management (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 169), especially during the initial response, and allow making the best use of limited and unpredictable funding.

The context of less developed commercial markets and national health care systems as well as the need to respect the principles of primary health care also do not warrant providing a large number of different health care goods. Moreover introducing new and sophisticated health care goods will be unsustainable after humanitarian organizations end their assistance to health care facilities has ended.

A limited number of health care goods only will be necessary to cover essential needs and conform to the essential drugs concept (WHO 1977). In countries with generally low levels of health care services and chronic lack of health care goods, health professionals would not be

able to make use of a wide variety of (sophisticated) health care goods. Moreover carefully selecting a limited number of essential drug products encourages rational prescription (WHO 1988a, 6).

Standardization limits the variety of goods which also facilitates cooperation with other humanitarian organizations and allows different humanitarian organizations to provide health care facilities with the same, or at least similar, health care goods.

The reduction of items as well as the use of prefabricated kits is indispensable in order to respond to emergencies quickly and to limit the complexity of providing health care goods to a large number of health care facilities across a large geographical area.

SIMPLICITY AND REDUCTION OF COMPLEXITY	Limited number and variety of items	Simplicity of handling and storage	Limit tiers of supply network	Simplicity of information system
Objectives				
Towards donors				
Efficiency	●	●	●	●
Openness, transparency and accountability	●	●	●	●
Towards recipient				
State				
Consideration for national health care system	●			
Giving priority to Primary Health Care	●			
Enable viability and long-term development	●			
Community				
Relevance, cover essential community needs	●			
Individuals or health facilities				
Immediate initial response	●			●
Management objectives				
Coordination with other humanitarian organizations	●			
Context and constraints				
Related to humanitarian organizations				
Internal management				
Provision of essential goods	●			
Standardization	●			
Donors				
Limited resources	●	●	●	●
Unpredictable funding	●	●	●	●
External management				
Coordination among humanitarian organizations	●			
Less developed countries				
Economy				
Limited availability and quality of products	●			
Poor telecommunications infrastructure				●
Social				
Lack of logistics professionals	●		●	●
Low level of health care services	●			
Chronic lack of health care products	●			
Complex political emergencies				
Armed conflict				
Insecurity and high levels of violence		●	●	●
Possibly sudden onset	●	●		●
Disruption of local and domestic economy	●	●		●
Damage to and destruction of infrastructure				●
Recipients				
Large number of wounded civilians	●			
Large number of sick civilians	●			
People in need spread over a wide area	●	●		
Number and location of people unpredictable		●		
Movement of displaced people unpredictable		●		●
Rapidly changing demand (place, type, quantity)		●		●
Immediate need for humanitarian assistance	●	●		●
Health care goods				
Characteristics				
Limited shelf life	●		●	

Table 7.3 Simplicity and reduction of complexity

The lack of logistics professionals also requires limiting the complexity of supply chain management and limiting the number of managed items will greatly facility donor reporting.

Limiting the variety of provided humanitarian assistance good, especially of items and sizes which can be substituted for each other, will reduce demand variations through risk pooling and therefore facilitate demand forecasting, allow reducing safety stocks and reduce the probability of goods expiring in stock.

Humanitarian organizations could not justify allocating valuable and limited resources for investment in expensive assets such as sophisticated stores and materials handling equipment. The need to respond to emergencies quickly requires setting up stores quickly, often improvising with readily available means, and does not allow time for lengthy planning and establishing complex structures. As a consequence of the disruption or collapse of local and domestic economies, sophisticated equipment will be unavailable, would require purchase abroad and incur high transportation costs.

Expensive assets cannot be fully recovered when humanitarian assistance programmes end and will increase the extent of financial losses in case the assets are damaged or destroyed in the course of the conflict.

Besides demand may quickly shift over large geographical areas and stores and warehouses may quickly become useless by closure of borders and transportation routes.

Limited financial as well as human resources also necessitate limiting the stages in the supply network as far as possible while maintaining the required level of service to customers. Limiting the number of stages in the supply network will avoid unnecessary shortening of remaining shelf-life and the number of stages must be kept as low as possible in insecure areas in order reduce the risk of damage and losses. Finally reducing the number of stages in the supply network reduces demand distortion (Lee, H.L., V. Padmanabhan, and S. Whang 2004, 1883), increases forecasting accuracy and therefore facilitates forecasting and planning (Klaus, P. 2004, 510).

In the context in which humanitarian organizations work, specialists for establishing, operating, using and maintaining complex information systems as well as the required time for planning and implementation are not available. Investment in expensive equipment would also divert valuable funds from assistance which benefits recipients directly and would incur large financial losses in case of theft, damage or destruction in the course of hostilities. The unpredictability of conflicts and rapidly changing demand would incur significant expenses for moving and reinstalling complex information systems.

The unavailability or unreliability of telecommunication infrastructure does not allow real time data exchange and resorting to satellite communications is often prohibitively expensive.

7.2.4 Effectiveness

Logistics and supply chain management is crucial for the effectiveness of humanitarian assistance (Thomas, A., and L.R. Kopczak 2005, 2) which is one of the requirements discussed in chapter 2. An overview of factors which determine the need for effectiveness is presented in table 7.6.

While effectiveness might be taken for granted in commercial logistics and supply chain management, humanitarian organizations will have to overcome several obstacles before humanitarian assistance goods can be delivered to the health care facilities where they are required. In this context effectiveness means providing the required amount of goods with the required specifications as well as required quality to the requested health care facilities at the requested time.

Effectiveness of logistics and supply chain management will in turn allow effective implementation of humanitarian assistance programmes, which is a key criteria for evaluating and assessing humanitarian organizations (ECHO 1999, 20). Since the primary objective of humanitarian organizations is the reduction and prevention of suffering, effectiveness translates into the extent to which logistics and supply chain management enables implementing and sustaining humanitarian assistance programmes which prevent and reduce suffering.

Unlike most commercial organizations, effectiveness will have priority over efficiency, especially whenever the respective humanitarian organization is the only source of essential health care goods and humanitarian organizations are preoccupied with determining the feasibility of assistance programmes (Perrin, P. 1996, 150). The objective is taking "all possible steps" (The Sphere project 2004, 5) to reach the people with the greatest need rather than providing services efficiently to the maximum number of people. Where recipients rely on humanitarian organizations, which are committed to providing only essential health care goods, as their sole source, any shortages will deprive health professionals of the means to treat people and save lives and can therefore have dire consequences (PAHO 2001a, 6). In the context of chronically under-resourced health care systems which is exacerbated by the armed conflict, shortages are prone to arise quickly.

Fulfilling the primary objective of saving and sustaining lives will, especially during the initial emergency response, warrant committing disproportionate resources such as using expensive air transportation for small amounts of health care goods or evacuating sick and injured.

Where peripheral health care facilities are not supplied, the few central health care facilities will be quickly overwhelmed with patients seeking treatment (Perrin, P. 1996, 196).

7.2.5 Reliability and consistency

In order to maintain their effectiveness and achieve measurable impacts, humanitarian assistance programmes require reliable and consistent logistics support (Shawkey, P., and C. Hart 2003, 7). The objectives, context and constraints which determine the need for reliable and consistent logistics services are shown in table 7.6.

Many medical conditions require regular administration of drug products over a certain period of time. Interrupting anti-infective courses of treatment can be conducive to the development of resistance to drug products and preventing epidemics requires consistent vaccination programmes in order to quickly reach minimum coverage of the affected population. Maintaining primary health care services requires a continuous supply of essential drug products (WHO 1978, 28). The ability to provide consist health services in hospitals depends on the regular and reliable supply of health care goods (Bloch, Y. (ed.) 2001, 118). Providing and installing essential health care equipment (for example autoclaves, operating lamps or diagnostic equipment) implies the obligation to provide operating equipment as well as ensuring maintenance and servicing until health care facilities regain their self-sufficiency.

Shortages of health care goods, which compromise the quality of provided health care services or even cause interruption and suspension of humanitarian assistance programmes, would undermine the credibility of humanitarian organizations towards donors as well as host countries.

The supply network must allow providing health care facilities regularly under stable conditions as well as when transportation routes are disrupted by adverse weather conditions, hostilities or when borders are closed.

While a rapid response may be essential during the initial emergency phase, reliability and consistency is essential in maintaining regular supply of health care goods. Once required stock levels are reached at the assisted health care facilities, the speed of replenishment shipments is of little importance provided no stockouts occur.

7.2.6 Flexibility and responsiveness

The need for flexible health care services (Hanquet, G. (ed.) 1997, 142) as well as the pervasive uncertainty of the context of humanitarian assistance programmes demands flexible and responsive logistics services (UNHCR 2000, 262). Some changes are gradual and can be anticipated, at least to some degree, others are sudden and unpredictable. On overview of factors which require flexible and responsive logistics services is shown in table 7.4.

Generally, high variability in demand requires responsive and flexible supply networks (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 370). Several factors require flexibility in providing different goods in changing quantities. Demand increases and decreases with the extent and intensity of conflicts and also depends on the type of weapons and warfare. Displacement, epidemics and deterioration of the nutritional status of the population will increase demand. Changes in standard treatment protocols as well as seasonal diseases increase demand for some items while decreasing demand for others. Finally lack of consistent inventory control policies at health care facilities can lead to erratic demand even though end-user demand is stable.

Even where end-user demand is stable, demand for health care goods will vary with increases and decreases of assistance to individual health care facilities as well as with changes in the number of assisted health care facilities. Despite unchanged needs, changes in funding will determine the kind and extent of assistance humanitarian organizations can afford.

Assistance by humanitarian organizations will also vary with changing capacities of the community and national health services as well as assistance by other humanitarian actors in the same area or even the same health care facility. Demand can also change quickly and unexpectedly with changes in the security situation and access to affected populations.

Even where the kind and quantities of demand remain unchanged, the required place of delivery may change depending on the development of the conflict, changes of access as well movement of displaced populations. Maintaining impartiality and balancing assistance may also require shifting assistance depending on changes of power structures and the political context. Demand may also quickly shift from a damaged or abandoned health care facility to another or away from a health care facility which has restored its self-sufficiency. New humanitarian actors may take over assistance from other humanitarian organizations who may in turn decide to shift their assistance to another place.

Supply network designs will need to be adapted to changes of supply sources as well as the location of assisted health care facilities. Even where both of these remain unchanged, networks will have to adapt to changes of security and access. Paradoxically increasing hostilities will inevitably increase demand while decreasing ease of access (Trintignac, F. (ed.) 1999). Opening and closure of borders as well as transportation routes may require setting up new stores and closing others at short notice. Suitable supply networks may need to adjust their capacities significantly in a short period of time.

Flexibility will also be required in the choice of modes of transportation. Roads, railways, ports and airports may be inaccessible for security reasons and access may be denied by authorities or as a consequence of sanctions. Authorities and parties to the conflict may also

deny over flight and landing rights for aircraft or completely close the air space for civilian aircraft.

FLEXIBILITY AND RESPONSIVENESS	Flexibility of goods and quantities	Flexibility in delivery	Flexibility of supply network	Flexibility of logistics capacities	Flexibility in mode of transport
Objectives					
Towards donors					
Relevance, effectiveness and (measurable) impact	●	●			
Towards recipient					
State					
Consideration for national health care system	●				
Consider national capacities	●				
Coordination with other humanitarian actors	●	●	●		
Community					
Security of affected population		●			
Reduction of morbidity and mortality	●				
Reaching and assisting the most vulnerable		●			
Balance assistance to different groups		●			
Consider local capacities and prevent dependency	●	●			
Individuals or health facilities					
Prevent and treat medical conditions	●				
Saving and preservation of human lives	●				
Prevent and reduce disabilities	●				
Prevent and alleviate suffering	●				
Management objectives					
Coordination with other humanitarian organizations	●	●	●		
Context and constraints					
Related to humanitarian organizations					
Donors					
Dependency on donations	●				
Unpredictable funding	●				●
External management					
Coordination among humanitarian organizations	●	●	●		
Possibly dependence on other organizations	●	●			
Less developed countries					
Politics / Government					
Potential political instability	●	●			
Economy					
Poor transport infrastructure			●		●
Delays for importation of goods			●		●
Complex political emergencies					
Armed conflict					
Lack or collapse of state authority	●	●	●		
Insecurity and high levels of violence	●	●	●		
Blocked or closed borders			●		●
Restriction, obstruction and denial of access			●	●	●
Possibly trade, transport and communication sanctions			●		●
Possibly sudden onset	●	●	●	●	
Unpredictable and dynamic conflict	●	●	●	●	●
Disruption and collapse of local and domestic economy	●		●		
Damage to and destruction of infrastructure			●		●
Recipients					
People in need spread over a wide area		●	●		
Number and location of people unpredictable	●	●	●	●	
Movement of displaced people unpredictable		●	●		
Rapidly changing demand (place, type, quantity)	●	●	●	●	
Erratic ordering	●				

Table 7.4 Flexibility and responsiveness

Means of transportation may be (temporarily) unavailable due to breakdowns and transportation infrastructure may be unusable or impassable due to damage or weather conditions such as landslides and floods. Changes in modes of transportation may also be imperative due to lack of funding.

7.2.7 Independence

Logistics services must support the general objective of humanitarian organizations to maintain their independence from parties to the conflict discussed in chapter 2. The factors requiring logistics services to maintain their independence are shown in table 7.5. The

provision of assistance by armed forces has contributed to the erosion of the notion of the neutrality of humanitarian assistance (Schneider, M. 2003, 140). Provision of humanitarian assistance by armed forces confuses recipients, is relatively costly and any association with local, domestic or international armed forces may endanger humanitarian workers (Sondorp, E., and A.B. Zwi 2002, 311). Moreover impartiality of humanitarian organizations is indispensable in gaining access to people in need (VENRO 2003, 16). Consequently armed forces should focus on providing security and protection for the civilian population rather than delivering humanitarian assistance (Sondorp, E., and A.B. Zwi 2002, 311).

The need for establishing and maintaining effectiveness, regardless of the context and constraints of humanitarian assistance programmes, requires logistics services of humanitarian organizations to avoid dependency on domestically available infrastructure and resources.

Especially in ethnic and religious conflicts, where employing national staff may put them at risk and compromise the impartiality and neutrality of the humanitarian organization, international staff is necessary especially for transportation operations. Specialists such as pilots or transport managers may be unavailable domestically and again require hiring international staff. During the acute emergency phase international staff may be indispensable until qualified national staff can be recruited.

Domestic transportation and storage capacities may be of limited quality, may have insufficient capacities, may not be (immediately) available at all and may lack the necessary expertise for handling health care goods.

Commercial suppliers which are associated with any of the conflict parties as well as services provided by governments, authorities, national or foreign armed forces could compromise the neutrality and impartiality of humanitarian organizations. Where humanitarian organizations compete for limited resources or commercial suppliers control the market, rates or conditions may be unreasonable and more expensive than own account transportation.

Commercial services can suddenly cease if the security situation deteriorates and commercial carriers may be unable to operate in conflict areas while conflict parties may still be obliged to allow humanitarian organizations access.

Where legal security and law enforcement is lacking, outsourcing logistics services can incur significant risks as there may be no recourse in case of damage or theft.

Health care goods available in domestic markets may be limited in range and quality or be counterfeit. Specialized goods, such as medical kits, will be unavailable and domestic commerce can be disrupted by trade sanctions. Complete dependency on domestic suppliers of health care goods carries the risk of disrupting supply of assisted health care facilities in case of shortages and stockouts.

Moreover several humanitarian organizations and other actors may be competing for the same (limited) domestic resources. Lack of legal security carries the risk of financial losses if contracts cannot be enforced and commerce may be suspended altogether in case the security situation deteriorates.

Domestic communication infrastructure is often poorly developed or damaged in the course of hostilities. Maintaining communications, which are indispensable for the security of staff and means of transportation, may require installation of independent radio, telephone or satellite communication networks for voice and data transmission.

Where the financial infrastructure is poor or has collapsed, humanitarian organizations may have to ensure regular supply of cash or use financial services of other countries for paying suppliers with foreign accounts.

INDEPENDENCE	Independence from domestic human resources	Independence from domestic logistics capacities	Independence from domestic suppliers	Independence from domestic communication networks	Independence from domestic financial infrastructure
Objectives					
Towards donors					
Relevance, effectiveness and (measurable) impact		●	●		
Towards recipient					
State					
Neutrality towards conflict parties	●	●			
Community					
Impartiality	●	●			
Individuals or health facilities					
Assure assistance reaches recipients, effectiveness		●			
Provision of high quality health care products			●		
Immediate initial response		●			
Management objectives					
Fulfill its mandate		●			
Comply with code of conduct		●			
Maintaining independence		●			
Security of staff, assets and stocks	●	●			
Context and constraints					
Related to humanitarian organizations					
Internal management					
Impartiality		●			
Less developed country					
Politics / Government					
Potential political instability		●	●	●	●
Poorly developed legislation and legal security		●	●		
Economy					
Poor financial infrastructure					●
Poor transport infrastructure		●			
Limited availability of third party logistics suppliers		●			
Poor telecommunications infrastructure				●	
Limited availability and quality of products			●		
High percentage of counterfeit drugs			●		
Social					
Low level of education	●				
Lack of logistics professionals	●				
Complex political emergencies					
Armed conflict					
Insecurity and high levels of violence	●	●	●	●	●
Restriction, obstruction and denial of access	●	●			
Trade, transport and communication sanctions			●		
Possibly sudden onset	●	●	●		
Unpredictable and dynamic conflict		●	●		
Disruption of local and domestic economy		●	●		
Recipients					
Immediate need for humanitarian assistance	●	●			
Health care goods					
Deterioration and damage					
Susceptibility to deterioration and damage		●			

Table 7.5 Independence

7.2.8 Rapid initial response

When a new complex political emergency arises in places where the communities and authorities do not have the capacity to cope with the increased needs of affected people immediately, humanitarian organizations must ensure a rapid initial response (Ockwell, R. 1994, 418). A rapid response by humanitarian organizations requires rapid provision of logistics services (PAHO 2001a, 131). An overview of factors which determine the need for a rapid initial response is presented in table 7.6. The same considerations apply to hostilities which arise in a previously fairly stable and peaceful area in a crisis region as well as to sudden changes in demand.

Especially in crises which attract significant media attention, donors will require swift interventions and demand humanitarian organizations to demonstrate that their assistance programmes have an impact on the plight of the affected populations very quickly.

Providing assistance to wounded people as well as interventions to pre-empt epidemics is required to be effective and timely interventions can make a difference between life and death (PAHO 2001a, 5).

The chronic lack of health care goods and the low quality of health care services in general implies that states and communities have few resources to cover the needs during the initial emergency phase and allow humanitarian organizations some time for responding. The World Health Organization estimates that one third of the world's population and half of the population in poor areas lacks access to even essential drug products (WHO 1998, 3).

However once assistance to health care facilities has started and stocks of all essential health care goods are established, quick replenishment is not adding any value as long as there is no danger of shortages and stockouts. Especially in protracted conflicts maintaining systems of responding to any demand rapidly will be unsustainable because of their high costs.

7.2.9 Efficiency

While effectiveness must be given priority over efficiency, the best possible use must be made of funds for which several humanitarian organizations are competing. Among several alternatives which can achieve the same results and impact, the most cost-effective alternative must be chosen (ODI 2006, 44). An overview of factors which determine the need for efficiency is presented in table 7.6.

While economic systems value all factors in financial terms (Badelt (ed.) 2002, 132) and efficiency in profit-making organizations can be defined as ratio between financial inputs and financial outputs, not-profit-making organizations do not seek financial gains or profits. Moreover social and humanitarian benefits of humanitarian assistance programmes cannot be measured in financial terms (Hallam, A. 1998, 85). Since the primary objective of humanitarian organizations is reducing suffering, efficiency can be understood as the extent to which suffering is reduced (output) with a certain amount of resources (input). Consequently logistics and supply chain management efficiency can be understood as the reduction of suffering which is achieved with a certain amount of humanitarian assistance goods and the resources required along the entire supply network for making them available to the end-user.

The careful use of funds is also an obligation towards donors (ECHO 2003, 2). Donors may be willing to fund effective but inefficient operations for a short period of time during the initial emergency response, such as deploying field hospitals or using expensive airlifts. As soon as the survival of the affected populations is no longer at risk and especially in protracted complex political emergencies, humanitarian organizations will have to resort to more efficient humanitarian assistance strategies.

Since humanitarian organizations can never satisfy all the needs, any decrease in efficiency will deprive some people in need of humanitarian assistance (Stockton, N. 2001, 11).

Increasing efficiency is an important means for humanitarian organizations to compete for limited funding as donors will want to maximize the impact of their funds. Once humanitarian organizations have been allocated funds, they will have to complete the programmes according to the proposed time schedule and within budget in order to be eligible for further funding.

7.2.10 Accountability

The international humanitarian systems lacks a clear legal framework (OECD 1999, 19). Instead provisions from various international, human rights, humanitarian as well as refugee

laws such as the Universal Declaration of Human Rights (1948), the Geneva Conventions, the International Covenant on Economic, Social and Cultural Rights (1966), the Convention on the Rights of the Child (1989), the Convention on the Status of Refugees (1951) as well as the Convention on the Elimination of All Forms of Discrimination Against Woman (1979) apply. The lack of generally accepted standards and benchmarks also hampers objective evaluations of the performance of humanitarian organizations.

In practical terms, humanitarian organizations are primarily accountable towards their donors (Koivusalo, M., and E. Ollila 1996, 101). Since most humanitarian organizations have only small financial reserves, donors will usually advance funds for implementation of humanitarian assistance programmes. Donors will demand to be kept informed of the final use of resources and need to satisfy themselves that their donations were used correctly and their contributions were useful (PAHO 2001a, 160).

Funding may be suspended if humanitarian organizations cannot account in detail how funds were used. Humanitarian organizations may be accountable after predetermined periods of time through intermediate reports or at least upon completion of the programme. Unsatisfactory accounting will disqualify them from continuation of funding or eligibility for applying for future funding. An overview of factors which determine the need for accountability of logistics services is presented in table 7.6.

Humanitarian organizations must not only account for the funds they have received but are also accountable towards donors for the humanitarian assistance programmes which they have carried out (Perrin, P. 2002, 22). Humanitarian organizations will have to provide detailed reports on their programmes, number and kind of recipients as well as the impact their programmes had on the assisted population.

Logistics services will have to justify and account for all purchases of goods and services, account for overall logistics costs and provide detailed reports on kind, quantity and places of distribution of humanitarian assistance goods.

Humanitarian organizations are also accountable towards the host countries and authorities which may have granted access and various privileges only on the condition that the population is assisted effectively. When suspicion arises among the public, conflict parties or recipients that humanitarian assistance goods have been mismanaged, logistics managers must be able to provide detailed reports on distributions (PAHO 2001a, 159).

Although recipients rarely have the possibility to choose among offered humanitarian assistance and to sanction the poor quality of provided services (Hilhorst, D. 2001, 15), one of the principles of the Code of conduct states that humanitarian organizations hold themselves accountable to those they seek to assist (The Sphere Project 2004, 320). Moreover assessments by independent auditors as well as media reports will point out shortcomings of assistance programmes and put pressure on humanitarian organizations to provide high quality services.

In order to provide accurate information and allow detailed auditing, logistics services need to keep meticulous records of all their purchases (tenders, purchase contracts etc.), details of kinds, quantities, dates and places of distributions as well as recipients and regularly prepare reports (Larragán, A.A., et al. 1998, 49).

Details on recipients as well as the date and place of distribution must also be recorded and provided for any goods which are subject to sanctions in order to prove that the civilian population rather than conflict parties benefited directly from the assistance.

7.2.11 Summary of logistics and supply chain management objectives

The logistics and supply chain management objectives derived above are summarized in table 7.6 which shows the relation between objectives, context and constraints of humanitarian organizations as well as characteristics of health care goods with the respective logistics and supply chain management objectives.

LOGISTICS AND SUPPLY CHAIN MANAGEMENT OBJECTIVES	Risk minimization	Quality assurance	Reduction of complexity	Effectiveness	Reliability and consistency	Flexibility and responsiveness	Independence	Rapid initial response	Efficiency	Accountability
Objectives										
Towards donors										
Demonstrate concern for affected people		●								
Compliance with humanitarian charter		●		●						●
Competence and professionalism				●	●			●		
Relevance, effectiveness and (measurable) impact		●		●	●	●	●			
Efficiency			●						●	
Openness, transparency and accountability	●		●						●	●
Visibility of donor										
Develop its own public profile										
Towards recipient										
State										
Respect for state sovereignty										
Accountability towards host state		●		●	●					●
Compliance with international law										
Neutrality towards conflict parties							●			●
Compliance with national legislation		●								
Consideration for effects on economy										
Consideration for national health care system			●			●				
Giving priority to Primary Health Care			●							
Enable viability and long-term development			●							
Provide assistance only based on actual needs										
Consider national capacities						●				
Coordination with other humanitarian actors						●				
Community										
Security of affected population	●					●				
Prevent epidemics		●		●	●			●		
Reduction of morbidity and mortality		●		●	●	●				
Reaching and assisting the most vulnerable						●				
Consideration for the central role of woman										
Balance assistance to different groups						●				●
Impartiality							●			●
Respect for culture, customs, traditions										
Show solidarity										
Relevance, cover essential community needs			●	●	●					
Local capacities and prevent dependency						●				
Approval by and participation of community										
Individuals or health facilities										
Assure assistance reaches recipients				●			●			
Provision of high quality health services		●		●			●			
Provision of high quality health care products		●								
Immediate initial response			●	●			●	●		
Prevent and treat medical conditions		●		●	●	●		●		
Saving and preservation of human lives		●		●	●	●		●		
Prevent and reduce disabilities		●		●	●	●				
Prevent and alleviate suffering		●		●	●	●				
Ensure non-discrimanation of recipients										
Show respect, preserve and restore dignity										
Management objectives										
Comply with legislation		●								
Secure funds										
Fulfill its mandate				●	●		●			
Comply with code of conduct		●		●	●		●		●	●
Maintaining independence							●			
Security of staff, assets and stocks	●									
Coordination with humanitarian organizations			●			●				
Carry out detailed assessment										
Careful and detailed planning										
Provide at least minimum standards		●		●						
Completion of programmes				●	●				●	
Learn from successes and mistakes										
Context and constraints										
Related to humanitarian organizations										
Internal management										
Non-profit organization									●	●
Lack of regulation of sector										
Impartiality							●			
Final user does not chose goods and services		●								
Provision of essential goods			●	●	●					
Standardization			●							
Distance between operations and head office										
Donors										
Dependency on donations						●				
Limited resources			●						●	
Unpredictable funding			●			●			●	
Earmarking of funds										

LOGISTICS AND SUPPLY CHAIN MANAGEMENT OBJECTIVES	Risk minimization	Quality assurance	Reduction of complexity	Effectiveness	Reliability and consistency	Flexibility and responsiveness	Independence	Rapid initial response	Efficiency	Accountability
Donors (continued)										
Donations in kind versus cash										
Accountability, reporting and auditing	●	●		●	●				●	●
External management										
Coordination among humanitarian organizations			●			●				
Possibly dependence on other organizations						●				
Competition for funds and professional staff		●		●	●				●	●
International or global										
Large geographical scope	●									
Language barrier										
Adaptation to cultural context										
Customs (crossing international borders)		●								
Less developed country										
Politics / Government										
Potential political instability	●					●	●			
High levels of corruption	●									
Inefficient administration		●								
High levels of bureaucracy										
Poorly developed legislation and legal security	●						●			
Poor pharmaceutical legislation and state control		●								
Economy										
Poor financial infrastructure	●						●			
Poor transport infrastructure	●					●	●			
Delays for importation of goods						●				
Limited availability of third party logistics	●						●			
Poor telecommunications infrastructure			●				●			
Limited availability and quality of products		●	●				●			
High percentage of counterfeit drugs		●					●			
High unemployment										
Low wages										
Social										
Low level of education							●			
Lack of logistics professionals			●				●			
Low level of health care services	●		●	●	●					
Chronic lack of health care products			●	●	●			●		
Environment										
(Sub)tropical climates		●								
Complex political emergencies										
Armed conflict										
Lack or collapse of state authority	●					●				
Insecurity and high levels of violence	●		●			●	●			
Blocked or closed borders	●					●				
Restriction, obstruction and denial of access						●	●			
Trade, transport and communication sanctions						●	●			
Possibly sudden onset			●			●	●	●		
Unpredictable and dynamic conflict	●					●	●			
Protracted conflicts										
Disruption of local and domestic economy			●			●	●			
Damage to and destruction of infrastructure	●		●			●				
Degradation of collapse of health services				●	●			●		
Recipients										
Large number of wounded civilians			●	●					●	
Large number of sick civilians			●	●					●	
People in need spread over a wide area			●			●				
Number and location of people unpredictable			●			●				
Large numbers of refugees and IDPs									●	
Movement of displaced people unpredictable			●			●				
Rapidly changing demand (place, type, quantity)			●			●		●		
Erratic ordering						●				
Lack of financial resources of population										
Immediate need for humanitarian assistance			●	●			●	●		
Diversion and theft of assistance goods	●									
Health care goods										
Characteristics										
High density										
Bulky										
Volatile										
Pressurized										
Sharp										
Dangerous (flammable, corrosive)										
Sterilized		●								
Limited shelf life		●	●							
High value	●									
Controlled/regulated										
Deterioration and damage										
Susceptibility to deterioration and damage	●	●					●			

Table 7.6 Summary of logistics and supply chain management objectives

The individual logistics and supply chain management objectives which follow from the objectives, context and constraints of humanitarian organizations can be summarized in ten objectives: minimizing safety and security risks, assuring high quality of provided health care goods, simplicity and reduction of complexity, effectiveness, reliability and consistency, flexibility and responsiveness, independence, rapid initial response, efficiency and accountability.

7.3 Trade-offs between objectives

The logistics and supply chain management objectives can be grouped into objectives related to risk, customer service and cost.

Significant security risks for recipients as well as humanitarian organizations are inevitable in the context of complex political emergencies. Consideration of the trade-off between benefits of caring for injured people and the risk for the people providing care themselves (Coupland, R., Å. Molde, and J. Navein 2001, 2) equally applies to staff providing support services.

To a certain degree the risks incurred by humanitarian organizations and by recipients are related. Centralization of services in safe areas and places will decrease the risk for humanitarian organizations but increase the risk for recipients and delay medical treatment since recipients need to travel to benefit from provided services (Coupland, R., Å Molde, and J. Navein 2001, 2). Independence, neutrality and impartiality will generally reduce the risk of threats and attacks from parties to the conflict.

Customer service provided to recipients, which ultimately reduces suffering, will increase with higher quality of health care goods, increased effectiveness, higher reliability and consistency of services, faster initial response and higher flexibility and responsiveness of services.

Greater efficiency as well as reduction of complexity and simplicity will reduce costs.

Accountability cannot be traded off as it is an external constraint which is a prerequisite for obtaining funds and therefore indispensable for humanitarian organizations to operate. Higher accountability towards recipients and donors requires increasing the quality of provided services but at the same time demands reducing costs and increasing efficiency.

While logistics managers will try to achieve all objectives, compromises will have to be found at all levels.

Several trade-offs between safety and security risk for humanitarian organizations as well as services provided to health care programmes and recipients need to be considered (figure 7.4).

The insecurity caused by the conflict can delay or even make health care programmes impossible. An immediate initial response to an emergency as well as changes of logistics services limit time available for analysing the context and situation and assessing safety and security risks. Once health care programmes have been implemented, humanitarian organizations must decide on a case by case basis whether to take the associated risks and provide services or postpone or even cancel humanitarian assistance programmes. For the same reasons humanitarian organizations may have to interrupt their services and therefore trade off incurring security risks and ensuring reliability and consistency of services.

A trade-off must be made between safety and security risk as well as efficiency and complexity and reducing risks by securing warehouses, taking detours for transportation, travelling in convoys or using air transportation which increase costs. A trade-off must also be

made between using mainly manual handling which requires more staff and increases their risk and the use of powered handling equipment which increases cost and complexity.

Operating independently from parties to the conflict, authorities, other humanitarian organizations, commercial organizations and the military may reduce the risk of being seen as partial in the conflict but at the same time increases logistics cost as resources cannot be shared.

An increase in effectiveness may increase cost and decrease efficiency when recipients are assisted in areas which are more difficult to reach and supply. An increase of the number of recipients will require covering a larger geographical area which incurs higher costs than concentrating on a smaller area.

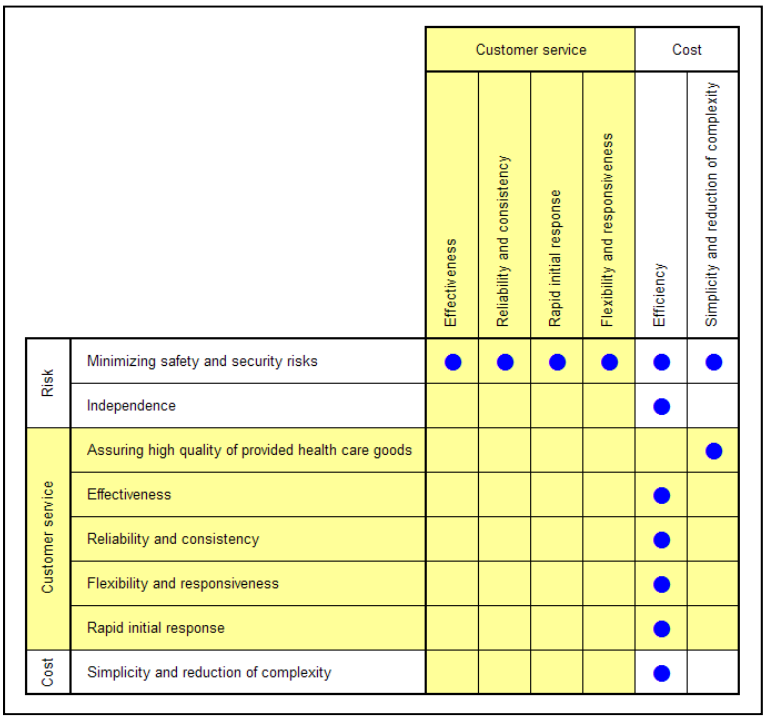

Figure 7.4 Trade-offs between objectives

Like in commercial logistics and supply chain management, greater reliability and consistency of services incur higher costs. Higher stock levels are required, alternative modes and routes of transport must be planned for and possibly more stores are needed closer to customers. Likewise a trade-off between flexibility and responsiveness as well as efficiency must be made (Chopra, S., and P. Meindl 2007, 55). Similarly a rapid initial response is more expensive than a slower response as it requires using more expensive means of transportation and limits the possibility of using third party logistics suppliers, especially in the crisis area, since their identification and contracting takes time.

The objectives of logistics and supply chain management can be summarized as enabling the greatest possible reduction of suffering at the lowest possible cost (Thomas, A., and L.R. Kopczak 2005, 1) while incurring the lowest possible safety and security risks for staff, assets, facilities and humanitarian assistance goods. The trade-offs between the three groups of logistics and supply chain management can be summarized as presented in figure 7.5.

Finally the trade-off between service and cost must be considered. Higher quality of health care goods, especially medical devices and equipment, are often more complex and use more

sophisticated technology which increases the complexity of required logistics services for installation, training, maintenance and servicing.

In general reducing suffering or increasing customer service as well as greater insecurity and higher safety and security risks will increase overall logistics costs. At a given amount of available resources, safety and security risks and customer service are inversely related. At any given level of insecurity and risks increasing services will increase costs and at a given level of service any increase of risks will also increase costs.

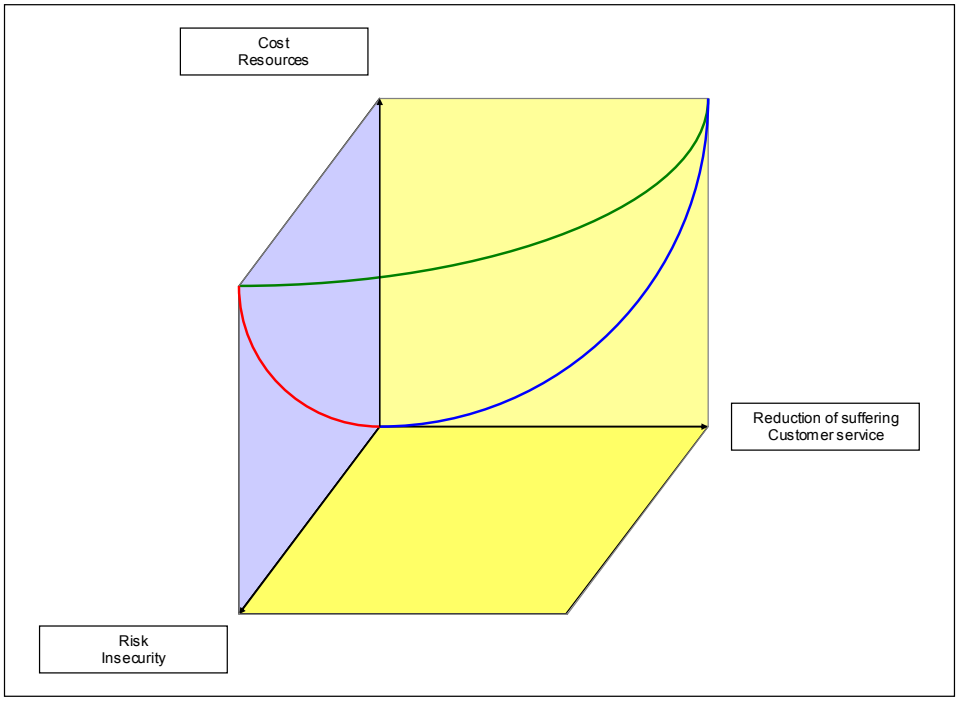

Figure 7.5 Summary of trade-offs between objectives

7.4 Framework dimensions

The two dimensions of Thorn's framework will be further explored, modified and extended before adding the aspects of time, distance and criticality.

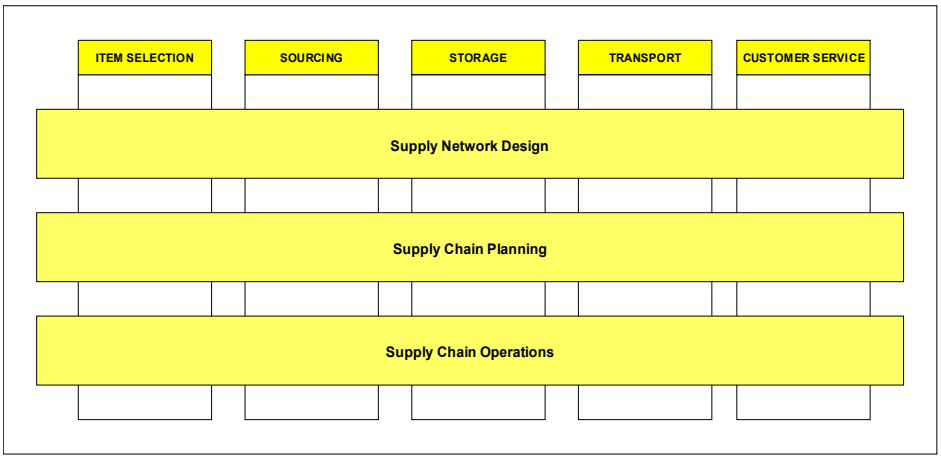

Figure 7.6 Adaptation of Thorn's framework

Because the characteristics of items have important implication for logistics and supply chain management, item selection is separated from sourcing and included as a separated logistics function.

The process of production is removed as humanitarian organizations generally are not concerned with manufacturing and production.

The process of distribution is differentiated into storage and transport, which may be carried out a several stages of the supply network, and the process of providing customer service is maintained to derive the framework presented in figure 7.6.

7.4.1 Management levels

Thorn distinguishes between strategic, tactical and operational supply chain planning levels (Thorn, J. 2002, 22). Various aspects of these levels are summarized in table 7.7.

Management Level	Strategic	Tactical	Operational
Customer scope	Health assistance strategy	Assistance programme	Health care facility
Supply chain management	Supply network design (Configuration)	Supply chain planning (Coordination)	Supply chain operations (Execution)
Aspect	Static structure (Space)	Dynamic flow (Time)	Individual transactions (Goods and information)
Management scope	Resources	Capacities	Transactions
Time horizon	Long-term (more than 2 years)	Mid-term (0.5 to 2 years)	Short-term (less than 0.5 years)
Resource allocation	Long-term	Mid-term	Short-term
Uncertainty and risk	High	Medium	Low
Cost of change	High	Medium	Low
Geographic scope	Worldwide and regional	National	Local
Decision making	Head office (global / centrally)	Mid-level management (national level)	Logistics staff (locally / decentralized)

Table 7.7 Framework management levels

The strategic planning provides direction and control for tactical planning which in turn determines operational plans (Lambert, R.S., and J.R. Stock 1993, 717).

Strategic supply chain management planning must support the overall objectives and strategy of the respective humanitarian organization in general and the assistance strategy for health care programmes in particular. This corresponds to the requirement in commercial logistics and supply chain management to link the logistics strategy to the corporate strategy (Gattorna, J. (ed.) 1990, 23).

Tactical management focuses on supporting specific assistance programmes in a country or region which supports a number of health care facilities while operational plans are directed towards serving a specific health care facility.

Supply chain management can be divided into the three hierarchical levels of supply chain design, supply chain planning and supply chain operations (Chopra, S., and P. Meindl 2007, 9). However the complexity of a multitude of suppliers and customers is more accurately reflected in the term supply network (Christopher, M. 2005, 5). For the strategic level the term supply chain configuration and for the operational level supply chain execution have also been proposed (Walther, J., and M. Bund (ed.) 2001, 17).

Supply chain design or configuration is concerned with decisions on the structure of the supply network such as location of suppliers and warehouse facilities or the type of information systems to be utilized (Chopra, S., and P. Meindl 2007, 9).

At the tactical level supply chain planning is carried out within the constraints and structure of the network design (Chopra, S., and P. Meindl 2007, 9).

Supply chain operations are concerned with individual customer orders and daily operations which are carried out within the confines of supply chain planning decisions (Chopra, S., and P. Meindl 2007, 9).

While all levels of logistics planning are concerned with the flow of goods, strategic management deals primarily with the static structure of supply networks (Thorn, J. 2002, 23). Tactical supply chain management is primarily concerned with managing and optimizing dynamic flows of information and goods within and through a given supply network while operational management is concerned with individual transactions.

Strategic management is concerned with determining and mobilizing required resources while optimizing processes and allocating capacities within the confines of a given structure is the task of tactical management. Operational management finally is concerned with carrying out individual activities.

Strategic management decides on the long-term allocation of resources (Chopra, S., and P. Meindl 2007, 9), tactical management is concerned with capacities of flows and operational management with transactions (day-to-day activities).

Strategic management decisions have a long-term effect on the organization and concern decisions which are valid for more than two years (Thorn, J. 2002, 22). These are further realized in mid-term tactical decisions which are taken for the next six months to two years while operational decisions concern the short-term future of less than six months.

The allocation and commitment of financial, human and technical resources corresponds to the time horizon (Gattorna, J. 1990, 45).

The uncertainty of future developments and therefore the risk that decisions will be wrong or require revision naturally increases with the time horizon.

The cost of changes at short notice increases with the time horizon as long-term decisions usually require significant investment and allocation of resources (Chopra, S., and P. Meindl 2007, 9).

Strategic decisions apply to the entire organization and therefore concern logistics management worldwide. Tactical decisions depend on the context and constraints of humanitarian assistance programmes and may therefore differ from country to country where humanitarian assistance is provided while operational decisions apply to the local level.

The level of decision making corresponds to the geographic area which is affected. Strategic decisions which affect the entire organization worldwide are taken centrally. Tactical decisions are taken by mid-level management at national level while operational decisions are the responsibility of staff at the respective site (Larragán, A.A., et al. 1998, 27).

7.4.2 Logistics functions

According to the above criteria various strategic, tactical and operational issues of the logistics functions can be determined as presented in table 7.8.

Logistics functions	Strategic issues	Tactical issues	Operational issues
Item selection	Logistical requirements Variety control Standard item catalogue	National standard list Kits versus separate items	Order placement
Sourcing	Supplier qualification Dual versus multiple sourcing Centralized versus decentralized purchasing Width of supplier base	Purchasing method Supplier selection Purchase contracts Domestic purchase Incoterms Donations	Purchasing transactions
Storage	Storage facility location Site and storage facility selection Ownership of storage facilities Contingency planning	Setting up stores in the field Demand analysis Collaborative planning and forecasting Inventory control Stock positioning of items	Warehouse and stores management Warehouse and stores operations Stock replenishment
Transporta-tion	Physical distribution channels Transport contingency planning Mode of transportation Ownership of transportation means	Dangerous goods Importation and exportation Distribution systems Selection of mode of transportation Outsourcing of transportation capacities Selection of means of transportation	Customs clearance Distribution to customers Reverse logistics
Customer service	Customer service policy Customer service elements Collaborative planning	Customer service plan	Order fulfilment Supply chain performance measurement
Controlling	Controlling strategy	Logistics evaluation	Performance measurement

Table 7.8 Logistics functions

At the strategic level criteria for including items in the standard item catalogue are determined which apply to all health care programmes of the humanitarian organization. According to the respective health care programmes in a country, selected items are included in the national standard lists from which customers in turn select items which are required for their health care facility.

The sourcing strategy defines general criteria for supplier qualification (Thorn, J. 2002, 23), the geographic scope as well as the overall number of suppliers. The format and participants for tenders as well as the type of purchase contracts are tactical decisions which are realized in operational purchasing transactions.

The location and ownership of storage facilities require significant investment and therefore a long-term strategic decision (Klose, A., and P. Stähly 2004, 482). The positioning of individual items and the inventory control policy are taken at a tactical level (Thorn, J. 2002, 17) and determined according to the needs and development of assistance programmes. Operational decisions are taken to replenish stocks and for the day-to-day management of warehouses.

The selection of physical distribution channels as well as mode of transportation affect the facility network and must therefore be made at a strategic level. Ownership of transportation means requires significant resources for acquisition as well as maintenance and therefore requires a long-term strategy. The selection of distribution systems as well as selecting among different available modes of transportation depends on the context and constraints of the country where humanitarian assistance is provided while routing and scheduling are operational decisions.

The worldwide customer service policy is translated into customer service plans for each health assistance programme while order processing is an operational activity.

The controlling strategy defines the overall framework, logistics evaluations assess the appropriateness of logistics resources and capacities and regular performance measurements assess the quality of services provided to customers.

7.4.3 Aspects of time, distance and criticality

The framework of Thorn can be extended by adding the aspects of time, distance and criticality.

Strategies for humanitarian assistance and interventions differ from the contingency phase before emergencies, the emergency phase, the rehabilitation and reconstruction phase as well as the development phase (OECD 1997, 10). As logistics managers provide services to humanitarian assistance programmes, they must also adapt priorities and strategies to these phases (Oloruntoba, R., and R. Gray 2003, 8). Moreover the context and constraints also differ between these phases.

Figure 7.7 Aspects of time, distance and criticality

However, rather than a smooth transition of these phases, most complex political emergencies are characterized by a shift between different phases for many years before the

conflict is resolved (Ballance, S. (ed.) 2005, 2). The conflict intensity in different parts of the same country or crisis may differ significantly at the same time. Moreover in some cases emergency assistance and measures to start rehabilitation might be carried out simultaneously (Perrin, P. 1996, 365). In any case humanitarian assistance programmes during the emergency phase should be provided in ways which will support rehabilitation and sustainable development (UN General Assembly Resolution 46/182, 1991).

Humanitarian organizations may not intervene immediately after the onset of an emergency because they do not have access, are not able to obtain funding or because domestic sources can cope with the emergency. Consequently the emergency phase for the humanitarian organizations starts at the time a decision is taken by the respective humanitarian organization to provide humanitarian assistance.

The second aspect refers to the distance to the crisis area and the associated safety and security risks. The context and constraints for logistics and supply chain management will change as humanitarian organizations approach the conflict area for two reasons. First, humanitarian assistance is mostly provided in less developed countries with poor infrastructure while for many humanitarian assistance goods supply networks commence in developed countries.

Secondly the insecurity and therefore the risk increases as the distance to the conflict area decreases. Supply networks commence in countries at peace and end at health care facilities in or at least near to the conflict area. The level of insecurity can increase gradually or abruptly, for example when crossing borders or a front line and within a country the security situation can differ widely between areas.

The physical distance between peaceful and conflict areas can be fairly short for example when a conflict area near to an international border is supplied from a neighbouring country which is at peace. However the physical distance can also be large where an entire geographical region is affected by the conflict and countries bordering on the conflict area are not entirely peaceful either.

The third aspect is related to the provided goods themselves. Logistics and supply chain management strategies will also depend on the criticality of humanitarian assistance goods. Highly critical items have to be of high quality, will have to be managed with a high degree of reliability, high customer service levels and require expediting in case of low stock levels or stockouts in any case.

Items are highly critical (Bowersox, D.J., and D.J. Closs 1996, 300) if they are life saving and a stockout could have detrimental consequences for patients and even lead to preventable deaths. For example replacement parts for autoclaves which are indispensable for any kind of surgery (Bloch, Y. (ed.) 2001, 121) or drug products used during resuscitation. Another criterion for criticality is the lack of available substitutes.

7.4.4 Framework overview

The two dimensions of management and planning levels as well as the logistics functions of Thorn's framework are extended by the three aspects of time, distance and criticality.

The transition between the management levels is continuous and may even overlap for some issues. Logistics activities are carried out consecutively, although goods will usually require storage and distribution at several stages of the supply network.

However the aspects of time, distance and criticality are independent of each other and each of them has to be seen in the context with the two other dimensions separately. Consequently

the framework might lead to conflicting conclusions for the three different aspects and require finding a compromise. For example the strategic framework for distribution of highly critical items will suggest using the fastest mode of transportation during the emergency phase while the high risk inside the conflict area suggests using the safest mode which may be road transportation.

8 ITEM SELECTION STRATEGY

Humanitarian organizations must carefully select appropriate humanitarian assistance goods and consider the specifications of goods which they distribute and donate.

Health professionals need to determine the kind and scope of humanitarian assistance their organization wants to provide and decide on the range, required functions, performance and effectiveness of health care goods which are necessary for implementing programmes.

However the selection of health care goods requires consideration of a number of logistical issues which are presented in figure 8.1.

This chapter will consider general requirements for health care goods since these must be selected in advance and must therefore be suited to any context and programme. At this stage the selection is independent of specific products or manufacturer.

8.1 Quality assurance

According to the World Health Organization (WHO), quality assurance is defined as ". . . a wide-ranging concept covering all matters that individually or collectively influence the quality of a product. It is the totality of the arrangements made with the object of ensuring that pharmaceutical products are of the quality required for their intended use" (WHO 2007g, 16). This definition equally applies to other health care goods.

Quality assurance measures must ensure that only high quality health care goods enter the supply network, ensure that this quality is not negatively affected, no deterioration occurs as health care goods flow through the supply network and that high quality health care goods are administered or applied to patients.

As the quality of health care goods can be impaired in a short time, the quality of products provided to end-users is only as good as the stage, service or activity throughout the supply network with the poorest quality assurance measures. For example a high quality product can be quickly damaged by inappropriate handling, storage or transportation at any stage of the supply network even for a short period of time.

Quality of products cannot be the responsibility of or be managed by one person or a department but rather everyone in an organization is responsible (Mitra A. 1998 10).

Quality awareness and quality assurance measures are important for nearly all logistics activities from product design and development, manufacturing including packaging, developing and implementing policies for qualification of products and manufacturers, sourcing and purchasing, storage, transportation as well as distribution at all stages of the supply network.

As quality assurance considerations and measures are an important part of many logistics activities, they are included in the respective chapters in order to avoid duplications of wide parts of the presented material.

8.2 Logistical requirements for health care goods

Several requirements apply to all categories of health care goods.

The need for high quality results directly from the logistics and supply chain management objectives discussed in chapter 7. The World Health Organization's guidelines on drug donations prohibits double standards in quality and by implication the quality of other health

care goods must also comply with the quality standards of the humanitarian organization's head office country.

The large geographical scope of international humanitarian assistance and the uncertainty over the country where humanitarian assistance goods will be provided requires that goods are accepted worldwide. Although no worldwide standards have been established, drug products must comply with internationally recognized pharmacopoeial standards and health care goods which conform, for example, to the standards of the European Union are likely to be accepted by recipient countries worldwide.

The large geographical scope as well as the necessary flexibility for distributing humanitarian assistance worldwide, implies the need for multilingual product information. The Guidelines for Drug Donations require that "All drugs should be labelled in a language that is easily understood by health professionals in the recipient country" (WHO 1999c, 9). For example The Interagency Emergency Health Kit is furnished with information in English, French and Spanish (WHO 2006n, 52).

Humanitarian assistance goods should be acceptable by a wide range of different cultures, traditions and religions. As far as possible symbols with religious connotations, even if these are not intended, should be avoided.

In the context of countries with low levels of education, a low level of health care services and lack of health care professionals, all health care goods should be sustainable, simple to use or require minimal training.

For the sake of simplicity, flexibility and reduction of transportation costs, wherever possible transportation and storage of humanitarian assistance goods should not be subject to special requirements such as certain temperature ranges (PAHO 1983, 12) or special packaging for dangerous goods.

For selection of humanitarian assistance goods the total cost of ownership throughout their expected lifetime should be considered since humanitarian organizations are accountable for all expenses and the use of provided goods should be sustainable. The cost of ownership include purchasing price, transportation and insurance, importation tax and customs, installation, training, cleaning, disinfection, maintenance, service, operations, refunds from warranties as well as final disposal. Electrical equipment may require providing expensive power generation.

The cost incurred by health care facilities after humanitarian assistance programmes are ended should also be considered. Packaging adds cost but can also save cost by reducing the likelihood of damage during transportation.

Despite the higher purchasing price and the need for disinfection and sterilization equipment, the overall cost of using and reconditioning reusable goods such as reusable syringes, catheters or surgical linen may be lower than for certain single use medical devices. Reusable goods do not require regular purchase and transportation, reduce storage costs throughout the supply network and reduce the costs associated with shortages and stockouts.

However reusable goods carry the risk of inappropriate cleaning and disinfection which can transmit infectious diseases (Quick, J.D. (ed.) 1997, 154). On the other hand the use of single use medical devices incurs higher costs for appropriate waste disposal.

All packaging must be furnished with detailed labels, especially since recipients are likely not to be familiar with the product and may heavily rely on the indicated information such as the type of product, specifications, country of manufacture (country of origin), manufacturing

date, required storage conditions as well as any possible hazards (Kaur, M., and S. Hall 2001, 6).

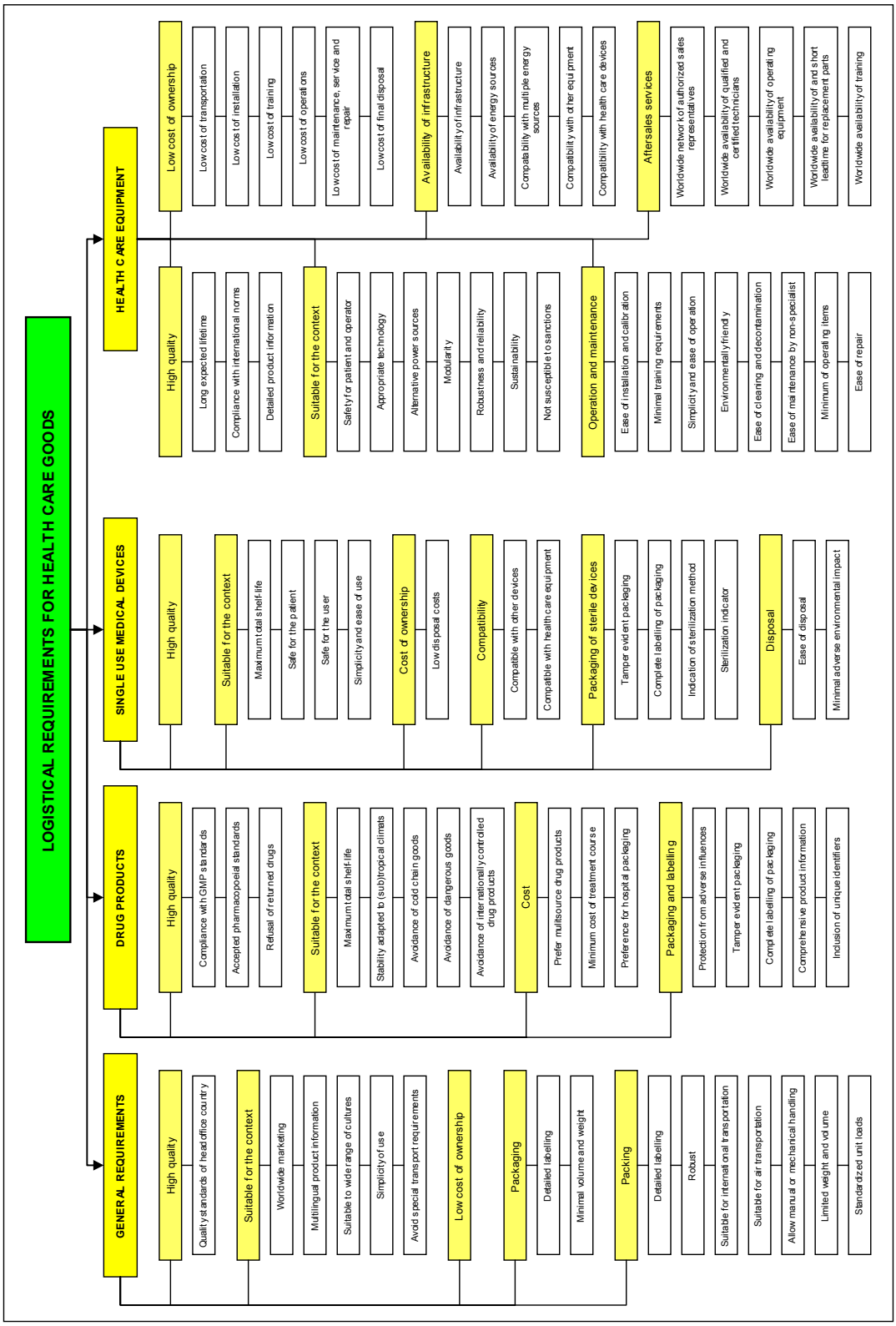

Figure 8.1 Logistical requirements for health care goods

In order to minimize transportation and storage costs, the volume and weight of health care goods should be as low as possible. For example pouches with solutions require less volume

than bottles and plastic packaging (ampoules, infusions) is much lighter than glass packaging. As far as possible drug products should be provided in the largest available quantity units and hospital packs (PAHO 2001a, 150) which have far smaller volumes than blister packaging of individual tablets or capsules. Powders, such as some drug products or x-ray developer, which can be reconstituted with water, significantly reduce weight as well as volume.

Apart from its main function of protecting goods, packaging also allows identification of goods and facilitates handling, storage and transport (Koether, R. (ed.) 2004, 361). As far as possible, packaging should protect goods against pilfering and theft.

Labels should identify the goods they contain and indicate the weight and volume of each package, handling instructions as well as special transportation and storage requirements. In order to avoid delays labels should be printed in languages understood in the recipient country and should withstand damage due to rough handling and adverse climatic conditions (PAHO 1983, 11).

Packaging must be robust and suitable for the context of recipient countries and possible distribution in remote areas. Lack of suitable storage facilities (PAHO 1983, 11) as well as transportation by carrying or by pack-animals may expose humanitarian assistance goods to adverse weather conditions. Especially health care equipment may require additional protective packaging.

Humanitarian assistance goods must be packed in accordance with international shipping regulations (PAHO 2001a, 150) and withstand multiple and possibly rough handling and transportation during international transport.

Where dangerous goods cannot be substituted and avoided, packaging must comply with the IATA Dangerous Goods Regulations, which may limit the maximum packaging quantities and require special packaging, to maximize flexibility in selection of modes of transportation.

As sophisticated and powered materials handling equipment is often not available in the recipient country and at receiving health care facilities, all packaging should be designed for manual or mechanical handling. For example the packaging specifications for the Interagency Emergency Health Kit require suppliers to attach handles to each carton (WHO 2006n, 51).

As far as possible, the weight and volume of individual parcels as well as master cartons should allow handling by a single person, movement in narrow stores as well as transportation in small aircraft, boats and vehicles as well as on carts or pack-animals. Equipment such as hospital furniture, operating tables or x-ray equipment might have to be packed in parts and be assembled at its destination.

The size of master cartons should be standardized at least for the internal supply network to ensure that they fit standard storage equipment and allow maximizing utilization of standard unit loads. Selection of standard sizes for unit loads such as pallets is also a strategic decision as storage and materials handling equipment throughout the supply network must be adapted to them.

Master cartons can be grouped into larger units to increase handling efficiency (Bowersox, D.J., and D.J. Closs 1996, 437). Unitization increases protection and security of goods and facilitates materials handling and documentation (Rushton, A., J. Oxley, and Ph. Croucher 2000, 98).

The selection of unit loads requires considering the possibilities and constraints of transportation and storage throughout the entire supply network. For international distribution equipment used for unitization of master cartons must be cheap as their return is

not economical. Pallets can be moved horizontally with inexpensive materials handling equipment and can be used as storage equipment in the receiving store.

For international shipments of large quantities of health care goods the use of standard ISO shipping containers can be considered. However the availability of powered materials handling equipment at the receiving store should be ensured.

Some special considerations are necessary for the selection of drug products. Medical criteria for selection of drug products are high efficacy, bioavailability, safety of application and minimizing adverse effects.

Although worldwide accepted and required standards for the quality of drug products have not been established, production according to Good Manufacturing Practices (cGMP) is generally considered as a standard requirement (WHO 1998e, 6). However no international standards for GMP certification have been established and the reliability of cGMP certification therefore depends on the standards established by national authorities in the country of manufacture as well as the quality of the certification procedure (WHO 1992d, 24).

Many countries have established their own pharmacopoeial standards to which drug products must conform. However, the standards of the British, European as well as International Pharmacopoeia (WHO 2003b) are generally accepted worldwide.

Compliance with the highest internationally available standards minimizes the risk that importation of drug products is refused and leads to a shortage at the assisted health care facility.

Any drug products that have already been issued to patients and then been returned to a pharmacy must not be donated as their quality cannot be assured (WHO 1999d, 8). Besides in countries, where the use of returned drug products is prohibited, their donation and use by humanitarian organizations would create a double standard.

All drug products imported into a country must conform to the requirements of national pharmaceutical regulations. The Guidelines for the use of the WHO Certification Scheme on the Quality of Pharmaceutical Products moving in International Commerce recommends that the importing country obtains assurance from the exporting country that the drug product is authorized for marketing in the exporting country (WHO 1995c, 32). However this scheme has no legal status and is a non-binding guideline (Creese, A., N. Gasmann, and M. Mariko 2004, 96).

Since humanitarian assistance goods are usually distributed through international supply networks with multiple stage and through several safety stocks, wherever alternatives are available, drug products with the longest possible total shelf-life should be chosen. For example powders which are reconstituted before application are often more stable and therefore have a longer total shelf-life than liquid preparations. This will ensure that drug products still have a remaining shelf-life of at least one year upon arrival in the recipient country (WHO 1999c, 8) and avoid expiry during transportation or storage. Longer total shelf lives allow using cheaper but slower modes of transportation during international shipping.

The World Health Organization recommends that drug products which are intended for marketing in (sub)tropical countries or in the global market are suitable for marketing under the conditions of the hottest and most humid climatic zone IV (WHO 1996d, 70).

Wherever possible, cold chain products and dangerous goods with their special and expensive storage and transportation requirements should be avoided and substituted. Drug products which are subject to United Nations conventions on narcotic drugs and psychotropic

substances should also be avoided and, wherever possible, substituted as exportation as well as importation may be delayed or even rejected.

While humanitarian organizations must make the best use of funds, patient safety must never be compromised by poor quality health care products (Kaur, M., and S. Hall 2001, 6).

Multisource ("generic") drug products, which are generally cheaper than innovator (branded) drug products, should be preferred (PAHO 1983, 50) provided that they comply with the required quality standards (WHO 1996d, 115).

For selecting drug products the costs of total treatments rather than unit costs should be compared (WHO 1998e, 5) and the cheaper alternative should be selected, wherever different dosage forms with the same utility for the patient are available. For example tablets are usually less expensive than capsules (WHO 1998e, 5).

In general hospital packs are far cheaper than individual blister packaging and are also less attractive for theft and resale.

The quality of packaging which offers protection against humidity, radiation, oxygen, contamination and physical damage is of particular importance for drug products and must comply with pharmacopoeial requirements.

In order to reduce the risk of pilfering and adulteration, drug products should be packaged in tamper-evident containers which are fitted with devices which irreversibly reveal, whether the container has been opened (The Stationery Office 1999, 14).

For drug products, which often cannot be distinguished from each other visually, labelling of the primary as well as secondary packaging are critically important. All active pharmaceutical ingredients must be identified by their international nonproprietary names (INN) which is also understandable for health professionals who are not familiar with the proprietary (trade) names. Labels must also indicate dosage form, strength of dosage unit, batch number, quantity of the packaging, manufacturing and expiry date, pharmacopoeial standard, manufacturer, country of manufacture as well as required storage conditions.

Vaccines may be furnished with vaccine vial monitors which irreversible change their colour after exposure to a predetermined amount of cumulative heat and warn health workers against application of spoiled doses.

Package inserts are an essential supplement to labels and inform patients and health professionals about indications, contraindications, precautions, mode of administration, duration of use, adverse effects as well as measures in case of an overdose (WHO 1997a, 36).

The application of unique identifiers, such as printing names or logos of the humanitarian organization on primary and secondary packaging, can contribute to preventing theft and counterfeiting of drug products but may delay distribution and increase cost (Quick, J.D. (ed.) 1997, 262).

Quality requirements for single use medical devices are not as clearly standardized and codified as for health care goods (Quick, J.D. (ed.) 1997, 151). For example the European Union has established stringent requirements and standards for medical devices (European Commission 1993). The trade-off between price and quality has to be considered while ensuring that the devices are safe and allow providing high quality treatment and care.

Like drug products, single use medical devices, including all sterile goods, should be manufactured and packaged with a maximum total shelf-life. The use and application of medical devices must be safe for the patient as well as the user (Cheng, M. 2003, 4).

Medical devices should be as simple as possible and the required skills for their use adapted to the lower level of education and skills often found in the context of humanitarian assistance.

The cost of collection and safe final disposal must be included in the cost of ownership.

Medical devices must be compatible with other devices as well as with health care equipment provided by humanitarian organizations. For example syringes must fit hypodermic needles, catheters, drains and tubing must be compatible with connectors and receptacles and x-ray films must fit x-ray cassettes. Incompatibility of two medical devices may render both of them useless and cause a shortage or require stocking a larger number of items.

Sterile packaging must be tamper evident to avoid accidental use of contaminated medical devices.

Labelling must indicate the batch number, sterilization date, sterilization method as well as expiry date (use by date). Each package should be furnished with a sterilization indicator which irreversible changes colour upon completion of sterilization by heat, ethylene oxide or irradiation (Kaur, M., and S. Hall 2001, 7).

In the absence of public waste management systems, the disposal of used medical devices should be possible with simple means such as incineration or burial and have a minimal adverse environmental impact.

Medical kits should be simple to use, adapted to the context of humanitarian assistance and designed by health professionals for a specific purpose and task. Standardized kits, which are used in different situations, will not cover all needs in a specific situation but should be designed to cover the majority of needs in the majority of situations. As far as possible, individual health care goods should not be included in several different kits to avoid redundancy when different kits are combined. Kits should be composed of standard items to ensure compatibility and allow continuation of assistance programmes without having to change health care goods to which health professionals have adapted.

The logistical requirements for drug products as well as single use medical devices discussed above also apply to the items contained in medical kits. Health care goods requiring special handling such as cold chain items, dangerous goods or controlled drugs should not be included with other items in the same kit. The expiry dates of individual items should not differ too much since otherwise eventually kits will have to be opened to replace items with the shorter remaining shelf lives.

Labelling of the outer packing must indicate the weight and volume of each parcel and indicate the quantities and expiry dates of each item contained in the kit as well as the storage and handling requirements for the kit as a whole.

Health professionals need to select health care equipment which is essential and considers the level of training in the countries where humanitarian assistance is provided (Kaur, M., et al. 2005, 181).

Health care equipment should have a long expected lifetime and comply with the respective national and international safety and performance standards (Kaur, M., and S. Hall 2001, 6) in order to minimize the probability that importation is refused.

Comprehensive and detailed multilingual product information, operating instructions, technical operating and service manuals, replacement part catalogues (Heimann, P., A. Issakov, and S.Y. Kwankam (ed.) 2000, 17) and diagrams as well as training manuals are particularly important since qualified technicians may not be available at the receiving health care facility.

Use of health care equipment must be as safe as possible for patients as well as operators (Skeet, M., and D. Fear 1995, 2) and should not pose electrical hazards or danger of fire or explosion.

The use of appropriate technology, which is adapted to the context of less developed countries, for health care equipment is one of the principles of primary health care (WHO 1978, 27). Wherever possible manual, mechanical and hydraulic equipment should be preferred and electronics and integrated circuits should be avoided.

In order to avoid dependency on unreliable power supply, health care equipment should be able to run on different energy sources (Kaur, M., and S. Hall 2001, 8). For example autoclaves should be designed to run on electricity, gas, liquid or solid fuels and refrigerators should have the possibility of running on liquid fuel or gas as well as electricity.

Electric equipment should be able to operate, at least temporarily, on rechargeable batteries to allow operations during power failure or in health care facilities where the mains electricity supply is unreliable or only available during certain times during the day.

A modular design of health care equipment allows upgrading equipment and adding or replacing defective modules without having to purchase an entirely new piece of equipment.

Health care equipment must be adapted to (sub)tropical conditions and should be resilient against high temperatures, humidity, corrosion and dust (Heimann, P., A. Issakov, and S.Y. Kwankam (ed.) 2000,18). It should be simple and robust (Quick, J.D. (ed.) 1997, 151), endure repeated disinfection or sterilization and be resilient against inappropriate operations due to lack of professional training as well as rough handling and neglected maintenance.

Since health care equipment is usually handed over to the health care facilities upon arrival or after humanitarian organizations close their programmes, its operation and maintenance should be sustainable. Operating equipment, accessories, replacement parts as well as repair and maintenance services should be affordable and available domestically (Kaur, M., et al. 2005, 56). In Sub-Saharan Africa up to 70% of health care equipment lies idle because of inappropriate use, lack of training or lack of technical support (Heimann, P., A. Issakov, and S.Y. Kwankam (ed.) 2000,10).

Health care equipment and components should not be potentially subject to sanctions which can delay or even prevent importation into the country where humanitarian assistance is provided.

Health care equipment should be easy to install, commission and calibrate by a general technician or health care professional but not require a specialist trained by the manufacturer.

Operation, maintenance and servicing of health care equipment should require a minimum of training of health care professionals as well as health care technicians and be simple and easy to use (Kaur, M., and S. Hall 2001, 5). Meters, gauges and displays etc. should indicate technical units of measure which are commonly used in the country receiving humanitarian assistance goods. For example Fahrenheit or degree Celsius on a thermometer, mmHg or kPa on a sphygmomanometer, mmol/l or mg/dl for diagnostic equipment or pressure units on suction machines and autoclaves. Indication of several units on parallel scales or the possibility to switch between units on electronic equipment allows worldwide use.

Health care equipment should cause as little pollution as possible, for example gallium has replaced the highly toxic mercury in thermometers. Health care equipment should be easy to dispose of and should not contain any components or materials which pose an environmental hazard which requires return to the manufacturer or specialists for final disposal.

Health care equipment should be easy to clean, disinfect and sterilize by simple means such as steam rather than expensive chemicals or special gases.
Health care equipment should be easy to maintain (Kaur, M., et al. 2005, 49) and repair either by health care professionals or by general technicians without specialist knowledge by following instructions in a detailed maintenance manual. Unused health care equipment decreases quality of care and wastes scarce resources (Skeet, M., and D. Fear 1995, 1).

Operating health care equipment should require a minimum of expendable operating equipment such as single use medical devices, electrodes, recording paper, reagents or filters (Heimann, P., A. Issakov, and S.Y. Kwankam (ed.) 2000, 18). For example the cost for single use test strips or cuvettes may far exceed the equipment cost over its lifetime.

The trade-off between cheap and low quality health care goods which require frequent repairs and replacement and a higher price but longer lifetime need to be considered (Kaur, M., and S. Hall 2001, 7). On the other it is not cost-effective to donate high quality instruments if they are not looked after carefully (Kaur, M., and S. Hall 2001, 7) or likely to be diverted.

Transportation costs, which may be considerable for international transport, need to be added to the overall costs. Wherever possible, heavy and bulky equipment, such as operating tables or x-ray machines should be packed and shipped in parts which can easily be assembled by non-specialists. Where surface transportation is not possible for security reasons, large aircraft, which may be needed for transporting heavy and bulky equipment, are expensive to operate and sufficiently long and stable runways may be unavailable near the intended destination.

Other costs which are incurred over the lifetime of equipment such as for installation, licensing, training, operations, maintenance, service, repair as well as decommissioning and disposal also need to be considered (Kaur, M., et al. 2005, 54).

Infrastructure requirements and the likelihood of their availability in recipient health care facilities also need to be considered. Health care equipment may require reliable water and power sources (Kaur, M., and S. Hall 2001, 8), significant space, special construction (radiation protection in x-ray rooms, support beams for operating lamps) or flat floors (mobile equipment). Sophisticated anaesthesia equipment requires reliable sources of oxygen, compressed air and possibly nitrous oxide. Installation of autoclaves requires facilities for cleaning, packing, packaging and storing sterilized materials and the installation of a dark room is indispensable for operating diagnostic x-ray equipment.

Availability as well as capacity of electric power supply networks or local power generation must be considered for electrical equipment (Heimann, P., A. Issakov, and S.Y. Kwankam (ed.) 2000, 1). Equipment should be easily adaptable to different voltages and resilient to power fluctuations and sudden surges. Plugs must fit wall sockets or be easy to exchange. If other energy sources are used, availability of fuels such as gas or kerosene must be ensured.

Different pieces of health care equipment must be compatible with each other as well as with any medical devices which are used during operations (Kaur, M., and S. Hall 2001, 6). For example sterilization drums must fit into autoclaves, receptacles must fit suction machines and x-ray cassettes must fit x-ray machines.

For sophisticated health care equipment, such as diagnostic imaging devices or anaesthesia machines, which require installation, commissioning, maintenance, service and repair by a specialist technician trained by the manufacturer, an international service network through authorized distributors and representatives is required. Health care equipment which cannot be serviced locally and requires hiring a specialist from abroad or sending equipment abroad

might be more expensive than purchasing a more expensive piece of equipment (WHO 1992c, 13).

Proof of regular maintenance may be a precondition for obtaining and renewing licences for operating health care equipment such as x-ray equipment.

Operating equipment and replacement parts should be available with reasonable short lead times domestically as well to ensure sustainability after handing over equipment to assisted health care facilities.

8.3 Variety control and reduction

In the year 2,000 an estimated one and a half million different medical devices were available in the global market (Cheng, M. 2003, V). The need to control and reduce the range and variety of provided health care goods follows from the objective of simplicity and reduction of complexity. The number of items used in an organization tends to gradually increase unless active measures are taken to control variety (Jessop, D., and A. Morrison 1994, 48).

"In the course of time, in any organisation, unless active measures are taken to control variety, the umber of items stocked and used will gradually increase" (Jessop, D., and A. Morrison 1994, 48).

Generally, reducing the overall number of different health care goods which are managed allows simplifying logistics activities (WHO 1999f, 11). A wider range than necessary increases purchasing and storage costs (Audit Commission 1996, 12) as well as the cost for quality assurance measures. Moreover providing a wide range and high variety contradicts the requirement of sustainability of health care services.

Providing larger quantities of a smaller number of items reduces purchase costs and increases the efficiency of overall logistics and supply chain management.

Measures for variety control and reduction (Lonergan, E. 2003, 92) intend to reduce the number of health care goods to an optimum which allow balancing the needs of humanitarian assistance programmes with the costs for managing large numbers of goods throughout the entire supply network. Substituting a standard item for a variety of similar items, models or products allows benefiting from risk pooling (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 345), increases forecasting accuracy and reduces safety stock levels without reducing customer service levels.

The reliable provision of a limited number of health care goods is more beneficial to recipients than the unreliable supply of a wider range (Simmonds, St., P. Vaughan, and S. W. Gunn (ed.) 1986, 222).

Several measures are available for controlling and reducing the variety of health care goods (see figure 8.2).

The international drug directory lists nearly 4,500 different active pharmaceutical ingredients and more than 50,000 proprietary names (trade names) of drug products from worldwide 17,000 pharmaceutical manufacturers (Index Nominum 2004). The World Health Organization has listed around 8,000 international nonproprietary names of pharmaceutical substances (WHO 2002b). More than two thirds of drug products on the world market are duplicates or

minor variations which offer no therapeutic advantage or are non-essential (Quick, J.D. (ed.) 1997, 122).

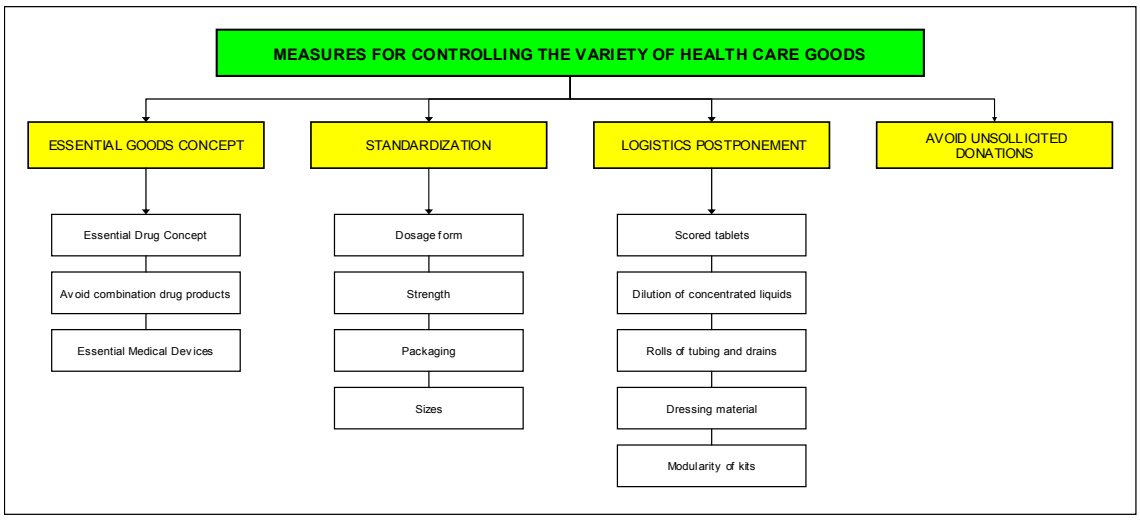

Figure 8.2 Measures for controlling the variety of health care goods

The Essential Drug Concept established by the World Health Organizations in 1977 (WHO 1998a, vii) and an important principle of the primary health care concept (WHO 1978, 28) is widely accepted and is an important element of many national drug policies in less developed countries. The core list of the WHO Model List (WHO 2007n) contains only around 300 effective, safe and cost-effective active pharmaceutical ingredients which cover the health care needs of the majority of the population and all needs of a basic health care system. The World Health Organization explicitly recommends that not-profit-making organizations should develop essential drug lists (WHO 1999f, 7). Adherence to the essential drug concept is included as a key indicator (The Sphere Project 2004, 266) for assessing standards of clinical services. Supply chain management is most efficient if the number of provided drug products is limited (Quick, J.D. (ed.) 1997, 8). Selecting items from the WHO essential drug list increases the probability that the drug products are also included in national essential drug programmes. The formulation of drug products as single compounds (WHO 1998e, 5) reduces the number of drug products since different drug products, which are also used for other treatments, can be administered together rather than having to manage additional combination drug products.

The same principles of the Essential Drug Concept can be applied to single use medical devices as well as health care equipment (WHO 2003a, 18).

Standardization is one way of reducing the number of health care goods (Audit Commission 1996, 12) which have to be handled by logistics services without compromising the quality of medical treatment, and therefore reducing variety. An estimated 12,000 manufacturers offer 750,000 different brands and models of health care equipment (Kaur, M., et al. 2005, 9).

Where several different dosage forms (for example tablets, capsules or syrups) are suitable for treating a medical condition with the same efficacy, one dosage form should be selected as a standard. For drug products where similar strengths can be used interchangeably (for example Metronidazole tablets 200 mg or 250 mg), one strength should be chosen as a standard.

A standard packaging size should be selected for drug products which are available in different quantities. Many solid dosage forms are available in blister packaging or hospital packs and liquid dosage forms are available as unit-dose ampoules or multiple-dose vials.

Although the concept of selecting essential goods is usually limited to drug products, it is equally important for expendable goods and health care equipment which account for around 80% of all health care goods (Quick, J.D. (ed.) 1997, 151).

From the large variety of different sizes of single use medical devices for example hypodermic needles, bandages, tubes, drains, gloves or x-ray films a selection must be made which allows covering all essential needs.

For single use medical devices which can be made from different materials, for example rubber or silicone catheters, a selection of one material should be made.

From the host of different models of health care equipment with a multitude of features, humanitarian organizations must select only the most essential pieces of equipment. Standardization of health care equipment also allows reducing the number of accessories, operating and replacement parts which need to be provided, reduces the number of suppliers (Lenel, A. et al. 2005, 25) as well as the overall cost of ownership (Kaur, M., et al. 2005, 55). Standardization allows more economical purchasing of health care equipment as well as replacement parts and materials for operation.

In the case of diagnostic imaging equipment the World Health Organization has established recommendations for standard specifications which are adapted to less developed countries and are suitable for humanitarian assistance, even though they are not formally accepted or compulsory standards. The World Health Imaging System for Radiography (WHIS-RAD) is designed for primary health care and allows making 95% of all x-ray examinations with simple equipment at low cost (WHO 1995, 2).

Another means of reducing variety is logistics postponement. It allows the end-user to carry out the final configuration of some generic health care goods according to the required specifications (Gattorna, J. 1998, 82) and therefore reducing the number of different health care goods which logistics services need to provide.

The World Health Organization recommends the use of scored tablets, which can be broken to obtain a convenient paediatric dose, when precise dosage is not mandatory (WHO 1998e, 5).

Different concentrations of disinfectants which are required for different applications (for example surfaces, surgical instruments, fabric) can be produced at receiving health care facilities by diluting a generic concentrate with water.

Some drains and tubing can be provided in long rolls and cut to the required length by the end-user before application.

Some dressing materials such as compresses are available in a large variety of sizes or combination of different materials (for example cotton and gauze). Providing generic products in large rolls or sheets allows end-users to configure the final product to their specifications and practices by cutting, folding and combining materials.

The use of modules allows configuring kits by combining different types and quantities of modules according to the level of health care and needs of the end-users at the supplying store rather than preparing a large number of different kits to suit all possible needs. The part standardization allows reducing stock levels through risk pooling and benefiting from economies of scale from purchasing larger quantities of a smaller number of items (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 345).

Unsolicited donations of any health care goods must be avoided, among others, because neither recipients nor humanitarian organizations have control over specifications. Unsolicited donations usually contain a great variety of health care goods and drug products in different strengths of dosage unit (WHO 1999c, 4) which are time-consuming to sort and difficult to manage.

8.4 Standard item catalogue

The standardization process results in establishing a standard item catalogue (Burt, D.N., D.W. Dobler, and St.L. Starling 2003, 257) which systematically lists all selected health care goods and indicates their specifications. Development of a standard item catalogue has important strategic implications as it limits the range of health care goods and therefore determines and possibly limits the type of assistance programmes which can be implemented, the level of care which can be supported as well as the level of sophistication of health care technology. The standard item catalogue must be comprehensive and allow covering all basic health care needs at all levels of care which the humanitarian organization intends to serve.

The idea of standardization is not new. During the First International Red Cross Conference of several National Red Cross Societies in Paris in 1867, an exhibition of model medical equipment such as field dressings, medical kits, surgical instruments, stretchers, ambulances was organized (Musy, A. 1997, 38) and the possibility of establishing a standard list for health care goods was discussed. During a further conference two years later, a resolution was passed that health care goods should be acquired by the different states according to the adopted models.

The drug products included in the WHO Model List of Essential Medicines (WHO 2007n) which are proven to be safe and efficacious, should be used as a reference for establishing a standard item catalogue (WHO 2007a, 26).

Standardization of health care goods has many advantages (see table 8.1) and a few disadvantages but without standardization, effective or efficient logistics and supply chain management in humanitarian assistance would be impossible.

All items must be identified by nonproprietary ("generic") names rather than proprietary (trade) names and especially drug products must be indicated with their international nonproprietary name (WHO 1999e, 12). Specific products or manufacturers are not indicated, except for specific health care equipment where only a single product can fulfil all necessary requirements. Operating equipment, accessories and essential replacement parts should be indicated for each piece of health care equipment.

Item descriptions must be clear, self-explanatory but brief as well as succinct and should be easily understood by all users. Item descriptions must be specific enough to clearly identify the item and ensure that different products are suitable substitutes for each other. At the same time item descriptions must be wide enough to comprise all products (possibly from different suppliers) which can be substituted for each other. The descriptions, order of information within the descriptions as well as abbreviations must be consistent.

The standard item catalogue must provide detailed information on each item which is sufficient for the user to decide on its appropriateness for a specific programme. However, over-specifications should be avoided as this (unnecessarily) limits the number of available suppliers and products which makes sourcing more difficult and is likely to increase the price.

For each item first the quantity of a body or substance (for example entity, weight or volume) which can be expressed as a number must be determined (Jessop, D., and

A. Morrison 1994, 48). The unit of measurement (UOM) or measurement unit allows comparing quantities of the same kind as a ratio of the two quantities.

If the unit of measurement is pieces, the smallest useful quantity should also be used as unit of measurement (UOM). To avoid confusion, wherever possible, the unit of measurement should be a (single) piece. For liquid drug products the volume should be indicated in the item description in order to allow using pieces as UOM. For sterile gloves, "pair" should be also indicated in the item description so that the unit of measurement of "piece" can be used. For diagnostic tests with reagents which are used for a number of tests, the number of tests in one packaging should also be indicated in the item description.

Advantages

Item selection

- Reduction of the overall number of items which need to be handled.
- Reduction of the overall complexity of logistics and supply chain management.
- Ensures that all items are essential.
- Allows selection of the most appropriate items with the most appropriate specifications.
- Allows selection of the overall most cost-efficient items.
- Ensures compatibility between all standard items.

Sourcing and purchasing

- Allows identifying suppliers which offer products of high quality health care goods in advance.
- Facilitates sourcing and purchasing.
- Ensures consistency of quality of purchased products.
- Allows economies of scale for purchasing.
- Allows establishing long-term contracts with commercial suppliers.

Inventory control and stock management

- Risk pooling, reduction of demand distortion and increase of forecasting accuracy.
- Allows maintaining stocks and ensuring (regular) stock turnover.

Customer service

- Ensures that customer are able to know the specifications of items at the time of ordering.
- Encourages adherence to standard treatment protocols.
- Ensures the continuity of item specifications provided over (longer periods of) time.
- Ensures continuity of medical treatment and care.
- Facilitates cooperation with other humanitarian organizations.

Disadvantages

- May reduce the potential number of available suppliers.
- May restrict the type of programmes and level of care which can be served.
- Does not allow adapting provided health care goods to national protocols and habits.
- Does not allow adapting items to personal preferences (disadvantage only for the respective individual).

Table 8.1 Advantages and disadvantages of standardization

The detailed information provided in the standard item catalogue (see table 8.2) is an indispensable information resource for recipients, humanitarian workers as well as logisticians. All sheets of the standard item catalogue should have the same layout and design and, ideally, provide information in several different languages. These catalogues should be easily available as hard copies as well as electronic resources to all potential users.

The standard item catalogue should also provide logistical information such as the weight, volume, packaging dimensions for bulky items and prices for each item as well as required transportation and storage conditions or restrictions on importation.

Wherever possible, logistical constraints of health care goods such as the cold chain and dangerous goods packaging requirements or restriction on importation and exportation, should be avoided.

- Publisher.
- Date of publishing.
- Version of the catalogue.
- Date of last changes.
- Date of inclusion of the item in the catalogue.
- Item code.
- Item description (international nonproprietary name for drug products).
- Brief explanation of and instructions for use (purpose, indication etc.).
- Indicative price (per unit).
- Detailed specifications (including composition, colours, tolerances etc.).
- Photograph.
- Technical drawings where appropriate (health care equipment for example).
- Information on performance (such as expected lifetime).
- Environmental conditions for operation (equipment, temperature range, resilience to humidity, dust etc.).
- References to other items which are compatible.
- Possibly (indicative) packaging quantities.
- Information on marking and labelling (where applicable).
- Replacement parts (for equipment).
- Maintenance requirements (for equipment).
- References to operating instructions (for health care equipment).
- Information on dangerous goods classification.
- Information on whether drug products are subject to international controls.
- Weight of item (including packaging).
- Volume of item.
- Dimensions of packaging.
- Type of transport packaging.
- Special requirements for transportation (especially cold chain).
- Information on materials handling.
- Required storage conditions (especially cold chain).

Table 8.2 Information required in the standard item catalogue

Management of standard items is facilitated by assigning distinct codes to each item which allow identifying items faster and classifying them in distinct groups. Item codes are also convenient for arranging stock and sorting documents.

8.4.1 Systems for item coding

An item code (commodity code) is a distinct alphanumeric sequence which is assigned to clearly defined and specified health care goods.

Item codes must be unique (bijective), unambiguous, must be clearly assigned to a specific and distinct item description and should not be changed. The coding system must allow to assign item codes to all items and allow accommodating items which may be added in the future without the risk of duplication.

Letters should not be case sensitive and particular care must be taken to avoid confusion between characters such as between the number 0 and the letter O. Moreover blank space as well as signs and symbols such as "-", "/" etc. should be avoided.

Item codes are used in a multitude of printed as well as electronic documents and records and any change would require extensive clerical work (Jessop, D., and A. Morrison 1994, 35) and cause confusion.

The use of item codes as several advantages. Item codes should appear on any printed or electronic document as well as on kits together with the respective item description it is assigned to. Item codes cannot replace the item description but the use of item codes has several advantages.

Systematically assigned item codes allow structuring a large number of items into distinct categories even if the item descriptions are not similar (Jessop, D., and A. Morrison 1994, 28).

Items can be quickly identified by checking or comparing a limited number of characters rather than checking long item descriptions and allows quickly distinguishing items with similar item descriptions such as items which differ only in their sizes or other specifications. Long lists can be easily and quickly sorted, filtered or analysed according to their item codes.

Staff which have no detailed knowledge of an item description or do not understand the language can easily and quickly identify the type of item such as drug product, surgical instrument or dressing material. The item category may be suitable for identifying suitable storage conditions (cold chain) and warehouse zones.

A large number of different coding systems have been developed by manufacturers and commercial suppliers as well as procurement agencies.

Item codes can be numerical (numbers), alphabetical (letters) or alpha-numerical (combination of numbers and letters). Groups of digits of long numbers may be separated by full stops.

Coding systems can be based on sequential catalogue numbers for example for vehicle replacement parts or the nature of items and the intended use.

Item codes can be entirely abstract or indicate the type of goods, their purpose, property and possibly their specifications. For example "S" may indicate sterile and numbers the sizes of compresses.

Humanitarian organizations may develop their own coding system, use manufacturer coding for worldwide standardized items (for example vehicle replacement parts) or combine their coding system with the manufacturer coding.

Clear rules for the creation and assigning of item codes must be established in order to ensure consistency and avoid assigning different item codes to the same item or assigning the same item code to different items by different people.

Code structures are developed by grouping all items into main groups and repeated subdivisions into subgroups.

Médecins sans Frontières (MsF), the International Federation of Red Cross and Red Crescent Societies (IFRC) as well as the International Committee of the Red Cross (ICRC) use a similar system of a 11 or 12 character alphanumeric code, respectively, for every item. The code is

composed of one letter for the "Group", 3 letters for the "Family", 4 letters for the "Category" or "Root" and 4 or 3 characters (letters and/or numbers), respectively, for specifications.

The 18 groups used by the Red Cross movement indicate the type of goods such as Administration (A), Drug products (D), Housing (H), Kits (K), Library (L), single use medical devices (M) or health care equipment (X).

Where a specific manufacturer can be used as a reference, humanitarian organizations may also combine their coding system with the product code of the manufacturer, especially when a large number of different items are available such as for surgical instruments.

8.5 Summary of item selection strategy

The following principles can be applied to selection of humanitarian assistance goods (see figure 8.3), irrespective of the complex political emergency and the humanitarian assistance programme.

In order to minimize the complexity of logistics services and allow a quick response, only prepacked kits should be provided during the initial emergency response. Although kits will not cover all needs, they will allow providing the great majority of essential humanitarian assistance goods effectively and efficiently (Hanquet, G. (ed.) 1997, 137). In a transition phase, individual items can be provided to complement the contents of kits. Finally, following a detailed needs assessment, analysis of demand data and as soon as the supply network is well established, individual standard items can be provided.

While humanitarian assistance goods must be limited to items to cover immediate survival needs (PAHO 2001a, 131), rehabilitation and development of health care facilities will require providing health care goods which are adapted to domestic and local standards, practices and traditions. The standardization of humanitarian assistance goods is indispensable for a rapid and effective emergency response. However it is unlikely that standard health care equipment will match equipment available in health care facilities and therefore to some degree contradicts the need to adjust to local and domestic standards.

During the emergency phase drug products will be limited to the Essential Drugs concept and the standard item catalogue. However during the transition to rehabilitation and development a larger variety of drug products which are included in the national drug register of the country receiving assistance can be provided.

Until health professionals have made sure that health care facilities have the knowledge, organization, facilities and resources to safely clean, disinfect and sterilize reusable medical devices and equipment, only single use medical devices should be provided, although they may be more expensive and require transportation of larger volumes.

The nearer assisted health care facilities are to the centre of the conflict area, the greater the insecurity and therefore the more difficult logistics and supply chain management becomes. Consequently the need to reduce the complexity of all aspects of logistics and supply chain management increases with the level of insecurity.

As collecting detailed information on demand from health care facilities in the conflict area is difficult, prepacked kits should be preferred while health care facilities in more secure areas can be supplied with individual items. In conflict areas health care facilities will focus on emergency services and saving lives and therefore require a smaller variety of health care goods than health care facilities in more secure areas where a larger variety of medical conditions will be treated. For the same reason supplied goods should be essential, highly standardized and have a low degree of variety. Since health care facilities in conflict areas are

likely to work under difficult conditions, lacking staff, sterilization facilities and perhaps energy supply, single use rather than reusable medical devices should be preferred.

The importance of quality assurance naturally increases with the criticality of items. While quality is important for all health care goods, the potential adverse effects of poor quality of anaesthetics or suture material are far higher than for example for bandages or hospital furniture. The variety of health care goods should be low for critical items in order to concentrate limited resources to the quality assurance of a small number of items. The more critical quality assurance is, the more central (upstream) the responsibility for selection should be placed where the required skills are more likely to be available.

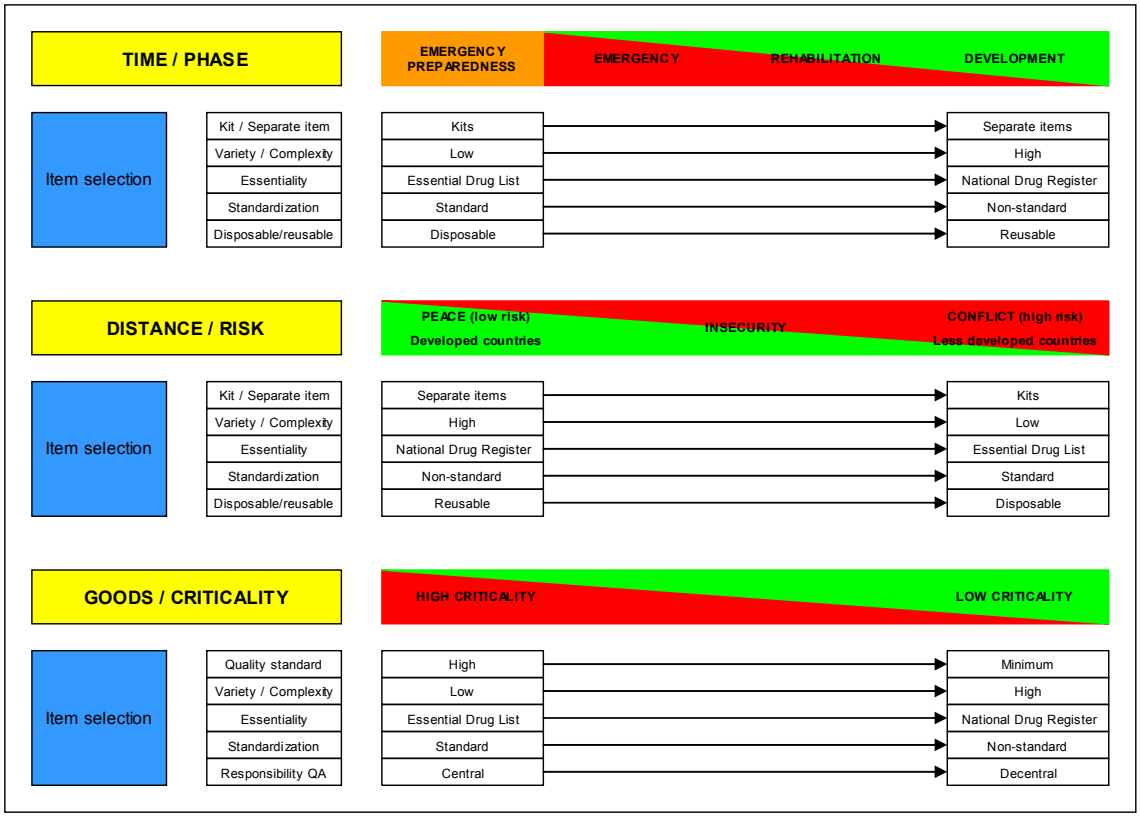

Figure 8.3 Item selection strategy

Critical items must comply with the standards defined by humanitarian organizations in order to ensure effectiveness and safety while strict standards are less important for non-critical items. For the same reason critical drug products should be part of the Essential Drug List while less critical drug products only need to comply with national drug legislation.

9 SOURCING STRATEGY

Sourcing includes identifying, qualifying and selecting suitable products, manufacturers and suppliers as well as purchasing goods and services. The overriding concern of humanitarian organizations must be to provide health care goods of high quality while considering costs and making the best use of funding. A further important concern is ensuring consistent availability, including during emergencies.

Donors might impose conditions on humanitarian organizations for funding their programmes and require that suppliers and their goods comply with defined quality standards (ECHO 2003, 14).

9.1 Policy for qualification of products and manufacturers

Quality assurance is the totality of measures taken to ensure that the quality of all health care goods complies with the required standards and specifications at the time of use or administration to the patient. Humanitarian organizations must foremost ensure that the quality of all health care goods entering their supply network comply with their quality requirements. The objective of all logistics activities after receiving health care goods from suppliers is ensuring that their quality is maintained. After receipt from suppliers the quality of health care goods can only be maintained but cannot be increased or improved although health care goods can deteriorate or be damaged through inappropriate handling, storage and transportation.

Every humanitarian organization which purchases health care goods should develop and implement their own quality assurance policy and system (WHO 2007a, 7). This policy should be documented in a quality manual which includes all required procedures.

The systematic and careful qualification of products and manufacturers is indispensable for eliminating, or at least minimizing, the risk of purchasing substandard, counterfeit or contaminated health care goods (WHO 2007a, 5). Such qualifications must be carried out by qualified and experienced experts in their field. Therefore this chapter does not intend to provide any guidelines but rather introduces some basic principles and outlines the complexity of this task.

"Careful supplier selection . . . is perhaps the most critical step in quality assurance"

(Quick, J.D. (ed.) 1997, 277).

One possible source of humanitarian health care goods are private or corporate donations in kind (PAHO 2001a, 147) which should conform to the same quality criteria as goods purchased from commercial suppliers. Humanitarian organizations need a clear strategic position concerning acceptance of donations of health care goods for further distribution in order to formalize a policy which can be disseminated among potential donors.

The qualification of all products and manufacturers requires establishing and maintaining a complex system which requires significant human and financial resources and therefore increases the cost of sourcing. Nevertheless, apart from the financial losses from disposing of poor quality health care goods which have already been purchased, the lack of diligence in qualification of products and manufacturers bears the risk of providing health care goods of poor quality and risking the safety of patients.

The main objective of product and manufacturer qualification is ensuring that all health care goods entering the humanitarian supply network consistently are of assured quality and comply with the quality standards defined in the quality assurance policy.

The qualification of products ensures that they comply with the required specifications as well as defined norms and standards in terms of safety, quality and, for drug products, efficacy.

The qualification of manufacturers must ensure that products are actually and consistently manufactured according to the defined specifications and that all processes comply with good manufacturing practices (GMP). Manufacturers which may have the ability and capacity to manufacture high quality health care goods may fail to comply with their quality standards or may manufacture health care goods of varying quality. Moreover manufacturers of a range of products may manufacture some products with high quality while failing the quality standards for other products, even in the same manufacturing plant.

Simply subjecting all batches of received health care goods of assumed (high) quality to testing and rejecting products which do not comply with the required quality standards is not a viable or efficient strategy. Testing of health care goods, especially of drug products, is expensive. Since the test requirements are independent of the quantity of products and every batch would have to be tested, the costs for testing may exceed the value of goods. Sampling and testing only a certain percentage of received health care goods only reduces, but does not eliminate, the risk of accepting health care goods which are of inferior quality. Testing of health care goods, especially of drug products, requires highly specialized laboratories which are not available in many countries and sending samples abroad for testing would cause long delays. While awaiting test results, health care goods would have to be placed in quarantine, making them unavailable for customers and therefore requiring significant increases in stock levels. Moreover, any batches which fail quality control, will have to be returned or disposed of which not only incurs costs but can also cause shortages until they have been (urgently) replaced.

"You cannot inspect quality into a product" (Waters, C.D.J. 1992, 313).

The concept of "Jidoka" (quality at source) requires that only products complying with the required standards are delivered in the first place and entering of any products which do not comply with required standards into the supply network is prevented. The quality assurance efforts and resources are transferred from detecting poor quality products through quality control to preventing their occurrence in the first place.

The resources consumed for sourcing, transportation, storage and handling of products which are eventually removed from the supply network because of poor quality, cannot be recovered. The further poor quality health care goods flow down the supply network, the more irrecoverable resources are lost and therefore wasted.

Staff responsible for qualification of product and manufacturers should have relevant qualifications and experience in pharmaceutics, manufacturing of health care goods, quality assurance, GMP, performing inspections, chemistry and quality control and ideally should have a background in drug regulatory affairs.

Staff members responsible for any of the steps in product and manufacturer qualification and purchasers as well as staff members responsible for evaluating product information and inspection of manufacturers should be independent of each other.

All information obtained from manufacturers through documents or during visits must be treated confidentially as it may be commercially sensitive.

A policy on qualification of products and manufacturers must be clearly documented and state detailed requirements and procedures.

The first step in qualification is the receipt and evaluation of detailed product information as well as product samples from the manufacturer. The product dossier contains information on the product specifications, the manufacturer, the licensing status in the country of manufacture and other countries, finished product specifications, stability testing, bioequivalence tests as well as label and insert information (WHO 2007a, appendix 6). Manufacturers which provide incomplete product dossiers or which offer products of (obviously) unacceptable quality do not qualify for inspection.

Together with the product information manufacturers should submit samples which should be tested in a quality control laboratory to confirm compliance with the stated finished product specifications (WHO 2007a, 34)

The next step is the inspection (verification by inspection) of manufacturing sites and premises. All manufacturing sites of finished drug products as well as the active pharmaceutical ingredient(s) should be inspected to ensure compliance with Good Manufacturing Practices (GMP) (WHO 2007a, 26). While analytical laboratory testing can confirm compliance of a certain batch, inspection allows to ensure that manufacturers have the capacity to ensure batch-to-batch consistency for all manufactured drug products.

An inspection should be carried out before the respective drug product is considered for purchasing from a specific manufacturer the first time.

ISO (International Standards Organization) certification or CPP (certificate of pharmaceutical product) are no guarantee for GMP compliance (WHO 2007a, 35). However inspections may be waived if a favourable inspection report for the product under consideration and for the respective manufacturing site is available from the responsible national drug regulatory authorities if all aspects of GMP are covered, the inspection report is not older than 24 months and the manufacturer has made no major changes to premises, equipment or key staff (WHO 2007a, 37).

Inspection should be carried out by at least two inspectors which have the relevant qualifications, training and experience in carrying out inspections in foreign countries as well as sound knowledge of quality assurance and GMP (WHO 2007a, 36).

Inspections of manufacturing sites must be well planned and prepared and at least three days should be allocated for each site (WHO 2007a, 115).

In order to ensure consistency, site inspections should be performed according to a written standard procedure.

The inspection should start with a company presentation, including range of products, production capacity, staff qualifications and training. The inspection should cover all aspects of GMP such as the quality assurance system (quality manual), receipt and storage of starting materials, sampling and weighing, packaging material stores, manufacturing facilities and equipment, utilities (heating, air-conditioning, ventilation, water), quality control laboratories, sanitation and hygiene, recall procedures, complaints management and documentation. The inspection should end with a closing meeting.

Inspectors should prepare a formal report for each manufacturing site according to a recommended format (WHO 2007a, 38). The inspectors will either qualify or disqualify the manufacturing site or propose corrective action which is verified six weeks to six months later with a follow-up inspection.

The outcome of the inspection including any proposed corrective action should be formally communicated to the manufacturer in writing.

A register with all qualified products and manufacturing sites should be maintained and reviewed and updated at regular intervals but at least once a year.

Routine re-evaluations of product information as well as re-inspections should take place at least every three years (WHO 2007a, 58). Non-routine re-evaluations should be carried out if supply has been suspended for more than one year, the manufacturer changed the formulation, manufacturing method or manufacturing site, products which do not comply with specifications are delivered or if a serious complaint has been received.

9.2 Dual versus multiple sourcing

Relying on a single source for any health care product should be avoided as it creates a complete dependency (Schulte, Ch. 1999, 235). Inability of the single supplier to deliver, especially during emergencies, may quickly cause a stockout at the assisted health care facility. The risk increases if the single source supplies other humanitarian organizations which are likely to place large orders to the same supplier at the same time. Consequently humanitarian organizations should source health care goods from at least two reliable suppliers. An overview of criteria for choosing dual or multiple sourcing is shown in figure 9.1.

Complete reliance on a single supplier also bears the risk of unavailability in case the manufacturing quality or supplier services suddenly deteriorate. Although a sudden increase of the purchasing price will not cause a stockout humanitarian organizations will have to bear the higher price until an alternative supplier can be found.

Single sourcing may be acceptable for health care goods which can be considered as commodities, which are available from a large number of suppliers and for which an alternative supplier can be found immediately.

Single sourcing may be inevitable for humanitarian assistance goods where only one supplier can offer products with the required specifications, such as sophisticated or standardized health care equipment. Purchasing similar health care equipment from several suppliers would carry the penalty of having to stock and provide several different sets of replacement parts and operating equipment. However, even where a specific product is selected as a standard, at least two intermediaries who hold stock should be available.

Relying on a single source may also be inevitable where drug products are available from only one manufacturer during the life of a patent. However most essential drug products have been on the market for decades and are available as multisource drug products.

Drug products for treatment of diseases not common in developed countries or rarely used vaccines may only be available from a single manufacturer because the market does not warrant competition.

In order to avoid dependency on suppliers as well as to allow a quick increase of purchased quantities in emergencies, at least two sources should be available for critical products (Quick, J.D. (ed.) 1997, 236). The availability of a second supplier also allows benefiting from the possibly shorter lead time of a second supplier (Tagaras, G., and D. Vlachos 2001, 416).

Unavailability of less critical health care goods will not jeopardize health care programmes as substitutes can be used until an alternative supplier is found.

Single sourcing of health care goods for which quality is critical allows enhancing quality assurance by concentrating available resources on a single manufacturer or supplier

(Schary, Ph.B., and T. Skjøtt-Larsen 2001, 186). Moreover quality of purchased products is more consistent with single sources (Ehrmann, H. 2003, 297). On the other hand lack of competition and the impossibility to compare the quality of different products may decrease quality. Moreover, new developments of competitors may be missed.

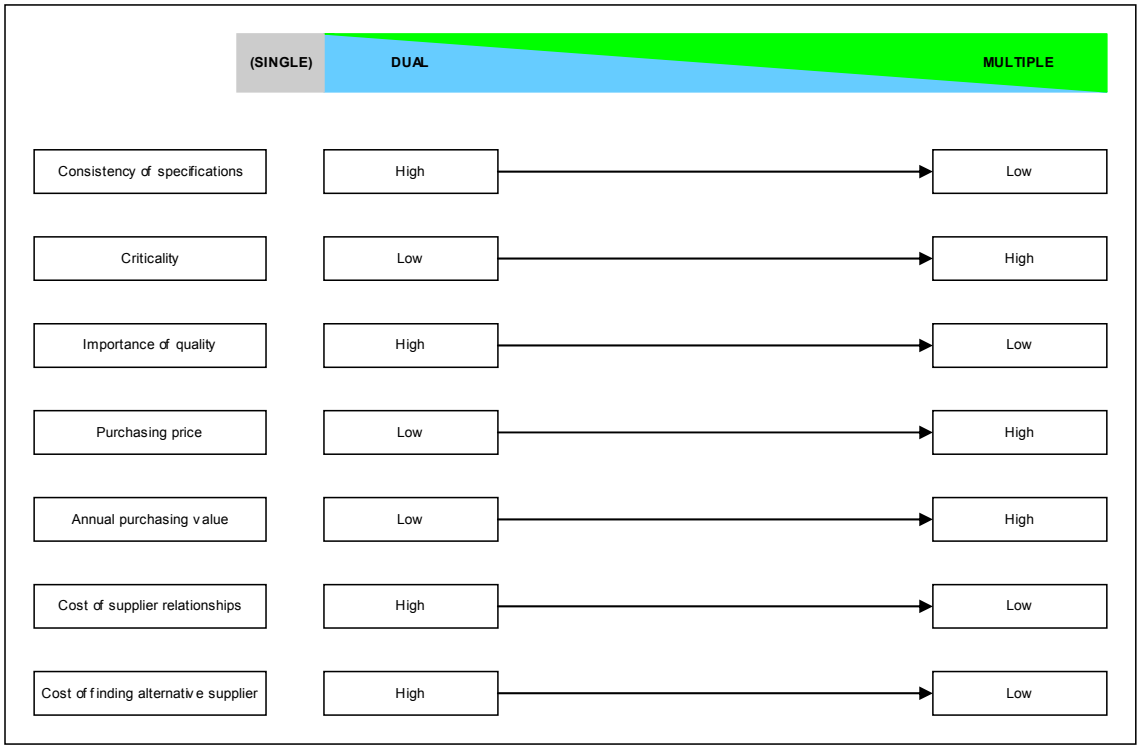

Figure 9.1 Dual versus multiple sourcing

For health care goods with low annual purchasing value, lower purchasing prices from competition among several suppliers are unlikely to offset the higher costs for maintaining relations with multiple suppliers. Conversely for expensive health care goods, such as equipment, or for goods with high overall purchasing value, multiple sourcing allows benefiting from competition and lower purchasing prices.

On the other hand humanitarian organizations may benefit from economies of scale by purchasing from a single supplier (Schary, Ph.B., and T. Skjøtt-Larsen 2001, 186) and must consider the trade-off.

High costs for sourcing, qualifying and regularly inspecting (alternative) suppliers, especially abroad, also favours dual rather than multiple sourcing.

9.3 Centralized versus decentralized purchasing

Purchasing strategies can be differentiated by the geographical scope of the customers they serve (Ehrmann,H. 2003, 476).

In the context of humanitarian assistance purchasing can be centralized in one location, often the head office country or in another developed country, which serves all medical distribution centres worldwide. At the other extreme purchasing services would be decentralized in each country or even in each place where the humanitarian organization assists health care facilities. Purchasing services can also be located between these extremes,

serving a continent, geographical region (for example central America or the Middle East) or a number of adjacent countries.

The scope of purchasing does not necessarily coincide with the scope of sourcing. Centralized purchasing services may purchase health care goods in the country of the head office or internationally, either directly or through intermediaries. Conversely decentralized purchasing services may purchase health care goods in the country where they are located as well as regionally or even internationally through intermediaries.

For any country of operations, the purchasing strategy may differ between different types of health care goods. For example drug products with high quality requirements may be purchased centrally while dressing material may be purchased from domestic manufacturers. Likewise the strategy may differ from country to country where in one country the majority of health care goods may be purchased domestically while in another country all humanitarian assistance goods are purchased centrally and shipped to the respective health care facilities.

	Advantages	**Disadvantages**
Centralized purchasing	• Facilitates enforcement of quality assurance policies. • Economies of scale and scope for purchasing. • Centralization of purchasing expertise and capacity. • Facilitates worldwide standardization of provided health care goods.	• Requires exportation and importation. • Requires registration in every country of supply. • Higher costs for (international) transportation. • Longer (transportation) lead times.
Decentralized purchasing	• No importation needed (avoids costs and delays). • Compliance with domestic drug legislation and regulations. • Lower transportation costs (for humanitarian organization). • Availability of stocks in the country of operations. • Shorter lead times. • Long-term sustainability. • Compliance with domestic language requirements. • Products corresponds to domestic medical practices and treatment protocols. • Often lower prices than in developed countries (even for the same products). • Ease of contacting suppliers. • Support of the domestic economy.	• Poor (central) control over compliance with quality assurance policies. • Requires qualified purchasers in each place of purchase. • Requires capacity for quality control in each place of purchase. • Reduces the economies of scale. • Limited range of available health care goods. • National drug regulatory authorities often not as strong as in developed countries. • Higher risk of purchasing counterfeit or substandard drug products and other health care goods.

Table 9.1 Advantages and disadvantages of centralized and decentralized purchasing

Among the various advantages and disadvantages (see table 9.1) national drug legislation and regulations need to be considered as the potentially greatest constraint as they usually require that all health care goods, or at least drug products (Quick, J.D. (ed.) 1997, 235) are registered in the country of importation. The (standard) products which a central purchasing

service may routinely purchase as well as the manufacturers from which they are purchased may not be registered in the country of operation. Even high quality health care goods are likely not to be registered as there is a practical limitation on the amount of goods the national drug regulatory authorities can register and the most expensive products will not be favoured.

In order to reduce transportation costs and lead time, both centralized and decentralized purchasing services, will favour suppliers in their vicinity, provided that offered products comply with the required quality standards. The main consideration is the trade-off between low transportation costs (cost) and short lead times (customer service) for decentralized purchasing and the increased risk of acquiring substandard and counterfeit health care goods (quality assurance) by purchasing in less developed countries. The criteria that need to be considered are shown in figure 9.2.

Regardless of the quality of available health care goods in the country receiving humanitarian assistance, the need for an immediate response to an acute crisis does not allow surveying the domestic or local market and qualify potential suppliers. Rather health care goods will have to be supplied from already qualified sources abroad until the availability and quality of health care goods in the domestic market have been assessed.

At the strategic level every humanitarian organization must define a quality assurance policy. Very stringent quality assurance policies which require compliance with the highest standards in developed countries will favour a centralized purchasing strategy. At the opposite end, decentralized purchasing will be favoured if the quality assurance policy only requires compliance with national standards and national regulatory requirements in the country of purchase.

Even for (high quality) health care goods which are available domestically, humanitarian organizations may prefer centralized purchase in order to benefit from economies of scale (Gadde, L.E., and H. Håkansson 2001, 156), provided that the savings exceed transportation costs for international distribution.

The reduction of overall annual transportation costs for international distribution favours sourcing heavy and bulky items such as infusions and dressing material domestically, especially if the annual demand is high and the value density is low.

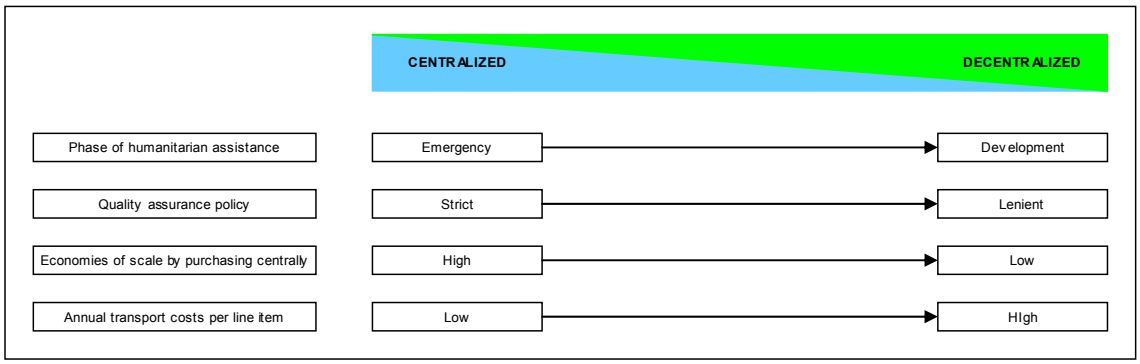

Figure 9.2 Criteria for centralized versus decentralized purchasing

The assumption is made that the quality assurance costs for centralized purchasing are comparatively low in a developed country since manufacturers as well as intermediaries have to comply with rigorous national quality standards and will be regularly audited by their respective national drug regulatory authorities.

In countries where the national quality assurance system does not satisfy the quality assurance requirements of the humanitarian organization, the cost of substituting the

shortcomings will depend on the quality of the national drug regulatory authorities but also depend on the range of health care goods which individual manufacturers or intermediaries offer. For example the national quality assurance systems may be considered as sufficient for dressing material and oral dosage forms of drug products but insufficient for injectable dosage forms and surgical sutures. The resources for inspecting and auditing manufacturers is more or less independent of the range of health care products manufactured at that site.

The costs for qualifying manufacturers and suppliers are basically the same whether a small quantity of a single product or large quantities of many products are purchased as the minimum quality standards are independent of quantities. Incurring high costs for auditing manufacturers or intermediaries may be cost-efficient if a large range of health care goods is offered and the total annual purchase value of those products is high. However generally high costs for substituting national quality assurance systems will favour centralized purchase.

High costs for establishing and maintaining multiple decentralized purchasing services which also depend on the quality assurance policy, will also favour centralized purchasing, even if high quality health care goods are available domestically.

While the decision on centralized or decentralized purchase needs to take all above criteria into consideration and compare the overall costs of ownership, the costs associated with quality assurance are of particular importance. Transportation costs are also an important criterion since important health care goods have low value but high weights (for example infusions) or high volumes (for example dressing materials). The trade-off between the annual costs for decentralized purchase of health care goods and the annual transportation costs for centrally purchased goods is critical (figure 9.3).The annual cost of quality assurance for each domestically purchased item depends on the national drug regulatory authorities, the cost for substituting quality assurance systems and on the number of different products one supplier is offering.

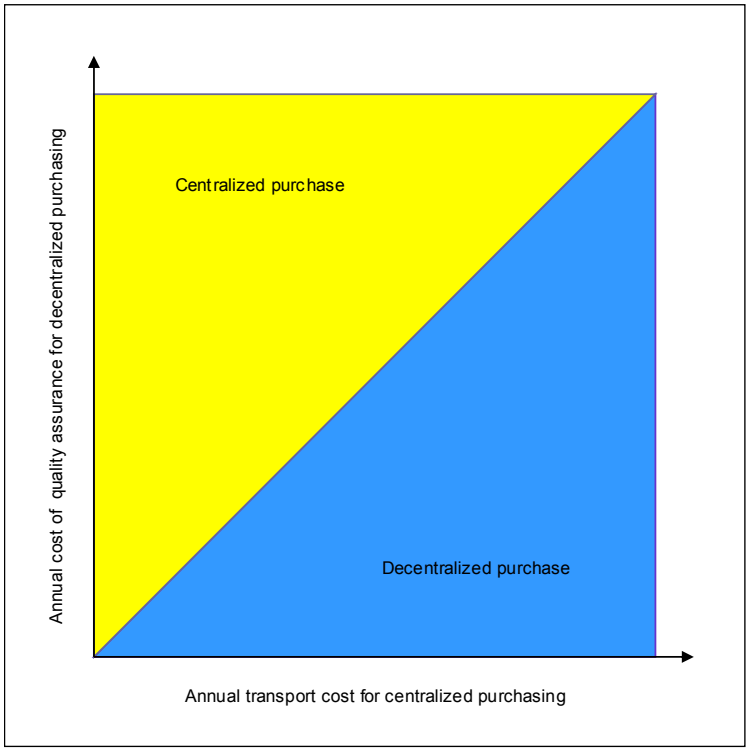

Figure 9.3 Centralized versus decentralized purchasing

One of the main disadvantages of centralized purchasing is the high cost of international distribution especially if air transportation is commonly used to shorten transportation lead time in order to avoid (or limit) deterioration of health care goods.

Consequently humanitarian organizations should focus on decentralized purchase of heavy and bulky items such as infusions or dressing material with high annual turnover and therefore high annual transportation costs, provided that the (higher) cost for quality assurance incurred by decentralized purchase is offset by a corresponding reduction in transportation costs.

9.4 Width of supplier base

The width of the supplier base refers to the overall number of suppliers (Gadde, L.E., and H. Håkansson 2001, 155) which are qualified and have been registered by the respective humanitarian organization. The width of supplier base is related to but does not coincide with the issue of dual versus multiple sourcing. Single sourcing each item from a different supplier leads to a wide supplier base while dual sourcing from two wholesalers offering the full range of required health care goods results in a narrow supplier base.

Generally, the required resources to maintain a large number of supplier relationships favour limiting the supplier base (Gadde, L.E., and H. Håkansson 2001, 174).

At the one extreme, each health care product is purchased from the supplier offering the best quality, price and services. While no manufacturer produces a full range of necessary health care goods, the supplier base can be reduced by purchasing all necessary health care goods which are available from that supplier, regardless of the price. At the other extreme all goods would be purchased from a single wholesaler. The issues which need to be considered are summarized in figure 9.4.

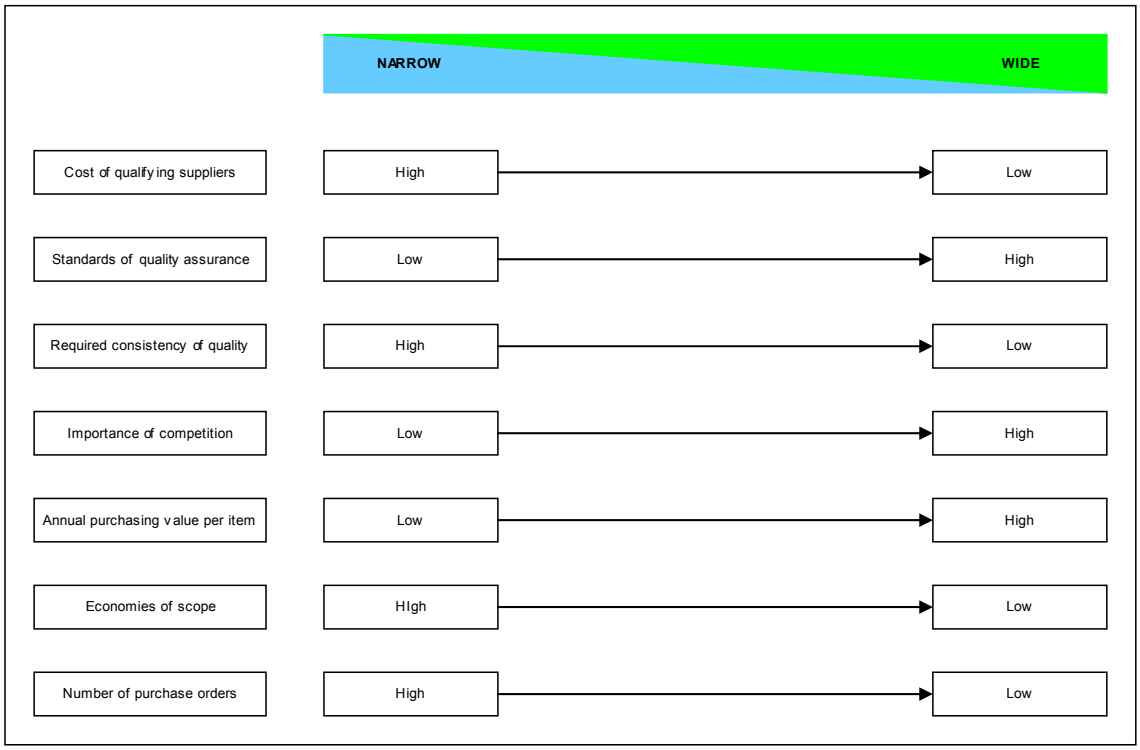

Figure 9.4 Width of supplier base

The costs for qualifying new manufacturers and suppliers depend on the costs for specialists to carry out detailed audits and the physical distance between manufacturers or suppliers and the purchasing service.

The cost associated with auditing and qualifying suppliers also depends on the stringency of national drug legislation and authorities. Where national quality assurance systems are weak, the cost of thorough auditing of a large number of individual manufacturers and suppliers can be prohibitively high. The benefit of higher consistency of quality within a range of products, such as injection supplies, sutures or surgical instruments, may outweigh the cost savings which could be achieved by purchasing individual items from different suppliers.

Ensuring compatibility of equipment and medical devices may also require purchasing from a single supplier even if cost savings could be achieved by purchasing individual health care goods from different suppliers.

For health care goods where competition is likely to improve quality and reduce prices, a wider supplier base is favourable. Humanitarian organizations can then quickly take advantage of the most suitable health care goods without having to source new suppliers or establish new supplier relationships at short notice.

For health care goods with a low annual purchasing value, the cost savings from minimizing prices by purchasing each product from a different supplier are unlikely to compensate for the fixed costs associated with maintaining several supplier relationships (Gadde, L.E., and H. Håkansson 2001, 158).

For health care goods or ranges of products where the annual purchasing value is significant enough to benefit from economies of scope, narrowing the supplier base can be an advantage (Gadde, L.E., and H. Håkansson 2001, 35).

Reducing the width of the supplier base allows to consolidate and therefore reduce the number of purchasing transactions which are each associated with a fixed cost (Audit Commission 1996, 23).

A related issue is purchasing directly from manufacturers or through intermediaries such as distributors or wholesalers. Appointed and authorized distributors which offer the full product range of a manufacturer will not necessarily reduce the number of suppliers but will allow purchasing without the need for importing goods from the country of manufacture. However intermediaries have to be qualified and every intermediary between the humanitarian organization and the manufacturer increases the risk of purchasing substandard or even counterfeit health care goods (WHO 1999a, 16). Especially when purchasing in less developed countries it may be difficult to trace the supply network back to the manufacturer. Moreover the danger of deterioration due to inappropriate transportation and storage also increases with the number of intermediaries. Therefore health care goods where the quality is important should be purchased directly from known and reliable manufacturers rather than through intermediaries (WHO 1998e, 6). If purchase through intermediaries are necessary, confirmation must be obtained from the manufacturer that the respective intermediary is authorized by the manufacturer to sell his products.

Wholesalers offer a wide range of different health care goods from several manufacturers and therefore allow reducing the width of the supplier base considerably. Even outsourcing all purchasing activities to a single wholesaler could be considered.

Wholesalers lower transaction costs as a large number of orders for individual items can be replaced by larger consolidated purchase contracts for a wide range of health care goods (Burt, D.N., D.W. Dobler, and St.L. Starling 2003, 346). Likewise transportation between wholesalers and the medical distribution centre of the humanitarian organization can be

consolidated. Warehouse operations are also facilitated as staff does not need to receive smaller shipments from a large number of different suppliers.

Wholesalers offer the additional advantage of being able to offer substitutes if the primary supplier is unable to deliver without the humanitarian organization having to urgently source for an alternative supplier.

Humanitarian organizations can benefit from economies of scale and large annual purchasing values will encourage wholesalers to provide high quality services.

Possible disadvantages are dependency on a small number of suppliers (wholesalers) and potentially high switching costs if humanitarian organizations are not satisfied with the services they receive. The mark-up of wholesalers on the manufacturer prices may be offset by lower transaction costs.

One means of reducing the width of the supplier base is by outsourcing the manufacturing of prepacked kits rather than purchasing individual health care goods and assembling kits. Specialized suppliers offer prepacked field hospitals with hundreds of items which can be purchased off the shelf in modules or as a single item.

9.5 Summary of sourcing strategy

Since speed of response is essential during the contingency phase and the initial emergency response and there is no time for tendering, goods will have to be selected from previously registered and qualified suppliers with a record of reliably providing health care goods of good quality (see figure 9.5).

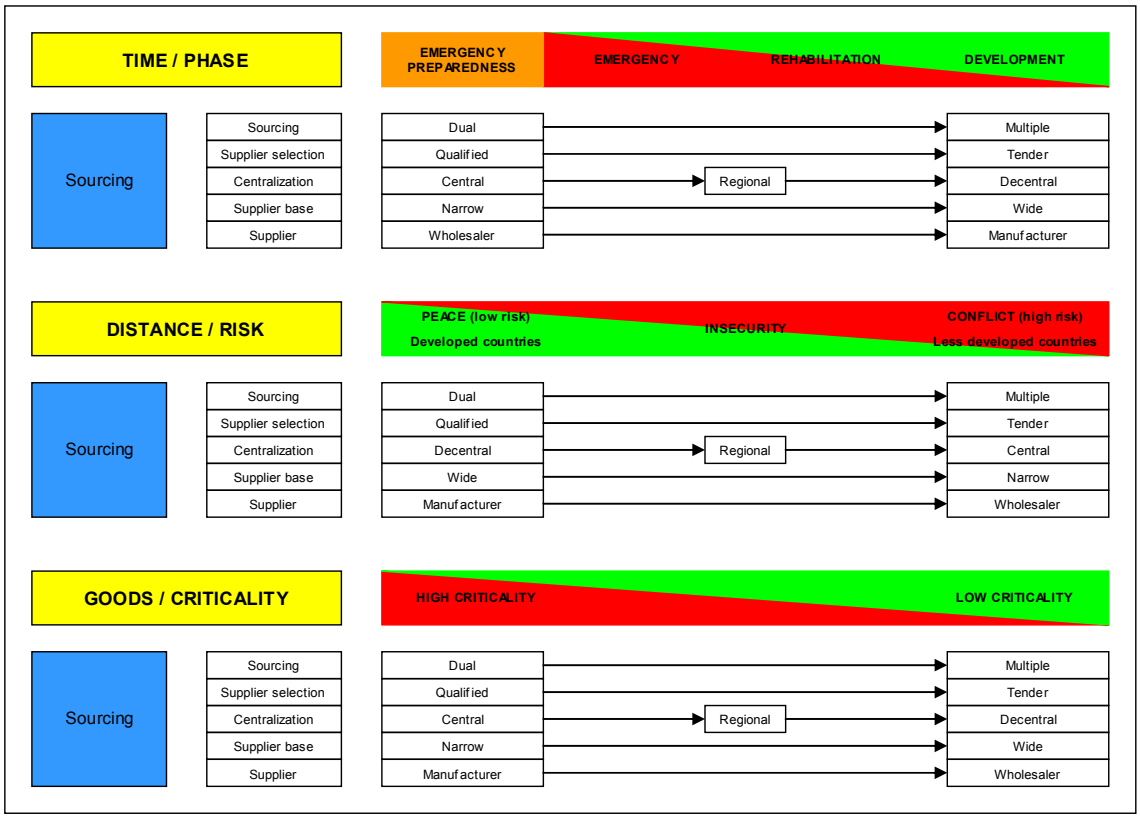

Figure 9.5 Sourcing strategy

In order to avoid complete dependency, humanitarian organizations should at least source health care goods from two suppliers. However efficiency and the need for a quick response do not allow sourcing from multiple sources at this stage. During later stages of humanitarian assistance where the objective is sustainability of health services and short lead times are less important, humanitarian organizations can benefit from the advantages of multiple sourcing. Since an immediate response to emergencies is imperative, centralized purchasing from known and well established suppliers is necessary. During the rehabilitation and development phase, purchasing services can move closer to the country receiving assistance and inside the country nearer to assisted health care facilities.

The imperative of simplicity and efficiency during the emergency requires limiting the width of the supplier base which can be expanded at a later stage especially in view of facilitating sustainability and self-sufficiency of health care programmes.

During the emergency phase lead times and purchasing resources can be reduced by purchasing health care goods from a small number of wholesalers, even if overall purchase costs are higher. During later stages direct purchases from manufacturers may allow benefiting from lower prices.

The general insecurity will favour purchasing goods only from qualified and known suppliers or resorting to centralized purchasing instead. Tendering requires more human resources and time and is therefore more suitable for purchasing services in safe markets.

The complexity of multiple sourcing and a wider supplier base is reserved to places further away from the conflict area for the same reason.

Since commercial activities for health care goods are likely to have decreased in and near the conflict area, in most cases humanitarian assistance goods will have to be provided from centralized purchasing services in secure countries. With increasing security, regional, domestic and eventually local purchasing can be resumed provided the quality of health care goods can be ensured.

Critical health care goods should be purchased only from qualified and known suppliers while for less critical purchasing methods such as direct purchasing may be used.

Assessing manufacturers and suppliers requires considerable resources. Therefore the number of potential suppliers should be limited for highly critical health care goods in order to concentrate available resources on a few but thorough rather than many more superficial assessments.

Highly critical health care goods, which therefore require high quality standards, should be sourced centrally as the required quality assurance resources are more likely to be available and can be used more economically for a few suppliers.

Wherever possible, highly critical health care goods should be purchased directly from the manufacturer, or at least as close to the manufacturer as possible, rather than through intermediaries in order to ensure their high quality.

10 FACILITY NETWORK DESIGN STRATEGY

The facility network design must determine the number, location as well as capacities of facilities (Lambert, R.S., and J.R. Stock 1993, 305). This chapter will first analyse the reasons why humanitarian organizations must maintain stocks and storage facilities, summarize relevant constraints and review some models before developing a strategy for designing the facility network. The strategy will consider only the facility network of the humanitarian organization and disregard the facility network of third party distributors. Finally criteria for selecting and owning sites and facilities will be discussed since they are also require long-term, strategic decisions.

The supply network (Chopra, S., and P. Meindl 2007, 4) consists of nodes (storage facilities) and links (transportation routes) which connect multiple source points (manufacturers and suppliers) with the demand points (customers and recipients of humanitarian assistance) and through which goods and related information flow.

Since humanitarian organizations are concerned only with distribution of finished goods, nodes are either storage facilities or places where goods change the mode of transportation (Pfohl, H.Ch. 2000, 350). The supply network can be seen as the collection of all possible network paths or routes along which goods and related information can flow (Chopra, S., and P. Meindl 2007, 54) with or without intermediate storage at its nodes. However goods do not necessarily have to flow through all nodes between the manufacturer and the end-user.

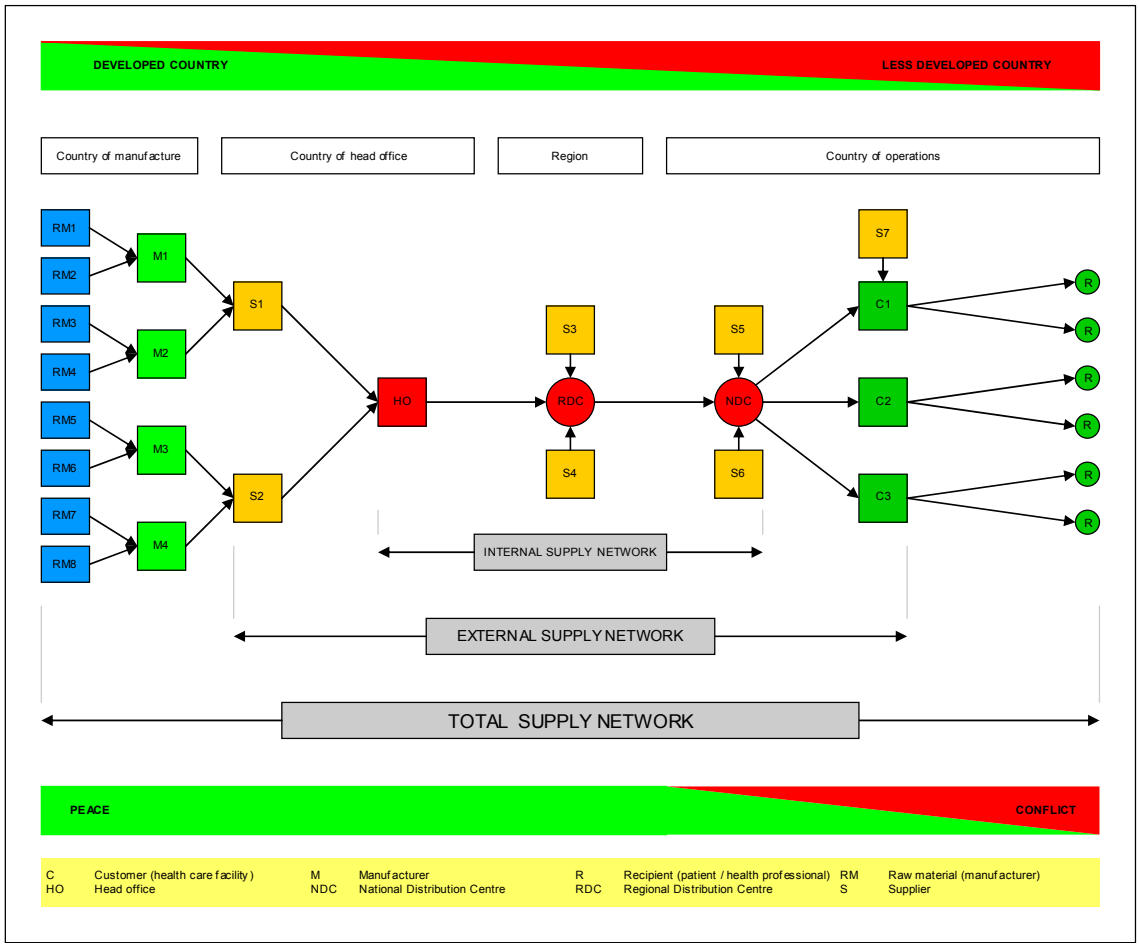

Figure 10.1 Total, external and internal supply network

The internal supply network (see figure 10.1) extends from the receiving store managed by the humanitarian organization to the last downstream store managed by the same organization. The external supply network extends beyond the humanitarian organization and includes the immediate upstream supplier as well as the demand points (usually assisted health care facilities).

While the length of the supply network between the manufacturer of finished goods and the end-user is determined by their respective locations, the length of the external supply network may vary from extending from the manufacturer to the end-user or being entirely outsourced with direct deliveries from the manufacturer to the end-user without involving logistics services of the humanitarian organization. Finally, the total supply network extends from the manufacturers of raw materials to the final user or recipient of health care goods.

Humanitarian organizations must take a strategic decision to determine the borders between their own supply network (Gudehus, T. 1999, 36) and the global commercial supply network of which it is a part.

10.1 Reasons for holding stock

Stocks of health care goods need to be held for numerous reasons. However, the main reason are reducing customer lead time and hedging against uncertainty of supply and demand (Waters, D. (ed.) 1999, 6) by decoupling demand from supply. Although health care goods (form utility through manufacturing) are always available somewhere in the network, they are only of value to customers if they are available near customers (place utility), belong to the customer (possession utility) and are available at the time needed (time utility) or at least within reasonable lead time (Lambert, R.S., and J.R. Stock 1993, 9).

Careful inspection of all health care goods entering the internal supply network by a qualified pharmacist is an indispensable quality assurance measure. Since finding and employing qualified staff downstream near the assisted health care facilities is more difficult or may be impossible, inspection needs to be centralized further upstream in the supply network. Centralizing inspection allows reducing the resources required for inspection (Jessop, D., and A. Morrison 1994, 226) but in turn requires intermediate storage before further distribution. As every batch requires inspection, purchasing larger quantities less frequently allows reducing required resources for inspection but also requires maintaining stocks.

Purchasing larger quantities of health care goods at a time allows benefiting from economies of scale by negotiating lower purchasing prices (Rushton, A., J. Oxley, and Ph. Croucher 2000, 233), reducing transaction costs by reducing the purchasing frequency as well as reducing transportation costs through less frequent supplier deliveries (Lambert, R.S., and J.R. Stock 1993, 267).

Stocks are necessary to hedge against uncertainty of supply (Pfohl, H.Ch. 2000, 100) which can occur at all stages throughout the supply network for various reasons. Health care goods, such as customized kits, may not be manufactured continuously and therefore not be available from the supplier immediately. Stockouts may occur at the supplier for a variety of reasons and during emergencies, when demand suddenly surges. Health care goods may have to be purchased at different times from different suppliers which may offer differing delivery lead times.

Delivery of available goods may be delayed, goods damaged during transport or rejected during inspection for non-conformity to the required specifications and quality (Steinbuch, P.A. 2001, 315).

Especially in countries receiving humanitarian assistance, customs clearance may be slow or delayed, borders and transportation routes may be blocked for security reasons or by sanctions and transportation routes may be damaged by natural causes (floods, landslides etc.) or effects of warfare.

As schedules as well as capacities of different means of transportation usually cannot be completely synchronized, temporary storage of consignments is necessary at nodes where means of transportation are changed (Pfohl, H.Ch. 2000, 125), for example between road and air transportation.

Maintaining stores allows consolidating several shipments from different stores and benefiting from transportation economies (Lambert, R.S., and J.R. Stock 1993, 267) as well as lower costs for customs clearance. Consolidation of shipments is mandatory when using expensive cargo aircraft. Besides transportation frequencies may be limited and irregular for security reasons or because of blocked transportation routes and air ports. Especially in the conflict area, transport frequencies may be limited by transportation costs and available resources, especially when using small aircraft.

Since health care facilities require regular delivery of numerous different health care goods, direct shipment from a large number of suppliers requires a consolidation point (CP) for increasing transportation efficiency. Suppliers may be unwilling to ship small quantities of products directly to a large number of customers and direct shipment is usually impossible in the conflict area for security reasons or because of unavailability of transportation means.

Stores allow receiving numerous health care goods from different suppliers, serve as a break bulk point, allow combining goods from different suppliers as well as consolidating outbound consignments to individual demand points (Lambert, R.S., and J.R. Stock 1993, 265).

Storage facilities may also be necessary for manufacturing kits (Rushton, A., J. Oxley, and Ph. Croucher 2000, 233) if they are not already manufactured by suppliers.

Maintaining safety stocks is also necessary to hedge against uncertainty of demand (Lambert, R.S., and J.R. Stock 1993, 268) caused by the unpredictability of the conflict, a sudden influx of patients as well as unforeseen movement of displaced populations. Other reasons for unpredictability of demand are seasonal diseases and epidemics. Although even large stocks cannot guarantee 100% stock availability, stocks can reduce the probability of shortages and stockouts. Moreover stocks near to demand points (customers) can reduce the need for expensive expediting of shipments in case of shortages or stockouts.

Unforeseen increases of established assistance to health care facilities as well as an increase in the number of assisted facilities, changes of treatment schedules as well as calculation errors, damage of stocks and expiry of goods can also cause unexpected variations of demand.

- Decoupling of demand from supply.
- Reduction of customer lead time.
- Providing space and time utility to customers.
- Inspection of health care goods upon delivery from commercial suppliers.
- Reduction of resources required for inspection (by less frequent purchasing).
- Reduction of purchasing frequency and purchase costs.
- Reduction of transportation costs for deliveries from commercial suppliers.
- Economies of scale for purchasing (quantity discounts).
- Reduction of transaction costs for purchasing.
- Hedging against uncertainty of supply.

- Differing supplier lead times.
- Stockouts at or delivery delays from upstream distribution centres.
- Damage or rejection of received health care goods.
- Delayed customs clearance and blocked borders.
- Blocked transportation routes (sanctions or natural causes).
- Change of mode of transportation with different capacities.
- Consolidation of supplier deliveries and transportation consolidation for onward transport.
- Transportation economies, especially for expensive (air) transportation.
- Reduction of costs for customs clearance by transportation consolidation.
- Breaking bulk.
- Combining and consolidating health care goods from different suppliers.
- Manufacturing of kits.
- Uncertainty of demand.
- Providing higher customer service levels to customers.
- Reducing costs for expediting urgent shipments.

Table 10.1 Reasons for holding stock

10.2 Storage facility location

For developing the facility network strategy the context in which humanitarian organizations work and some specific constraints need to be considered.

10.2.1 Context and constraints

The risk that access to assisted health care facilities is blocked by parties to the conflict and therefore the inability of humanitarian organizations to provide required health care goods, increases with the distance to the supplying storage facility. On the other hand the safety and security risks for staff, storage facilities and stocks decrease with increasing distance to the conflict area. The primary concern for logistics managers is minimizing the exposure of staff, assets and goods to conflict related risks. Storage facilities must be located in the safest available areas which are exposed as little as possible to conflict related risks.

National borders and front lines may have to be considered as impassable for political and security reasons, even if the physical distance between assisted health care facilities and an ideally located storage facility across the divide is small. Minimizing the risk of transportation between stores and assisted health care facilities takes priority over minimizing transportation costs. Transit along the shortest route through a third country may also be impossible for security reasons.

Locating storage facilities close to assisted health care facilities reduces the risk that transportation routes between them are blocked as a consequence of the conflict. However, although intentional attacks on health care facilities are considered as a war crime (Rome Statute Art. 2.b (ix)), locating stores in the conflict area also increases the risk that staff are harmed and goods are looted, damaged or destroyed. Consequently logistics managers must seek a compromise between ensuring the reliable supply of health care facilities even during intense warfare and limiting the safety and security risks to acceptable levels.

In order to ensure instant availability of health care goods, even in peace times, hospitals will maintain stocks irrespective of stock holding costs (Harrison, A., and R. van Hoek 2002, 90).

Blocking, shelling, looting or damage to a central storage facility in the conflict area carries the risk that supply to all assisted health care facilities will be interrupted. This risk can be dispersed and therefore reduced by locating stocks directly at assisted health care facilities. If one health care facility and its store are damaged or destroyed, the others still can continue to provide services. However in order to provide the same level of service to several health care facilities, overall larger network stocks are required than with one central storage facility.

The locations of recipients are determined by health programme managers based upon a needs assessment, cannot be changed by logistics managers and can therefore be considered as fixed (Gudehus, T. 1999, 74). However logistical constraints should be considered by health programme managers in their planning.

Because of the limited funding, lack of security and the overall difficulties of providing humanitarian assistance in the context of high insecurity, compared to commercial organizations in developed countries, the number of health care facilities assisted by individual humanitarian organizations in the respective countries is low.

The storage and distribution needs for other assistance programmes by the same humanitarian organization will also be a determining factor. Where humanitarian organizations have already established offices and storage facilities, for example for food, accommodating health care goods in the same location will reduce costs. However, since customers for different humanitarian assistance goods may not be located in the same places, the location of a storage facility might be optimal for one set of demand points but less suitable for another set. However, using an existing distribution network is likely to increase the overall efficiency and avoids the need for establishing a separate, parallel system for optimizing flows of health care goods (sub-optimization) which would increase overall distribution costs.

The location of consolidated storage facilities will eventually be determined by the type of humanitarian assistance goods with the largest volumes (flows) of distribution. Similar considerations apply for transportation means which have already been deployed for distributing humanitarian assistance goods other than for health programmes or for transportation of staff.

The overall strategy for designing the facility network must be global since complex political emergencies can in principle emerge anywhere in the world.

The sources of health care goods are determined by the strategic considerations developed earlier. The complexity of and required resources for supply chain management will decrease with decreasing distance between suppliers and assisted health care facilities. Therefore local purchasing will be preferred to domestic and domestic to international purchasing, provided that all suppliers comply with the required quality standards.

Even if high quality health care goods are available from domestic suppliers, the facility network strategy must consider alternative sources from abroad since the necessary time for qualifying suppliers will not be available during the emergency phase.

The facility network strategy must consider the possibility of significant delays for customs clearance by sanctions or the authorities on either side of international borders. The possibility of a complete and permanent closure of international borders as well as front lines must be considered in any case.

10.2.2 Theoretical models

Several traditional quantitative warehouse location models are based on minimizing costs or maximizing profits (Klose, A., and P. Stähly 2004, 482).

Von Thunen's model proposes a strategy based on minimizing transportation costs of products while Weber's model attempts to minimize costs for transporting raw materials to a manufacturing plant as well as finished goods to the market (Lambert, R.S., and J.R. Stock 1993, 313). Hoover's model considers the decrease of relative transportation costs with increasing distances which favours locating facilities further downstream rather than at intermediate locations. Greenhut included other factors such as the environment and security and his model aims at maximizing overall profits. As the primary objective of humanitarian organizations is to maximize reduction of suffering, neither minimizing costs nor maximizing profits can be a primary objective.

Hoover distinguishes between market positioned, production positioned and intermediately positioned location strategies (Lambert, R.S., and J.R. Stock 1993, 311). The market positioned strategy locates facilities near to the final demand point in order to maximize customer service. Production positioned warehouses are located near the sources of products and serve as collection and mixing facilities for products from different sources which reduces customer service but allows consolidation of shipments. The third location strategy is a compromise where facilities are located between source points and demand points in order to balance customer service levels and transportation costs.

Quantitative location models can also be divided into planar models, network models and discrete models (Klose, A., and P. Stähly 2004, 483). In planar models the sum of distances between the facility and all demand points it serves is minimized.

Network models are more realistic as potential locations of facilities are restricted to the vicinity of the transportation network (Lambert, R.S., and J.R. Stock 1993, 317).

Discrete models consider fixed as well as variable facility costs and select the best facility location from a limited number of feasible options (Mau, M. 2002, 32).

Facility network designs can be approached by starting from the sources of goods or by considering the location of end-users and planning the supply network backwards up to the sources (Klaus, P., and W. Krieger (ed.) 2004, 446).

Since it is not possible to quantify all relevant criteria for designing the network, decision makers must ultimately use their judgement (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2003, 307). Exact algorithms require exact data and often require complex computations while heuristics allow providing good even if not optimal solutions (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 91). The analysis of constraints allows eliminating certain solutions beforehand and limits the number of possible solutions from which the final solution can be selected (Gudehus, T. 1999, 75).

In the context of humanitarian assistance, physical transportation distances are often a poor parameter for modelling or planning as transportation times will greatly depend on often poor road conditions as well as the security situation which may require extensive detours.

10.2.3 Facility network design in humanitarian assistance

The delivery of all health care goods from the manufacturer directly to assisted health care facilities would avoid costs and risks associated with their intermediate storage and handling (Gudehus, T. 1999, 269). Even if the best store is no store at all (Koether, R. (ed.) 2004, 50), in practice maintaining intermediate storage facilities is necessary for numerous reasons

(Lambert, R.S., and J.R. Stock 1993, 263) as discussed earlier. However, storage facilities must not be added to a facility network unless they can be justified considering the trade-off between service and cost (Bowersox, D.J., and D.J. Closs 1996, 392). Generally supply networks should be as simple as possible and legs which do not add any value to customers should be eliminated (Klaus, P. 2004, 352).

Since the complexity of the context as well as various aspects such as the security situation or transportation infrastructure are difficult to model mathematically, the strategy will be developed by reasoning and heuristics.

A general framework for building a facility network design can be derived by starting from the simplest possible network and expanding it by successively considering the strategic objectives, premises, constraints and the overall context developed above.

In a direct shipping network (Chopra, S., and P. Meindl 2007,395) all goods are shipped directly from supply points (S) to the respective customer (C) (figure 10.2). This facility network is the simplest in the sense that it does not require establishing or maintaining any intermediate storage facility (Pfohl, H.Ch. 2000, 6).

Figure 10.2 Direct distribution

However, direct distribution would require feasibility for and willingness of suppliers to ship goods directly to health care facilities in a conflict area. Because the required health care goods are often not available with the required quality in countries of the recipients, direct shipment would require transportation across international borders with the associated risk of delays. Direct shipments would also make health care facilities dependent on lead times offered by the respective supplier. Direct shipments would only be economical if the quantities allow fully utilizing means of transportation (Gudehus, T. 1999, 21) which is unlikely with a large number of suppliers.

Health care facilities require a significant amount of different health care goods and individual shipments of a few items from several supply points to a single demand point lead to inefficient transportation. Especially where the majority of health care goods are sourced from abroad, a consolidation point (CP) is necessary near to the suppliers (Gudehus, T. 1999, 22) which corresponds to a convergent system (Minner, St. 2000, 64). Goods from different suppliers are received, inspected, consolidated according to customer orders and shipped to the demand point by benefiting from transportation economies (figure 10.3 A). This system also has the advantage that demand points can be supplied with all necessary health care goods with a single shipment (Bowersox, D.J., and D.J. Closs 1996, 483).

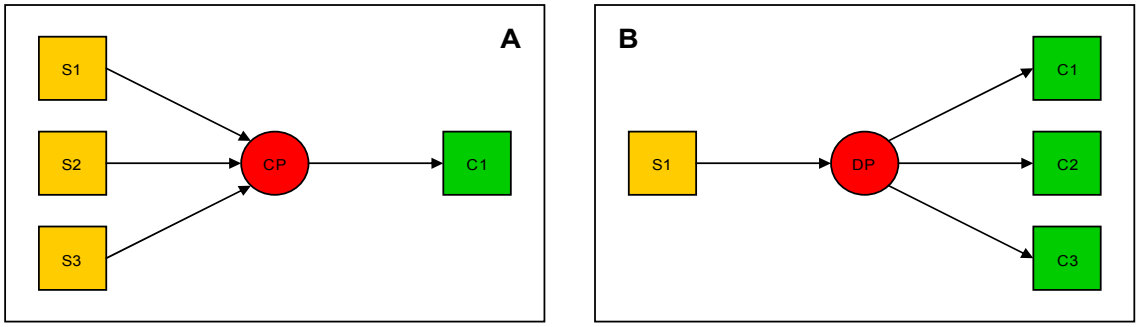

Figure 10.3 Consolidation and distribution point (Pfohl, H.Ch. 2000, 6)

This consolidation point may be located in the recipient country, a neighbouring country, a regional distribution centre or the country where the humanitarian organization is headquartered. A storage facility, which may be located at the head office or in another country, where health care goods are purchased and stored for further worldwide distribution to all health care facilities supported by the respective humanitarian organization, will be called an international distribution centre (IDC).

Likewise direct shipment of individual consignments from one supply point to several demand points leads to inefficient transport, especially when suppliers are located abroad. Consequently an intermediary storage facility is needed to receive consignments from supply points, break bulk, prepare smaller consignments according to individual customer orders and distribute consignments to the final demand points. Figure 10.3 B corresponds to a divergent system (Minner, St. 2000, 63). This distribution point (DP) can be located in the geographical region or within the country. However hedging against the risk of delays for customs clearance and closed borders requires a national distribution centre in the country where humanitarian assistance is supplied (Bichler, K., and N. Schröter 2004, 178). As will be discussed later, a national distribution centre is also necessary for immediately responding to any emergency inside the country.

At the national level, the overall distribution costs in a supply network are composed of several elements (Rushton, A., J. Oxley, and Ph. Croucher 2000, 123) and the trade-off between the number of distribution centres and overall transportation costs must be considered.

Every medical store or warehouse incurs costs for building or renting, building services (heating, cooling, lighting etc.), materials handling and storage equipment, information and communication systems, labour as well as management. Therefore overall storage costs will increase with the number of storage facilities in a country. Storage costs increase if a given stock value is split and spread over several storage facilities (Rushton, A., J. Oxley, and Ph. Croucher 2000, 117) as larger storage facilities can be operated more efficiently. Moreover according to the "square root rule" overall safety stocks (and their value) in a country are proportional to the square root of the number of storage facilities (Rushton, A., J. Oxley, and Ph. Croucher 2000, 184). For example reducing the number of storage facilities from 4 to 1, would allow reducing overall stocks (and therefore overall stock value) in all stores by 50% while providing the same stock availability.

Transportation costs within a delivery zone ("drop" mileage) are independent of the number of storage facilities.

Finally only the primary transportation costs (trunking costs, "stem mileage") decrease with the number of storage facilities in a country. However with a small number of demand points and infrequent (for example monthly) deliveries these costs will be comparatively low.

Since all other cost elements increase with the number of storage facilities, overall distribution costs tend to increase with the number of storage facilities. Even if in some cases additional storage facilities may reduce overall costs, their ideal location may change whenever additional health care facilities are assisted or assistance to other health care facilities is ended. Given the uncertainty of situations in which humanitarian organizations work, costs for moving these additional distribution centres from one ideal location to another when the locations of demand points change will generally be prohibitively high.

Therefore, because of the relatively small number of health care facilities humanitarian organizations assist inside a given country, a single storage facility, which will be called a national distribution centre (NDC), should supply all demand points in this country. A single storage facility requires fewer resources and allows providing the same level of service with

lower echelon stocks than several distribution centres in the country (Gudehus, T. 1999, 33). As far as the security situation allows, this national distribution centre should be located near to the assisted health care facilities in order to minimize overall transportation distances and transportation costs.

In networks with long transportation lead times between national distribution centres and health care facilities, a large number of assisted health care facilities or the danger that transportation between national distribution centres and health care facilities may be interrupted by warfare, the question of the need of an additional stage of storage facilities arises. Additional stages increase complexity (Thorn, J. 2002, 14), incur additional costs for establishing and maintaining storage facilities and increase demand distortion.

Generally, a larger number of demand points and a larger number of smaller consignments favour a more decentralized distribution with additional stages of storage facilities (Ehrmann, H. 2003, 472). Additional regional storage facilities for serving a region within a country could only be justified if significant transportation economies can be gained from consolidating transportation between the national distribution centre and the regional store. However the overall volume of health goods required for assisting health care facilities is low and humanitarian organizations usually assist only a limited number of health care facilities.

On the other hand the danger of transportation routes being interrupted by warfare is always a danger that must be considered. However establishing additional storage facilities between national distribution centres and assisted health care facilities does not eliminated this risk. Even storage facilities located within the same town or city of health care facilities receiving assistance may be cut off by rapidly changing front lines. Moreover, delivery of heath care goods even from nearby stores may be impossible for security reasons during open combat, shelling or aerial bombardments. Looting, damage or destruction of the regional store will deprive all assisted health care facilities of further supply.

The only way of preventing interruption of supply is by locating storage facilities within the premises of assisted health care facilities either by extending pharmacies and medical stores or by establishing additional storage facilities. During a crisis no facility can be considered as absolutely safe. However the relative safety of health care facilities is one of the major criteria for assisting them. Moreover health care facilities are protected under International Humanitarian Law und must never be attacked (Geneva Convention I, Art. 19).

Compared to a regional store, increasing the storage capacity at each health care facility or establishing an additional store at the health care facility increases the overall storage costs as well as overall stock levels. However storage facilities at health care facilities are the only way of avoiding interruption of supply and fulfilling the primary requirement of effectiveness. Moreover any additional stage such as regional stores increases demand distortion while increasing stock levels at assisted health care facilities does not, provided that all stocks at the health care facility are managed as one entity. Finally, even without any restrictions on supplying health care facilities, these must in case maintain stocks for covering the review period. As any assisted health care facility must maintain a pharmacy, the issue is not whether to locate stocks in the premises but only determining the required stock levels.

Establishing storage facilities within health care facilities or within their premises has the additional advantage of availability of resources and services such as security, water and power supply. Where available, storage facilities can be established in empty buildings and therefore do not require renting or building facilities. Health care facilities, rather than landlords of rented facilities, can also benefit from any repairs or renovations of existing buildings after humanitarian organizations end their assistance.

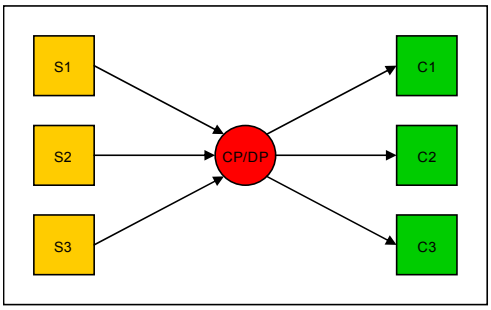

Figure 10.4 Joint consolidation and distribution point

Where humanitarian organizations purchase goods from several suppliers and distribute them to several health care facilities (figure 10.4), an intermediary storage facility can serve as a consolidation as well as break bulk and distribution point at the same time (Pfohl, H.Ch. 2000, 124).

Since health care goods are often sourced outside the country of final distribution, a consolidation point is needed near to the suppliers (figure 10.5) in order to benefit from transportation economies and a second storage facility is needed near to the demand points (Gudehus, T. 1999, 22).

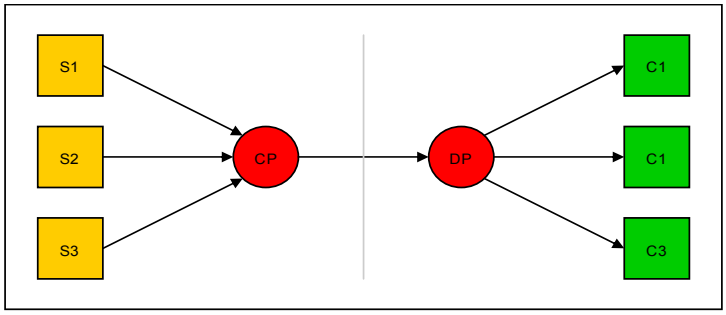

Figure 10.5 Consolidation and distribution points in different countries

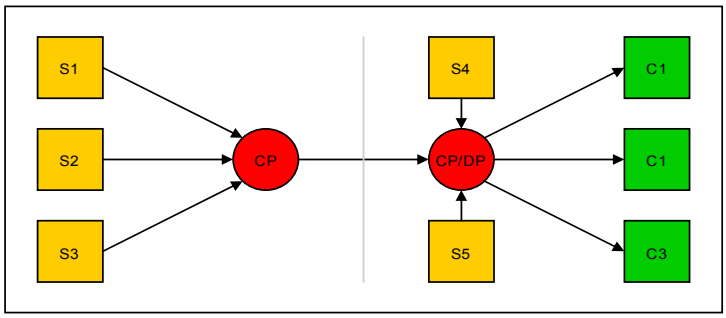

Figure 10.6 Distribution point as consolidation point for domestic purchase

Wherever quality and price permit, humanitarian organizations will try purchasing health care goods domestically in order to reduce transportation costs and reduce lead times. In this case the distribution points in the recipient country will also serve as consolidation points (figure 10.6).

These national distribution centres combine the functions of consolidation, breaking bulk and combining health care goods to complete consignments for health care facilities (Jessop, D., and A. Morrison 1994, 3).

In cases where high quality health care goods can be purchased in the vicinity of assisted health care facilities, local purchase reduces transportation costs and allows direct delivery to the demand points (figure 10.7).

Local purchase is often an alternative for other essential goods such as food, fuel or cleaning materials. Finally on-site sourcing or production may be an option for water supply (sinking wells), electrical power generation with fuel driven generator sets as well as food production for example in a hospital bakery.

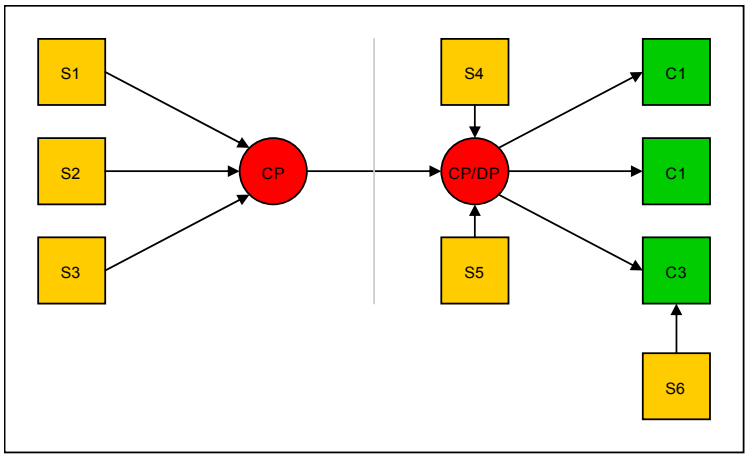

Figure 10.7 Facility network with domestic purchase

Especially where significant amounts of health care goods are purchased centrally at international distribution centres, regional distribution centres (RDC) allow reducing transportation costs through consolidation and serve as distribution points for downstream national distribution centres (Gudehus, T. 1999, 24). Moreover regional distribution centres in countries with developed pharmaceutical markets can serve as consolidation points for domestically purchased health care goods (figure 10.8).

Regional distribution centres also reduce the dependency of national distribution centres from international distribution centres in terms of shortages, interruption of international transportation as well as their limited capacity, especially in responding to several emergencies simultaneously. If all required health care goods are available in the country where the regional store is located, then the facility network corresponds to the facility network in figure 10.6.

International distribution centres must be located in developed markets and in the vicinity of major suppliers of health care goods. Besides international distribution centres should be located near airports with an extensive international transportation network as well as a seaport for international shipment of large amounts of bulky and heavy goods.

Likewise regional distribution centres should be located in fairly developed markets with good transport connections to the countries in which humanitarian organizations are assisting health care facilities.

National distribution centres need to be located in the vicinity of international airports, rail heads, sea and inland ports as well as along major transportation routes. Where the major mode of transportation is by road, national distribution centres must have good transportation connections to ports of entry from neighbouring countries where consignments can be cleared from customs.

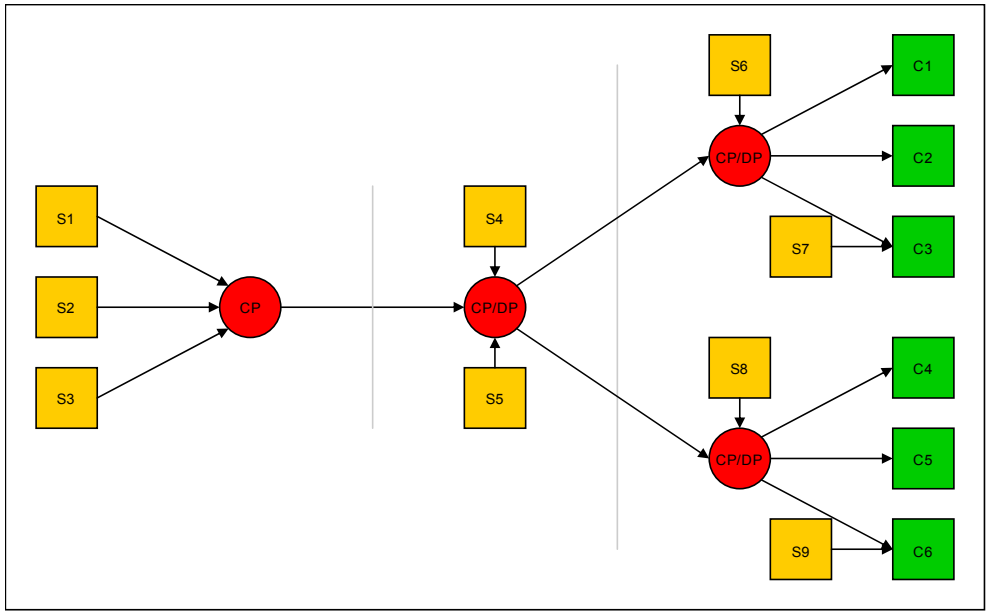

Figure 10.8 Facility network with regional distribution centre

Locating national distribution centres in national capitals is often a logical choice because of the available infrastructure (PAHO 1983, 28) and since humanitarian organizations usually maintain offices there. However the location of national distribution centres should also minimize transportation times to assisted health care facilities. Depending on the road infrastructure, front lines and the security situation, the routes with the shortest transportation time may not necessarily coincide with the shortest distances.

Each storage facility must have sufficient capacity for storage as well as for managing the throughput required to serve all downstream storage facilities and demand points (customers). Moreover storage facilities should be selected or planned to allow future increases of storage capacity either by renting or building adjacent stores.

10.3 Site selection

The macro perspective, which considers the geographical location of storage facilities, needs to be complemented by the micro perspective of the exact site location (Lambert, R.S., and J.R. Stock 1993, 311).

The exact location of a storage facility within a city or town does not change the global structure of the facility network. However the selection of sites and facilities, which require significant investments for establishing and maintaining, must also be considered as a long-term, strategic decision.

The main considerations are security and safety of the site, sufficient size, configuration and the possibility of expansion, availability of utilities and services, access by vehicles as well as vicinity to main transportation infrastructure.

The size of the site must allow accommodating a variety of facilities (see table 10.2).

The ideal site for storage facilities will rarely be available, especially when a facility is rented or leased. However all relevant aspects should be nevertheless considered and if more than one site is available, the one which is closest to the ideal should be selected.

- Warehouse building(s), including offices.
- Store for dangerous goods.
- Fuel store and fuel station.
- Workshop facilities.
- Vehicle cleaning.
- Amenities for workshop staff and drivers.
- Building (shelter) for generator set.
- Vehicle parking area.
- Visitor parking area.
- Building for security guards.
- Perimeter wall or fence with main gate, barriers and security lighting.
- Security shelter.
- Well or bore hole, water tower or water tank and hydrants.
- Connection to public sewage network, septic tank or soak pit.
- Incinerator and waste disposal facility.

Table 10.2 Facilities at a warehouse site

The primary concern must be minimizing security risks for staff, assets, facilities and goods as well as the possibility that the security situation can deteriorate very quickly (Roberts, D.L. 2005, 121). The site selection must not only consider the current security situation but consider conflict dynamics and try anticipating future changes in the security of a site.

The geographic location of storage facilities as well as the site selection will first of all require the acceptance by the conflict parties as well as the community. Notifying conflict parties of the position of storage facilities is an essential security measure which will avoid unintentional attacks and damage (Roberts, D.L. 2005, 74).

The proximity to military installations such as barracks or checkpoints, military airports, radar stations or anti-aircraft positions must be avoided. Moreover locations in the vicinity of facilities and infrastructure, such as government buildings, residences of dignitaries, factories, strategic roads, airports, rail heads, bridges, telecommunication facilities, radio and television facilities, power stations, dams or fuel depots, which are prone to become military targets, should be avoided (Roberts, D.L. 2005, 122). However these risks need to be balanced against the advantages of locating storage facilities near to main transportation infrastructure such as inland ports and seaports, airports, railheads or major road networks.

The level of crime, the possibility of vandalism as well as the proximity to areas of potential demonstrations or civil unrest such as markets, religious buildings, universities and diplomatic areas should be taken into consideration when considering suitable areas in a town or city (Bickley, S. 2003, 50). Moreover it must be possible to monitor and guard the site outside normal working hours, especially during the night.

The compound must be surrounded by at least 2.5 metre high wall (Van Brabant, K. 2002, 134) or fence to prevent unauthorized entry and be furnished with security lighting around the perimeter.

A security shelter should be available for warehouse staff to provide protection from small weapons, grenades and the effects of nearby explosions (Roberts, D.L. 2005, 110).

The site should not be exposed to natural hazards such as floods, landslides, mudslides, avalanches, earthquakes, volcanoes, bush fires or tornados.

The site should also be accessible to emergency services such as the fire department or rescue services and buildings should be accessible from all sides.

The use of the site as a storage facility must be permissible according to national legislation and regulations as well as possibly restrictions by the community. For example, a suitable site may be located in a residential area or access by heavy vehicles may be restricted.

If there are plans to develop a site, erecting buildings and other facilities must be permissible according to local zoning and building laws which may restrict the height or size of buildings.

Future extension of buildings or infrastructure as well as erecting further buildings must be in principle permissible under national legislation and regulations.

The site should be located in the vicinity to major road and rail networks, (international) airports as well as inland and seaports.

The availability of public transportation services for staff should also be considered.

Water is needed for cleaning, cooking, personal hygiene, sanitation as well as fighting fires. The site should be connected to the public water network or allow sinking a borehole or digging of a well.

The site should also be connected to the public sewage system or have other facilities for disposal of waste water such as septic tanks and soak pits.

The site should be connected to the public power supply network. Electricity is essential where refrigeration or air-conditioning are needed as well as for operating telecommunication equipment. However, this utility can be substituted by installing generator sets of sufficient capacity.

A connection to the public telephone network should be available for voice and data transmission and the site should be served by postal services.

The site should be accessible for emergency services such as fire engines and allow access of the largest vehicle envisaged for use. Access with heavy vehicles must be possible during all seasons and must not be blocked by rain water which is not drained from access routes, snow or ice. In addition the slope of the site and access roads together with adverse weather conditions needs to be considered.

The possibility that road access will be hampered by future developments outside the site and congestion should be considered.

Access by heavy vehicles must not be prohibited by local regulations for example to protect neighbourhoods from noise and pollution.

The site must be large enough and have a suitable configuration to accommodate the storage facility and other facilities (Rushton, A., J. Oxley, and Ph. Croucher 2000, 134) and existing buildings should be suitable for use as medical warehouses. The site must also be large enough for allowing manoeuvring of (heavy) vehicles, preventing vehicles from blocking each other as well as congestion.

The site must be large enough to extend existing facilities in future inside the site.

Selected sites must be large enough to allow future extension of existing buildings or other facilities.

The ground strength (load bearing) must be sufficient to support heavy vehicles as well as buildings or facilities which need to be erected. At least the loading bays, drive ways and car

park must be paved with concrete, asphalt or gravel, especially if the warehouse is accessed by heavy vehicles.

Figure 10.9 Paved drive way

The site must be level and well drained to prevent flooding of buildings during heavy rains. Any (slightly) sloped surfaces should be fitted with non-slip surfaces to prevent vehicles from sliding when the surfaces are wet or covered with snow or ice.

The energy consumption for ventilating, cooling and heating of buildings can be reduced by considering some principles of climate responsive building. As many less developed countries are situated in hot climates, the major concern is cooling of buildings.

Every building creates a micro-climate in its vicinity which influences wind, sun and moisture content of the air. Buildings reflect sunlight, cast shades and divide the site into a sun side (hot zone) and shade side (cool zone). This phenomena can be enhanced by fitting buildings with shades or verandas as well as placing buildings in the shade of trees, adjacent buildings or features of the landscape. Plants around buildings provide shade and cool the air through evaporation of water.

Elongated buildings should be sited so that the long walls are exposed to as little sunlight as possible. The outer walls of rooms where health goods are stored should not face the sun.

Finally selection of sites will depend on the cost for renting, leasing or purchasing.

A) Security

- Distance from military installations.
- Proximity of facilities which are prone to military attacks.
- Level of crime in the area.
- Proximity to areas of potential demonstrations or civil unrest.
- Possibility of guarding the site.

- Compound surrounded by fences or walls and furnished with security lighting.
- Security shelter for all staff.

B) Safety

- Absence of natural hazards.
- Accessibility of site by emergency services.
- Accessibility of buildings from all sides.

C) Legal and national regulatory requirements

- Use of site permissible under national legislation and regulations.
- Absence of restrictions by the community.
- Permission to erect buildings, if necessary.

D) Proximity to main transportation infrastructure

- Proximity to major road and rail networks.
- Proximity to airports.
- Proximity to inland and seaports.
- Availability to public transportation services.

E) Utilities

- Access to a public water network.
- Depth of water table.
- Access to the public sewage system.
- Access to and reliability of the public electricity grid or generator sets of sufficient capacity.
- Access to telecommunication infrastructure.

F) Vehicle access

- Accessibility for emergency services.
- Type and quality of roads.
- Accessibility throughout the year (no obstacles by rain, snow or ice).
- Access by heavy vehicles.
- Possibility that future land development in the vicinity will impede operations.
- Restriction of vehicle access during certain periods of the day.

G) General considerations

- Large enough and suitable configuration to accommodate the warehouse and other facilities.
- Large enough for manoeuvring (heavy) vehicles.
- Ground strength (load bearing) sufficient for heavy vehicles and supporting buildings.
- Paved car park, drive ways and loading bays.
- Level and well drained site.
- Suitability of existing buildings and facilities and possible need for replacement.
- Orientation of building.
- Cost for rent, lease or purchase.

Table 10.3 Criteria for selecting sites

10.4 Storage facility selection

Selected storage facilities must be large enough to accommodate required stocks and storage areas as well as ancillary facilities. The possibility of later extension inside or outside the facility must be considered during the planning stage (Bowersox, D.J., and D.J. Closs 1996, 408).

The layout of the storage facility which is initially selected can have a big influence on the flexibility and possibility of extension. A storage facility with many small rooms has the least flexibility. Buildings and storerooms with widely spaced columns and wide-span structures are more expensive to build but are much more flexible when the layout of storage facilities has to be changed. High storerooms allow increasing storage capacity by increasing the height of storage equipment at a later stage (although this may be expensive) but require more energy for heating and cooling. For any given surface area, buildings with a square footprint have the least wall surface and therefore minimize costs for heating and cooling.

Openings of the building (doors, windows, ventilation openings) should be protected by blast walls (Roberts, D.L. 2005, 115).

The construction of buildings must comply with national building codes and regulations, especially in terms of fire safety.

Storage facilities must be structurally sound (PAHO 1983, 28) in order to provide the required protection of health care goods and must have sound foundations and walls. Timber structures should be avoided as they are less durable, can be damaged by termites, pose an increased fire hazard and generally non-combustible materials should be preferred.

Tents or prefabricated structures can be set up quickly, especially during the emergency phase (Ockwell, R. A. 1994, 444) but, if at all inevitable, must be used only as temporary facilities (UNHCR 2000, 260) in modest climates. They are very difficult to heat or cool and offer no protection against intrusion. ISO shipping containers are unsuitable for storage of health care goods and should be used only as a last resort. The aisle along the entire length required to ensure access to all of the stock prevents efficient use of available space and the use of suitable materials handling equipment is nearly impossible. Larger stocks are inevitably scattered in different ISO shipping containers which also offer poor insulation and quickly heat up in the sun.

ISO shipping containers and tents are unsuitable for the storage of health care goods!

The high value of health care goods as well as the financial loss and possible harm to patients their deterioration can cause warrants and requires investing in sound storage facilities.

One-storey buildings should be preferred as construction costs are lower (Jessop, D., and A. Morrison 1994, 195) and they are easier to maintain. The capacity to carry weights is lower for upper floors than for the ground floor. Materials handling is easier and cheaper as, except possibly for unloading and loading, no powered vertical handling (lifting) is required. In order to minimize costs for heating, cooling and ventilation, the internal height of storerooms should not be higher than necessary for accommodating the storage equipment.

If only buildings with more than one storey are available, the ground floor should accommodate stocks while upper storeys should be used for offices, utilities and amenities.

If only part of a building is used for storing health care goods, rooms on the shady side of the building should be preferred for storage while rooms and areas exposed to the sun can accommodate docks, building services, ancillary services and amenities.

The roof must be sound, intact, in good condition and completely free of any leaks which would allow rain water to enter and damage the building or stocks. Rain water should be collected in gutters and drained off by pipes or in drainage channels around the outside of the building in order to avoid damage to the foundations of the building.

All buildings should be furnished with lightning protection to prevent fires from lightning strikes.

In cold climates the roof should be well insulated. In hot climates the roof should have a light colour and be made of a reflective material to reflect as much sun light as possible and the space below the roof should be ventilated to prevent building up of hot air. Any skylights must be secured with bars to prevent break-ins through the roof.

Additional ceilings which should completely seal off the storeroom from the space below the roof increase insulation against heat and cold and help protecting stocks from dust, dirt and pests.

Walls and columns should be made from brick, stone or concrete, be sound and free of cracks or other structural defects. Walls should be dry and free of rising moisture. Thicker walls provide better insulation against heat and cold and reduce energy needs for heating and cooling. Walls should be smooth, plastered, painted and in good condition in order to avoid creation of dust from crumbling surfaces. Outside walls should preferably be plastered or painted in light colours to reflect sunlight and reduce the need for cooling and air-conditioning.

Figure 10.10 Protective roof above warehouse entrance

Canopied bays usually provide 5 or 6 metres of protection, protect the dock and rear of the truck and allow loading and unloading without being exposed to wind, sun, rain and snow.

Entrance and any other outside doors must be lockable and should be made from metal or at least sturdy timber with additional metal gratings. Internal doors should preferably be made

from metal to impede the spreading of fire. All doors must be wide enough for allowing materials handling equipment with their loads to pass through.

Large buildings should be fitted with a sufficient number of additional fire doors.

Vehicle or loading bays protect goods and staff from the weather during loading and unloading and prevent sensitive health care goods from being exposed to high or low temperatures and direct sunlight. They also prevent air-conditioned warehouses from warming and heated warehouses from cooling when the doors are opened.

Enclosed loading bays completely cover vehicles and provide good protection and comfort to staff. However they require a lot of space, are expensive to build and may require ventilation to remove exhaust fumes from the vehicle (Rushton, A., J. Oxley, and Ph. Croucher 2000, 139).

Loading and unloading of vehicles can be greatly facilitated if the vehicle floor is level with the warehouse floor. One possibility to accomplished this is a sunken vehicle access. The slope of the road should not exceed 10 degrees and the area adjacent to the dock should be flat so that the vehicles are level for unloading. The sunken vehicle access must be drained to remove rain water. The advantage of a sunken vehicle access is that the floor of the warehouse does not have to be elevated which is expensive. Disadvantages are that these facilities require constructive measures and vehicles may skid on the slop.

If the warehouse floor is higher than the ground surrounding the warehouse a raised dock can be used which is level with the warehouse floor. Since vehicles may have different heights, dock levellers can be used to bridge the different heights of docks and vehicles and allow movement of hand pallet trucks and counterbalanced forklift trucks.

Figure 10.11 Dock leveller

If the storage facility has no enclosed loading bay, the roof of the warehouse must at least protrude to cover the dock as well as the end of the vehicle. A simple dock shelter can provide additional protection against the weather from the sides.

The warehouse should be protected from damage by reversing vehicles by dock bumpers.

The size of loading bays and docks depends on the type of vehicles which are loaded and unloaded. The number of docks is determined by the number of vehicles which can be loaded and unloaded simultaneously. This in turn depends on the number of available staff as well as the number of materials handling equipment, if the trucks are not loaded and unloaded manually.

Figure 10.12 Vehicle loading bay and docks

By default warehouse entrance doors through which consignments are received and dispatched should be furnished with strip doors. These keep out birds and insects, prevent or at least reduce entry of sand and dust and help to maintain the internal warehouse temperature without the need for constantly opening and closing doors.

Figure 10.13 Strip door

Except for office rooms, wherever possible, windowless storage facilities and storage rooms are preferable as they avoid exposure of stocks to direct sun light and greatly reduce the need and costs for heating and cooling.

In any case direct exposure of health care goods to sun light and ultraviolet radiation must be prevented by curtains, shades, frosted glass or shutters. Window glass should be in good condition and must not broken or cracked. All windows, including skylights, must close tightly and should be protected from intrusion by metal gratings or bars. Windows which can be opened should also be fitted with mesh and mosquito screens to prevent insects, birds and other pests from entering.

The construction of the building should protect the storage facilities from bats, rats, birds, (flying) insects and termites. Measures for pest proofing include covering all necessary openings (ventilation openings, pipe ducts), especially below roofs, with gratings or wire mesh. Any holes or gaps in the ceiling, walls, floors or below doors should be closed.

Floors require special attention since defects are more difficult and more expensive to remedy than faulty roofs or windows for example.

Floors must be completely free of rising dampness and should be made from concrete, bricks or stone and be finished with concrete, tiles, terrazzo, vinyl sheeting or asphalt. They must be level (have a horizontal plane) and flat (even) to allow use of materials handling equipment as well as be smooth (but not slippery) to facilitate cleaning. The painting of surfaces can (temporarily) reduce dust but the paint is often not durable, wears off and therefore requires re-painting.

Floors must bear the loads of storage equipment and stored goods as well as loads of and vibrations from materials handling equipment. The floors of storage facilities designed for the entry of heavy vehicles must support the respective floor loading.

Floors should be free of any obstacles such as steps or stairs which prevent the use of materials handling equipment. If different parts of the floor are situated at different levels they must be connected by ramps which are furnished with non-skid surfaces such as parallel groves in a concrete surface. The slope of the ramps must not exceed the maximum stated by manufacturers for the respective materials handling equipment.

Buildings should be pest proof to prevent entry of bats, rats, birds, flying insects and termites.

Smoke detectors should be installed in all storerooms and connected to a fire alarm system.

The entire building should either have sufficient natural or artificial lighting and be furnished with a sufficient number of wall sockets.

Depending on the climate, the building must be furnished with cooling, heating and possibly ventilation.

Water taps should be available in sanitary facilities and the kitchen (area) and be connected to the plumbing system.

Finally telecommunication facilities such as radio base stations, telephones, telefax and Internet connections should be installed.

A) General considerations

- Large enough to accommodate stocks, storage equipment and ancillary facilities.
- Possibility of future extension.
- Openings of building protected by blast walls.

B) Construction

- Compliance with national building codes and regulations.
- Structurally sound building.
- Sound foundations.
- Sound and dry walls.
- One-storey buildings should be preferred over multi-story buildings.
- The internal height should not be greater than necessary.
- If only part of a building is used, the external walls of the medical store should not face the sun.
- Sound and intact roof with gutters.
- Lightning protection.
- Roof insulated in cold climates and light coloured and reflective in hot climates.
- Space below roof well ventilated.
- Sound and intact ceiling.
- Walls and columns made from brick, stone or concrete.
- Walls free of cracks and structural defects.
- Walls dry.
- Walls plastered or painted.
- Preferably metal doors.
- Doors tightly closing and lockable.
- Doors wide enough for using materials handling equipment.

- Sufficient number of fire doors.
- Vehicle bays or protected docks.
- Docks furnished with strip doors.
- Preferably windowless buildings.
- Windows (if inevitable) shaded.
- Tightly closing and barred windows.
- Pest proofing of any necessary openings.
- Concrete, brick or stone floors finished with concrete, terrazzo or asphalt.
- Level and even floors.
- Floors able to bear load of storage as well as materials handling equipment.
- Floors free of obstacles (steps, stairs, ramps etc.).
- Pest proofing of building.

C) Building services

- Smoke detectors and fire alarm system.
- Sufficient natural or artificial lighting.
- Wall sockets (power points).
- Ventilation.
- Cooling.
- Heating.
- Water taps.
- Plumbing system.
- Telecommunication means.

D) Cost

- Acquisition costs.
- Operating costs.

Table 10.4 Requirements and selection criteria for storage facilities

If several suitable facilities are available, the final selection will be based on the acquisition and operating costs.

Although every attempt should be made to find the most suitable site and storage facility, in practice compromises will have to be made and the best available site and storage facility will have to be selected which, if necessary, can be improved at reasonable costs.

10.5 Ownership of storage facilities

The strategic decision of commercial organizations whether to in- or outsource establishing and operating storage facilities (Lambert, R.S., and J.R. Stock 1993, 268) applies equally to humanitarian organizations.

Outsourcing storage to commercial operators offers the advantage of not having to invest in establishing facilities, not having to carry the risk of its damage or destruction and the flexibility of changing the location of facilities quickly and at little cost. However humanitarian organizations have little control over stocks which is associated with a higher risk of theft or confiscation. Outsourcing also makes humanitarian organizations dependent on commercial organizations which can jeopardize the reliability and consistency of supplying humanitarian assistance programmes. Handing over stocks to third parties in a country lacking legal security as well as the use of the same storage facility by other customers who are implicated in the

conflict may also pose security risks. Perhaps with the exception of large cities and ports, public warehouses which are owned and operated by commercial companies are unlikely to be available in less developed countries with poor infrastructure, especially in a conflict area.

In some cases humanitarian organizations may be able to make use of storage facilities of (government) authorities or other humanitarian organizations.

Alternatively humanitarian organizations can operate private warehouses. Since building facilities requires time, which is not available in emergencies, possible options are leasing or purchasing facilities. Ownership requires significant investment (Lambert, R.S., and J.R. Stock 1993, 406) which donors will be reluctant to fund, reduces flexibility of relocating facilities and means carrying the risk of confiscation, damage and destruction. However purchasing storage facilities may be an option for international or regional distribution centres which are established in safe countries and are expected to be used at least for several years.

Consequently the most practical alternative is for humanitarian organizations to lease (rent) existing facilities including available storage and materials handling equipment, and operate them with their own staff. In this option facilities are available immediately, do not require large investments, the risk of damage and destruction of storage facilities remains with the owner and humanitarian organizations maintain full control over staff and stocks. Own storage capacities can be complemented by temporary use of public warehouses to accommodate sudden unexpected increases in stock levels (Bowersox, D.J., and D.J. Closs 1996, 403).

Leasing storage facilities has the advantage of maintaining the flexibility of relocating facilities (Lambert, R.S., and J.R. Stock 1993, 272) if deteriorating security requires abandoning a location or because the locations of assisted health care facilities change. Storage of health care goods directly at the assisted heath care facility avoids having to establish and maintain a store at all and in fact is a way of outsourcing storage entirely.

A disadvantage of leasing storage facilities is that in case of reduced needs for storage, capacities may remain unused without reducing fixed costs (Lambert, R.S., and J.R. Stock 1993, 274), for example when humanitarian assistance programmes are reduced.

A lease must be concluded with the owner among others in order to avoid later disputes. This formal contract should be drafted by a professional lawyer with good knowledge of the laws and legal system in the country. A number of issues need to be considered in a warehouse lease agreement (see table 10.5).

Building warehouses will be the exception rather than the rule. Construction is expensive, humanitarian organizations usually do not commit themselves in advance to long-term assistance programmes and investing in countries with poor legal security is risky. Forecasting the security situation in any country is difficult and the entire investment may be lost if the storage facility has to be abandoned for security reasons. The capital invest is considerable and storage facilities may be confiscated or damaged in the course of an armed conflict. However building warehouses may be considered for example when establishing regional logistics centres in a secure and safe country.

Building a new warehouse may be more cost-efficient than rehabilitation or renovation of an existing building and may be necessary if suitable storage facilities are simply unavailable. Capital investment for rehabilitation or renovation might be considerable while the result may not be as satisfactory as a new warehouse. Building a warehouse may incur less costs over ten or twenty years than the operating costs of a rented or leased building, especially if the cost for leasing commercial storage facilities are unreasonable.

- Receipt of legal documents confirming ownership, right of use etc.
- Obligations and rights of the owner.
- Obligations and rights of the lessee, tenant or buyer.
- Duration of contract.
- Amount of rent and other payments.
- Currency of payment.
- Terms of payment (period allowed for payment, instalments, cash, check, money transfer etc.).
- Purpose and scope of use of the facility.
- Right of noise and pollution.
- Right of modifications to buildings and property.
- Terms of returning facility after use (reversing modifications, painting, renovation etc.).
- Obligations concerning renovation and rehabilitation.
- Obligations concerning maintenance of utilities and building services (water, electricity, sewage etc.).
- Obligations concerning insurance, insured risks and insurance coverage (facility, vehicles, stock).
- Right of sublease.
- Conditions for termination of contract (reasons, length of prior notice, continuation of payments).
- Settlement of legal disputes (country, place and authorities).

Table 10.5 Contractual agreements of a warehouse lease

Warehouses must be carefully planned to ensure that they serve their purpose, allow efficient warehouse operations and are cost efficient.

As assistance programmes may change, possible future needs must be taken into account to ensure that the facility will not be become obsolete.

A project team including an architect, engineer, a consultant specialist in warehouse design and construction as well as a specialist for storage equipment should be formed. The project plan must include a detailed plan of the warehouse, storage and materials handling equipment as well as the building site. The construction as well as future operating costs must be carefully calculated and a time plan for construction and start up should be developed. Any plan must consider local laws and regulations.

Once a design has been decided upon a tender should be issued to prevent corruption and favouritism. The final contract must specify the obligations of the builder in detail, the cost as well as the time frame to avoid later disputes.

- Internal expansion (more efficient use of existing storage facilities and capacities).
- Lease (rental) of commercial storage facilities.
- Use of storage facilities owned or operated by the authorities or other humanitarian organizations.
- Purchase.
- Renovation or rehabilitation of (leased or purchased) storage facilities.
- Conversion of existing building into a storage facility.
- Construction.

Table 10.6 Possibilities for acquiring storage capacities and facilities

Since long-term investment in sophisticated storage and materials handling equipment carries a high risk, simple storage systems such as shelving and floor pallets as well as mechanized materials handling equipment should be used. During the initial emergency phase

and when stores are initially set up, floor pallets may be the only available storage equipment. However these are sufficient since initially the majority of health care goods will arrive in prepacked kits which do cot require put-away of a large number of individual items.

For stores and warehouses with high flows of goods, the use of powered materials handling equipment can be considered, provided that availability of fuel, maintenance and repair services can be ensured.

10.6 Contingency planning

The ability to respond rapidly and effectively as soon as a humanitarian organization decides to provide assistance in a complex political emergency requires developing a worldwide contingency plan in advance which can be implemented immediately (Center on International Cooperation 1999, 3).

Contingency plans are required during different phases of crises (WFP 2001, 2). The permanent contingency plan which prepares for crises which are not foreseeable and is developed at a strategic level will be called emergency preparedness plan. The contingency plan which is developed in preparation of an expected or imminent emergency and before the humanitarian organization commences any programmes in a specific region or country will be called an emergency intervention plan. Contingency plans may comprise several scenarios which are derived from various assumptions (IASC 2007, 15) concerning political developments, the type of humanitarian crises as well as the impact on the affected populations.

Finally contingency plans which are maintained throughout the duration of ongoing humanitarian assistance programmes (WFP 2001, 5), especially in protracted armed conflicts, and which are intended to respond to unexpected events will be called emergency response plans.

Providing humanitarian assistance to health care facilities quickly requires, among others, establishing and maintaining contingency stocks (WHO 1996a, 17). Permanently maintaining stocks will avoid any delays for purchasing health care goods when they are urgently needed and hedge against the risk of stockouts at suppliers caused by high demand for the same goods from other humanitarian organizations. On the other hand maintaining contingency stocks incurs costs and donors are often reluctant to fund them (Center on International Cooperation 1999, 4).

In order to minimize costs for storage of stocks which might not be used for a long time, contingency stocks should be stocked in storage facilities which are maintained for serving ongoing humanitarian assistance programmes. Within the existing storage facility network a decision must be taken at what level contingency stocks are held.

Contingency stocks can be stored centrally, regionally, nationally, locally as well as inside health care facilities. Compared to decentralized (downstream) contingency stocks, keeping contingency stocks upstream allows reducing global contingency stock levels and increasing turnover of stocks but increases lead time and therefore increases response time (Center on International Cooperation 1999, 5). Establishing contingency stocks in the country where a crisis is anticipated avoids delays caused by importation or congestion of ports after a crisis has emerged (PAHO 1983, 42). On the other hand, unlike regional contingency stocks, contingency stocks which have already been imported into a country suffering from chronic lack of health care services, may be difficult to export again for use in another programme abroad if they are not needed during the crisis.

A compromise to balance the overall contingency stocks and responsiveness is to keep stocks for emergency preparedness centrally and regionally and move them downstream to regional or national distribution centres when a crisis is anticipated or imminent. This strategy will allow using cheaper means of transportation (Perrin, P. 1996, 423), such as scheduled flights by commercial airlines, in preparation for a crisis rather than having to rely on expensive transportation, such as charter flights, to respond when the crisis has already emerged. Moreover, depending on the distances and geography, regional and national distribution centres will more often allow using road transport for distributing contingency stocks in case they are needed. A further advantage is that available infrastructure can be assessed and tested before humanitarian assistance programmes commence. Difficulties encountered with third party logistics suppliers, unsuitable infrastructure such as airports or delays for customs clearance in certain ports allow making changes before humanitarian assistance goods are requested by end-users. Stocks which are not used for responding to the emergency can either be used for ongoing humanitarian assistance programmes or shifted back upstream and maintained for the emergency preparedness plan.

The worldwide value of contingency stocks as well as the transportation costs in case of an emergency can be reduced by storing bulky goods with low value density such as infusions or dressing material further downstream while stocking small items with high value density such as surgical instruments, sutures or diagnostic tests centrally.

Another means of balancing global stock values and responsiveness is maintaining contingency stocks of different sizes throughout the supply network. Immediate needs after an emergency need to be covered from local resources since it takes time to assess needs, transmit them upstream, prepare and transport health care goods (PAHO 1983, 5). Every health care facility should be prepared to cope with a large number of casualties and have sufficient stocks for the first few days (Perrin, P. 1996, 230). These contingency stocks at health care facilities allow sufficient time for deliveries from national distribution centres to arrive. The later in turn would maintain stocks only to cover emergency needs for a few days until stocks can be replenished from regional or international distribution centres. This strategy also avoids the problems which may be caused by delays for customs clearance.

Another strategic decision concerns the ownership of contingency stocks. Commercial consignment stocks are stocked and turned over by suppliers (Center on International Cooperation 1999, 8) but available in contractually agreed quantities. This arrangement avoids expenses for storage of contingency stocks which might not be used for months and also avoids expiry of goods in stock. However contracted suppliers must be reliable in order to ensure that contingency stocks are not sold to other humanitarian organizations in the event of complex political emergencies and are therefore no longer available.

In order to avoid duplications, contingency plans should also consider contingency stocks of other humanitarian organizations, governments or health care facilities (PAHO 1983, 26). Overall contingency stock levels across humanitarian organizations can be decreased by dividing responsibilities for different contingencies such as a cholera outbreak (Hanquet, G. (ed.) 1997, 147), need for a mass vaccination campaign or care for war-wounded among different humanitarian organizations.

10.7 Summary of facility network design strategy

The overall facility design strategy (figure 10.14) must aim at providing the required service within given constraints (Gudehus, T. 1999, 13) while at the same time minimizing safety and security risks as well as minimizing overall transportation and storage costs.

Generally facility networks can be temporary and flexible or permanent (Gudehus, T. 1999, 37). The emergency preparedness plan requires a highly flexible design in order to be able to respond quickly to any complex political emergency anywhere in the world. Logistics managers must consider the trade-off between costs for additional storage facilities and responsiveness (Chopra, S., and P. Meindl 2007, 50). The facility network design may include storage facilities which are poorly utilized for long periods of time but are indispensable for a rapid response. Emergency response plans still need to be flexible to allow adapting to possible changes in entry points into the country as well as to changing programmes within the conflict area.

After the acute emergency phase and once the humanitarian organization has decided on their assistance strategy and the locations of assisted health care facilities have been determined, a more efficient facility network can be tailored to known needs. In the development phase facility network designs can remain more or less fixed since development assistance programmes are planned to last several years.

Global networks can combine permanent and flexible networks at different levels (Gudehus, T. 1999, 38). Upstream in the supply network, humanitarian organizations can use fixed commercial networks such as the networks of international air carriers and airports while building a flexible network with their own means downstream in the country where humanitarian assistance is provided (Bowersox, D.J., and D.J. Closs 1996, 403).

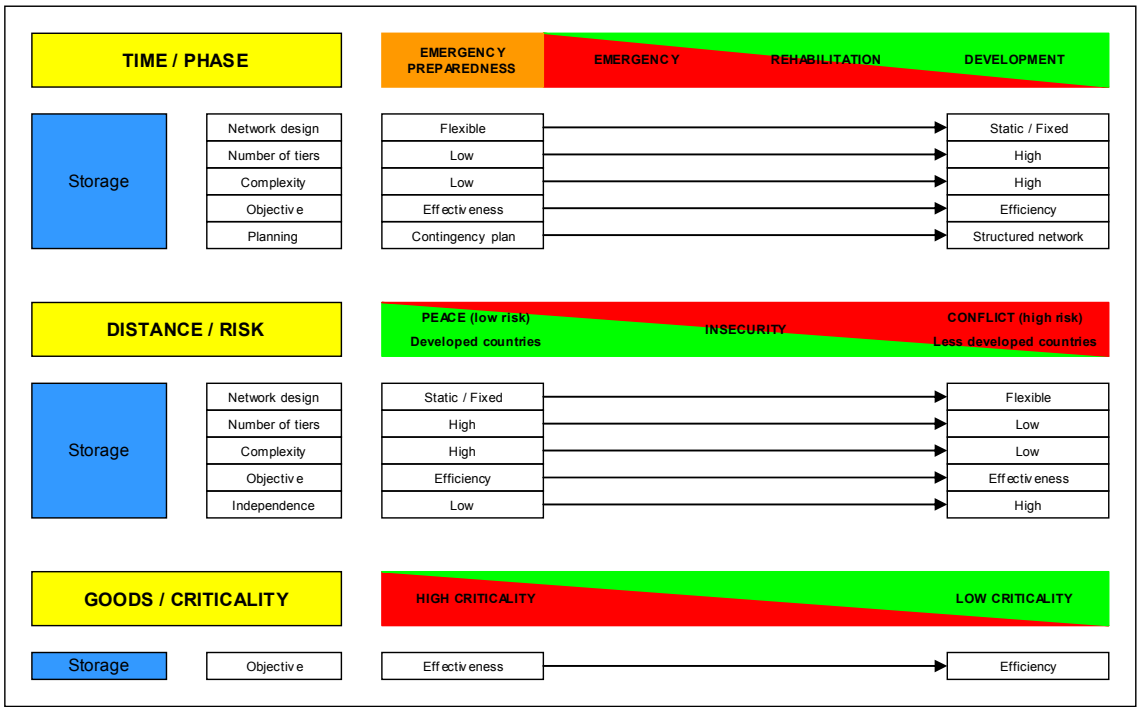

Figure 10.14 Facility network design strategy

At the onset of a complex political emergency there may not be sufficient time for thoroughly assessing the infrastructure of a country or area and finding suitable storage facilities. Consequently humanitarian organizations will resort to direct deliveries from international or regional distribution centres to assisted health care facilities relying mainly on air transport. As soon as the security situation permits and suitable storage facilities have been found, national distribution centres can be set up. The increase in number of stages of the facility network then allows benefiting from transportation economies as well as resorting to cheaper surface transportation.

During the emergency phase the main objective is to provide urgently needed health care goods to assisted health care facilities rapidly and effectively. Consequently the facility network design must be simple, relying mainly on direct deliveries. Once the immediate needs are covered and a more complex facility network has been established, logistics managers can focus on reducing costs and increasing the efficiency of the supply network.

During the emergency preparedness phase the context of future emergencies is not known and planning must consider all possible crises the humanitarian organization intends to respond to. During the emergency phase, the planning of logistics managers will have to make do with incomplete information about the location, context of the respective complex political emergency and the infrastructure in the conflict area. Once a thorough logistical assessment has been carried out and health programme managers have determined their assistance strategy (UNDAC 2000, chapter L, 2), a structured facility network which is tailored specifically to programme needs can be developed and established.

Even after the immediate emergency phase has ended, in protracted complex political emergencies, facility networks within a conflict area must remain highly flexible in order to quickly respond to changes in the security situation as well as changing needs of the affected population. For example storage facilities may need to be evacuated if the location is attacked and sudden movements of large populations will require quickly shifting assistance to other health care facilities. Consequently the facility network must remain flexible so it can be tailored to changing needs.

Conversely, the facility network design in safe areas such as adjacent areas or countries can be more static and focus on efficiency of the network.

Lack of security requires limiting the number of stages and storage facilities within the conflict area in order to reduce the risk of confiscation, blocking, damage and destruction of storage facilities and stocks.

Flexibility of facility networks also implies that the number of stages is kept as low as possible. A complex facility network within the conflict area would incur considerable costs for dismantling, moving and re-establishing storage facilities.

Since generally management of storage facilities inside a conflict area is more difficult, their complexity should be kept as low as possible. Consequently buildings, infrastructure, storage and materials handling equipment, utilities and building services, information systems and human resources management should be kept as simple as possible.

Within the conflict area the main objective must be to ensure that health care goods reach assisted health care facilities on time even if this requires expensive transportation. Outside the conflict area overall supply chain management can focus on efficiency for example by establishing additional storage facilities and benefiting from transportation economies and using cheaper modes of transportation.

Due to the overall lack of security, humanitarian organizations must be in control of storage facilities inside conflict areas. This requires having full control over (leased) storage facilities and premises as well as their security, hiring and managing staff and operating storage facilities. In order to avoid interference and possible security risks, storage facilities should be used only by the respective humanitarian organization or shared with other humanitarian organizations provided they remain neutral in the conflict.

Conversely ownership and operations of storage facilities outside the conflict area may be shared with other users or outsourced, for example relying on facilities of freight forwarders or public warehouses.

The design of facility networks for highly critical health care goods must ensure effectiveness of provision to health care facilities even if high costs are incurred, for example by establishing more complex facility networks. Conversely logistics managers can focus on increasing efficiency of the facility network for health care goods with low criticality.

11 PHYSICAL DISTRIBUTION STRATEGY

Physical distribution, as the dynamic element of the supply network, enables the physical flow of goods from manufacturers to recipients (and sometimes in reverse) with or without passing through storage facilities.

11.1 Physical distribution channels

Physical distribution channels are collections of cooperating organizations which organize and manage the flow of goods (and related information) from the manufacturer to the end-user as well as intermediate storage throughout the supply network (Lambert, R.S., and J.R. Stock 1993, 72).

Humanitarian assistance goods can in principle flow along any network path through a supply network according to tactical and operational decisions, for example depending on the recipients, security constraints or characteristics of health care goods.

However since the facility network design and the selection of physical distribution channels are interdependent, logistics managers must also take some strategic decisions concerning the structure and management of physical distribution channels. Different modes of transportation may be used for the same physical distribution channel at different stages of the supply network, for the same transportation leg at different times or for consignments with different characteristics.

Humanitarian organizations need to take a strategic decision whether goods flow through commercial or humanitarian networks (see figure 11.1). Commercial suppliers as well as humanitarian organizations may decide on a tactical and operational level whether distribution services are in- or outsourced. Consequently the decision is related to the question which organization controls the flow of goods.

Since both networks are unlikely to extend from the manufacturer up to the end-user, in most cases a combination of both networks will be necessary. Direct pickup of purchased goods by humanitarian organization at the manufacturer will be an exception. Likewise only in exceptional cases will the supplier be able to deliver purchased goods directly to assisted health care facility. Consequently the strategic decision is to what extent humanitarian organizations generally want to rely on commercial supplier networks and at what stage goods should pass from one network to the other.

The use of supplier networks has several advantages. Supply networks of manufacturers or intermediaries are already established and immediately available while humanitarian organizations might have to build the network to link manufacturers and end-users. At least upstream in the supply network, suppliers will be able to benefit from transportation economies and therefore operate more cost-efficiently than humanitarian organizations.

The use of supplier networks reduces the risk of losses or damage of goods up to delivery to a facility managed by the humanitarian organization as commercial suppliers usually carry the risk.

Shipment and storage of some health care goods, such as equipment susceptible to damage, heavy or bulky equipment or dangerous goods which require special packing, can be handled better by experienced suppliers.

Finally resources needed to track and trace shipments are reduced for humanitarian organizations as the supplier is fully in charge until goods are delivered to a facility managed by the humanitarian organization.

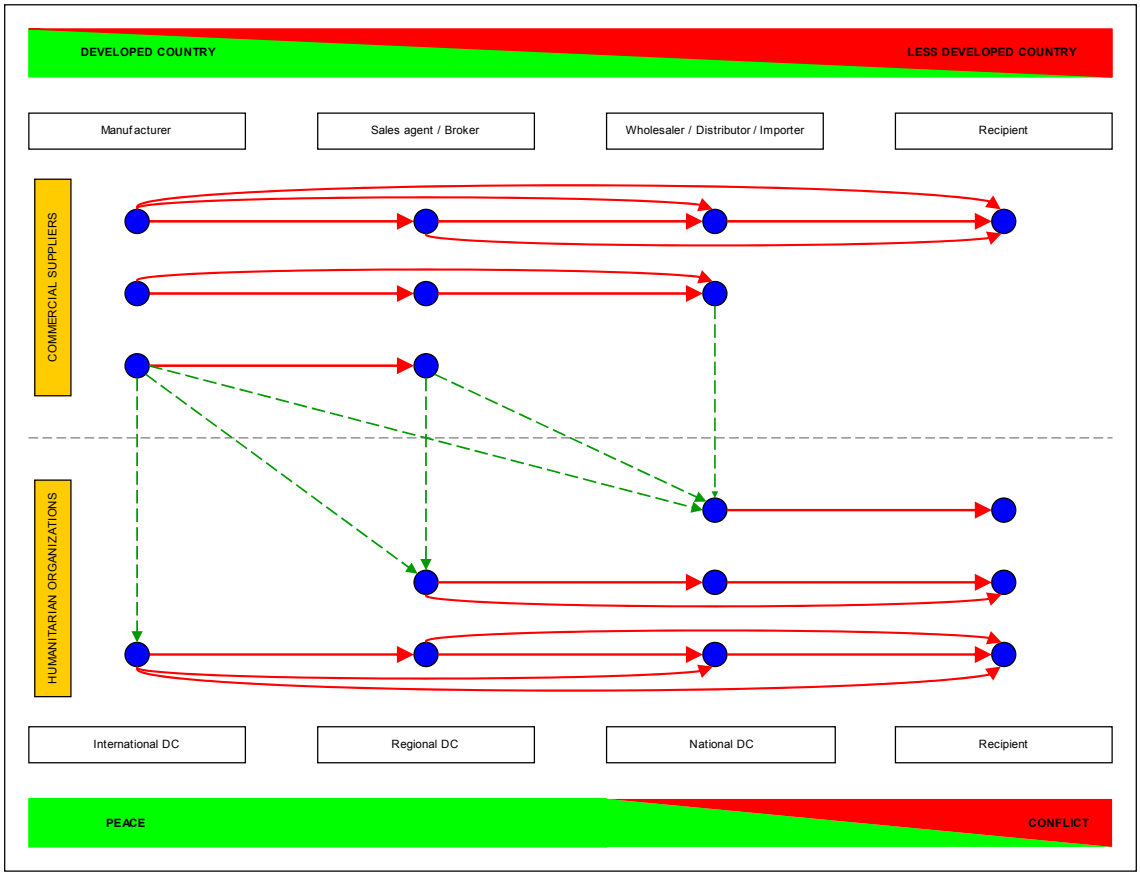

Figure 11.1 Physical distribution channels

On the other hand using supplier networks leads to dependency on their services and especially their transportation lead times. Moreover following up the order status as well as the current location of goods is likely to be more difficult than if distribution is managed by the humanitarian organization.

The control of the flow of goods by humanitarian organizations reduces the risk of adulteration or introduction of counterfeit products between the manufacturer and the recipient.

Obviously humanitarian organizations must resort to their own supply network where suppliers have not established their own networks. Suppliers are less likely to maintain their own networks in less developed countries with unattractive markets and will not maintain or suspend distribution of goods in countries or areas where security is poor.

Finally, humanitarian organizations are likely to benefit from transportation economies downstream towards and especially inside the conflict area, especially if they provide a range of other humanitarian assistance goods to the affected population.

11.2 Transportation contingency planning

The contingency plan developed in chapter 10.6 must be complemented by provisions to ensure immediate availability of suitable transport (Center on International Cooperation 1999,

8). The capacity must be sufficiently large to allow distribution of essential health care goods as soon as humanitarian organizations decide to commence assistance. In case of crises which involve a large number of humanitarian organizations competition for transportation resources may lead to a shortage of transportation capacities, especially large long distance charter aircraft, and significantly increase prices.

Humanitarian organizations can take the strategic decision to pre-position their own transportation resources such as trucks and boats which will ensure availability in case of a crisis but on the other hand incur significant costs for maintenance and storage.

The emergency preparedness plan can comprise transportation resources such as vehicles which are operational and pre-positioned at strategic locations near international airports and can be shipped to any crisis region at short notice. Pre-positioning only at international distribution centres allows minimizing the value of valuable resources, which may remain unused for significant periods of time, but entails longer lead times and higher costs for deployment compared to pre-positioning at regional or even national distribution centres.

An alternative to storing and maintaining idle transportation resources is developing regional plans for withdrawing part of the vehicle fleet used in ongoing programmes and shifting vehicles to another conflict area at short notice.

Another possibility to avoid valuable resources remaining idle is to conclude contracts with commercial air carriers for chartering aircraft or with manufacturers to guarantee immediate availability of new vehicles or boats. Such contracts also avoid delays caused by sourcing and tendering for transportation resources in an emergency especially if they occur during public holidays. Arrangements can also be made with international air carriers which operate worldwide and can guarantee transportation at least up to any international airport.

11.3 Mode of transportation

The modal choice will depend on the context, situation as well as on the type of health care goods. Nevertheless some strategic decisions which apply to any humanitarian assistance programme can be taken by humanitarian organizations.

Air transportation will be the only reasonable means of transportation of humanitarian assistance goods over great distances in emergencies as well as for expediting urgent shipments, while slower surface transportation can be used once stocks have been established and demand is stable. However humanitarian organizations may decide to use only air transport, wherever available, for drug products in order to minimize exposure to potentially adverse environmental conditions or for health care equipment in order to reduce the probability of damage. Faster air transportation may also be selected in order to shorten transportation lead times which in turn allows reducing safety stocks, and therefore reducing network stocks, as well as reducing overall storage costs (Chopra, S., and P. Meindl 2007, 401). Alternatively humanitarian organizations may decide to use slower surface transportation for ongoing humanitarian assistance programmes for health care goods which are bulky, have low value densities or very predictable demand, even for international distribution (Larragán, A.A. et al. 1998, 70). As a consequence larger capacities at distribution centres will be need to increase cycle stock levels.

Humanitarian organizations may also take a strategic decision to use air transportation within a conflict area if it proves to provide higher levels of safety and security than surface transportation even if overall transportation costs increase significantly.

Since higher levels of responsiveness are associated with higher costs (Chopra, S., and P. Meindl 2007, 30), health programme managers must make a strategic choice concerning the desired responsiveness of physical distribution systems in general.

A strategic decision is also necessary to establish a "fast track" for shipping urgently needed goods to customers, for example by concluding contracts with package carriers offering worldwide services while using routine shipments with slower means of transportation for routine orders.

11.4 Ownership of transportation means

Like commercial organizations, humanitarian organizations can use private, contract or common carriage (Bowersox, D.J., and D.J. Closs 1996, 29) for distribution of humanitarian assistance goods within the supply network. Moreover humanitarian organizations may also be able to use transportation capacities of other humanitarian organizations, authorities in the host country as well as domestic or foreign armed forces (Larragán, A.A. et al. 1998, 66).

While many decisions concerning transportation management are taken on a tactical or operational level, the use of own resources rather than outsourcing transportation services requires a far reaching strategic decision which must be taken before humanitarian assistance programmes commence. Humanitarian organizations may rely entirely on their own transportation resources, complement them with commercial resources or rely entirely on commercial transportation capacities. An overview of criteria for the ownership of means of transportation is shown in figure 11.2.

Transportation assets such as vehicles, ships and aircraft are expensive, require careful selection of the most suitable equipment and obtaining funds for purchasing these assets. Operating vehicle fleets and especially aircraft requires skilled and experienced staff such as vehicle fleet or air operations managers. Moreover operating vehicle fleets depends on the capacity to provide fuel, maintenance and repair services in the field as well as to provide a wide range of replacement parts to workshops in the field.

The decision on operating means of transportation by humanitarian organizations is also linked to the strategic decision whether logistics and supply chain management in conflict areas is considered as a core competency. Increasing competition among humanitarian organizations as well as pressure by donors requires humanitarian organizations to concentrate available resources on their core activities and core competencies (Larragán, A.A. et al. 1998, 25). Areas in which humanitarian organizations do not have any comparative advantage over other organizations which can provide the same service should be outsourced (Larragán, A.A. et al. 1998, 27).

Commercial organizations have greater experience and expertise in transportation management than humanitarian organizations. However they generally lack the willingness, experience and capacity to operate in conflict areas or their vicinity.

Outsourcing transportation services makes investment in expensive assets, which donors may be unwilling to fund (Larragán, A.A. et al. 1998, 69), unnecessary and generally reduces the complexity of supply chain management. Outsourcing of transportation also allows calculating all related costs exactly.

Generally commercial carriers, who specialize on transportation services and have more experience than humanitarian organizations, can operate more cost-efficiently. Especially for international transportation and transportation along major routes commercial carriers can benefit from transportation economies by consolidating consignments from several

humanitarian organization or combining them with commercial consignments. The possibility of shipping smaller consignments to health care facilities more frequently allows delivering goods whenever needs arise rather than having to rely on less frequent scheduled transportation of consolidated consignments of humanitarian assistance goods.

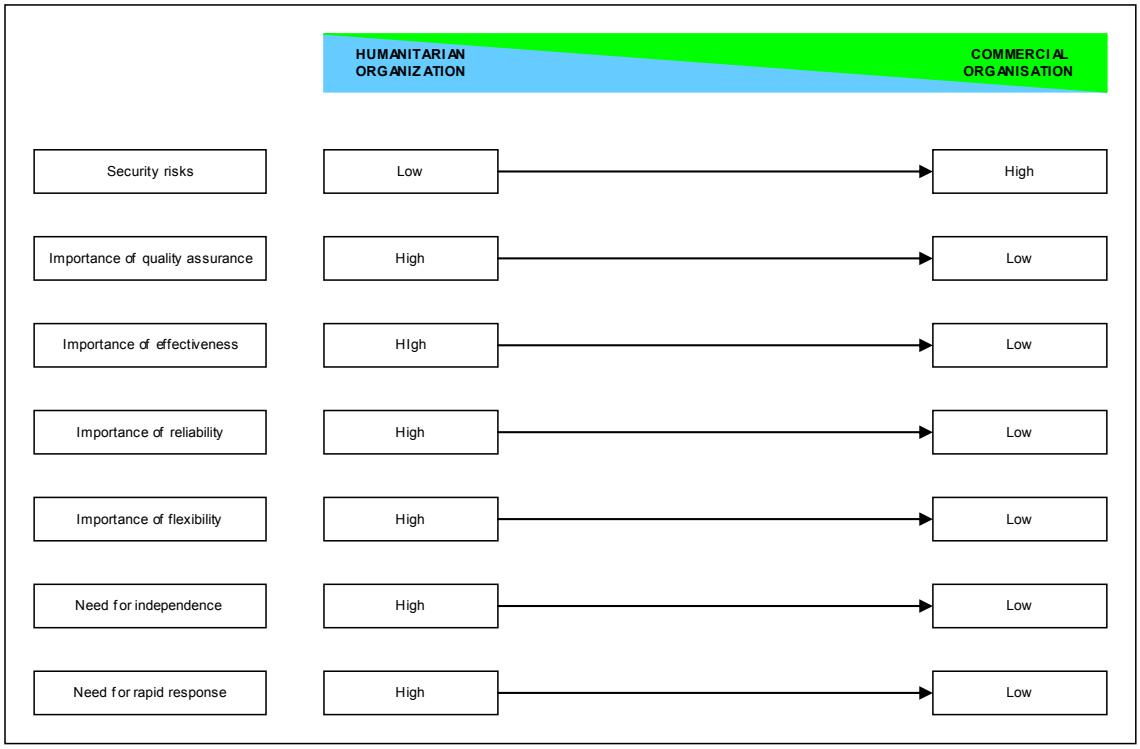

Figure 11.2 Criteria for ownership of transportation means

Domestic carriers will be more familiar with legislation, regulations as well as road and weather conditions in the country. Moreover humanitarian assistance goods flow almost entirely in one direction while commercial carriers may be able to increase their vehicle utilization through backloads (Bowersox, D.J., and D.J. Closs 1996, 367).

Commercial carriers offering tracking and tracing services allow closely monitoring the location of goods without humanitarian organizations having to implement and maintain their own information system (Larragán, A.A. et al. 1998, 74).

In-house transportation resources have the advantage of not affecting operations by shortages of commercial transportation capacities and subsequent (unreasonable) price increases. Control over transported goods is also higher with in-house transport. Because of the lack of legal security humanitarian organizations are unlikely to be able to retrieve goods stolen during transportation.

Moreover humanitarian organizations may have cost advantages through tax exemptions for importing vehicles into the country as well as for purchasing fuel on the domestic market. Finally in-house resources are not subject to the security constraints of commercial organizations. If humanitarian organizations deem an area safe enough to provide assistance, then transportation means can be operated in the same area.

The priority and first consideration are minimizing safety and security risks to staff, assets and humanitarian assistance goods. Outsourcing of distribution services to other commercial, humanitarian or military organizations has the advantage of avoiding the risk of damage or loss of expensive transportation resources. However the risk is transferred only partially as

humanitarian organizations will be charged higher transportation rates to cover the higher cost of insurance.

However since commercial carriers and the armed forces may be less accepted in the conflict area than humanitarian organizations, the former may be prone to being denied access or becoming a target. This not only increases the risk for staff, goods and assets but also jeopardizes the effectiveness of humanitarian assistance programmes. On the other hand in some cases where humanitarian organizations are being seen as partial, they may encounter greater risks than commercial organizations.

Although humanitarian organizations may prefer outsourcing transportation in areas with high levels of security, they may be unable where commercial organizations are not available or unwilling to operate.

Maintaining the quality of health care goods throughout the entire supply network requires the capacity to transport certain types of goods such as cold chain items or sensitive health care equipment under certain conditions. Wherever commercial carriers with the necessary expertise are not available, humanitarian organizations will need to maintain their own capacities.

Entirely outsourcing transportation services carries the risk of interrupting humanitarian assistance programmes at any time without prior notice. Commercial carriers may be unavailable, unwilling to operate in the conflict area or be refused permission by authorities or conflict parties for operating. Other humanitarian or military organizations may not be able or willing to provide transportation capacities to humanitarian organizations or lack sufficient capacity.

Available commercial carriers may not comply with international standards, especially concerning air worthiness of aircraft, and therefore not be considered safe enough to provide transportation services especially for staff and patients.

Since humanitarian organizations must ensure continued and uninterrupted assistance to health care facilities, reliability and consistency of transportation services are essential. Consistency, which can be considered as the most important characteristic of the quality of transportation services (Bowersox, D.J., and D.J. Closs 1996, 29) requires ensuring minimum variation in transportation lead times.

In order to ensure effectiveness as well as reliability and consistency, humanitarian organizations need to be able to quickly resort to their own means of transportation if commercial carriers suspend their services or reduce their capacities.

Transportation resources owned by humanitarian organizations allow a maximum of flexibility and responsiveness as transportation resources and capacities can be quickly adapted to the needs of humanitarian assistance programmes. Commercial carriers serving other customers may not be able to adjust their services immediately or lack additional capacities when they are needed.

Humanitarian organizations may be unable to make use of commercial or military transportation resources without compromising their independence towards the conflict parties. The decision to accept services of armed forces is highly political and will also depend on donors funding humanitarian organizations (Larragán, A.A. et al. 1998, 71). Cooperation can lead to the association of humanitarian organizations with political and military objectives of armed forces and increase insecurity for humanitarian workers (ECHO 2004, 72). Some humanitarian organizations believe armed forces should not be involved in provision of humanitarian assistance at all, others that humanitarian organizations should resort to their assistance if they are overwhelmed (Mayhew, B 2004, 23).

	Advantages	Disadvantages
In-house transportation	• Independence from shortages of commercial transportation capacities. • Independence from (unreasonable) price increases. • Closer control over routing and scheduling. • Better control over transported consignments. • Higher acceptance by conflict parties. • Often better means of communication.	• Large investment in purchasing assets. • Inflexibility for increasing or reducing transportation capacities. • Fixed costs independent of utilization. • Inflexibility (assets may not be suitable for all operations). • High costs and delays for moving transportation means to other operations. • Requires skilled and experience staff for maintaining and operating. • Cost inefficiency because of lack of backloads. • May not be core competency.
Outsourcing transportation to commercial carriers	• Great flexibility in transportation capacities. • Flexibility in choice of types of means of transportation. • Greater experience. • Familiarity with national legislation and regulations. • Familiarity with the geography of the country. • Familiarity with road and weather conditions. • Greater cost-efficiency (load consolidation). • No need for investment in assets. • No need to manage assets and staff. • Reduces complexity of supply chain management. • Knowledge of exact transportation costs. • Possibly offer of tracking and tracing services. • Outsourcing of risks associated with damage and loss of transportation means. • Support of domestic economy.	• Possible unavailability of carriers. • Entry into conflict areas may be refused by conflict parties. • Requires knowledge of the transportation market. • Poor control over consignments and risk of theft. • Carrier may refuse transportation to and in unsafe areas. • Lack of commitment to a specific customer. • Dependency on unreliable services. • Transportation delays by load consolidation from different customers. • Possibly limitation of choice of transportation means and unit loads. • Lack of knowledge of handling health care goods. • Complete interruption of humanitarian assistance in case carrier suspends services. • Dependence on overall requirements for transportation capacities. • Possibly lower safety standards and therefore higher risks (air transportation). • Risk of sharing transportation resources with other (unknown) customers. • Lack of influence on neutrality of carrier.

Table 11.1 Advantages and disadvantages of outsourcing transport

Likewise the sharing of transportation resources with other humanitarian organizations may have strong political implications, especially if humanitarian organizations providing transportation services do not strictly respect their neutrality towards all conflict parties. Cooperation with one party to the conflict may make it impossible to safely operate within the area under control of an opposing party to the conflict (ECHO 2004, 73) and therefore erode impartiality in the conflict.

Dependence on limited commercial transportation capacities carries the risk of interruption of transportation services if commercial carriers are no longer permitted to operate or suspend their services because they are not willing to take the risk. Moreover humanitarian organizations will be affected by shortages in case overall demand for transportation resources increases, for example when the number of humanitarian organizations requiring transport in an area increases (Larragán, A.A. et al. 1998, 68).

By managing their own transportation services, humanitarian organizations not only avoid dependency on commercial carriers, but can also exert closer control over routing and scheduling as well as over the transported goods and reduce the risk of theft. Moreover commercial carriers carry the danger of compromising the neutrality of humanitarian organizations by transporting weapons, alcohol or drugs.

Sourcing and purchasing transportation services requires knowledge of the market as well as time for obtaining, comparing bids and adjudicating tenders. Such delays can be avoided by maintaining transportation resources in-house which can be mobilized or re-directed at short notice.

In-house transportation services facilitate recording the exact time and location of distributions of humanitarian assistance goods which are required for donor reporting.

Humanitarian organizations need to take a strategic decision whether they want to rely entirely on their own means of transportation or make use of commercial transportation services, transportation offered by other humanitarian organizations, governments or armed forces. Sharing transportation capacities can significantly reduce transportation costs but may lead to dependencies and reduce control over the physical distribution system. Besides conflict parties may consider cooperation with other organizations, which may or may not take sides in the conflict, as contravening the humanitarian organization's impartiality and neutrality.

11.5 Summary of physical distribution strategy

During the initial emergency phase the main objectives are to respond quickly to demand (PAHO 2001a, 131) and to ensure required health care goods actually arrive at the assisted health care facilities.

In order to avoid dependency and possible interruption of assistance, humanitarian organizations will utilize their own distribution channels and use their own means of transportation, at least near or in the conflict area. When the security situation improves and commercial suppliers and carriers restore their services, humanitarian organizations can resort to using the more efficient commercial distribution channels as well as commercial carriers.

In order to minimize lead times, humanitarian organizations will favour shipments from available sources of health care goods directly to assisted health care facilities. Once stocks have been established throughout the supply network, humanitarian assistance programmes can be supplied from their next upstream store, minimizing lead time as well as transportation costs.

During the emergency phase the fastest mode of transportation will be selected even if high costs are incurred. Transportation management in terms of mode and means of transportation as well as transportation routes must be highly flexible to allow quick reaction to changes of the situation as well as changing needs. Once the humanitarian assistance programmes as well as the supporting supply network and stocks have been established, distribution management can focus on increasing efficiency and reducing overall distribution costs.

While humanitarian organizations need to consider efficiency of physical distribution to the country or area where humanitarian assistance is provided, they must again focus on effectiveness, responsiveness and flexibility within the crises area.

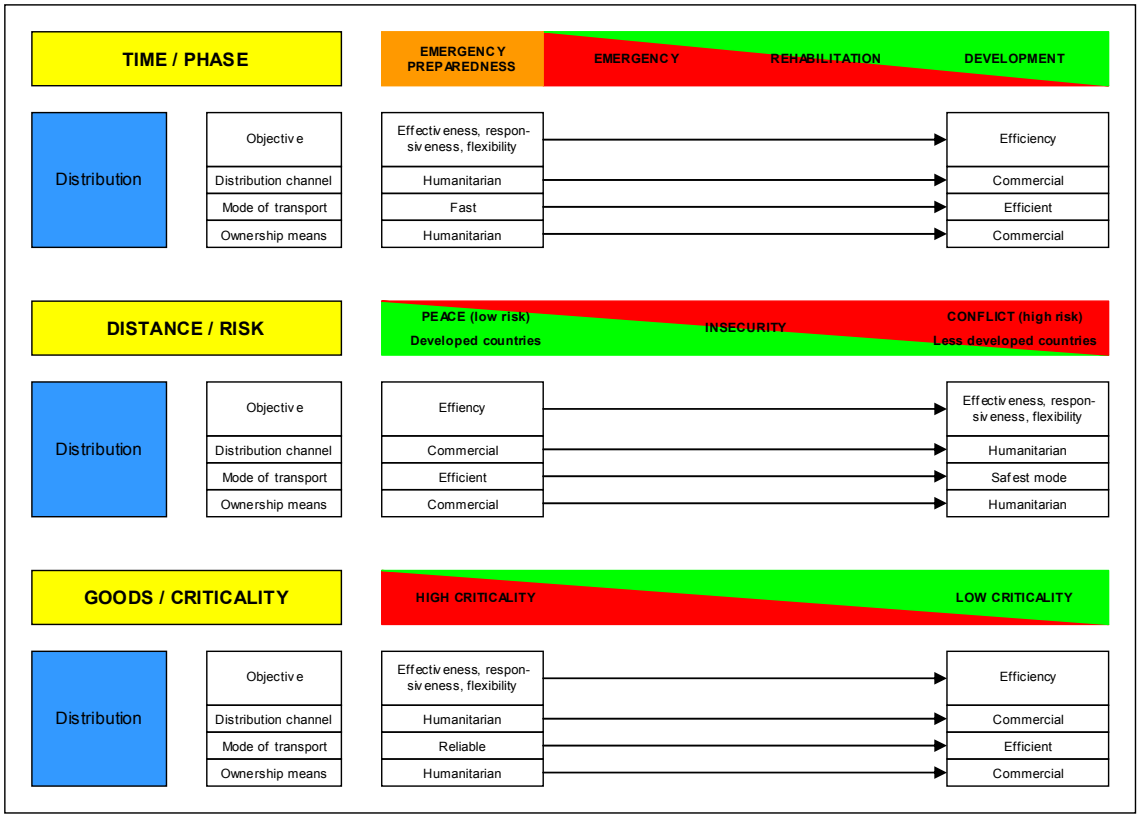

Figure 11.3 Physical distribution strategy

Commercial distribution channels and carriers can be used as far towards the conflict region, country or area as commercial activities are not affected, impeded or interrupted by the conflict. Near and inside the conflict area humanitarian organizations will rely on their own distribution channels to ensure that provision of essential humanitarian assistance goods is reliable and not interrupted.

Within the conflict area humanitarian organizations must use the safest mode of transportation while using the most efficient mode of transportation outside the conflict area.

For essential and critically important health care goods, the priority must be ensuring reliable delivery to assisted health care facilities while distribution management can focus on efficiency for non-critical and substitutable health care goods.

Humanitarian organizations will also want to closely control the distribution of critical and valuable health care goods directly to assisted health care facilities and therefore prefer using their own distribution channels and transportation means.

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12 CUSTOMER SERVICE MANAGEMENT

Although not for the purpose of gaining profits (Chopra, S., and P. Meindl 2007, 4) or competitive advantage (Harrison, A., and R. van Hoek 2002, 209), customer satisfaction as the global objective of supply chain management (Govil, M., and J.M. Proth 2002, 67) also applies to humanitarian organizations. Ultimately customer satisfaction lies in the prevention or reduction of suffering of people receiving assistance, achieved through provision of high quality health care goods in the place and at the time they are needed. Satisfaction of health care professionals receiving and applying health care goods, of health programme managers as well as donors also requires some consideration.

Development of a customer service policy, determining required services as well as defining customer service levels are essential for planning and allocating required logistical resources and capacities (Lambert, R.S., and J.R. Stock 1993, 637). Defining customer service objectives is necessary for measuring and monitoring performance, focusing resources on defined objectives as well as for a coherent approach of all staff and departments in providing services.

12.1 Development of a customer service policy

In order to plan their assistance, health programme managers need to know what kind as well as what level of services they can expect from logistics.

Corporate mission statements which, among others, determine products and services provided, customers as well as geographical markets, serve as basis for developing logistics mission statements (Lambert, R.S., and J.R. Stock 1993, 637).

Development of a customer service policy must start by identifying elements of service which are most important to customers (Rushton, A., J. Oxley, and Ph. Croucher 2000, 39) such as quality of health care goods, stock availability and lead times. Since eventually patients receiving health care services are the ultimate customers, but rarely have the knowledge and opportunity to select appropriate health care goods, in practice immediate customers are health programme managers as well as health care professionals.

Determining the relative significance and minimum required service levels for each customer service factor (Rushton, A., J. Oxley, and Ph. Croucher 2000, 40) allows monitoring service levels and ensuring that customer expectations are met.

Depending on the context and constraints, customer service requirements and required service levels may need to be tailored to the needs of individual humanitarian assistance programmes as well as the importance of individual goods.

Like in commercial organizations (Rushton, A., J. Oxley, and Ph. Croucher 2000, 40), humanitarian assistance programme managers need to carefully balance desired services as well as customer service levels with the costs of providing these services.

12.2 Customer service elements

Elements of customer service can be categorized into pre-transaction, transaction and post-transaction elements (Harrison, A., and R. van Hoek 2002, 36).

The customer service policy as a pre-transactional customer service element, should be stated in writing and made available and distributed to customers (Lambert, R.S., and J.R. Stock 1993, 114), health programme managers as well as assisted health care facilities.

A single order contact point should be established which is easily accessible at any time (Christopher, M. 2005, 49), including after-hours as well as during holidays and placing orders should be as simple and convenient as possible.

Logistics service must be as flexible as possible to accommodate unexpected customer requests (Bowersox, D.J., and D.J. Closs 1996, 9) as well as changes of orders at short notice and response times to customer inquiries should be as short as possible.

All orders received by logistics services must be acknowledged and provide information on available stocks and expected delivery time.

Transaction elements are related directly to the physical distribution (Christopher, M. 2005, 48). Order size constraints may arise where larger but often significantly cheaper (hospital) packaging is provided as a standard. However where large quantities are not suitable for providing assistance to small scale programmes, logistics services should also be able to provide smaller packaging sizes.

The expertise, willingness and ability to quickly offer a substitute for stocked out items, especially in emergencies, are important to avoid delays in providing assistance.

One key customer service element which must be measured and closely monitored is stock availability of items defined in national standard lists. On the other hand offering a stock availability of thousands of health care goods like a commercial wholesaler, would exceed the resources humanitarian organizations have at their disposal and not necessarily improve health services provided to patients. Customer service can be measured as line item fill rate per order or as in-full rates for entire customer orders (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 335). Stock availability can be measured at all stages of the supply network. As stockouts upstream in the supply network do not necessarily cause a stockout for end-users (Lambert, R.S., and J.R. Stock 1993, 119), stock availability at the assisted health care facility has the greatest relevance.

The quality of labelling as well as providing product information in several languages is an important criterion for facilitating handling of consignments at customs and in recipient countries.

The offer of frequent deliveries must be balanced against the higher cost of not being able to consolidate shipments of consignments.

A second key customer service element is the total order lead time and the percentage of on-time deliveries. However, the later also depends on the ability of programme managers to plan ahead rather than placing urgent orders. The time elapsed from placing a customer order until receiving the consignment, rather than only the time from receipt of customer orders by logistics services until shipment, must be measured (Lambert, R.S., and J.R. Stock 1993, 515).

The ability of humanitarian organizations to expedite urgently needed consignments is essential for managing emergencies as well as for avoiding stockouts or providing urgently requested replacement parts for health care equipment.

Service reliability and consistency are essential (Bowersox, D.J., and D.J. Closs 1996, 9) since they allow better planning than with on average faster but more unreliable order lead times. Consequently logistics services should first seek to improve reliability of delivery before making efforts to reduce order lead times.

Maintaining the high quality of purchased goods throughout the supply network and avoiding damage during transportation, handling, storage and distribution is essential, especially for sensitive health care goods such as cold chain items or health care equipment.

The completeness and correctness of documentation, such as shipping documents or certificates of analysis, are essential for avoiding delays for customs clearance as well as for donor reporting and maintaining accurate stock records.

The measures of order fill rates and delivery time can be combined into "on-time, in-full" (OTIF) deliveries (Christopher, M. 2005, 65). Completeness, on-time delivery, quality of documentation and the perfect condition of delivered goods make up the "perfect order" concept which is considered as the ultimate measure of quality in logistics operations (Christopher, M. 2005, 79).

The ability of logistics service to provide regular and accurate order status information, information on the location of goods as well as information about products, services and prices is also essential (Govil, M., and J.-M. Proth 2002, 86).

Finally the total logistics costs for filling orders is an important service element as any savings allow programme managers to increase the value of provided humanitarian assistance goods.

Post-transaction elements refer to services required after humanitarian organizations have distributed health care goods.

Even if a humanitarian organization could continuously provide perfect services, perfection of logistics services would be unaffordable (Gudehus, T. 1999, 166). Consequently humanitarian organizations must make provisions for recovery in case of malfunction (Bowersox, D.J., and D.J. Closs 1996, 10) such as health care goods which do not conform to the required (quality) specifications, mispicking, incorrect documentation or misled consignments. In these cases swift treatment of complaints and corrective action are essential.

Post-transaction services must also assist end-users in maintaining and maximizing the lifetime of health care equipment. Health care equipment should only be provided if after-sales services are ensured either by the manufacturer, humanitarian organizations or domestic health services. Since manufacturers or their representatives may be absent in the country or area receiving humanitarian assistance, logistics services of humanitarian organizations have to provide unavailable services and link commercial suppliers with the end-users.

Health care professionals need to be provided with comprehensive information and training on the use of health care equipment as well as on ensuring safety of patients and staff. Engineers and technicians must have access to all necessary information for installing, maintaining, servicing and repairing equipment as well as to detailed replacement part catalogues.

Logistics services of humanitarian organizations may have to ensure availability and rapid distribution of essential replacement parts. They must also recover malfunctioning, broken or damaged health care equipment and should provide temporary replacement products for essential equipment.

Finally health care equipment containing environmentally harmful substances may require return to the supplier for safe disposal.

12.3 Customer service strategy

Logistics services of humanitarian organizations need to develop a general customer service policy but also need to tailor services to the context, constraints and requirements of individual humanitarian assistance programmes as well as to the needs of the respective end-users.

During the emergency phase of humanitarian assistance programmes the scope of services will be limited to providing essential services in order to use available resources to maximize the effectiveness of the response. For example during the emergency phase only prepacked kits may be provided while at later stages the range of provided health care goods can be extended.

Providing the highest possible customer service level is essential during the emergency phase in order to avoid any delay of implementing humanitarian assistance programmes. Later the high costs of providing high customer service levels must be balanced against the benefits, minimizing total logistics costs for achieving a predetermined customer service level (Schulte, Ch. 1999, 9)

Logistics services can only be tailored to specific needs of humanitarian assistance programmes and to specific end-users once a certain routine for their supply has been established and individual needs are determined. For example, providing non-standard items, convenient packaging sizes, adjusting delivery schedules to the routines at health care facilities or servicing health care equipment.

During the immediate emergency phase detailed information on the needs of health care facilities is usually not available yet and health programme managers will have to select the most suitable goods and quantities based on their experience and assessment of the situation. After a detailed assessment has been carried out, health professionals at assisted health care facilities will become the primary customers.

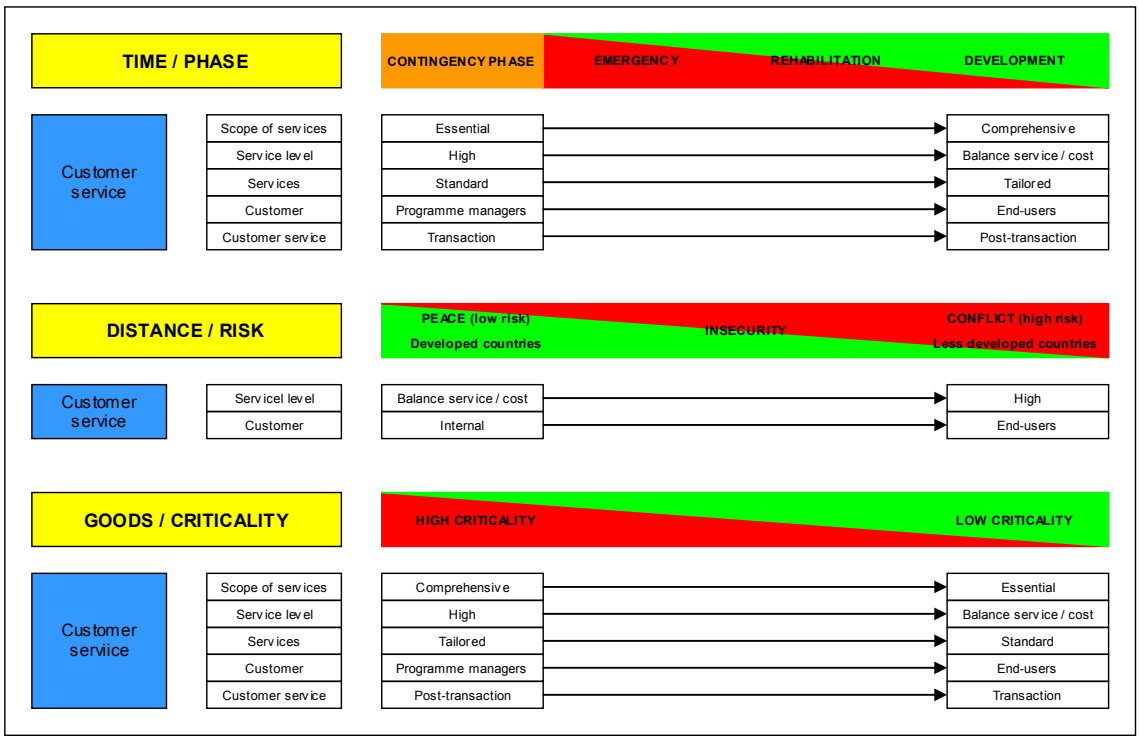

Figure 12.1 Customer service strategy

During the initial emergency phase immediate availability of logistics services, a single point of contact, high flexibility and high stock availability are essential to ensure an effective immediate response. Once reliable supply networks have been established, logistics managers must also ensure adequate post-transaction services such as returns or maintenance and repair of equipment. In an emergency, humanitarian organizations may have no choice than to

provide standard health care equipment, even at the risk that authorized distributors are unavailable domestically and equipment cannot be serviced or repaired in the country.

In a multistage supply network the intermediary storage facilities between the international distribution centre and the end-user can also be considered as customers. While logistics managers need to balance customer service levels and costs at upstream distribution centres, the highest possible customer service levels must be provided downstream and especially at assisted health care facilities.

Upstream logistics services will mainly serve internal customers such as intermediate distribution centres or programme managers, while the end-user becomes the only customer in the conflict area.

For highly critical health care goods and especially health care equipment, the scope of provided services must be large, such as customization of products, specialized packaging, training, installation and maintenance.

Instead of providing the highest customer service level for the most profitable products (Christopher, M. 2005, 59), in humanitarian assistance the highest customer service levels must be provided for the most critical goods, especially for indispensable drug products and health care equipment.

Tailored services such as repair and maintenance, technical upgrades or regular training of technicians are justified for highly critical health care goods and logistics managers will therefore focus on ensuring adequate and sustainable post-transaction services.

The more critical health care goods are for the humanitarian assistance programme, the more programme managers will want to be involved in their selection.

12.4 Good Donation Practices

The primary responsibility for planning and implementing donations of health care goods lies with health programme managers who will have to carry out a detailed assessment and feasibility study before ordering health care goods. Donations are a complex and intricate issue and this chapter will be limited to the aspects which are of immediate concern to logisticians.

Humanitarian organizations must comply (only) with the national legislation and regulations in the country where they donate health care goods and possibly quality requirements demanded by their donors. However humanitarian organizations may voluntarily subject themselves to more stringent quality requirements and in the most stringent case require that all donated health care goods comply with the quality standards in a country with highly developed pharmaceutical legislation and regulations.

Major humanitarian organizations have found a consensus on basic rules and minimum quality requirements for drug products which have been published as the "Guidelines for Drug Donations" (WHO 1999c). However most of the principles apply equally to single use medical devices as well as health care equipment (Quick, J.D. (ed.) 1997, 156). These guidelines should be applied to all health care goods donated to assisted health care facilities but equally to donations "in kind" which humanitarian organizations receive from donors for further distribution.

These guidelines are not internationally binding regulations as such and governments and humanitarian organizations should translate them into their own guidelines for presentation to their donors.

12.4.1 Problems with inappropriate donations

Although donations of health care goods are an effective way of assisting health care facilities, some donations create more problems than they solve (WHO 2000a, 2). Table 12.1 gives an overview of disadvantages inappropriate donations can have and problems they can cause.

Problems with donations are manifold and notorious. The kind of donated health care goods may not be needed (PAHO 2001a, 147), inappropriate for the context or not fit the epidemiology of the recipient country (WHO 1999c, 3). Unsolicited donations which arrive unsorted, unlabelled, poorly packaged, used or outdated are virtually useless (PAHO 1983, 8). Donors often have no insight into the priorities and may donate health care products which are not needed or have already been donated in sufficient quantities (Forte, G.B. 1994, 6). Unneeded health care goods waste transportation and storage capacities. Finally donated drug products may simply be of poor quality (Forte, G.B. 1994, 6).

The manufacturers and suppliers are likely not to be registered and validated by the humanitarian organization and appropriate storage between manufacturing and donation is not ensured.

For health care goods which can be purchased domestically with the required quality, humanitarian organizations waste transportation costs while increasing lead time for assisted health care facilities. In some cases transportation costs may even exceed the value of health care goods (Forte, G.B. 1994, 6).

Donated health care goods are unlikely to be registered by the national drug regulatory authorities in the recipient country and are often not part of the national essential drug programmes.

Health care goods which are not identifiable because of labelling in foreign languages or use of proprietary rather than international nonproprietary names require large resources of scarce health care workers for sorting and recording (PAHO 2001a, 26).

The large number of different drug products in a multitude of dosage forms, presentations and strengths makes continuous treatment impossible and increases the complexity of logistics management.

Small packaging quantities, for example in blister packaging, require large shipping and storage volumes.

The cost of appropriate disposal of unwanted health care goods has to be born by the humanitarian organization or the health authorities of the recipient countries.

Donations of drug products which do not comply with the World Health Organization's guidelines must be discouraged (WHO 1999c, 6). Donations should be based on expressed needs and approval of recipients and be relevant for the context. They must be approved for use in the donor country, must be commonly used in the recipient country and be obtained from reliable sources which comply with international quality standards. Samples or drug products returned from patients must not be donated (WHO 1999c, 8). The remaining shelf-life upon arrival in the recipient country must be sufficient to use drug products before expiry. Drug products must be labelled in a language that is understood in the recipient country and hospital packagings should be preferred.

However donations of required health care products and standard kits from registered manufacturers are useful.

A) Recipients

- No involvement of recipients in deciding on type and quantities of health care goods
- Unpredictable time of arrival.
- Unpredictable delivery intervals.
- Too late arrival.

B) Suitability

- Large variety of different health care goods, often in small quantities.
- Larger than required quantities of individual health care goods.
- Donation of health care goods which are not essential.
- Donation of health care goods which are not needed or not wanted.
- Health care goods of poor quality.
- Health care goods with specifications (strength, presentation, size etc.) which are commonly not used.
- Health care goods unsuitable for an acute crisis.
- Health care goods unsuitable for the context.
- Health care goods inappropriate for the level of care (for example too sophisticated).
- Drug products which do not fit the epidemiological situation (prevailing diseases).
- Health care goods which are unknown to health care professionals and patients.
- Lack of consistency of treatment because of small quantities of different drug products.
- Health care goods not relevant to the needs of recipients.
- Incompatible medical devices.
- Unsustainable health care equipment.
- Creating wants for previously not available (and not necessarily essential) health care goods.

C) Packaging

- Small packaging sizes (rather than hospital packagings).
- Drug products marked only with their proprietary names.
- Labelling in a language not understood by health professionals in the recipient country.
- Lack of proper labelling and patient information.

D) National pharmaceutical legislation

- Drug products which are not registered in the country of receipt.
- Health care goods which do not comply with national treatment protocols.
- Encouraging pilfering and black markets.

E) Quality

- Quality of health care goods which does not comply with national standards.
- Short remaining shelf-life of health care goods.
- Expired health care goods (which are therefore useless and potentially dangerous).
- Donation of returned drug products collected from households.

F) Logistics

- Unsorted health care goods.
- Consignments without packing lists.
- Transportation costs higher than actual value of donated health care goods.
- Waste of resources for handling, storage and transportation.
- High costs for disposal of unwanted donations and placing financial burden on recipients.
- Customs clearance at the expense of recipients.
- Extra workload for sorting, storage and distribution.
- Blocking of valuable storage space and transportation capacities.

Table 12.1 Disadvantages and problems of inappropriate donations

Unfortunately there are abundant examples of inappropriate donations (WHO 1999c, 15-16).

Armenia 1988: Only one third of 5,000 tons of health care goods worth USD 55 million were suitable to the emergency situation after an earthquake but took 50 people six months to sort. (Hairapetian, A. et al. 1990).

Eritrea 1989: seven truckloads of expired aspirin tablets took six months to burn, a whole container of unsolicited cardiovascular drug products with only two months remaining shelf-life and 30,000 bottles of expired amino-acid infusions were received (Woldeyesus, K., and B. Snell 1994, 879).

Sudan 1990: contact lens solution, appetite stimulants, drug products against hypercholesterolaemia and expired antibiotics were among donated health care goods, all labelled in French, which is not spoken in Sudan (Cohen, S. 1990, 745).

France 1991: 80% of 4,000 tonnes of unused drug products collected from 4,000 pharmacies and sorted in 88 centres were unusable and had to be burnt (PIMED 1994).

Guinea-Bissua 1993: a donation of 8 tons contained 22,123 packages of 1,714 different products with quantities between one and 100 tablets (WHO 1999c, 16).

Lithuania 1993: eleven woman treated for endometrities with a drug product received without product information or package insert, which in fact was a veterinary anthelmintic, temporarily lost eyesight ('t Hoen, E., C. Hodgkin, and D. Milkevicius 1993).

Rwanda 1994: antibiotics that were not approved by the Food and Drug Administration or the World Health Organization were donated by a commercial company (Nemecek, S. 1998, 31).

Former Yugoslavia 1994 - 1995: only 45% of drug products mostly donated by European countries and received by the WHO field office in Zagreb were useful and 340 tons of expired drugs accumulated (Forte, G.B. 1994).

Bosnia and Herzegovina 1992 - 1996: 50-60% of all donations were inappropriate and the estimated disposal cost for 17,000 tons was USD 34 million. Donations included health care goods left over from World War II (which ended 1945), thirty year old plaster tapes and drug products for treating leprosy (Berckmans, P. et al. 1997).

Calcutta 1996: a USD 12 million donation contained nearly no essential drug products at all according to the recipient.

Albania 1999: an estimated 50% of drug products donated during the Kosovo crisis were inappropriate or useless (WHO 1999c, 16).

Kosovo 1999: USD 1.5 million worth of health care goods from companies which received a tax break for their donations, included such items as lip balm, haemorrhoid ointment, cough syrup and anti-smoking inhalers (Abelson, R. 1999, 1).

There are numerous reasons why bad donations practices are still very common. Despite their best intentions, donors may lack understanding of the situation and the context in recipient countries as well as the implications for and consequences of donations for recipients.

*Probably the most important factor is the **common but mistaken belief that in an acute emergency any type of drug product is better than none** at all and that expired products are good enough for people in need" (WHO 1999c, 4).*

Another cause of inappropriate drug donations may be the lack of time or means to carry out an assessment for determining needs of recipients before planning donations.

Donors may be unaware of the difference between donations of possibly useless but rarely dangerous humanitarian assistance goods such as food and shelter material and the possible dangers of inappropriate health care goods.

The lack of communication between donors and recipients is generally conducive to inappropriate donations.

Finally commercial companies can enhance their image by making donations and benefit from significant tax breaks for donations of any kind of health care goods while at the same time saving the significant costs for disposal of (nearly) expired drug products of approximately USD 2,000 per metric tonne). For example, in 1997 approximately 40 percent of all marketed drug products (22,500 tonnes) had to be destroyed (Berckmans, P. et al. 1997).

Incidentally exportation of expired drug products contravenes the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1989).

The "Basel convention on the control of transboundary movements of hazardous wastes and their disposal" (done at Basel, 5 May 5 1989) also applies to "waste pharmaceuticals, drugs and medicines".

This global environmental treaty which was adopted in 1989 and entered into force in 1992, does not apply itself but obliges signatories to enact national legislation and regulations in order to implement and enforce the convention's provisions.

The Basel convention which aims at reducing the risk posed by hazardous wastes to human health as well as the environment, can be summarized in a few basic principles (see table 12.2).

- Environmentally sound management of hazardous wastes.
- Reduction and minimization of hazardous waste generation (quantity and danger) at the source.
- Treatment and disposal of hazardous wastes as close as possible to their source.
- Reduction to a minimum of the transboundary movements of hazardous wastes.

Table 12.2 Principles of the Basel convention

The convention recognizes the right of states to ban the importation and disposal of foreign hazardous wastes and particularly intends to protect less developed countries from becoming "dumping grounds" for hazardous wastes.

Any wastes listed in Annex I of the convention are considered as hazardous, unless they do not possess any of the characteristics contained in Annex III, such as being oxidizers, poisonous, corrosive, toxic (upon inhalation or ingestion) or ecotoxic (having an adverse impact on the environment). Under Y3 of Annex I "Waste pharmaceuticals, drugs and medicines" are listed as a category of wastes which must be controlled. In addition states may define types of wastes not listed in the convention as hazardous.

The convention would allow exportation of wastes only if the expertise and facilities for disposal are not available in the country of exportation and prohibits exportation of hazardous wastes to states non-party to the convention.

In case of illegal traffic, the state from which hazardous wastes were exported must ensure that the exporter, the generator or, if necessary, the state itself takes back the waste or, if impracticable, disposes of the waste in accordance with the provisions of the convention.

Under the convention transportation for the purpose of returning illegally exported hazardous wastes to the exporting state is permissible. Moreover states which are party to the convention must introduce national legislation to prevent and punish illegal traffic.

Problems with donations of health care equipment may arise where new but inappropriate devices are donated or donors primarily want to get rid of outdated and redundant health care equipment (FACT and WCC 1994, 2). Moreover, donations of different types and makes of health care equipment which are not compatible and each require different replacement parts and operating supplies cause problems for recipients. Storerooms in health care facilities with broken and sometimes brand new but never used health care equipment are unfortunately very common.

12.4.2 Principles for donations of drug products

The benefit of donations for recipients can be improved by adhering to the twelve articles of the "Guidelines for Drug Donations" (WHO 1999c) and four core principles (table 12.3). These aim at encouraging good donation practices rather than discouraging donations (WHO 1999c, 6).

Donations should first and foremost benefit recipients to the greatest possible extent and therefore donations should be based on the expressed need of recipients. Donations must not be made for the benefit of donors such as obtaining tax breaks or disposing of unneeded stocks and unsolicited donations should be discouraged.

"Gifts of supplies, before being sent to a theatre of war, shall be subjected to careful examination"(International Red Cross Conference 1869, chapt. 1, para. 5.)

The authority of recipients and their wishes must be respected and donations must comply with health policies as well as national legislation and regulations in the recipient country.

Double standards are not allowed and drug products must not be donated if their quality does not comply with quality standards in the donor country.

Recipients must be informed of the detailed contents as well as delivery dates of donations.

- Maximum benefit to the recipient.
- Respect for wishes and authority of the recipient.
- No double standards in quality.
- Effective communication between donor and recipient.

Table 12.3 Core principles for donations

The requirements are further specified in 12 articles which cover selection of drug products, quality assurance and shelf-life, packaging and labelling as well as information management (table 12.4.). These articles also specify situations when exceptions from the rule are justified.

Article 1 requires that recipients specify their needs and donated drug products must be relevant for treating medical conditions prevailing in the recipient country. Ideally recipients should be able to indicate the required drug products, required quantities as well as their priorities. Unsolicited, unannounced and unwanted donations must be avoided and recipients must have the possibility to refuse any donation rather than having to fear that assistance will be stopped.

In acute emergencies exceptionally drug products included in the "WHO Model List of Essential Medicines" (WHO 2007n) may be sent without prior consent of recipients.

Article 2 requires that all drug products appearing on the national essential drug list, are registered for use in the recipient country by the national drug regulatory authorities and comply with national health policies. Therefore donated drug products must be subject to the same requirements as manufactured or imported drug products. In countries without national essential drug lists the "WHO Model List of Essential Medicines" (WHO 2007n) can be used as a reference instead. This provision avoids that donated drug products are unnecessary or unknown in the recipient country. Exceptions can be made for newly emerging diseases or in case of the sudden outbreak of an uncommon disease.

According to article 3 the dosage form, strength of dosage unit and formulation of donated drug products should be similar to those commonly used in recipient countries. This provision ensures that health professionals are familiar with donated drug products and do not have to change (standard) treatment protocols for example because of different strengths of dosage unit of donated drug products. Any changes of treatment protocols bears the risk of mistakes and consequently inappropriate treatment of patients.

In order to avoid double standards, article 4 requires that drug products are obtained from a reliable source and comply with quality standards in the donor as well as in the recipient country. The "WHO Certification Scheme on the Quality of Pharmaceutical Products Moving in International Commerce" should be applied but can be waived, for example in acute emergencies, if the donor gives an explanation.

Drug products must only be donated if they have been manufactured according to Good Manufacturing Practices for Pharmaceutical Products (cGMP) and are registered for sale with the national drug regulatory authorities in the country of manufacture. Drug products purchased in recipient country must comply only with national requirements.

Article 5 categorically forbids donations of any drug products which had been issued to patients and later returned to a pharmacy or collected in another way or were given to health professionals as free samples. Patients return unused drug products to pharmacies for their safe disposal not for any kind of reuse.

It is not permissible to issue drug products returned by one patient to another patient since their quality cannot be guaranteed. Therefore the permission to donate these returned drug products in another country would create a double standard forbidden by article four.

Appropriate storage of returned drug products by patients cannot be ensured. For example these are often stored in bath rooms with excessive humidity and may be exposed to high temperatures. Moreover packaging is often broken, the remaining shelf-life will be relatively short, quantities are small while the variety of drug products is often very high. Consequently much time is wasted by health professionals on identification and sorting of such donations. Moreover health professional are forced to frequently change treatment protocols and dosages according to ever changing proprietary names and strengths of dosage unit, especially for patients with chronic diseases or requiring long-term treatment.

Article 6 requires that, by default, the remaining shelf-life of donated drug products should be at least one year at the time of arrival in the recipient country. For drug products with a total shelf-life upon manufacturing of less than two years, at least one third of the total shelf-life should remain at the time of arrival in the recipient country.

Exceptions to these general rules can be made if drug products are donated directly to a specific health care facility, the recipient is aware of the remaining shelf-life in advance and agrees to the donation and the drug products can be used before expiry.

The general notion that in emergencies donated drug products will be used quickly is wrong. On the contrary, large quantities of the same drug product may be donated from other donors and supply systems may be overloaded or disrupted because of the crisis leading to delays in receipt, processing, distribution and transportation of donated drug products.

On the other hand the strict and unreflected application of the requirement for one year remaining shelf-life can lead to the disposal of high quality drug products which are needed in the recipient country.

Article 7 requires that all drug products are labelled in a language that is easily understood by health professionals in the recipient country. The labelling must at least include the international nonproprietary name, batch number, dosage form, strength of dosage unit, name of the manufacturer, quantity in the container, storage conditions and expiry date. The route of administration should be indicated for injectable drug products (for example i.v., i.m., s.c.).

Proprietary names are very specific to the country where they are marketed and they may be completely unknown in the recipient country.

According to article 8 as much as possible drug products should be donated in larger packaging quantities and hospital packaging. These are generally cheaper, incur less costs for transportation and storage and are better adapted to public supply systems in less developed countries. Incidentally large packaging are less attractive for pilfering and theft as the quantities are too large to sell to individual customers.

Selection of drug products

1. Donations based on expressed needs and relevant to the disease pattern in the recipient country.
2. Drug products should be included in the national essential drug list of the recipient country.
3. The dosage form, strength of dosage unit and formulation should be similar to those commonly used in the recipient country.

Quality assurance and shelf-life

4. Donated drug products should comply with quality standards in both donor and recipient country.
5. No donation of returned drug products or free samples.
6. Remaining shelf-life of one year or less, if recipient can make use of donations before expiry.

Packaging and labelling

7. Labelling in a language understood in the recipient country.
8. Donation of larger quantities and hospital packages.
9. Detailed packing list with exact contents of each parcel.

Information management

10. Information of recipients of all donations (under consideration, prepared or already shipped).
11. Declared value based on wholesale price of multisource equivalent in the recipient country.
12. Logistics costs (transportation, storage and handling, importation) paid by donor.

Table 12.4 Articles of the "Guidelines for Drug Donations" (WHO 1999c, 7f.)

Article 9 requires that all donations are properly packaged and are accompanied by a detailed packing list specifying the international nonproprietary names, dosage forms, quantities, batch numbers, expiry dates and special storage conditions of the contents of each parcel as well as the weight and volume of each parcel. Drug products should not be mixed with other humanitarian assistance goods in the same parcel and the maximum weight of any parcel must not exceed 50 kilograms in order to allow manual handling.

According to article 10 recipients should be informed of all donations which are planned or have been prepared as well as shipped consignments. Recipients must receive advance shipping notices in order to be able to prepare receipt, coordinate their work with other donors and possibly plan further distribution. This information must include contact information of the donor, details of the packing list as well as the expected date of arrival and port of entry.

Article 11 requires that the value declared on customs documents should be based on wholesale prices of equivalent multisource drug products in order to prevent high costs for taxes, customs clearance and handling in the recipient country.

According to article 12 donors should pay for international and domestic transportation, storage and handling as well as customs clearance. This provision prevents recipients to be burdened with covering costs for possibly unwanted donations.

12.4.3 Health care equipment donations

Like for drug products, there are no international regulations concerning donation of health scare equipment but the World Health Organization has issued the "Guidelines for Health Care Equipment Donations" (Heimann, P., A. Issakov, and S.Y. Kwankam (ed.) 2000). The core principles developed for donations of drug products (see table 12.3) equally apply to donation of medical devices (Heimann, P., A. Issakov, and S.Y. Kwankam (ed.) 2000, 1).

Inappropriate donations of health care equipment may cause recipients more problems than benefits (FAKT and WCC 1994, 1) and become a, mainly financial, burden for the receiving health care facility as well as the supporting health system, rather than improving health services.

The donation of health care equipment is far more complex and intricate than the donation of other humanitarian assistance goods and requires careful planning. The introduction of health care equipment, the utilization, including regular purchase of single use accessories as well as the maintenance requires substantial financial, organizational and human resources (Heimann, P., A. Issakov, and S.Y. Kwankam (ed.). 2000, 10).

For example in Sub-Saharan Africa due to poor planning, lack of training of operators and users and lack of technical support, up to 70% of all health care equipment lies idle (Heimann, P., A. Issakov, and S.Y. Kwankam (ed.). 2000, 10).

A detailed donation plan should cover all resources and responsibilities of recipients as well as donors.

Recipients must assume various responsibilities before receiving health care equipment donations (see table 12.5).

First and foremost recipients must have a genuine need for the health care equipment under consideration, it must be appropriate and contribute to improving the level and quality of health services provided to patients. Recipients must specify the required quantities as well as priorities for different types of health care equipment. As far as possible, types of equipment known to staff at the recipient health care facility should be provided.

Some types of health care equipment require approval and licensing by the health authorities for example by the national radiation protection board.

The receiving health care facility must have, or be able to acquire, the capacity and the means to sustain and operate donated health care equipment.

Recipients must have sufficient financial resources at their disposal for preparing the installation, installing, operating, servicing, maintaining and repairing health care equipment. In particular recipients must be able to cover the costs for regularly purchasing any required single use accessories such as test strips, filters, single use tubing, reagents etc. and replacement parts which are regularly needed due to wear and tear such as light bulbs, fuses or heating elements. These single use accessories must also be available domestically.

Competent and qualified staff must be available which can be trained to appropriately and safely operate health care equipment and some equipment requires specialist health professionals. Sufficient staff must be available for operating health care equipment as well as supporting and sustaining operations.

The health care facility must provide a suitable site and environment for installing health care equipment. Sufficient space, sufficiently strong floors (autoclaves) or ceilings (operating lamps) and possible separate rooms may be needed, for example for diagnostic imaging equipment. Most health care equipment requires a regular and stable supply of electricity of sufficient capacity. Other health care equipment such as kerosene and gas refrigerators or autoclaves require regular supply of fuels. Some equipment requires pneumatic power.

Autoclaves and some laboratory equipment requires availability of water with defined quality standards and drainage of water needs to be considered. Other equipment may require a controlled environment for operations and therefore require heating, cooling and ventilation. Diagnostic imaging equipment may require special radiation shielding of rooms.

Some health care equipment which is used in a process may require ancillary equipment. For example autoclaves require setting up sterilization services with cleaning and storage facilities and x-ray machines require dark rooms for developing exposed x-ray films. The capacity for disposal of single use accessories should also be considered.

For health care equipment or reusable parts any required cleaning, disinfection and sterilization facilities as well as capacities must be available.

Finally replacement parts and services for installing, calibrating, commissioning, servicing, maintaining and repairing donated health care equipment must be available either from maintenance staff at the receiving health care facility or from authorized representatives of the manufacturer.

- Actual need for the health care equipment in question.
- Permission from national health authorities.
- Capacity and means to operate and sustain health care equipment.
- Financial viability.
- Staff for safely operating health care equipment.
- Appropriate site and environment for installation and operation.
- Availability and sustainability of any required power supply (electricity, gas or fuel).
- Availability of necessary ancillary equipment.
- Availability of cleaning, disinfection and sterilization facilities and capacities.
- Availability of maintenance, replacement parts and repair services (manufacturer representative).

Table 12.5 Requirements from recipients before donating health care equipment

Health care equipment considered for donation must fulfil a range of requirements (see table 12.6). For donations, only new health care equipment purchased from a supplier under warranty should be considered. Used health care equipment generally causes overwhelming

problems for recipients. Refurbished health care equipment is delivered without any warranty, supplier support (replacement parts, operating equipment, maintenance and) may no longer be available and the remaining lifetime will be significantly shorter than for new equipment. According to estimates less than 30% and perhaps as few as 10% of donated used equipment becomes operational (Heimann, P., A. Issakov, and S.Y. Kwankam (ed.) 2000, 23).

Any donated health care equipment must fully comply with the manufacturer's safety and performance specifications and have approval by the regulatory agency of the donor country. Health care equipment must also fully comply with national legislation, standards and regulations in the recipient country. For example diagnostic imaging equipment may require obtaining and regular renewal of a licence from the radiation protection board.

The technology of health care equipment must be appropriate for the environment in which it will be installed and used and should not be more complex than necessary. The selected models should allow modification and upgrading which is facilitated by a modular design. Health care equipment should be simple to install, operate, maintain, service and repair, if possible by general technicians rather than specialists.

Health care equipment should have low levels of energy consumption and noise emission. Electric equipment must be compatible with the voltage and frequency of the domestic mains electricity supply or the equipment must allow the required adjustment such as allowing alternative use of 110 volt or 220 volt. Plugs must be compatible with wall sockets or the plugs must be changed. Electric equipment should tolerate electrical power fluctuations or be supplied together with voltage regulators of sufficient capacity.

Wherever possible, operation with an alternative energy source should be possible. For example an operating lamp which can be powered by a battery during power failure, a refrigerator which can run on solar power or an electric autoclave which can also run on gas, kerosene or char coal.

As far as possible, substances which can pose an environmental hazard during eventual disposal should be avoided.

Health care equipment should be resilient to hostile environmental conditions such as heat, high humidity, dust and sand in the country where it will be used

The legends on instrument controls such as meters and gauges must be written in a language which is commonly understood in the recipient country. The units should be commonly used in the country (imperial units versus SI-system) or indicated in both units.

Any health care equipment must be accompanied with complete user documentation such as installation, training, user, operation, maintenance, service and repair manuals, including a list with the specifications of replacement parts. The documentation must also be provided in a language understood in the recipient country.

Health care equipment must be delivered with all necessary components and accessories and be fully operational. Where applicable special tools required for routine servicing and maintenance as well as any calibration or testing equipment should be supplied.

Operating of health care equipment should require only a minimum of single use operating supplies, these as well as replacement parts must be available in the recipient country and affordable for the recipient health care facility.

The operating costs comprised of staff costs, energy supply, servicing, replacement parts, maintenance and repairs must be affordable for the recipient.

Where applicable, health care equipment must be compatible with other health care equipment at the recipient health care facility.

The equipment itself as well as any required operating supplies should be easy to dispose of without harming the environment.

The donor should ensure and purchase a minimum of 2 years after sales support from the supplier or an authorized representative in the recipient country, including replacement parts, servicing, repair and maintenance for the recipient.

- Full compliance with manufacturer's safety and performance specifications.
- Approval by regulatory agency of the donor country.
- Compliance with national laws and regulations in recipient country.
- Appropriateness of technology for the environment in the recipient country.
- Not unnecessarily complex.
- Allow upgrading and modification.
- Simplicity of installation, operation, maintenance, servicing and repair.
- Low energy consumption.
- Compatibility with (or possibility to adjust) to voltage and frequency of domestic mains electricity supply.
- Compatibility (or adaptation) of plugs to wall sockets.
- Tolerance to electrical power fluctuations or provision of voltage regulators.
- Where possible, dual energy sources.
- Low levels of noise emission.
- Avoiding environmentally hazardous substances.
- Resilience to hostile environments (heat, humidity, dust).
- Legends on instrument controls, meters etc. in a language commonly understood in the recipient country.
- Availability of complete documentation (operating , repair and service manual).
- Availability of user documentation in a language commonly understood in the recipient country.
- Provision of all necessary components, accessories and supplies.
- Provision of special tools for maintenance and service as well as calibration and testing equipment.
- Minimal requirements for operating supplies.
- Availability of operating supplies and replacement parts in the recipient country.
- Affordable operating costs (staff, energy supply, replacement parts, maintenance and repairs etc.)
- Compatibility with other health care equipment at recipient health care facility.
- Fully operational.
- Easy to dispose of and without harming the environment.
- Minimum of 2 years sales support including replacement parts, servicing, repair and maintenance.

Table 12.6 Requirements for health care equipment

Donors must also assume a range of responsibilities (see table 12.7). Donors must negotiate and conclude a purchase contract including clearly defined details on the length as well as the exact coverage of the supplier warranty.

The purchase contract should ensure that the recipient is eligible for the warranty.

For complex and sophisticated health care equipment the donor may test equipment at the supplier before taking delivery.

Apart from the original supplier packaging, health care equipment must be appropriately packed for international transport and the possibly rough handling and poor road conditions in

the recipient country. Heavy equipment and accessories may have to be partially dismantled to reduce the size, weight and volume of individual packages for air transport as well as for allowing handling without powered materials handling equipment in the recipient country.

Donors, or suppliers in case of direct deliveries from suppliers, must issue a complete set of shipping documents and clear consignments for exportation as well as importation.

Finally donors must arrange and pay for international transportation and deliver the health care equipment up to the recipient which must receive a document of warranty issued by the supplier.

- Careful and detailed purchase contract.
- Clearly defined supplier warranty.
- Ensuring that recipient is eligible for supplier warranty.
- Possibly testing at the supplier.
- Sound packaging for international transport in addition to original supplier packaging.
- Packaging for air shipment according to maximum weight and volume allowances.
- Issuing of complete shipping documents.
- Customs clearance (exportation and importation) by donor.
- Arranging international transportation.
- Delivery to the recipient.
- Handing-over of document of warranty issued by the supplier.

Table 12.7 Responsibilities of donors

Finally, a range of responsibilities must be assumed after delivery of health care equipment to the receiving health care facility (see table 12.8). Upon receipt the consignment must be checked for any damages during transportation as well as completeness of the equipment and its accessories.

Depending on the purchase contract, either the recipient or the supplier will be responsible for preparing the installation site.

- Checking consignment for any damages.
- Preparing installation site (for example space, water, electricity supply, drainage, heating, cooling, ventilation, radiation shielding).
- Handing-over of complete equipment, accessories, replacement parts etc. according to purchase contract.
- Provision of tools required for servicing, maintenance and repair.
- Handing over of software.
- Handing over of documentation.
- Installation by agent authorized by the supplier or competent technician.
- Calibrating equipment.
- Carry out equipment tests (according to manufacturer recommendations).
- Commissioning of equipment.
- Training of operators or health professionals.
- Training of maintenance staff.

Table 12.8 Responsibilities after delivery

The complete equipment, including accessories, replacement parts, software, technical documentation as well as special tools for calibration, testing and repair have to be handed over to the recipient.

Depending on the type of equipment as well as the purchase contract, either an agent authorized by the supplier or a competent technician will carry out installation. Where applicable, health care equipment requires calibration, testing and commissioning (verification of proper and safe operation) according to the manufacturer's recommendations.

Finally operators as well as maintenance staff need to be trained.

The donor should verify that the donated health care equipment is operational and otherwise assist the recipient with any problems.

13 PERFORMANCE MANAGEMENT STRATEGY

Like any other organization, humanitarian organizations must constantly seek ways of continuously improving services provided to their customers and improving efficiency. Performance management starts with measuring and monitoring progress towards achieving strategic objectives, availability of resources and compliance with standard operating procedures as well as measuring performance metrics. The subsequent analysis allows determining deviations between set standards and goals and is the basis for initiating corrective action. Finally the effect and, hopefully, success of management activities is measured and confirmed by further monitoring.

Performance management can be seen as the equivalent to quality assurance in production management and performance metrics are the "vital signs" (Gattorna, J. (ed.) 1990, 344) of an organization. It must be driven by a spirit of improving services and helping people to achieve improvements rather than searching for faults.

Business intelligence is the processes, tools and technologies which provide the data and information which are indispensable for performance management (Eckerson, W.W. 2011, 32) while dashboards are tools and technologies for accessing, analysing and displaying data and information.

Performance management must focus on key activities and services which matter to customers rather than getting lost in measuring a large number of performance metrics without eventually initiating any corrective action or other measures.

13.1 Objectives of performance management

Performance management is an indispensable management tool for assisting in improving the effectiveness, efficiency and quality of provided logistics services at the strategic, tactical and operational level.

Performance management, among other means, allows managers to communicate their objectives and goals throughout the organization and helps ensuring that all departments and employees work towards and focus their activities and energies on the same goals and objectives (Eckerson, W.W. 2011, 4). Performance management enhances visibility of operations at all levels within the organization, helps coordinating activities of departments and employees and ensures meaningful reporting. If done with the right motivation and communicated appropriately, performance management can be a source of motivation for the entire organization. Finally, it allows reacting to changes of situations and constraints faster and adapting activities better and faster.

At a strategic level, performance management looks forward and measures progress towards set goals, ensures adherence to the strategic orientation of the organization and ensures development in the right direction (Eckerson, W.W. 2011, 26).

At the tactical level, performance management looks at the past for determining trends and developments at a qualitative and quantitative level. Qualitatively by comparing available with required resources as well as measuring, monitoring and ensuring compliance to standard operating procedures for setting up services and routine processes. For example, the appropriate set-up of customer services and a medical warehouse or the following of standard operating procedures for receiving goods or packing a cold chain consignment. And at a quantitative level, performance metrics are monitored for ensuring they stay within the

desired limits as well as for determining trends and intervening before processes and services fall below minimum standards.

Pragmatically, performance management at the operational level will be limited to data collection and ensuring that the performance and quality of individual transactions remains within the desired limits.

13.2 Process of performance management

Performance management should follow a structured approach (see table 13.1). A clear vision for the organization, a well defined logistics and supply chain management strategy as well as standard operating procedures for setting up services and all main processes are prerequisites for developing a performance management system. Eventually every measurement must be compared against a clearly defined standard or goal.

A system for collecting data, preparing standardized reports and transmitting them upstream needs to be established.

While the evaluation of compliance with standard operating procedures requires comprehensive evaluations, suitable quantitative and qualitative performance metrics and key performance indicators need to be selected for measuring the quality of logistics activities. For both types of performance metrics benchmarks should be obtained from other organizations or related industries for setting performance targets and acceptable deviations.

- Stating strategic objectives and standard operating procedures.
- Establishing systems for collecting data and information.
- Establishing reporting systems.
- Selecting suitable performance metrics.
- Selecting key performance indicators.
- Determining benchmarks.
- Determining and setting performance targets and acceptable deviations.
- Collecting data and information.
- Analysing measurements.
- Monitoring measurements.
- Determining whether targets have been reached.
- Early detection of problems and undesired developments.
- Determining bottlenecks in the supply network.
- Determining reasons for failing to reach set targets.
- Detecting and determining lack of resources for providing high quality logistics services.
- Reporting to logistics services as well as customers.
- Initiating suitable measures for corrective action.
- Measuring the impact of corrective action.
- Learning from poor performance and mistakes.
- Enabling and ensuring continuous improvement.
- Ensuring that a high quality of logistics services is maintained or achieved.

Table 13.1 Process of performance management

Collecting, analysing and monitoring data allow determining whether performance targets were reached. Regular measurements and monitoring of performance allow early detection of

emerging problems as well as undesired developments. The analysis of measurements allows detecting bottlenecks and determining any lack of resources needed for providing high quality logistics services as well for improving the utilization of available resources.

Analysing results in detail for identifying reasons for poor performance and failing to reach set targets is the next critical step. Apart from lack of knowledge, training and adherence to defined standard operating procedures, any lack of resources required for providing high quality logistics services need to be determined.

The measurements and conclusions need to be documented systematically in a report and suitable measures for corrective action need to be initiated if the set targets were not reached. These must focus on addressing the root causes and providing support and if needed additional resources to staff rather than issuing reprimands and instructions. The impact of the taken measures again needs to be monitored. Reporting the results to customers is equally important as it is essential for their planning.

Like any other organization, humanitarian organizations need to learn from poor performance as well as mistakes and ensure continuous improvement in order to achieve and maintain a high quality of logistics services provided to health programmes.

13.3 Performance measurement dimensions

Among the multitude of qualitative and quantitative measurements, different dimensions can be distinguished (see table 13.2).

Measures can be expressed in absolute values such as the number of items in stock or as relative measures such as a proportion (ratio) or percentage, for example stock availability. Wherever a parameter is measured more than once, average, minimum and maximum values can be measured and the distribution of values can be determined and measured (for example the standard deviation).

For planning and customer service measures, the reliability or consistency of performance which is determined by the variability or fluctuation, is more important than the absolute or average values.

In many cases flow measures such as stock turnover are more relevant than static measures such as stock on hand which capture only a point in time.

For various parameters, measurements can be made for a single item or activity or they can be aggregated over time, geographical areas or customers. Moreover measurements can be made for different classes following a Pareto analysis.

Measurements of parameters can be analysed separately or can be combined with each other for further analysis. For example the number of items delivered on time can be combined with the number of items or consignments delivered without any damage.

Among the objects which can be measured, logisticians are first interested in health care goods or products and their measurements such as their numbers, weights, volumes or values.

Distances such as between places and the length of transportation routes are needed for planning purposes and measuring the efficiency of transportation services.

The measurement of various lead times is crucial for measuring logistics performance in general.

The measurements of financial values such as purchasing, transportation or storage cost are needed for determining the efficiency of logistics services.

Determining and measuring the availability of resources (human resources, information system infrastructure, storage facilities etc.) is essential for comparison with required resources for determining any shortcomings or underutilized resources.

Apart from quality assurance for health care goods in general, the measurement of quality is the basis for evaluating compliance with standard operating procedures for various aspects of logistics services as well as procedures. Qualitative measurements require establishing a rating scale as well as criteria for assigning ratings.

The measurement of customer service as the ultimate objective of all logistics activities lies at the core of all performance measurements.

Some measurements such as the distance between places or the surface area of a given warehouse are fixed while most measures are variable (dynamic) and therefore require repeated measurements.

Quantitative or quantifiable measures can be measured objectively for example by counting or measuring a time span and in clearly and precisely defined units of measurement.

On the other hand qualitative measures such as the overall quality of logistics services cannot be measured objectively and measurements will be subjective to some degree.

Productivity measures (output, "how much") such as the number of treated customer orders or picked line items are measures of activities which are derived by counting. These must be well distinguished from performance metrics ("how well") such as the number of line items picked per storekeeper per day which measure how efficiently an activity is performed.

The quality of logistics services received from an upstream supplier or medical distribution centre must be distinguished from the services provided downstream to customers. These are closely related as stock availability of a medical distribution centre greatly depends on the reliability of upstream suppliers.

In principle effectiveness measures only determine the extent to which a defined result or outcome has been achieved. However, timeliness is implicit in all effectiveness measures. For example a transportation activity is effective whenever a consignment arrives at its destination. However, the notion of effectiveness also implies that this activity is completed within a reasonable time period.

Effectiveness measures, which indicate only whether a goal has been reached, must be well distinguished from quantitative or qualitative efficiency measures which relate the measured outcome (output) to the resources (input) necessary for achieving the outcome. In measuring efficiency, isolating the inputs which have generated the outputs can be difficult such as allocating the time staff spends on different tasks.

Time measurements can be made or averaged over short or long time horizons and can be calculated as cumulative values from a certain starting point in time or over rolling time horizons (for example over the most recent six months).

The geographical scope of measurements can cover a single medical distribution centre, all logistics services provided at a certain location, the global logistics services provided in a country, in a geographical region or worldwide.

Measures can be limited to the internal supply network of a humanitarian organization or be extended to the external or even the global supply network.

Humanitarian organizations usually measure their own performance but the performance of all humanitarian organizations or even the international humanitarian community in a specific country or a specific crisis may also be of interest.

For various logistics activities a single aspect (function) such as the lead time for order treatment or the lead time for the total service of order fulfilment can be measured.

Customer service metrics can be measured for individual customer orders, aggregated over all orders from a specific customer or can be aggregated over all customers.

Performance should also be measured separately for emergency items such as kits, national standard list items, other items as well as for the entirety of supplied items.

An important distinction is the performance in routine operation and emergency situations in acute crises.

Contexts where logistics services of humanitarian organizations are already well established should be distinguished from contexts where logistics services have to be established.

A) Types of measurements

- Absolute versus relative (proportion, ratio or percentage).
- Absolute - average - minimum - maximum - distribution of values (standard deviation).
- Absolute versus reliability (consistency, variability, fluctuation).
- Static versus flow measure.
- Single versus aggregate measures, Pareto analysis.
- Single versus combined measurements.

B) Measurement objects

- Goods (number, weight, volume, value etc.).
- Space (distance).
- Time span.
- Cost.
- Resources.
- Quality.
- Service.
- Fixed versus variable (dynamic).

C) Aspects of measurements

- Quantitative (quantifiable) versus - qualitative measures.
- Productivity (activity, quantity) versus performance (efficiency, quality).
- Logistics services received versus logistics services provided to customers.
- Effectiveness versus efficiency.

D) Scope of measurement

- Time horizon: short versus long, cumulative versus rolling.
- Geographic: local - domestic - regional - international.
- Supply network: internal - external - total.
- Organization: own - humanitarian community.
- Services: single aspect (function) - complete.
- Customers: individual orders - all orders of one customer - all customers.
- Emergency items - national standard list items - non-national standard list items.

E) Context

- Routine operations versus acute crises.
- Existing or newly established services.

Table 13.2 Measurement dimensions

13.4 Requirements for performance measurement systems

A useful performance measurement system must fulfil several requirements (see table 13.3).

The scope of the performance measurement system must cover all important and pertinent activities, functions, services and departments throughout (at least) the internal supply network but must not attempt to bee too comprehensive by attempting to measure everything. Rather, each key area should be represented by a limited number of performance metrics and duplications should be avoided. All of the included performance metrics should be coherent and consistent with each other.

Rather than concentrating on separate activities and static measures, performance measurement systems should focus on processes and be integrative, that is to say they should promote coordination across functions and departments. Otherwise there is a great danger that the performance measurement system will encourage sub-optimization of particular activities or functions.

The performance measurement system must be coherent with the overall logistics strategy which in turn must be coherent with the overall objectives of the humanitarian organization. For example the overall focus on effective provision of services will limit the importance of financial metrics.

Any performance measurement system must place the quality of services provided to external as well as internal customers at its centre. While performance must be measured by all services at, and between, all stages, all services throughout the supply network must focus on the final customer, the assisted health care facility, health professional or patient.

Therefore selected performance metrics as well as the overall measurement system must be mainly determined by customer needs and what matters to them rather than by internal (cost) efficiency measures.

The selection of individual performance metrics as well as of the whole performance measurement system must consider the behaviour of staff members as well as managers it provokes and encourages. Once performance metrics have been established, managers will try to improve the results of these performance metrics and may consider primarily their own interests, possibly without further consideration of the overall objectives.

Therefore, performance metrics which are not carefully selected can encourage counter-productive acts or game-playing. For example if maximizing the number of items on hand is the primary objectives, there may be a temptation to withhold order picking until stocks are replenished and thereby increasing order lead times as well as decreasing the quality of provided services.

Instead, performance measurement systems must ensure creating incentives for desirable behaviour, that is to say behaviour which is consistent with the overall customer service focus and conducive to improving customer service.

The individual performance metrics which constitute the performance measurement system must be specific, easily understandable by concerned staff and must provide guidance for improving customer service rather than being measured for their own sake.

Consequently the design of performance measurement systems must also carefully consider the persons who will use the results.

The performance measurement system must balance the resources required for collecting and analysing data with the benefits of implementing the corrective action they imply. However since the overall objective of improving customer service cannot be measured in

financial terms, the various trade-offs are not exactly quantifiable and selection of performance metrics will ultimately depend on judgement.

In any case performance measurement systems must not include performance metrics which are measured for their own sake or because data is readily available rather than providing information which allows improving decision making and ultimately improving services. Moreover for any given measurement the required level of detail must be considered.

Overly complex performance measurement systems yielding measurements which are difficult to interpret will be quickly distrusted and disregarded. Rather, performance measurement systems should be fairly simply, clear and transparent and allow staff members to relate their own performance to the immediate outcome of performance measurements. Only if the measurements are clearly understood by all staff members can they be translated into appropriate actions.

While ideally a performance measurement system will fulfil all the requirements above, they may conflict with each other to some degree. The main trade-off to be considered is between process orientation (integration) and utility. Increasing the scope of the measurement system reduces the immediate meaningfulness and utility for managers of individual functions or services as their influence and control is limited.

However this problem can be overcome by simultaneously using several performance metrics with different scopes.

- Completeness, consistency and coherence.
- Process oriented and integrative.
- Coherence with overall objectives of humanitarian organization and the logistics strategy.
- Focused on customers and customer service quality.
- Encourage desirable behaviour.
- Utility (decision oriented).
- Economical.
- Simplicity, clarity and transparency.

Table 13.3 Requirements for performance measurement systems

13.5 Business intelligence

Many organizations collect large amounts of data and develop a vast amount of applications for their analysis throughout the organization. However, these "spreadmarts" are often created by different individuals, in different places, at different times, using different data sources and different rules for defining performance metrics (Eckerson, W.W. 2011, 64). Apart from the inefficiency of processing data manually, it is nearly inevitable that data is inconsistent, incomplete, data items are defined in different ways and measurements obtained by different means and in different ways are not comparable.

"Because data are at the heart of most performance management systems organizations need to treat data as vital corporate asset, as important as other assets, such as buildings, people, and cash" (Eckerson, W.W. 2011, 52.

Therefore humanitarian organizations need to build a consistent and coherent system for collecting, processing, storing and analysing data.

The term business intelligence covers a wide range of applications for data warehousing, data integration as well as analysis and reporting (Eckerson, W.W. 2011, 32).

Business intelligence applications provide reliable, historical data which are collected according to well defined rules throughout the organization. This centralized and integrated source of "corporate information", which can be accessed by users throughout the organization directly and timely, is a sound basis for building performance management systems.

The user interfaces of sophisticated performance dashboard applications allow selecting, presenting, combining as well as detailed and complex "drill down" analysis of any set of data.

13.6 Performance management framework

Humanitarian organizations need to manage performance in all places and at the strategic, tactical and operational level (see table 13.4).

At the strategic level, performance management is carried out by the head office while regularly sharing the results with all sites. Strategic performance management is carried through regularly reviews, for example every three months, with a global scope, using various forms of analyses and with a clear vision of the long-term future of the organization. The main objective is determining the state of implementation of the worldwide, long-term strategy and improving existing or implementing additional procedures in order to achieve strategic goals.

For example, review of the profiles of employed logistics staff, implementation of new information systems or specific applications and tools, compliance with the sourcing strategy, the global supply network (and its changes) or the appropriateness of the customer service policy for supporting health programmes.

If shortcomings of the strategy are detected, corrective action could lie in change or adapting the strategy or some of its elements or adapting resources and standard operating procedures.

Management level	Strategic	Tactical	Operational
Supply chain management	Supply network design	Supply chain planning	Supply chain operations
Responsible	Head office (only)	Logistics coordinators / Health care logisticians	(Health care) logisticians
Time horizon	Long-term (more than 2 years)	Mid-term (0.5 to 2 years)	Short-term (less than 0.5 years)
Geographic scope	Worldwide	National	Local (site)
Focus	Strategic objectives	Standard operating procedures / Performance metrics	Day-to-day transactions
Activity	Analysis	Monitoring	Data collection
Frequency	Quarterly	Monthly	Each completed transaction
Measurement	Progress towards strategic goals		
	Worldwide aggregation ←	Resources and standard operating procedures	
	Worldwide aggregation ←	Aggregation of performance metrics at national level ←	Performance metrics

Table 13.4 Performance management framework

In order to ensure that all services are monitored, head offices must also aggregate, and if necessary complement and adjust, the performance measurements collected at the country level in order to supervise work in the field but also for identifying areas where support is needed. These include summaries of logistics evaluations as well as monitoring key performance indicators aggregated by country.

In the field, the health care logistician in each country must regular carry out complete logistics evaluations (for example quarterly) and monitor implementation of the proposed corrective action. The focus lies on looking in the past and analysis of historic data. These logistics evaluations ensure that resources for managing logistics services are adapted to needs, all staff comply with all standard operating procedures and standard operating procedures are constantly optimized.

Every month, health care logisticians and/or logistics country managers also need to collect, aggregate, analyse and monitor qualitative and quantitative performance measurements from all sites in the country for measuring key performance indicators and customer satisfaction. Corrective action may consist in increasing or improving required resources (staff, storage capacity etc.), enforcing standard operating procedures or providing training to staff.

At the tactical level, each service (customer service, medical store, transportation department etc.) at all sites should monitor performance of individual transactions such as lead times and immediately implement corrective actions if measurements drop below the set targets.

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14 TACTICAL PLANNING

Tactical planning concerns mid-term allocation and coordination of resources and capacities for supporting health programme programmes in a specific country. Before setting up logistics services in a country where the humanitarian organization has so far not been present, a logistics assessment should be carried out. If assistance programmes in a country without presence of the humanitarian organization are necessary at short notice, an emergency intervention plan needs to be established for contingency planning and establishing logistics services. The emergency intervention plan is then adapted for establishing a national health care logistics plan for every country which is maintained as long as the humanitarian organization maintains its presence in the country.

14.1 Logistics assessment

Before considering any humanitarian assistance programme, a thorough security assessment must be carried out even before entering the country or the affected area.

Before implementing any assistance programme, a thorough assessment of the available logistics infrastructure must be carried out. Otherwise, there is a great danger that staff and goods are moved to a crisis area without appropriate support services, storage facilities and resources for onward transportation and distribution. Health programmes may be able to start but will not be sustainable because of lack of continuous and reliable logistics support.

Based on an assessment of the logistics infrastructure, humanitarian organizations will decide whether they need to complete or completely substitute certain resources and service for establishing their supply network. The assessment will also allow considering different options as well as comparing their efficiency and cost. Depending on the source of goods, the logistics infrastructure within the assisted country, neighbouring countries as well as the countries where humanitarian assistance goods are purchased need to be assessed.

Logistics managers must assess the feasibility of managing services and the flow of goods as well as the flow of information. Like the flow of goods, transmission of accurate and timely information will be quite easy within developed countries but can be very difficult within the crises area or less developed countries. Therefore, supply chain managers must be just as keen on identifying resources enabling the timely flow of information as they are on identifying resources enabling the timely flow of goods and services.

Sharing information with other (humanitarian) organizations is vital. It saves resources, benefits all parties and will improve the quality of humanitarian assistance provided to the affected population in general.

For each aspect of the supply network, several factors must be considered in the assessment (see table 14.1).

- Availability of resources and services (transportation, warehousing, customs clearance, suppliers etc.).
- Reliability and efficiency of services.
- Capacity.
- Lead times (from suppliers, transportation lead times etc.).
- Cost.

Table 14.1 Factors of logistics assessment requiring consideration

Supply chain managers must also analyse the results of the general assessment of the humanitarian situation carried out by programme mangers. They must receive general information on the affected area, climate, the number of affected people, population centres, the severity of the crisis as well as military and political developments.

14.1.1 Definition

A logistics assessment is a comprehensive review of the available resources and services, means, conditions and capacities, which are necessary for managing the flows of information and goods throughout a supply network in a given place, in a country, area or place where the humanitarian organization is not (yet) present.

14.1.2 Objectives

Logistics assessments may be undertaken for various reasons (see table 14.2) and might need to be repeated after a certain period. Logistics assessments may need to be carried out in various places, regions and countries to cover the entire supply network from manufacturers to end-users.

- Advising programme managers on the feasibility of humanitarian assistance programmes in the planning and preparation phase.
- Advising programme managers on advantages and disadvantages of different locations (for example when considering establishing an IDP camp).
- Capacity planning before starting humanitarian assistance programmes.
- Commencing a humanitarian assistance programme in a new place or area.
- Changes of programmes and especially increases in volume of provided humanitarian assistance goods.
- Changes of conditions in a place where humanitarian assistance programmes are currently carried out (security, infrastructure, changes in legislation, climate change etc.).

Table 14.2 Reasons for carrying out a logistics assessment

The objective of the logistics assessment is to gain a complete overview of resources and services in an area rather than to assess the quality of an existing supply network, which is the objective of a logistics evaluation.

Capacities of civilian and military authorities, the private (commercial) sector as well as other humanitarian organizations should be identified.

The assessment should include damaged infrastructure and facilities, which may be easy to repair, or are in the process of being repaired and are therefore expected to be available in the near future.

14.1.3 Data and information collection

Data refers to collected numbers and facts. Their collation, analysis and placing them in a context, allows to derive information which is meaningful and useful.

The collected data must be accurate and updated and should be substantive rather than anecdotal. It is important to decide on a case-by-case basis how much detail is necessary.

Data as well as information can be collected by various methods such as studying documents and references, direct observations and conducting interviews.

Using standardized forms will allow a structured approach and avoid forgetting collection of important data. Standard forms also allow comparing data and information from different places easier and faster.

Data and information for the initial phase of the logistics assessment can be collected from various sources. Emergency preparedness plans should provide detailed information on available logistics staff, contingency stocks and available transportation resources.

Information about the affected region such as local maps, sea and airports in the region and possibly storage facilities will be partially available from databases. A vital source for information will be staff working on assistance programmes in the affected or in neighbouring countries. Information can also be collected from other organizations, governments or local authorities, which are present in the crisis region.

The United Nations head office in New York administers the United Nations International Emergency Network (UNIENET), which supports United Nations agencies with databases containing contact lists and equipment stockpiles. The World Food Programme (WFP) administers the International Food Aid Information System (INTERFAIS) from its head office in Rome, Italy. Its reports include detailed descriptions of obscure ports and logistical facilities in less developed parts of the world.

- Own humanitarian organization.
- Maps (general and thematic): geography, national boundaries, topography, populated areas, infrastructure (roads, railways, seaports, airports, borders).
- Databases: transportation infrastructure, commercial suppliers, legislation.
- National laws: legislation on importation/exportation, transportation, labour law.
- Documents and reports by other humanitarian organizations.
- Media reports, photographs and films.
- Aerial and satellite photography.
- Contingency plans (own or from other humanitarian organization).
- Interviews of humanitarian workers from other humanitarian organizations.
- Reports on previous humanitarian assistance programmes in the area.
- Interviews of national staff who are living abroad.
- Commercial companies providing logistics services (freight forwarders, haulers, warehouse managers etc.).
- Airlines, pilots.
- (Truck) Drivers.
- National and local authorities (Ministry of transport, Ministry of Health)
- Affected people and beneficiaries
- Personal visits and assessments.
- Telephone calls.

Table 14.3 Possible sources of information

The objective is to collect relevant information with the available resources and within the available time.

Some information can be obtained from abroad while other information will have to be collected on the spot during visits of logisticians.

14.1.4 Performing a logistics assessment

Performing a logistics assessment requires a structured and systematic approach. The assessment should be made for specific users and useful and understandable to them.

Especially in emergencies, time is limited and it is important to gather all important and relevant information without getting lost in details. The assessment should be carried out rapidly but nevertheless be sound. An experienced team leader should be in charge of planning, setting objectives, establishing the terms of reference and supervising other team members.

The first step is to obtain detailed information from programme managers on the location and size of the crisis area, the population centres and on population movements since goods and services will have to brought to the people in need. In parallel to the logistics assessment, programme managers must carry out an assessment of the situation and the needs of the affected population.

Ideally, a specialist will assess information systems and communications infrastructure. However if no specialist is included in the assessment team, the logistician should carry out a basic assessment because communication is so important to logistics.

Before travelling to the region or area some basic information should be collected from maps, reports and databases. This will give a rough orientation about the infrastructure and determine which places need to be visited for collecting more information.

Depending on the number of places, which need visiting, and the scope of the planned humanitarian assistance operation, a whole team and simultaneous assessments in different places may be needed.

Before visiting a certain place, a list of information, which needs to be obtained, must be available. This will allow logisticians to ask specific questions and make the best use of their time.

If time and resources are limited, an initial assessment with a broad scope should be made which can be followed by more detailed assessments of various issues at a later stage. The initial assessment does not have to provide all details but should provide the full picture. During the initial assessment, the need for further information gathering should be assessed as well. Some issues might require separate assessment by a specialist, especially airports and air transportation or assessment of the pharmaceutical market.

An assessment is like a snapshot of the current situation. Depending on how fast the situation changes, regular follow-ups will be needed.

All sources as well as the obtained information should be well documented for future reference and for comparison with other information. As far as possible, the information should be quantitative rather than qualitative. The final document should organize and present data and information, which is convenient for the intended users.

14.1.5 Contents of the logistics assessment

Context

- Country and area where humanitarian assistance is necessary.
- Geography, topography and climate.
- Nature of the conflict and emergency.

- Number of affected people.
- Immediate and mid-term needs for humanitarian assistance.
- Intended plan of action for the immediate phase of providing humanitarian assistance.
- Locations where immediate needs are expected to be the greatest.
- Other actors (government, humanitarian organizations, peacekeeping forces etc.).

Security and safety

- Risk of criminality (theft, robbery, murder etc.).
- Risk of armed banditry (kidnapping, high jacking etc.).
- Risk of lawlessness (riots, looting etc.).
- Conflict related risks (shooting, explosive devices, mines, artillery, aerial bombing etc.).
- Availability of preventive and protective measures (shelters).
- Presence and availability of a police force.
- General discipline of the combatants.
- Military operations in the area.
- Attitude of conflict parties towards humanitarian organizations and their programmes.
- Vicinity of offices, warehouses and workshops to military installations.
- Security of transportation infrastructure (roads, seaports, airports, railheads etc.).
- Safety and security of roads, seaports and airports.
- Security risk of driving by night.
- Use of transportation infrastructure by the military (roads, airports, seaports, etc.).
- Danger of natural hazards (floods, tornados, earthquakes, landslides, avalanches etc.).
- Dangers from industrial installations (dams, power plants, nuclear plants etc.).

Information systems

- Availability of information technology (computers) and replacement parts.
- Availability of repairs and services.
- Availability of service providers (data transmission, Internet).
- Commonly used software (word processing, spreadsheets, databases).
- Management of records and files in offices, warehouses and hospital pharmacies.

Communications systems

- Availability, capacity, reliability and coverage of public mail services.
- Availability, capacity, reliability and coverage of private mail services (courier services).
- Availability, reliability and cost of Telex and TOR services.
- Availability, reliability and cost of packet radio PACTOR satellite packet radio.

- Availability, reliability and cost of public telephone networks and telefax.
- Availability, reliability and cost of mobile telephone networks.
- Availability, reliability and cost of satellite telephony.
- Availability, reliability and cost of electronic mail services.
- Availability, reliability speed and cost of Internet connections.
- Availability, reliability frequencies and coverage of VHF and UHF networks.
- Availability, reliability frequencies and coverage of HF networks.
- Availability and quality of maintenance and repair services for communications equipment.
- Regulatory licensing authorities for radio equipment.
- Available radio frequencies.
- Communication infrastructure of civilian authorities.

Financial infrastructure

- Value of local currencies and inflation.
- Availability and reliability of banks.
- Possibility of cashless money transfer.

Utilities

- Availability, reliability and cost of mains water supply (potable as well as use water).
- Availability (schedule), capacity, reliability and cost of electric power.
- Voltage and frequency of electric of the mains electricity supply.
- Availability, reliability and cost of gas.
- Availability, reliability and cost of fuel (gasoline diesel).
- Distribution system for fuel.
- Source of fuel and dependency on importation.
- Availability, reliability and cost of waste water and solid waste disposal services.
- Availability, quality and cost of generator sets.

Legislation and regulations

- Legal and judicial system (enforcement of contracts).
- Pharmaceutical legislation (importation, exportation, storage, distribution, donation and disposal of health care goods, employment of pharmacists).
- Legislation and regulations concerning medical equipment (x-ray, sterilization equipment etc.).
- National drug regulatory authorities, drug and manufacturer licensing and registration.
- Implementation of an essential drug programme and availability of a national essential drug list.

- List of registered drug products.
- Controlled drug legislation.
- Legislation and regulations concerning storage and transportation of dangerous goods.
- Legislation and regulations concerning disposal of (health care) waste.
- Labour and social welfare laws.
- Transportation law, Highway Code regulations concerning driving hours of truck drivers.
- Building code.
- Legislation concerning importation, registration and operation of communications equipment.

Human resources

- Ethnic composition of the work force.
- Affiliation with groups and political parties in the area.
- Availability and level of technical and professional skills (drivers, mechanics, clerks, warehouse managers, purchasers etc.).
- Language skills.
- General level of literacy and numeracy.
- Computer skills (word processing, spreadsheet applications, database management).
- Prior experience in humanitarian assistance.
- Average salaries and social benefits.

Suppliers

- Available sources of health care goods (government, donations, commercial market).
- Type of suppliers (manufacturers, authorized distributors, importers, wholesalers).
- Availability of and audit of manufacturers.
- Supplier registration and certification (government, WHO etc.).
- Origin, general and stock availability, quality, lead times and prices of humanitarian assistance goods (drug products, single use medical devices and health care equipment).
- Quality assurance system of suppliers.
- Ability of and lead times for importation.
- Supplier services (warranty, delivery, maintenance, servicing), especially for equipment.

Customs

- Location of border crossings, seaports and airports.
- Customs laws and regulations for importation, exportation and transit of goods.
- Required custom documents.
- Responsible authorities.

- Taxes, duties, fees and possibility for applying for exemption.
- Procedures and lead times for customs clearance.
- Availability and cost of customs, clearing and forwarding agents.
- Office hours and possibility of clearing urgent consignments during after hours.
- Restrictions and procedures for controlled drugs.

Warehousing

- Availability, location, accessibility, size and capacity of commercial (government other humanitarian organizations) warehouses.
- Possibility to extend buildings.
- Size of receipt, quarantine and dispatch area.
- Accessibility for vehicles and trucks.
- Vicinity to major roads, railheads, seaports and airports.
- Loading docks and parking area for vehicles.
- Condition (soundness, roof, walls, hard floors, ventilation, lighting, fire proofing).
- Cleanliness and tidiness.
- Ownership and contact person.
- Cost for rent, leasing, buying or building warehouses (per month, per square metre).
- Insurance coverage against theft and war risk.
- Vicinity to military installations and conflict areas.
- Natural hazards (earth quakes, floods etc.).
- Security measures (perimeter barriers, lighting, guards, locks, barred windows etc.).
- Safety measures, especially fire prevention.
- Communications infrastructure (telephone, fax, Internet).
- Availability of power (mains electricity supply, electricity from generator sets).
- Availability, capacity and cost of heating, cooling and ventilation.
- Availability and qualifications of staff.
- Availability, capacity and condition of motorized (forklift trucks) and mechanical (hand pallet trucks) materials handling equipment.
- Availability, type, capacity and condition of storage equipment (pallets, shelving, pallet racking).
- Availability, type, quality and condition of refrigerators and ice-pack freezers.
- Availability of storage for dangerous goods.
- Number of items, volume and value of stock.
- Warehouse documentation, inventory control system and observance of stock rotation.
- Procedures for physical stock counts.

- Stock rotation.
- Batch traceability.
- Qualifications and competence of staff.

Distribution management

- Current suppliers of health care facilities.
- Location of stores, distance from customers and system of distribution.
- Main routes and distribution network (location of suppliers, warehouses and customers).
- Number of customers serviced.
- Number of orders, number of items and value of received orders.
- Procedures for treating orders.
- Average lead time for filling orders.
- Delivery frequency.

Transportation

- For all modes of transportation, the infrastructure (roads, bridges, seaports, airports) and the means of transportation (vehicles, vessels, aircraft) need to be considered.
- Availability, services and costs of freight forwarding agents.
- Possibility and infrastructure for intermodal transportation.

a) Animals (beasts of burden)

- Commonly used animals (donkeys, horses, camels, yaks, water buffaloes).
- Availability.
- Cost.
- Transportation capacity per animal.
- Daily transportation distance.
- Commonly used food.
- Availability of food along the transportation route.
- Availability, capacity and cost of carts.

b) Porters

- Availability.
- Cost.
- Transportation capacity per person.
- Daily transportation distance.
- Availability, capacity and cost of carts.
- Availability, capacity, daily travelling distance and cost of bicycles.

c) Road transport

- Infrastructure

- Geography of road network (map) and passable roads.
- Location, capacity, storage facilities of and handling equipment at transfer points (seaports, inland ports, railheads, airports).
- Possibility and capacity of intermodal transportation (loading and unloading of ISO shipping containers).
- Quality of roads and usability in different seasons (rain, snow etc.).
- Roads being passable for cars, four-wheel drive vehicles, small and heavy trucks.
- Restrictions on weight, axle load, length or height of vehicles (especially at bridges and in tunnels).
- Impassable routes (floods, construction work) and any damages.
- Availability of bypasses for damaged road sections and weight limitations.
- Type of roads (tracks, paved roads, highways etc.) and maximum load.
- Maximum average speed for travelling with vehicles.
- Location of bridges.
- Quality and reliability of bridges.
- Load capacity of bridges.
- Location of tunnels.
- Maximum width and height of vehicles allowed in tunnels.
- Breakdown services for vehicles.
- Availability and quality of workshops (for repair and maintenance).
- Availability of lubricants and replacement parts.
- Traffic control and emergency services.
- Type, availability and price of fuel.
- Geography of fuel distribution network.

- Means of transportation

- Availability, number, type, capacity and maximum pay load of commercial vehicles.
- Cost for renting, leasing and buying vehicles.
- Insurance of cargo for commercial transport.
- Transportation capacity of authorities, army and other humanitarian organizations.
- Availability and cost of drivers.
- Freight rates per tonne/km.

d) Rail transport

- Infrastructure

- Geography of single- and double track railway network and location of stations.
- Conditions of tracks.
- Location and condition of bridges.
- Damaged and blocked rail sections.
- Power source (electricity, diesel, coal) of locomotives.
- Availability of cargo handling equipment.
- Capacity for transporting and handling containers.

Means of transportation

- Type and condition of railway carriages.
- Capacity of railway network.
- Reliability of railway services.
- Freight cost per tonne/km.
- Timetables and transport times.

e) Sea transport

- Infrastructure

- Location of seaports.
- Depth of approach channels.
- Availability of tugboats.
- Size, accessibility and capacity of seaports.
- Availability, number and sizes of berths, piers and wharves as well as turning basins.
- Landing fees, cargo handling and other charges.
- Possibility of night operations.
- Capacity of and equipment (cranes) for handling of cargo.
- Possibility and capacity for container handling.
- Availability, services and cost of brokers.
- Availability, type, capacity and cost of storage facilities.
- Availability, cost and capacity of local labour.
- Working hours of the port.
- Type, availability and cost of fuel.
- Accessibility of seaports and connection with road and railway networks.

- Means of transportation

- Availability, type, capacity and cost of ships.

- Freight costs for sea transport.

f) Inland sea transport (inland navigation?)

- Infrastructure

- Geography of canals, rivers and lakes.
- Restrictions posed by bridges and locks.
- Availability, capacity and cost of locks.

- Means of transportation

- Availability, type, capacity and cost of vessels.
- Availability, type, capacity and cost of barges.

g) Air transportation

Infrastructure

- Location (coordinates), elevation and name of airstrips, airports and heliports or helicopter landing sites.
- Responsible authorities and contact person.
- Direction, type (grass, dirt, paved, asphalt concrete), length and width as well as condition of runways.
- Maximum load (size of aircraft) which can use runway.
- Availability and condition of runways and approach lighting.
- Seasonality of accessibility (rainy season, wintertime, fog etc.).
- Possibility of night operations, available facilities and condition.
- Availability of parking areas for (cargo) aircraft.
- Availability and condition of taxiways, parking areas as well cargo handling areas.
- Availability of storage facilities (if not at the airport, distance from the airport).
- Availability of lighting of cargo handling areas for night operations.
- Availability and capacity of cargo handling equipment and operators.
- Facilities for (mandatory) aircrew rest.
- Availability and services of terminal building.
- Availability, type, quantity and condition of cargo handling equipment (forklift trucks, scissor lifts, cargo dollies, trucks etc.).
- Availability of operators and fuel for cargo handling equipment.
- Availability, quantity and quality of fire fighting equipment.
- Landing fees.
- Hours of operation.
- Availability of navigational aids for guiding aircraft.

- Availability of meteorological monitoring equipment (temperature, wind direction, wind speed, clouds etc.).
- Availability, reliability and type of communication facilities.
- Possibility of communication from the ground with an aircraft in flight.
- Availability, quality and cost of aviation fuel quantities and quality.
- Availability of start-up equipment, including operators and fuel.
- Availability of maintenance operations (facilities, staff, hours).
- Distance and connection to major road networks and railheads.

- *Means of transportation*

- Availability of local air carriers and their rates (fixed and rotary wing aircraft).
- Availability of aircraft, their capacity and operating range.
- Name and services of owners and agents.
- Availability of local aircraft, pilots and maintenance staff.
- Local regulations for pilots (maximum flight hours, rest periods etc.).

- *Civil aviation*

- Authorities in charge of the airspace.
- Possibility of obtaining over flight and landing clearances.
- Availability of air traffic control services.
- Permission for civilian and military aircraft to land.
- Working hours of airport staff and possibility of working 24 hours.
- Landing fees and block charges.
- Availability of custom clearance.

Health care logistics

- Type, number and locations of existing health care facilities as well as number of beds at hospitals.
- Type and quantities of available drug products, medical devices and health care equipment.
- Current suppliers of health care facilities.
- Average demand of essential drug products and single use medical devices.
- Size, capacity and management of hospital pharmacies.
- Inventory control system used for replenishment orders.
- Availability, reliability and cost of maintenance services for medical equipment.

14.1.6 Logistics assessment of some humanitarian organizations

The World Food Programme has devised the "Logistics Capacity Assessments" (LCA), a formal assessments designed to obtain a baseline understanding of a region's food aid transportation infrastructure. It concentrates on critical components of the supply network, such as seaport capacities, road and rail networks, storage facilities, handling procedures, labour rates and local transportation resources. Particular attention is paid to identifying any physical or material shortcomings, which may result in bottlenecks in the food delivery "pipeline".

A technology used by MsF during the Rwanda crises and may gain importance, is the use of aerial photography. It allows locating displaced populations and estimating their numbers quickly and accurately.

14.2 Emergency intervention plan

At the time of establishing an emergency intervention plan for an expected or imminent emergency, a logistics assessment may or may not be available for the respective country (or countries). In the later case, to the extent available time allows, the logistics assessment will be be part of the initial contingency planning. Ideally the logistics assessment will include a detailed map which is developed using GIS software.

The national health care logistics plan in figure 14.1 can be used for developing an emergency intervention plan for a specific country and becomes a national health care logistics plan as soon as the intervention starts as in principle both plans require considering the same issues. As soon as a decision for establishing an emergency intervention plan is taken, health care logisticians start filling the template an start establishing, updating and completing supporting documents appended to the plan.

While the logistics assessment, provided the required information is available, studies and documents all available options, the emergency intervention plan includes the selected or a small number of most suitable options.

The emergency intervention planning starts with collection of basic information on the country (size, population, langue, culture etc.), an overall assessment of the general as well as humanitarian situation in the country by head office staff.

The starting point of any emergency intervention plan must be the planned, or at least envisaged, health programmes which are foreseen as soon as the decision for intervention is taken. These are planned according to an assessment of the humanitarian situation as well as the health services available in the country. Although at the outset, the planning of health care programmes may be very rudimentary, it will provide crucial information on the most likely places and areas of intervention, the likely target population and the expected number of beneficiaries. A rough estimate on the estimated budget as well as the number of staff will also have to be determined in the early stages.

The human resources section records logistics staff which are currently working on the emergency intervention plan or are designed to be join the team.

At the outset planning of the national standard list will be based on and limited to contingency stocks, mainly of kits, available at international and regional medical distribution centres.

Domestic purchase can be considered if the market for health care goods in the respective country is known and purchasing is at all possible.

National Health Care Logistics Plan	2011	[Country]	By [Name]	Last update [Date]

1 HEALTH PROGRAMMES

Manager at head office:	Country manager:	Health coordinator:

Programmes	Total budget	Direct costs	Health care goods	Expatriate staff	National staff
Programme [A]					
Programme [B]					
Programme [C]					
Programme [D]					
Total	**0**	**0**	**0**	**0**	**0**

2 HUMAN RESOURCES

Logistics Coordinator	Medical Logistician	Health coordinator:

Meetings with Health: [frequency] Logistics meetings: [frequency]

3 ITEM SELECTION: National standard list and contingency stocks

Last national SL revision: [month/year]	Line items: [number]	Contingency stocks revised: [month/year]

Site	Kit A	Kit B	Kit C	Kit D
Total	0	0	0	0

National Drug Act: [last update] Essential Drug List: [available?]

4 DOMESTIC PURCHASE

Validated suppliers: [number] Validated items: [number]

5 SUPPLY NETWORK

6 STORAGE

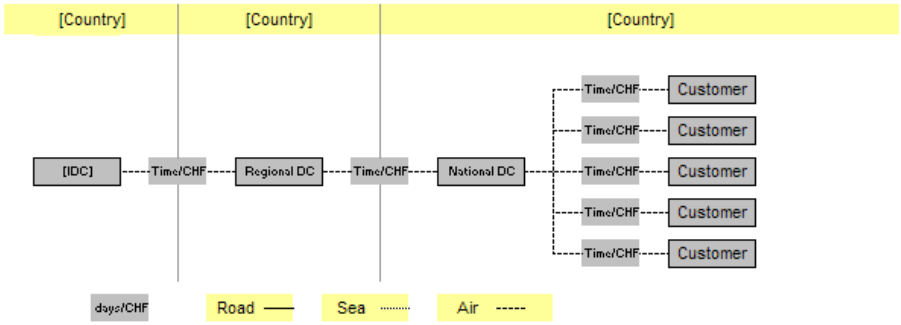
Place	Supervisor	Staff	Size/m²	Shelves/m³	Pallets/m³	A/C BtU	ock value/C	allet handlin	Refrigerator
Total		**0**	**0**	**0**	**0**		**0**		**0**

7 INVENTORY CONTROL AND STOCK REPLENISHMENT

Place	Forecast	Safety stock	Repl. lead time	Review period	OUL	Type of stock

Internationally controlled drug products: [review period]
Cold chain: [review period]
Dangerous goods: [review period]

8 PHYSICAL DISTRIBUTION AND CUSTOMS



Place	Motorbike	Passenger cars	Land cruisers	Trucks	Trailers	Air craft	Boats

Type of goods	Exportation from [country]	Importation into [country]
Health care goods		
Int. contr. drug products		
Cold chain		
General restrictions		

9 CUSTOMER SERVICE

Order leadtime: [days] Remaining shelf life: 6 mth Target stock availab.: 98% RO status: information system

APPENDICES

1 Health programmes
☐ Annual health plan and budget

2 Human resources
☐ Telephone numbers and emergency co
☐ Organization chart
☐ Job descriptions
☐ Medical Logistics library

3 Item selection
☐ National standard list
☐ List of contingency stocks
☐ National EDL

4 Domestic purchase
☐ Items validated for domestic purchase
☐ Financial regulations

6 Storage
☐ Warehouse plan
☐ Warehouse asset register
☐ Fire safety plan
☐ Cold chain emergency plan
☐ Cleaning plan
☐ Security plan (shelter)
☐ Warehouse maintenance plan

8 Physical distribution and customs
☐ Country map with supply network
☐ Importation procedures
☐ National Drug Act

9 Customer service
☐ Customer register
☐ Briefing for health staff
☐ Customer service plan

Figure 14.1 National health care logistics plan

The supply network planning should include several paths and points of entry to have alternatives in case modes or transportation, routes or points of entry into the country or area are blocked.

Storage considers temporary facilities at points of entry, if possible more permanent solutions and must, where necessary, plan for storage of cold chain goods.

The emergency intervention plan for physical distribution and delivery to customers should consider different modes of transportation and list commercially available transportation resources as well as means of transportation which can be quickly moved into the country.

Various supporting documents should be appended to the emergency intervention plan in a systematic way.

14.3 National health care logistics plan

Where health programmes are continued after an emergency intervention, the last version of emergency intervention plan can be simply updated and adapted if needed. For countries where the humanitarian organization has not been working before, a national health care logistics plan should be established as soon any new health programme is being planned. In any case the emergency response plan for the respective country should be integrated into the national health care logistics plan.

The national health care logistics plan should indicate facts and issues which are specific for the respective country but should not repeat information already available in standard operating procedures.

Documenting the current set-up on one only two pages allows giving a quick but comprehensive overview while details can be included in the various appendices.

The national health care logistics plan helps health care logisticians to keep an overview, is the basis for planning changes of resources and set-up, encourages continuity and consistency of management and provides a quick reference for briefing of staff.

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15 ITEM SELECTION

Preventive health care, diagnosis, medical and surgical treatment as well as nursing care and physical rehabilitation require a wide range of different health care goods. While (health care) logisticians dealing with health care goods do not need to be pharmacists or specialists for medical devices or health care equipment, they should have some basic understanding of different types of health care goods and their significance.

The term “item” is used for a drug product, single use medical device or piece of health care equipment with defined specifications but independently of any products from specific manufacturers which usually differ in the more detailed specifications. Therefore for any item such as a tablet, syringe or stethoscope usually many different (although very similar) products are available in the market which all suit the respective item specifications. The term health care goods will be used as a summary term for either items or products.

15.1 Classification of health care goods

Health care goods can first of all be divided into expendable goods which can only be used once and non-expendable health care equipment. Expendable health care goods can be further divided into drug products and single use medical devices.

Drug products can be very roughly divided according to their route of administration into external, enteral and parental products.

Single use medical devices can be classified by types which correspond to their function and field of application, such as dressing materials, catheters, injection materials, gloves or surgical sutures. Single use medical devices, many of which are sterile, can be used only once and must be discarded after use. Some medical devices such as certain injection devices, tubes or catheters may be available as single use or reusable products. However since reusable goods carry the risk of transmitting diseases if they are not cleaned and sterilized properly, single use medical devices goods are safer and generally preferred.

Health care facilities require a wide range of furniture as well as mechanical, electrical and electronic equipment for laboratory diagnosis, diagnostic imaging, anaesthesia, sterilization and especially surgery. Some pieces of equipment require various accessories (Kaur, M., et al. 2005, 56) such as filters, calibration liquids or single use parts for operation and require stocking replacement parts such as batteries, fuses, light bulbs or heating elements as well as special cleaning materials.

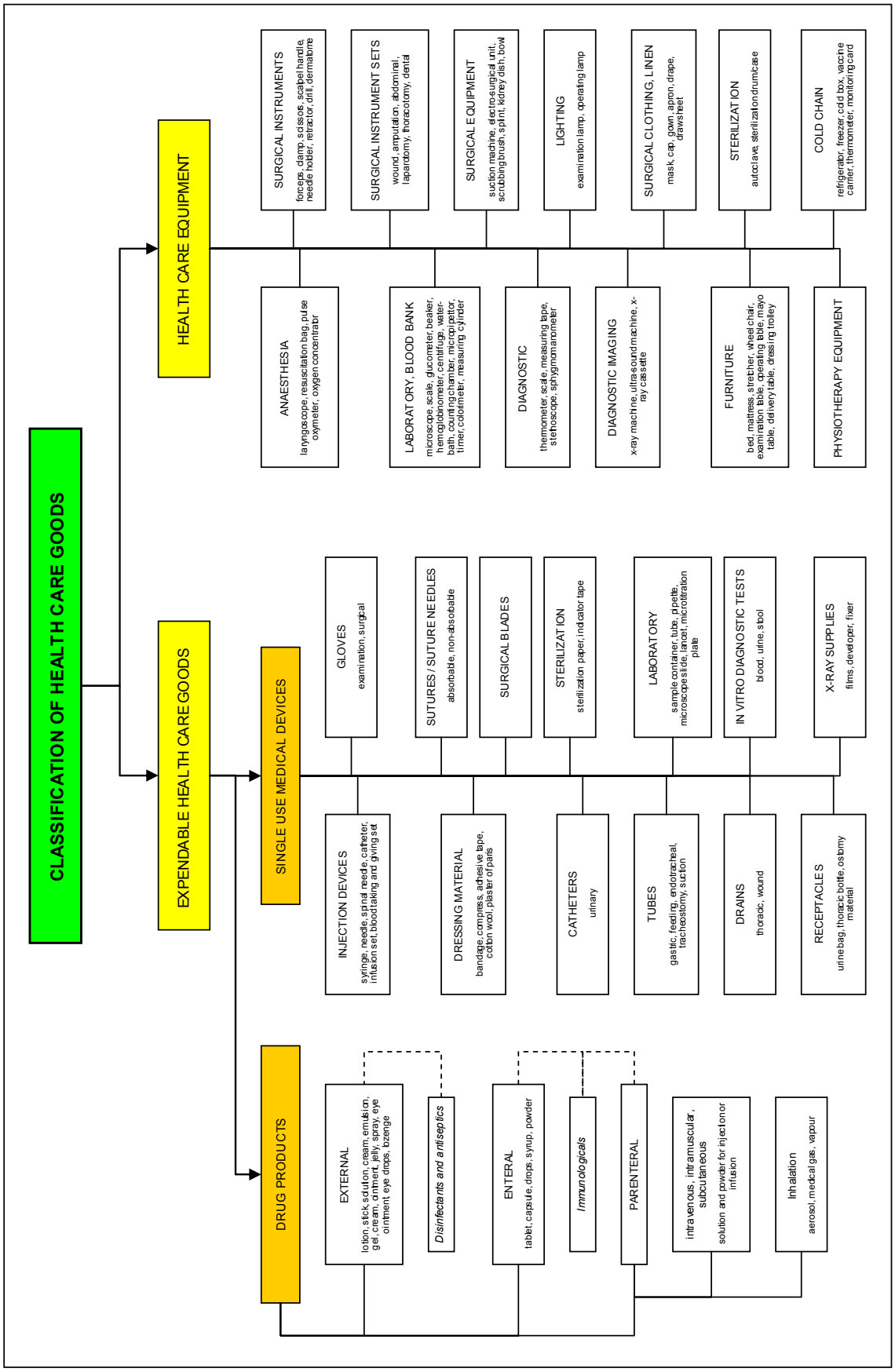

Figure 15.1 Classification of health care goods

15.2 Drug products

Drug products are defined as substances or mixtures of substances that are intended for treatment, mitigation, cure, prevention or diagnosis of diseases, abnormal physical states or symptoms, abnormal physiological conditions or the restoration, correction or modification of organic functions in humans (WHO 2007a, 307).

Finished drug products are drug products which have under gone all stages of production and quality control, are packaged in their final container intended for marketing and are labelled (WHO 2007a, 307). For the sake of simplicity and because humanitarian organizations deal only with finished drug products purchased from manufacturers, the term drug product is used for short throughout this handbook.

The substances, also called drug molecules ("molecules"), which cause the intended effect on the human body are called active pharmaceutical ingredients (API). Apart from their exact chemical names, the World Health Organization has established a standard nomenclature which assigns unique and universally applicable international nonproprietary names to substances regardless of the manufacturer. For example the chemical (2S,5R,6R)-3,3-dimethyl-7-oxo-6-[(phenoxyacetyl)amino]-4-thia-1-azabicyclo[3.2.0]heptane-2-carboxylic acid is assigned the INN phenoxymethlypenicillinum.

In addition to the active pharmaceutical ingredient(s), drug products may be formulated with various excipients such as fillers, diluents, thickeners, glidants, softeners, binders, emulsifiers, stabilizers, antimicrobial preservatives, solvents, lubricants, coatings, colorants, disintegrating and dispersing agents, flavours or sweetening agents.

The term pharmaceutical covers active pharmaceutical ingredients as well as excipients and their raw materials.

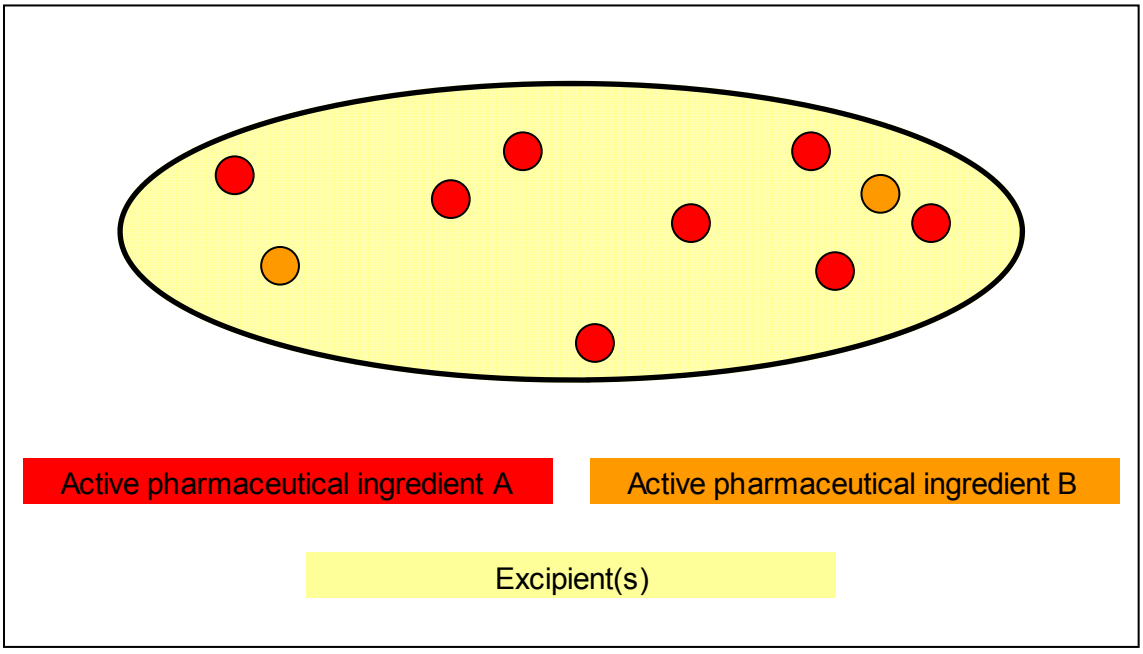

Figure 15.2 Components of drug products

15.2.1 Classification

Drug products can be classified by therapeutic group, their importance (VEN), their dosage form and the type of marketing authorization.

The classification according to pharmaceutical categories is not very convenient for logistics activities as it requires expert knowledge.

The WHO Model List (WHO 2007n) classifies drug products according to therapeutic categories and distinguishes between a core list for the most common and most important medical conditions as well as the complementary list.

1	Anaesthetics
1.1	General anaesthetics and oxygen
1.2	Local anaesthetics
1.3	Preoperative medication and sedation for short-term procedures
2.	Analgesics, antipyretics, non-steroidal anti-inflammatory medicines
2.1	Non-opioids and non-steroidal anti-inflammatory medicines
2.2	Opioid analgesics
2.3	Medicines used to treat gout
2.4	Disease modifying agents used in rheumatoid disorders
3	Antiallergics and medicines used in anaphylaxis
4	Antidotes and other substances used in poisonings
4.1	Non-specific
4.2	Specific
5	Anticonvulsants/Antiepileptics
6	Anti-infective medicines
6.1	Anthelminthics
6.1.1	Intestinal anthelminthics
6.1.2	Antifilarials
6.1.3	Antischistosomiasls and antitrematode medicine
6.2	Antibacterials
6.2.1	Beta Lactam medicines
6.2.2	Other antibacterials
6.2.3	Antileprosy medicines
6.2.4	Antituberculosis medicines
6.3	Antifungal medicines
6.4	Antiviral medicines
6.4.1	Antiherpes medicines
6.4.2	Antiretrovirals
6.4.2.1	Nucleoside/Nucleotide reverse transcriptase inhibitors
6.4.2.2	Non-nucleoside reverse transcriptase inhibitors
6.4.2.3	Protease inhibitors
6.4.3	Other antivirals
6.5	Antiprotozoal medicines
6.5.1	Antiamoebic and antigardiasis medicines
6.5.2	Antileishmaniasis medicines
6.5.3	Antimalarial medicines
6.5.3.1	For curative treatment
6.5.3.2	For prophylaxis

6.5.4	Antipneumocystosis and antitoxoplasmosis medicines
6.5.5	Antitrypanosomal medicines
6.5.5.1	African trypanosomiasis
6.5.5.2	American trypanosomiasis
7	Antimigraine medicines
7.1	For treatment of acute attack
7.2	For prophylaxis
8	Antineoplastic, immunosuppressive and medicines for palliative care
8.1	Immunosuppressive medicines
8.2	Cytotoxic medicines
8.3	Hormones and antihormones
8.4	Medicines used in palliative care
9	Antiparkinsonism medicines
10	Medicines affecting the blood
10.1	Antianaemia medicines
10.2	Medicines affecting coagulation
11	Blood products and plasma substitutes
11.1	Plasma substitutes
11.2	Plasma fractions for specific use
12	Cardiovascular medicines
12.1	Antianginal medicines
12.2	Antiarrythmic medicines
12.3	Antihypertensive medicines
12.4	Medicines used in heart failure
12.5	Antithrombotic medicines
12.6	Lipid-lowering agents
13	Dermatological medicines (topical)
15.1	Antifungal medicines
15.2	Anti-infective medicines
15.3	Anti-inflammatory and antipruritic medicines
15.4	Astringent medicines
15.5	Medicines affecting skin differentiation and proliferation
15.6	Scabicides and pediculicides
14	Diagnostic agents
14.1	Ophthalmic medicines
14.2	Radiocontrast media
15	Disinfectants and antiseptics
15.1	Antiseptics
15.2	Disinfectants
16	Diuretics

17	Gastrointestinal medicines
17.1	Antacids and other antiulcer medicines
17.2	Antiemetic medicines
17.3	Anti-inflammatory medicines
17.4	Laxatives
17.5	Medicines used in diarrhoea
17.5.1	Oral rehydration
17.5.2	Medicines for diarrhoea in children
17.5.3	Antidiarrhoeal (symptomatic) medicines in adults
18	Hormones, other endocrine medicines and contraceptives
18.1	Adrenal hormones and synthetic substitutes
18.2	Androgens
18.3	Contraceptives
18.3.1	Oral hormonal contraceptives
18.3.2	Injectable hormonal contraceptives
18.3.3	Intrauterine devices
18.3.4	Barrier methods
18.3.5	Implantable contraceptives
18.4	Estrogens
18.5	Insulin and other antidiabetic agents
18.6	Ovulation inducers
18.7	Progestogens
18.8	Thyroid hormones and antithyroid medicines
19	Immunologicals
19.1	Diagnostic agents
19.2	Sera and immunoglobulins
19.3	Vaccines
20	Muscle relaxants (peripherally-acting) and cholinesterase inhibitors
21	Ophthalmological preparations
21.1	Anti-infective agents
21.2	Anti-inflammatory agents
21.3	Local anaesthetics
21.4	Miotics and antiglaucoma medicines
21.5	Mydriatics
22	Oxytocics and antioxytocics
22.1	Oxytocics
22.2	Antioxytocics
23	Peritoneal dialysis solution
24	Psychotherapeutic medicines
24.1	Medicines used in psychotic disorders

24.2	Medicines used in mood disorders
24.2.1	Medicines used in depressive disorders
24.2.2	Medicines used in bipolar disorders
24.3	Medicines used in generalized anxiety and sleep disorders
24.4	Medicines used for obsessive compulsive disorders and panic attacks
24.5	Medicines used in substance dependence programmes
25	Medicines acting on the respiratory tract
25.1	Antiasthmatic and medicines for chronic obstructive pulmonary disease
25.2	Other medicines acting on the respiratory tract
26	Solutions correcting water, electrolyte and acid-base disturbances
26.1	Oral
26.2	Parenteral
26.3	Miscellaneous
27	Vitamins and minerals

Table 15.1 WHO classification of drug products

The VEN classification in vital, essential and non-essential allows prioritizing drug products according to their importance and impact on (public) health for example when prioritizing scarce resources (Quick, J.D. (ed.) 1997, 212).

The classification according to dosage forms is of great importance for logistics as different specific dosage forms often correspond to specific storage conditions and also have implications for the importance of quality assurance.

Dosage forms are types of formulated preparations which are designed for a specific way of delivery and routes of administration (see table 15.2).

Most solid dosage forms are intended for oral administration.

Tablets are usually made by compressing powders or granulations into a large variety of sizes and shapes and may have lines, break-marks or surface markings. They are usually intended for oral administration by swallowing, chewing, absorption directly in the mouth (buccal, sublingual) or dissolution or dispersion in liquids prior to administration

Tablets may be coated in order to protect them from air, moisture or light, masking unpleasant tastes and odours or improving their appearance. Gastro-resistant coatings prevent destruction or inactivation by gastric acid or irritation of the gastric mucosa and delay disintegration and release of active pharmaceutical ingredients until after passing through the stomach. Modified-release tablets are formulated that they release the active pharmaceutical ingredient over a certain (extended) period of time.

Capsules contain powders, granules or liquids which are enclosed in soft or hard shells of various shapes and sizes which are soluble and usually made from gelatin or starch.

Granules are dry aggregates of powder particles which are intended for oral administration with or without prior dissolution or dispersion in liquids.

Lozenges are solid preparations which are formulated to dissolve or disintegrate slowly in the mouth and usually intended for treatment of local infections.

Medicated chewing gums contain active pharmaceutical ingredients which are released during chewing and absorbed in the mouth or gastrointestinal tract.

Solid

- Tablet (uncoated, coated, gastro-resistant, modified-release, chewable, soluble).
- Capsule (hard, soft, gastro-resistant, modified-release).
- Granules (coated, gastro-resistant, modified-release).
- Lozenge (oral).
- Medicated chewing gums.
- Powder for reconstitution (oral, injection or intravenous infusions).
- Topical powder.
- Implant.
- Stick (for wounds).
- Suppository.

Semi-solid

- Ointment (hydrophobic, hydrophilic, ophthalmic).
- Paste.
- Cream (hydrophobic, hydrophilic).
- Gels (hydrophobic, hydrophilic).

Liquid

- Solution (oral).
- Drops (oral, eye, ear, nose).
- Spray (nasal).
- Suspension (oral).
- Emulsions (oral)
- Solution (injection, infusions, irrigation, dialysis).
- Washes (mouth, nose, ear, eye).
- Lotions (cutaneous application).
- Topical suspensions (cutaneous application).
- Shampoos (skin, scalp).
- Paints (skin, mucous membranes).

Preparations for inhalation

- Aerosol.
- Vapours (evaporated liquids).
- Powders.
- Gases (anaesthetics, oxygen).

Table 15.2 Different dosage forms of drug products

Powders for oral administration are dissolved or dispersed before ingestion. Some drug products for injection or infusion are formulated as powders because they are not stable (vaccines) as solutions or prone to biological contamination (syrups). They require reconstitution with diluents after which they can be used only for a limited period of time.

Topical powders are intended for application on wounds or injured skin.

Implants are solid preparations which are usually placed subcutaneously with a special injector and release their active pharmaceutical ingredients (often hormones) over a period of time.

Sticks are conical or rod-shaped solid dosage forms for local application which are formulated to dissolve or disperse at body temperature for example in wounds.

Suppositories are solid dosage forms which release their active pharmaceutical ingredient after melting or dissolving at body temperature and are usually intended for rectal application.

Ointments are semi-solid, single-phase formulations in which solids or liquids are dispersed and intended for external application to the skin or mucous membranes, in particular to the eyes.

Pastes are also intended for topical application but contain more dispersed solids than ointments and are therefore stiffer.

Creams consist of lipophilic and aqueous phases in which active pharmaceutical ingredients are dissolved or dispersed for application to the skin or mucous membranes.

Gels (sometimes also called jellies) are formed by particles linking together to a network which holds a liquid.

Oral solutions are liquids containing dissolved active pharmaceutical ingredients and are administered by ingestion. Solutions containing alcohol may be called spirits or elixirs. Syrups are concentrated solutions of sugars or sweetening agents which contain active pharmaceutical ingredients and sometimes are flavoured and coloured.

Drops may be diluted in liquids for oral administration or applied to the eye, ear or nose with droppers. Liquids may also be applied to the nose in sprays.

Suspensions are liquids for oral or topical application which contain solid and not soluble particles and which are therefore dispersed throughout the liquid phase. They may be formulated as powders which require reconstitution before administration.

Oral emulsions are two-phase systems in which one liquid is dispersed throughout the other liquid in small droplets. The oil-in-water or water-in-oil emulsions require stabilization by emulsifying agents which prevent the droplets from merging which eventually would lead to a separation of phases. The active pharmaceutical ingredients may be dissolved in either or both of the phases.

Solutions are liquids in which active pharmaceutical ingredients may be dissolved (uniformly dispersed) and are intended for injection, infusion, irrigation (rinsing of wounds or body cavities) or dialysis.

Washes are liquids containing active pharmaceutical ingredients which are applied to mucous membranes, for examples eyes or mouth, and may require prior dilution.

Lotions are emulsions with low viscosity which are intended for topical application to intact skin.

Topical suspensions are liquids which contain dispersed solid particles and are intended for application to intact skin.

Shampoos are liquid preparations containing active pharmaceutical ingredients which form foam upon rubbing with water and are usually applied to the scalp.

Paints are applied to mucous membranes or the skin and form a film after the liquid evaporates.

Drug products may be administered by inhalation into the lungs for either local effects on the lungs or systemic effects.

Aerosols are dispersions of liquid or solid particles in gas which are administered with pressurized canisters or dry-powder inhalers. Liquids containing active pharmaceutical ingredients can be evaporated in vaporizers or nebulizers before inhalation. Volatile

anaesthetics are evaporated in specially designed vaporizers which allow mixing them with other gases and accurately adjusting the concentration.

Medical gases such as oxygen or nitrous oxide are administered through face masks or endotracheal tubes.

The routes of administration (see table 15.3) of drug products are the most useful classification of drug products as they widely correspond to different types of packaging, physical characteristics as well as storage conditions.

Drug products can be applied externally to the skin, ear, nose or mouth. Ophthalmic preparations are often considered separately as contamination can cause harm to the eyes and even blindness and these drug products must be sterile.

The most common way of administration of drug products is enterally, by absorption through the gastrointestinal tract. Drug products can be absorbed though mucous membranes in the mouth, the stomach or intestines.

As drug products may be destroyed or inactivated during their passage through the gastrointestinal system or are not absorbed at all, drugs can be administered by circumventing the gastrointestinal system. Drug products can be administered by intradermal (into the skin), subcutaneous (under the skin), intramuscular (into muscles), intravascular (into blood vessels), intraspinal (into the spinal fluid) or intraosseous (into the bone marrow) injection or infusion.

Drug products can also be applied topically during operations through implantation or irrigation of wounds or body cavities.

Drug products such as oxygen, volatile anaesthetics or antiasthmatics can be administered directly through the respiratory system.

Some disinfectants as well as in vitro diagnostic tests are not applied to patients directly.

External

- Topical application (skin, ear, nose, mouth).
- Ophthalmic preparations.

Enteral

- Oral.
- Rectal.

Parenteral

- Injection and infusion.
- Irrigation.
- Implantation.
- Inhalation.

Table 15.3 Routes of administration

Over the counter (OTC) drug products show minimum side-effects and toxicity and can be soled by licensed distributors without requiring customers to present a medical prescription (nonprescription drugs). Prescription drugs (prescription only medicines) require prescription by a licensed and registered health professional and must be dispensed only by a licensed pharmacist.

15.2.2 Quality standards

The national drug regulatory authorities which may be a Ministry, department or agency, determine the quality and manufacturing standards for their respective countries which are codified in the respective national pharmacopoeias. However, as establishing and updating pharmacopoeias requires considerable resources, and are not available in many countries, manufacturers may manufacture according to internationally recognized standards such as the British, Japanese or European Pharmacopoeia.

The World Health Organization has published The International Pharmacopoeia (WHO 2003b) with quality standards for essential drug products which are adapted to resources of less developed countries and allow national drug regulatory authorities to develop their own standards.

Pharmacopoeias provide chemical definitions of drug molecules, define tolerances for their concentrations and describe their characteristics. Moreover they define and describe analytical test methods (assays) for identifying molecules (substances) as well as their concentration, purity and potency (Beringer, P. et al. 2006, 496).

Pharmacopoeias generally contain monographs on raw materials of active pharmaceutical ingredients and excipients as well as monographs on dosage forms which include, for example, tests on disintegration, dissolution and for sterility.

Any drug product must comply with a range of quality criteria (see table 15.4).

- Identity (active pharmaceutical ingredients and excipients).
- Purity.
- Potency (concentration of all ingredients).
- Uniformity of dosage form (size, shape, colour and consistency).
- Bioavailability.
- Stability.

Table 15.4 Quality criteria for drug products

Drug products must contain the correct active pharmaceutical ingredients as well as excipients which are indicated in the product information and stated in the pharmacopoeial standard to which the dosage form was manufactured.

Dosage forms must contain only the stated ingredients and must not be contaminated with impurities such as degradation products, other ingredients, visible particulate or foreign matter which may be harmful. Especially sterile dosage forms must be free from micro-organisms as well as bacterial cells or endotoxins produced by micro-organisms which are not destroyed by sterilization and can cause an increase in body temperature (pyrogens).

The contents and concentration of active pharmaceutical ingredients of each unit of a dosage form must be within the ranges stated by the respective pharmacopoeia. As it is nearly impossible to manufacture dosage forms without any variations, the British Pharmacopoeia for example allows tolerances of between 99% and 101% of paracetamol.

Strength of a drug product = contents or concentration of active pharmaceutical ingredients.

Dosage of a drug product = prescribed quantity (per administration or day)

The size, weight, volume, shape, colour and consistency should be uniform and should not vary among different units of the same drug product. Lack of uniformity may not impair safety or efficacy of dosage forms but may indicate problems with the manufacturing process and may reduce acceptability by health professionals and patients.

Compliance with quality requirements for all the above mentioned criteria alone does not guarantee the required bioavailability of active pharmaceutical ingredients as due to its formulation the drug product may not dissolve and be absorbed in the intended way. The intended therapeutic effect requires the concentration of active pharmaceutical ingredients to reach a certain level at the respective site or organ within a defined period of time and for a certain length of time. For drug products which are administered into or absorbed into the blood stream, the blood plasma concentration of the active pharmaceutical ingredient(s) is the measure for bioavailability. The bioavailability can only be determined by clinical tests.

All dosage forms intended for application into the eye or parenteral administration must be sterile. Solutions for injection and infusion in particular must not contain any particles, chemical impurities, micro-organisms or pyrogens which can cause an increase in body temperature. Any drug products which contain two or more phases must be homogenous and must not show any signs of phase separation.

In addition to compliance with all the quality criteria mentioned above, drug products must be stable over the shelf life stated by the manufacturer.

Stability is defined as the ability of a finished drug product in its primary packaging to retain its chemical, physical, microbiological and biopharmaceutical properties within specified limits throughout its shelf-life (WHO 1997a, 49) provided it was always subject to the storage conditions specified by the manufacturer since the time of manufacture.

Drug products do not suddenly lose their efficacy on their date of expiry but rather degrade, decompose and deteriorate slowly with a decrease in the contents and concentration of active pharmaceutical ingredients and possibly the formation of toxic products. Moreover vaccines and other drug products may be instantly and irreversible damaged if they are frozen even for a very short period of time.

The stability of drug products is affected by product related factors such as physical and chemical properties and the packaging as well as environmental factors during transportation, handling and storage (see table 15.5).

- Dosage form.
- Composition of the dosage form (ingredients and quantities).
- Stability of active pharmaceutical ingredients and excipients.
- Physical and chemical interaction between ingredients.
- Formulation and manufacturing process.
- Packaging material and system (container and closure system).
- Environmental conditions during transportation, handling and storage.
- Time elapsed since the time of manufacture.

Table 15.5 Factors affecting the stability of drug products

Drug products are composed of chemicals which, depending on their temperature, tend to react with each other, even after the manufacturing and packaging process is completed.

Their may be several reasons for the instability of dosage forms. Various ingredients of the dosage form may be incompatible and react in an undesirable manner which may not leave any visible signs or may lead to precipitation or a change in colour (Gennaro (ed.) 1995, 642).

Oxidation, even if it may occur very slowly at room temperature, is one of the primary causes for instability of drug products (Gennaro (ed.) 1995, 642).

Some ingredients are prone to hydrolysis (splitting of water molecules into hydrogen cations and hydroxide anions), the rate of which depends, among others, on the temperature and the content of water and moisture.

The changing from an optically active compound into a pharmacologically less active form (racemization) is accelerated by increased temperatures as well as light and a major factor of pharmaceutical instability (Gennaro (ed.) 1995, 642).

The absorption of the energy of visible, infrared and ultraviolet light by drug products can lead to photochemical reactions and photolytic degradation (Gennaro (ed.) 1995, 642), catalyse various reactions in drug products and, for example, increase oxidation and hydrolysis.

According to the relationship found by Arrhenius, the rate of thermal degradation increases exponentially with the increase of temperature. The rate of most chemical reactions increases with an increase of temperature and typically an increase of 10° Celsius leads to a two- to five-fold increase in the decay of ingredients (Aulton, M.E. 1988, 243). The provision of energy by increasing the temperature may initiate and accelerate all chemical reactions such as oxidation and hydrolysis.

Moreover an increase of temperatures may lead to degradation by physical changes such as melting of suppositories and the phase-separation of emulsions.

Drug products may also degrade and become contaminated by interaction with their packaging material. Chemicals from the dosage form may be absorbed into the packaging material and chemicals from the packaging material may be dissolved in the drug products. Such changes can lead to degradation of dosage forms, increase in toxicity, precipitation as well as colour change (Aulton, M.E. 1988, 219) and dosage forms may become contaminated with glass or plastic particles.

The degradation and contamination of dosage forms may or may not be visible. Therefore the absence of visually detectable changes by no means implies the absence of deterioration.

Manifestations of degradation of dosage forms may be changes and variations in colour, discolouration, unusual smells (caused by formation of gases), rancidity of oils, interactions with packaging materials and contamination with visible particles.

Visible changes in solid dosage forms may be capping (horizontal fracturing and separation into two parts), laminating (separation into several horizontal layers), chipping, cracking, splitting, breaking, crumbling and inhomogeneous surfaces as well as changes in consistency (stickiness, melting or hardening).

In liquid dosage forms degradation may manifest itself in agglomeration, sedimentation, caking, crystallization and phase separation of emulsions which cannot be reversed by moderate shaking. Moreover the appearance of particles, turbidity and precipitations.

Manufacturers determine the influence of temperature variations, humidity, light and other variables over time by carrying out extensive stability studies during development of new drug products and as a requirement for obtaining a marketing authorization. Stability tests are performed on finished drug products in their final packaging foreseen for marketing.

Real-time stability studies are conducted at temperatures of + 25° Celsius and a relative humidity of 60% over a period of at least 6 months for the initial registration process but are continued over the foreseen shelf-life. The results of the subsequent tests must all remain within the stated specifications of the drug product.

Accelerated stability studies at + 40° Celsius and a relative humidity of 75% allow shortening the testing time by determining any degradation and inferring the degradation of drug products maintained within the recommended storage conditions.

One of the main objectives of stability studies is establishing the required storage conditions as well as the shelf life of a drug product which usually varies between six months and five years. The expiry date is determined by adding the shelf life established for each drug product to the manufacturing date.

The manufacturer guarantees that all characteristics of drug products remain within the stated specifications until the date of expiry, provided that they have been kept within the storage conditions indicated by the manufacturer during transportation, storage and handling from the day of manufacture and the packaging was not opened. If the expiry date indicates only the month of a year, the drug product can be safely used until the last day of that month.

In order to extend the shelf life of less stable drug products, manufacturers may add an excess amount (overage) of active pharmaceutical ingredients (Gennaro (ed.) 1995, 645) provided that the quantity and concentration remains within the range specified by the respective pharmacopoeial standard. Figure 15.3 shows and example of a drug product which requires the concentration of the active pharmaceutical ingredient to remain between 110 - 130% of the stated concentration.

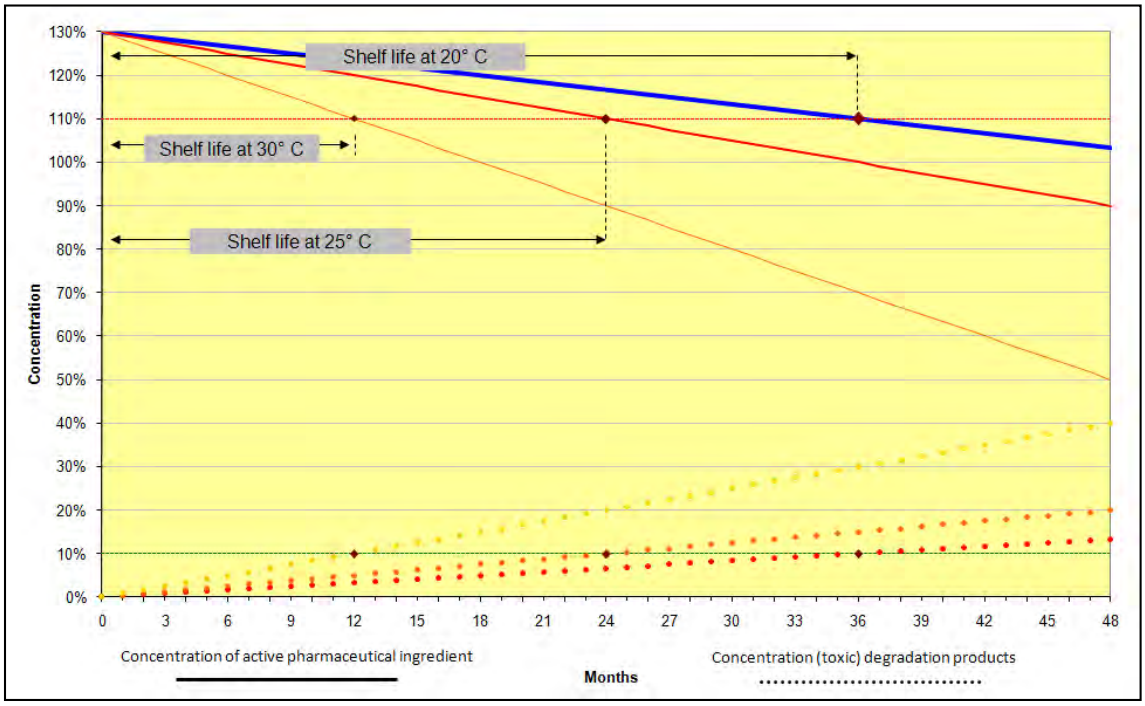

Figure 15.3 Decrease of contents of active pharmaceutical ingredient over time

The contents of drug products after their expiry date are likely to be outside stated specifications with the risk of underdosing and possibly administering drug products with unacceptable levels of (toxic) degradation products.

Storage of drug products outside recommended storage conditions may only reduce their shelf life but could also lead to immediate damage which makes the drug product unusable and possibly dangerous. For example, cold chain items may be irreversibly damaged within a very short period of exposure to room temperature.

In addition to the expiry date, manufacturers must state an utilization period for multidose containers of sterile drug products or which require reconstitution before administration. Reconstituted drug products are usually stable only for a few days, opened multidose containers are prone to biological contamination and must be discarded after the stated utilization period, even if the expiry date has not been reached.

The consequences of poor drug quality basically correspond to those of counterfeit and substandard drug products (see table 14.10.).

15.2.3 Packaging

Drug products often have several different levels of packaging. The primary packaging, also called immediate container, is (by definition) in direct physical contact with the drug product, for example blister packaging, tubes or bottles.

Primary packages, such as a bottle of syrup or a hospital packaging of tablets, may be labelled and marketed directly or one or several primary packagings, for example blister packagings, may be consolidated in secondary packaging, for example a carton box.

Manufacturers often pack several primary or secondary packagings into marked and labelled transport packaging intended for distribution.

Packaging of drug products has several important functions (see table 15.6). One of the primary functions is preserving drug products from mechanical, physical and chemical damage as well as contamination (WHO 2002e, 121) which may impair its quality.

Packaging provides mechanical protection of drug products against physical damage such as pressure (stacking during transportation and storage) and shocks which would could cause breakage of solid dosage forms.

Some drug products require protection from oxygen (for example by blister packaging), ultraviolet radiation or light (for example by coloured glass), moisture, humidity and water (for example by plastic containers).

Sealed packaging also protects drug products against biological contamination such as from fungus, dirtying (dust) as well as vermin (insects).

Special tamper-evident containers discourage opening and therefore provide some degree of protection from adulteration, tampering and theft. These may be designed as film wrappers, blister packaging, heat-shrunk bands or wrappers, paper foil, plastic packs, bottles with inner mouth seals, tape seals, breakable cap-ring systems or sealed tubes (WHO 2002e, 135).

Child-resistant packaging is specially designed to prevent or at least discourage and delay accidental opening by and poisoning of children.

Containment, especially of liquid and semi-solid dosage forms, as well as preventing diffusion and permeation is one of the most fundamental functions of packaging which enable them to be transported, stored and used. Moreover packaging consolidates several units and facilitates handling.

Packaging generally serves as containers for dispensing and some packaging, especially for liquids, may provide simple metering devices such as graduations on bottles.

Packaging is essential for identification of drug products in stores, by health professionals as well as patients and serves manufacturers for presentation and marketing purposes.

Packaging of drug products as well as enclosed printed information are an important source of information for health professionals and patients and especially outer packaging allows displaying important warnings.

The (elaborate and sophisticated) design of packaging and various security features impedes and therefore discourages counterfeiting.

- Mechanical protection (physical damage, pressure, shocks, breakage etc.).
- Environmental protection (air, oxygen, ultraviolet radiation, light, moisture, humidity, water).
- Protection against biological contamination (fungus).
- Protection against dirtying (dust).
- Protection against vermin (insects).
- Protection against adulteration.
- Discouraging tampering and theft.
- Protection of children.
- Containment (especially liquid and semi-liquid dosage forms).
- Consolidation.
- Facilitation of handling.
- Dispenser (and possibly metering device).
- Identification (of contents).
- Product presentation and marketing.
- Carrier for product information (communication).
- Display of warnings for health professionals and patients.
- Impeding counterfeiting.

Table 15.6 Functions of packaging of drug products

Primary packaging materials used for manufacturing containers as well as closures must fulfil a range of requirements (see table 15.7).

The packaging material must be compatible with and must not be degraded by the packaged drug product over the full shelf life stated by the manufacturer and different packaging components must be compatible with each other. The packaging material must be chemically inert, must not react chemically or physically with the drug product and must not alter the drug product or its quality in any way.

No ingredients must be adsorb or absorbed by the packaging material. On the other hand the packaging material must not release any chemicals (such as plasticizers) which leach into the drug product or any visible or subvisible particles (rubber, glass etc.). The packaging material must also prevent (reverse) permeation (migration) of vapours and substances (such as inks from printing or labels) through the packaging material.

Packaging material must be sufficiently robust and rigid to form a container which can hold the drug product and withstand handling.

Packaging material must be resistant and highly impermeable to water, moisture and vapour.

For some types of containers, the packaging material must be light-resistant (opaque) while some containers, especially for liquid dosage forms, must be highly transparent in order to allow detection of discolouration, particles or other changes of its contents.

Packaging material must withstand the respective manufacturing process, especially if sterilization is required and should cause minimal environmental harm after final disposal.

- Compatibility with packaged drug products.
- No degradation of packaging material through contact with drug product.
- Chemical inertness (no interaction with drug products).
- Absence of chemical reactions between the packaging material and the drug product.
- No adsorption or absorption of ingredients by the packaging material.
- No release of chemicals and leaching of chemicals from the packaging materials into drug products.
- No release of visible or subvisible particles (rubber, glass etc.).
- Robustness and rigidity.
- Resistant to humidity and moisture.
- Impermeability to water, moisture and vapour.
- Light-resistance (possibly).
- Transparency (possibly, especially for liquid dosage forms).
- Resistance to the manufacturing process (especially sterilization).
- Minimal environmental harm after final disposal.

Table 15.7 Requirements for primary packaging materials

Various types of paper, plastics, glass and metals can be used for manufacturing immediate containers and closures.

Glass is often the material of choice for bottles, ampoules, vials, cartridges and injection syringes especially for corrosive substances. Glass is a robust and strong material, chemically very inert, can resist sterilization, can contain liquids and can be made very transparent but has the disadvantage of being brittle, breakable and heavy.

Various types of plastics such as high-density and low-density polyethylene, polyethylene terephthalate (PET), polystyrene, polyvinyl chloride (PVC), polypropylene or nylon are commonly used as packaging materials for bottles, bags, tubes and closures. These materials are nearly unbreakable, flexible and collapsible, can contain liquids, can be made transparent, are light weight and can be deflated before disposal. Plastic pouches allow the use of pressure cuffs and also deflate as the infusion solution is drained and, compared to rigid bottles, eliminate the danger of aerial contamination from air entering though the air inlet of the infusion set. However, some plastics are permeable to gases (oxygen), moisture or vapour and plastic containers can be punctured or cut fairly easily and may leak. Most plastics also have the disadvantage of not being as clear as glass and therefore impeding inspection and detection of contamination. Closures of water tight containers are often made from rubber.

Metal, mainly aluminium and stainless steel, is used for foils for blister packaging, (collapsible) tubes, (rigid) cans, aerosol containers which may be lined or coated as well as gas cylinders. Metal is strong and robust, unbreakable, does not shatter, impermeable to gases and light-resistant but can be used only for non-parenteral dosage forms.

Closures such as stoppers for vials and bottles as well as plungers for prefilled syringes are made from plastic (polyethylene or polypropylene) or elastomeric materials such as rubber.

Immediate containers and their closures, which are in direct contact with the drug product, must fulfil a number of requirements (see table 15.8) and addition to the requirements of the materials they are made of which were discussed earlier.

Drug products which are manufactured in conformity to pharmacopoeias must likewise conform to the respective quality requirements and testing methods which are stipulated for primary packaging materials, containers and closures in some pharmacopoeias. Studying the suitability and stability of packaging materials as well as their compatibility with the drug products is part of the development and design process for new products.

Containers and closures must be suitable for the manufacturing process, especially for filling, additional packaging and sterilization where applicable.

The entire container and its closure must be robust enough to contain the goods, withstand normal handling and withstand the pressure from stacking of transport packaging.

Ideally, all packaging should be tamper-evident by fitting devices which withstand usual handling but irreversibly reveal that the container has been opened. Tamper-evident packaging may be achieved by foils (blister packaging, sealed bottles), aluminium caps (vials) or plastic strips on bottles which must be removed before opening them the first time. Tamper-evident packaging reduce the risk of pilfering and adulteration of drug products.

Containers must close tightly in order to contain drug products and provide protection, at least, from contamination with dust, particles and solids. It must be possible to tightly re-close multidose containers, such as cans or bottles with tablets, several times. For sterile drug products in multidose containers, withdrawal of liquids must be possible throughout the stated utilization period without any contamination.

Depending on the drug product the container and its closure must provide safe protection against mechanical, physical and chemical damage and may have to be transparent or be light-resistant (visible and ultraviolet light). Desiccants such as silica gel may be placed inside containers to absorb humidity and protect drug products.

For protection against air and oxygen, some drug products may require airtight containers such as sealed plastic bottles or blister packaging.

Containers and closure systems must be convenient and easy to use for patients, health professionals and dispensing pharmacists in terms of size, weight, opening as well as re-closing (where applicable) as well as allow safe administration of drug products to patients.

- Compliance with pharmacopoeial standards (where applicable).
- Suitable for the manufacturing process (especially filling and sterilization).
- Robust.
- Tightly closing and re-closing (where applicable).
- Tamper-evident packaging.
- Protection against physical, chemical and biological influences.
- Transparency or light-resistance.
- Airtight (where applicable).
- Convenience and ease of use.
- Allow safe administration to patients.

Table 15.8 Requirements for containers and closures

Immediate containers are devices comprising the container, possibly liners as well as closure (systems) which are intended to contain and hold drug products with which they are in direct contact (WHO 2002e, 122).

Reclosable glass, plastic or metal bottles, cans or jars with lids or screw-tops are used for solid or semi-solid dosage forms.

Blisters consist of aluminium or plastic forms which hold individual tablets, capsules or ampoules and a plane paper, plastic or metal foil which firmly adheres to the entire surface of the plastic form.

Sachets are made from paper, plastic or aluminium foil and hold individual doses of solid dosage forms such as tablets or powders.

Collapsible plastic or aluminium tubes, which may be lined or coated and sealed, are used as containers for semi-solid dosage forms. Possibly after breaking the seal, the contents is released through the nozzle by squeezing the tube which can closed with a cap.

Ampoules are glass tubes with a bulb at one end (one ended ampoule) which should be autobreakable and allow removal without the need for prior filing (WHO 2002c, 49). Plastic ampoules are usually opened by breaking the closure through twisting. As glass ampoules are breakable they should be packaged in blister packaging, paper or plastic trays and be protected by outer cartons.

Vials are glass bottles which are closed with a rubber stopper which is in turn secured to the bottle with an aluminium or plastic cap (overseal) which are crimped under the lip of the vial or bottle to hold them in place. Vials are used for liquid dosage forms or powders which require reconstitution before administration. After removing the cap, the required amounts of liquid can be withdrawn by piercing the rubber stopper without the need for removing the stopper and therefore maintaining protection of the solution. After withdrawing the needle the elasticity will reseal the stopper and protect the remaining contents from contamination for future use throughout the stated utilization period. The entire cap and stopper must never be removed as the solution will be exposed to contamination and lose its sterility immediately.

Cartridges are cylindrical containers with a rubber stopper which hold liquid dosage forms for administration, usually in dentistry, with a specially designed apparatus.

Prefilled syringes with plungers and with or without attached needles (themselves fitted with protective caps) are mainly used for single doses of vaccines.

Glass, plastic or metal bottles with tightly fitting lids or screw-tops are used for packaging liquids dosage forms.

Infusion solutions can be packaged in transparent glass bottles with rubber stoppers and aluminium caps or (collapsible) plastic bottles, bags or pouches with rubber or plastic stoppers and aluminium or plastic caps (overseals). Infusion solutions are administered through giving sets which are pierced through the stopper after removing the cap and are intended for single use. The opening will not close if the giving set is withdrawn which would expose the remaining infusion solution to contamination. However, administration of infusion solutions can be interrupted for short periods of time by closing the clamp on the giving set.

Containers must be sturdy, unbreakable, leakproof and transparent in order to allow detection of any particles or discolouration.

In order to allow hanging infusion bottles upside-down, disposable plastic hangers should be provided for each glass bottle or hanging devices should be integrated in plastic bottles.

Aerosol canisters are complex devices which serve as a container as well as a complete drug delivery system for one or several active pharmaceutical ingredients dispersed as solids or liquids in a gas. The pressurized devices are comprised of a strong and shatter-proof container, active pharmaceutical ingredient(s), the propellant (gas), a valve and actuator. The contents is released at atmospheric pressure and room temperature upon pressing the actuator.

Gas cylinders are made from metal or composite materials and hold medical gases under high pressure. They are fitted with a regulator which allows reducing the pressure and regulating the outflow of gases such as oxygen or nitrous oxide at room temperature and atmospheric pressure.

- Bottle, can or jar with lid or screw-top.
- Blister packaging.
- Sachet.
- Tube with cap.
- Ampoule.
- Vial with rubber stopper (and aluminium cap).
- Cartridge.
- Prefilled syringe.
- Infusion bottle, bag and pouch with rubber or plastic stopper (and aluminium or plastic cap).
- Aerosol canisters.
- Gas cylinders.

Table 15.9 Types of immediate containers

Single-dose containers such as sachets, blister packaging, tubes or ampoules hold a single dose of solid, semi-solid or liquid dosage forms while multiple-dose containers hold several tablets, capsules or powders and liquids for several administrations.

Device packaging comprises the dosage form as well as an administration device such as a dropper, applicator, prefilled syringe or an aerosol canister which increases convenience as well as safety of application.

Multiple-dose containers such as cans, tubes, bottles, vials and aerosol canisters allow repeated withdrawal of solid, semi-solid or liquid dosage forms. Multiple-dose containers containing sterile liquids are resealed through self-sealing rubber stoppers.

Containers for tablets and capsules may be designed to hold small quantities (for example 5 - 10 units) or large quantities of up to 1,000 units.

Smaller packaging quantities are used faster, reduce the risk of expiry and are generally safer in terms of stability of drug products. However drug products packaged in smaller quantities are more expensive, occupy more volume and require more time for handling and counting.

Solid dosage forms packaged in larger packaging quantities ("hospital packs") are cheaper per unit and occupy less volume and space. However containers have to be repeatedly opened and closed and drug products have to be dispensed and possibly repackaged by a pharmacist with all the associated risks, especially the danger of confusion.

15.2.4 Labelling and package inserts

Labelling designates any display of written, printed or graphic matter placed on immediate containers and other packaging by the manufacturer. Labelling may be effected by imprinting

directly on immediate containers or other packaging, embossing packaging material, attaching printed adhesive labels, by furnishing packaging with preprinted wrappers or by electronic devices such as RFID (radio frequency identification) tags.

Package inserts (patient information leaflet) are printed leaflets which are inserted into packaging, accompany the drug products and provide patients and health professionals with detailed information on the product and its use.

The World Health Organization has published "Guidelines on packaging for pharmaceutical products" (WHO 2002e, 119) but general requirements for labelling as well as the contents are subject to national legislation and regulations.

Labels allow identification by anyone handling or using drug products as well as by manufacturers by reading as well as registration by information systems through scanning devices for bar codes or RFID tags. Labelling informs patients and health professionals and thereby increases patient safety and compliance. Cautionary labelling warns about dangers, for example concerning damaging storage conditions or adverse effects on patients. Labelling contributes to maintaining the quality of drug products by providing storage instructions.

The indication of batch numbers on packaging is a prerequisite for allowing batch tracing and manufacturers use labelling for marketing purposes.

Labelling in general as well as special features such as holograms are an important contribution to hamper their counterfeiting and thereby making distribution of counterfeit drug products more difficult.

The minimum requirements for the contents of labelling depends on national legislation and regulations but the World Health Organization provides recommendations (see table 15.10) for minimum standards (WHO 2002e, 151).

Drug products usually prominently display their proprietary name (trade name or brand name) under which the manufacturer markets the drug product and which may or may not have any resemblance with the international nonproprietary name.

In addition to the proprietary name indicating the international nonproprietary name of all active pharmaceutical ingredients is compulsory. Brand names may or may not be known to health professionals and patients but the international nonproprietary names will be understood by any health professional even if unfamiliar with the product.

The dosage form as well as the strength per dosage unit must be indicated as an absolute quantity (for example milligrams per tablet) or as a weight or volume concentration (for example 2% lidocaine).

The quantity of dosage units per packaging (for example 20 tablets per packaging) must be indicated.

The clear and prominent indication of the batch number assigned by the manufacturer is compulsory in order to allow tracing of batch, particularly in case a recall by the manufacturer is necessary.

At least the month and the year of the expiry date, which applies only if drug products are stored under the required storage conditions, must be clearly indicated in a understandable and uncoded form while the day of expiry may or may not be indicated. If no day is indicated, the drug product can be safely used until and including the last day of the month of the year indicated.

Special storage conditions such as the need for cold storage or protection from moisture must be indicated.

The indications for use, contraindications, major interactions with other drug products, advice on use during pregnancy and lactation as well as recommended duration of use must be indicated (WHO 1997a, 36).

Any necessary directions for the use, such as the route of administration, as well as any necessary warnings and precautions (for example "Keep out of the reach of children", "Do not freeze") must be indicated.

The name and address (including the country) of the manufacturer or the person or organization holding a valid marketing authorization must be indicated.

Where applicable the pharmacopoeial standard to which the drug product was manufactured may be indicated.

The manufacturing day, month and year or only month and year may be indicated.

The licence number (product registration, marketing authorization number) as well as the country in which the marketing authorization was obtained and is valid may be indicated.

Labels may indicate that the drug product must not be sold without a prescription.

Where applicable, the label may indicate instructions for reconstitution of drug products as well as the utilization period during which the reconstituted drug product can be used safely.

Minimum requirements

- Proprietary name of the drug product.
- International nonproprietary names (INN) of all active pharmaceutical ingredients (identity).
- Dosage form.
- Strength (quantity or concentration of active pharmaceutical ingredients).
- Quantity of dosage units in the packaging.
- Batch number assigned by the manufacturer.
- Expiry date (at least month and year) in uncoded form.
- Special storage requirements and instructions as well as handling precautions.
- Indications for the use and recommended duration.
- Contraindications for use and major interactions with other drug products.
- Advice on use during pregnancy and lactation.
- Directions for use and any necessary warnings and precautions.
- Name and address of the manufacturer or entity holding the marketing authorization.

Additional content

- Pharmacopoeial standard.
- Manufacturing date (at least month and year).
- Licence number (marketing authorization).
- Country in which marketing authorization was obtained.
- Restrictions on sale.
- Instructions for reconstitution.
- Utilization period (after reconstitution).

Table 15.10 Contents of labelling and packaging inserts of drug products

Labels must be printed in the language understood in the country in which the marketing authorization was obtained but may also be labelled in further languages such as English or

Arabic. Abbreviations and acronyms which are not commonly understood should be avoided. Bar coding must be visible as well as accessible and readable for scanning devices.

Labels, including embossings, must be sufficiently large and easily legible. Printed ink must be durable, must not fade, be smearproof and must not rub off by usual handling. Adhesive labels must be well attached and must not lose their adhesiveness through exposure to humidity and moisture.

Package inserts (patient information leaflet) are packaged together with drug products but are not marked with the batch number, manufacturing or expiry date. Package inserts do not replace the labelling but rather provide supplementary information and advice for patients and health professionals. The package inserts must never be (permanently) removed from packaging throughout the distribution process and entire packagings including the package inserts must be distributed to customers at all times.

Package inserts contain pharmaceutical information on the international nonproprietary names of active pharmaceutical ingredients as well excipients, the dosage form, strength and quantity of dosage units per packaging. The required storage conditions and possibly the total shelf life at the time of manufacturing are indicated.

Pharmacological information includes the description of pharmacological effects and mechanism of action.

One of the main purposes of package inserts is providing detailed clinical information on the indications, dosage regimens according to different ages or body masses, dosing intervals, duration of treatment as well as directions for use and administration. Pharmacokinetic data and changes of dosages for special medical conditions such as renal, hepatic or cardiac deficiencies may be included.

Package inserts must clearly indicate contraindications such as certain medical conditions, pregnancy or minimum age as well as precautions and warnings such as concerning use during lactation or advising against driving or use of (heavy) machinery after administration.

Potential adverse effects, including possible drug dependency, interactions with other drug products, alcohol or certain foods as well as clinical symptoms of overdosage, recommended medical treatment and, where applicable, specific antidotes must also be indicated.

15.3 Single use medical devices

Although single use medical devices may be regarded as less important than drug products (Quick, J.D. (ed.) 1997, 151), they are just as important and indispensable for operating health care facilities at all levels of care.

The number of different devices and makes is vast and up to five times more medical devices than drug products are used in health care facilities (Quick, J.D. (ed.) 1997, 155).

The term "disposable" is often used instead of single use. However, while some single use medical devices such as syringes or surgical blades are used only briefly and immediately disposed of, other devices such as catheters, sutures or dressing materials may be used on patients for some time before they are removed and disposed of. Moreover, the term "single use" underlines the importance of not reusing medical devices even if this may be technically possibly.

Various items such as syringes and a variety of tubes and catheters are available as reusable or single use medical devices. Reusable medical devices require cleaning and possible sterilization before reuse.

There is no universally accepted definition of medical devices. However, the Global Harmonization Task Force, a voluntary group of representatives from medical device regulatory authorities and the regulated industry which provide non-binding guidance have agreed on the following definition:

"“Medical device” means any instrument, apparatus, implement, machine, appliance, implant, *in vitro* reagent or calibrator, software, material or other similar or related article, intended by the manufacturer to be used, alone or in combination, for human beings for one or more of the specific purposes of:

- diagnosis, prevention, monitoring, treatment or alleviation of disease
- diagnosis, monitoring, treatment, alleviation of or compensation for an injury
- investigation, replacement, modification, or support of the anatomy or of a physiological process
- supporting or sustaining life
- control of conception
- disinfection of medical devices
- providing information for medical purposes by means of in vitro examination of specimens derived from the human body and which does not achieve its primary intended action in or on the human body by pharmacological, immunological or metabolic means, but which may be assisted in its function by such means" (GHTF 2005b, 3).

In general single use medical devices should be preferred as they eliminate the risk of improperly cleaned, disinfected and sterilized medical devices being used on and infecting another patient. Some reusable medical devices such as catheters or gloves are available but are difficult to clean and suitable disinfectants as well as safe sterilization equipment may not be available or inappropriate methods may be used. On the other hand, single use medical devices may be reprocessed because of lack of resources and in this case reuse of reusable medical devices may be safer.

15.3.1 Classification

The vast number of single use devices can be separated into health care goods which are applied to or used directly on patients and which can be classified according to the type of goods and those which are not directly used on patients and can be classified according to the respective clinical (support) service (see table 15.11).

Various forms such as admission, books, patient records, anaesthesia records or treatment cards for clinics are used for patient documentation and administration of clinical and non-clinical services at health care facilities.

Dressing materials such as compresses and cotton absorb liquids and compresses fastened with bandages and adhesive tape stop bleeding, protect wounds or allow application of creams and ointments. Plaster of Paris (gypsum) is used for immobilizing joints and (fractured) limbs.

Injection devices such as hypodermic needles, intravascular catheters and syringes are used for injecting drug products. Infusion sets are needed for administering infusion solutions and blood giving sets for transfusing blood products from blood bags.

Catheters are inserted into body cavities for irrigation as well as draining liquids or air.

Endotracheal tubes and tracheostomy tubes are inserted into the wind pipe for securing the airway, gastric tubes are inserted through the oesophagus into the stomach for drainage or irrigation and feeding tubes are used for administering liquid food. Suction tubes are used to remove liquids from tubes or wounds during operations.

Wound drains remove liquids and facilitate wound healing while thoracic drains allow removal of liquids and air from the pleural cavity. Ostomy products allow drainage and protection of the surroundings of stomas, artificial openings in the abdominal wall which are connected to the intestinal or urinary tract.

Various types of receptacles with the appropriate connectors allow collection of liquids.

Sterile and non-sterile gloves are needed in almost any service for protecting patients as well as health professionals and caretakers from infection.

Surgical linen and clothing is often reusable but in emergencies as well as for hygienic reasons often disposable gowns, caps, masks as well as various drapes are used.

Most surgical instruments are reusable but disposable scalpels are often used and surgical and dermatome blades are always single use.

A large variety of absorbable and nonabsorbable sutures with needles are used for holding wound edges in apposition during healing and ligature sutures are used for ligating vessels for stopping bleeding during operations.

Disinfectants used for equipment and which are not used on patients are considered as medical devices. Sterilization paper provides protection from contamination after sterilization and is essential for wrapping various surgical instruments and dressing materials. Various indicators are used for monitoring the sterilization process.

- Stationery: forms.
- Dressing material: bandages, plaster of Paris, compresses (sterile, non-sterile), gauze, cotton, adhesive tape.
- Injection devices: hypodermic needles, intravascular catheter, syringe, safety container.
- Infusion and transfusion devices: infusion set, blood bag and blood transfusion set.
- Catheters: urinary catheter, urine collection bags, supra-pubic bladder drainage, thoracic catheter, chest drainage bottle.
- Tubes: endotracheal, tracheostomy, gastric, feeding, suction, mucus extractor.
- Drains: wound, colostomy, ileostomy, urostomy.
- Gloves: sterile, non-sterile.
- Surgical linen and clothing: surgical mask, cap, surgical gown, surgical drape.
- Surgical instruments and blades: scalpels, surgical blade, dermatome blade, instrument oil.
- Sutures and suture needles: absorbable, nonabsorbable, surgical needle.
- Disinfection and sterilization: disinfectants, sterilization paper, tape, TST indicator.
- Laboratory devices: lancet, specimen container, tube, pipette tip, microscope slide, filter paper.
- In vitro diagnostic tests: reagents, rapid diagnostic tests, blood glucose, haemoglobin.
- Diagnostic imaging: x-ray film, photochemicals, ultrasound gel.
- Miscellaneous: tongue depressor, umbilical tape, razor, bag for drugs.

Table 15.11 Classification of single use medical devices

Sharp lancets are used to prick the skin for obtaining blood for analysis. Laboratories use various containers for collecting specimen as well as a wide range of different tubes for

collecting, processing and analysing specimens. Single use pipette tips are attached to pipettes for accurately measuring very small volumes of liquids.

A wide range of rapid diagnostic tests for infectious diseases are available for in vitro diagnostics and a range of reagents is used to process and often stain specimen for microscopic analysis.

Taking x-rays requires x-ray films of various sizes as well as photochemicals for developing and fixing.

Various miscellaneous items such as small bags for dispensing drug products, tongue depressors or razors are commonly used.

According to Council Directive 93/42/EEC of the European Union (EU) as well as the GHTF (Global Harmonization Task Force), medical devices can be divided into four classes (see table. 15.12). The classification is rather complicated so the table below is a simplification.

EU	GHTF	Description
Class I	Class A	Non-invasive devices, invasive devices for transient use.
Class IIa	Class B	Sterile devices, non-invasive devices for channelling or storing blood, body liquids, liquids for infusion, surgically invasive devices for transient or short-term use.
Class II b	Class C	Invasive devices for long-term use, non-invasive devices intended for modifying the composition of blood, devices for contraception.
Class III	Class D	Devices which are absorbed.

Table 15.12 Classification of medical devices according to the EU and GHTF

15.3.2 Types of items and specifications

The technical specifications following below are mainly based on volumes 1 through 4 of the Medical Catalogue (Bretton, M., V. Cruyt, A.-F. Maes, and I. Verelst (ed.) 2008) published by Médecins sans Frontières.

A number of different forms are designed specifically for use in health programmes and health care facilities. Health cards are issued for each patient, used as a record for all their consultations at clinics and may be provided with a plastic cover (bag) for protection. Growth charts ("road to health chart") allow charting the weight against and age of children and monitoring their development. Immunization cards are used for recording personal data and recording dates and kinds of vaccinations.

Admission forms are issued during the admission of patients to hospitals and patient treatment records allow recording personal data as well as any diagnosis and treatment. Intensive care records are more comprehensive and detailed than treatment records and anaesthesia records serve as protocols during operations. Various forms are also used for clinical services such as for x-rays, the laboratory as well as the blood bank.

Pure and absorbent gauze bandages (surgical gauze) are used to secure and cover a primary dressing. The gauze is woven with at least 20 threads (warp and weft) per square centimetre and selvedges prevent fraying and ensure absence of loose threads and ravellings. The rolls of non-elastic and non-adhesive gauze with a width of 6 to 10 centimetres and around 5 metres length should be packaged individually.

Crepe bandages are also made from pure cotton but woven in a way that makes them elastic and allows stretching them up to twice their length. Crepe bandages also have around 20 threads per square centimetre, are woven with selvages, are around 4 metres long and have widths of 8 or 10 centimetres.

Adhesive, elastic bandages are used for moderate compression for supporting joints without immobilizing them. The rolls are made from lengthwise woven cotton with a hypoallergenic, zinc oxide-based adhesive which keeps the bandage in place after application and are made with a width of around 10 centimetres and a length of 4 metres without stretching.

Emergency pressure bandages are ready made packages consisting of a dressing pad and an attached elastic bandage for dressing a wound and stopping bleeding quickly with a single device. The dressing pad is placed on the wound before wrapping and fastening the bandage (usually) around the limb for applying pressure.

Tubular bandages (also called Jersey or "stockinette") are seamlessly knitted or woven, ladderproof, lengthwise elastic cotton bandages which are available in widths of 4 to 15 centimetres and on rolls of 25 metres. They are slipped over a limb for protection before applying plaster of Paris (casts).

Plaster of Paris bandages are gauze rolls impregnated and coated with plaster of Paris which turns into a paste after immersing in water and irreversibly solidifies after drying. They are applied for immobilizing broken or otherwise injured joints and bones with rigid casts. The gauze should have around 20 threads per square centimetre and dry bandages should weigh about 20 grams per square metre. The plaster of Paris is wrapped around a plastic tube for facilitating soaking with water and bandages of 10 to 20 centimetres width and 2 to 3 metres length must be individually packaged in waterproof sachets.

Sterile compresses are used as primary dressing which are in direct contact with the wound and placed on wounds for promoting wound healing, protection (mechanical and infection), preventing adhesion of secondary dressings, preventing desiccation, absorbing liquids, stopping bleeding, increasing patient comfort, improving appearance of the wound site as well as for cleaning and disinfecting wounds.

Compresses are made from absorbent, cotton gauze with around 20 threads per square centimetre and a weight of about 25 grams per square metre. Commonly compresses with 8 or 12 plies (layers) in sizes of 10 by 10 or 10 by 20 centimetres are used. The surgical folding ensures that no cut gauze edges or loose threads are exposed and prevents fibres from entering wounds. Often two sterile compresses are packed together in individual peel pouches.

Apart from sterility, non-sterile compresses must conform to the specifications of sterile compress and are often packaged in 100 pieces. These may be used as secondary dressing material or be sterilized before use.

Sterile abdominal compresses (laparotomy compresses) with four layers, sewn edges to ensure absence of loose threads, radiopaque threads, a loop for holding and sizes of 40 to 45 side length are packaged in peel pouches. Non-sterile abdominal compresses are also available and have to be sterilized before use. Abdominal compresses may also be made from gauze in the hospital.

Gauze with 17 threads per square centimetre may be provided in rolls of 60 to 90 centimetres width and 100 metres length for manufacturing various types and sizes of compresses (for example in combination with absorbent cotton) at health care facilities for sterilization before use.

Absorbent (hydrophilic) cotton, which consists of pure cellulose fibres and absorbs 23 grams of water per gram of cotton, is the basic surgical absorbent used in various secondary dressing materials. The cotton is bleached, carded and packaged in rolls of 500 or 1,000 grams.

Adhesive tape is used to secure dressings as well as medical devices such as catheters and tubes.

Zinc oxide tapes are made from textile tape which are treated with zinc oxide-based adhesives mixed with rubber. Zinc oxide tape is inelastic, waterproof, adheres well to dry skin and is well tolerated although some patients may be allergic. The tape may be furnished with notches for easy tearing by hand and is available in widths of 2 to 10 centimetres and is typically available on rolls of 5 metres.

Acrylate (a synthetic rubber) adhesives on fabric or nonwoven backings are hypoallergenic and do not cause any damage to the skin.

Although in general needles are not hollow, the term hypodermic needle also has the specific meaning of a thin, sharply pointed and hollow attachment which is used with a hypodermic syringe.

The diameter of needles and cannulas is traditionally measured in gauges, which are inversely proportional to the diameter and therefore diameters decrease with increasing gauge numbers. The rather arbitrary gauge system was invented in the 19th century by Peter Stubs (Ahn, W., J.-H. Bahk, and Y.-J. Lim 2002, 1125) for measuring the thickness of wires. Successive gauge numbers, for hypodermic needles from around 7 - 34, are not linear and do not represent an arithmetic progression (where the increments between two successive gauges would be identical). Instead, around 12% of the diameter is added to any gauge to derive the diameter of the next smaller gauge which therefore present a geometric progression. Gauges are also not precise dimensions but have tolerances, and the precise definition of gauge measurements may differ from manufacturer to manufacturer. Moreover the inner diameter of two hypodermic needles with the same gauge may differ because of their different wall thickness.

Sterile hypodermic needles are made from stainless steel with long or short bevels, coated with silicone for facilitating insertion and fitted with a polypropylene base with a Luer connection. The device is protected by a tapered polypropylene cap which is discarded before using the hypodermic needle. Hypodermic needles are available in sizes between 14 G and 27 G with different lengths respectively. Depending on their size they may be used for subcutaneous (beneath the skin), intravenous (into a vein) or intramuscular (into a muscle) injection as well as for perforating the stopper of infusion bottles and vials for preparing or withdrawing drug products.

Sterile spinal cannulas are introduced into the sub-arachnoid space for taking samples of cerebrospinal fluid for laboratory analysis (for example for diagnosing meningitis) as well as for injecting local anaesthetics into the cerebrospinal fluid.

The short bevelled tip of the fine, stainless steel cannula is shaped in a characteristic way (called "Quincke") in order to separate dural fibres during insertion rather than cutting them and the cannula is fitted with a polypropylene or polyamide base, a Luer connector and a cap. The precisely fitted, stainless steel stylet, which is as long as the cannula, strengthens the cannula and prevents occlusion of the cannula with tissue during introducing. Typically sizes of 19 G to 25 G are used. The device is protected by a long plastic cap which is removed before inserting the cannula.

Sterile, intravenous (iv) catheters are inserted into peripheral veins for injection or infusion of drug products or blood (products). The device consists of a triple-bevelled stainless steel

trocar for puncturing tissues and increasing the stability of the surrounding fine metal cannula. The issue of blood from the cannula after withdrawing the trocar confirms puncture of a vessel. The metal cannula in turn is surrounded by the actual flexible intravenous catheter which is made from polyurethane or Teflon and is fitted with a Luer lock connector and a cap. The lateral injection port is fitted with a silicone anti-reflux valve which allows injecting liquids but prevents the reflux of blood or the liquid being infused through the main port. Two small flexible wings facilitate holding the device during puncturing as well as holding the device in place with adhesive tape. The tip of the trocar as well as the entire catheter are protected by a conical cap which is removed before use.

Intravenous catheters are available in sizes between 16 G (160 millilitres per minute) to 24 G (18 millilitres per minute) each in a different colour and respective catheter lengths of approximately 20 to 55 millimetres.

Sterile syringes are used for administering sterile solutions through hypodermic needles or catheters and may be used for taking samples of body liquids.

The barrel is graduated with water resistant marks and made of polyethylene or transparent polypropylene in order to allow detecting air bubbles. The conical Luer tip which is tapered 6% is concentric (in the centre) for 1, 2 and 5 millilitre syringes and eccentric for 10 and 20 ml syringes.

The plunger is made of polypropylene and slides easily inside the barrel while providing a watertight seal during injection.

1 millilitre syringes with graduations of 1/100 ml are used for the accurate administration of small volumes of insulin or other drug products, especially in infants and may be fitted with hypodermic needles.

The plungers of auto-disable syringes are fitted with a locking clip which allow drawing back the plunger for aspirating the vaccine but locks the plunger after injection and prevents pulling the plunger back again. Auto-disable syringes safely prevent re-use and are recommended for all immunization programmes.

Sterile syringes with volumes of 50, 60 or 100 millilitres with conical or Luer tips are used for tube feeding as well as aspiration of liquids from gastric tubes. The barrel is made from polyethylene or transparent polypropylene and marked with water resistant graduations. The polypropylene plunger is fitted with a tip made from elastomer for ensuring a watertight seal.

Single use cardboard safety containers are intended for collecting, storing and incinerating contaminated or unusable needles, intravenous catheters, surgical blades and other "sharps" and prevent injury of health professionals as well as staff during disposal. Inflammable containers are lit after filling according to the instructions printed on the container for destroying the contents or can be disposed of in an incinerator.

The 1.5 mm thick cardboard material is covered with a plastic film which makes the container waterproof and resistant to punctures. New (unused) safety containers are collapsible for reducing volume during transport, can be assembled by folding according to the instructions printed on the carton and are furnished with a handle for carrying. Containers with 5 litres are intended for health care facilities while 15 litre containers are intended for mass vaccination campaigns.

Infusion sets are sterile single use devices for parenteral administration of infusion solutions and liquid drug products but which must not be used for blood transfusions.

The tapered perforator is inserted into the infusion bottle, bag or pouch, drains the liquid and allows air to enter into rigid bottles through an air inlet which is fitted with an air filter.

The attached semi-rigid and transparent drop-counting chamber which is fitted with a 15 µ filter allows visualizing and counting the number of drops infused per minute. The flow regulator which is attached to the tubing allows changing the flow rate as well as stopping the flow. The tubing with a diameter of about 3 millimetres and with a length of about 150 centimetres is attached to a male Luer lock connector which can be attached to intravenous catheters after removing the protective cap. Some devices are furnished with injection ports which allow injection of liquids into the tubing without interrupting administration of the infusion.

The use of standard infusions sets with children can be very dangerous as the accidental infusion of large volumes, and in the worst case the entire bottle of infusion solution, can quickly lead to hypervolaemia. Moreover, standard infusions sets do not allow accurately measuring the infused volume.

Sterile, paediatric infusion sets consists of a tapered perforator in which an air inlet is incorporated and a connector which can be inserted into a standard bottle, bag or pouch of infusion solution. A clip on the connecting tube allows securely stopping the flow from the infusion bottle to the graduated chamber once it is filled with the required volume. The transparent plastic chamber with a volume of 150 millilitres and graduations every millilitre is connected to drop chamber which allows counting the number of drops per minute and calculating flow rates. The chamber is fitted with a security gauge which prevents air from entering the tubing when the chamber is emptied. Approximately 150 centimetres long transparent PVC tubing, which allows detecting air bubbles, with an internal diameter of 3 millimetres connects the drop chamber with a Luer lock connector which can be attached to an intravenous catheter. The flow regulator allows accurately adjusting flow rates as well as closing the tubing while filling the graduated chamber from the infusion bottle and the tubing may be fitted with an injection port.

Sterile blood taking sets are closed, sterile devices for collecting, storing and transfusing blood. The devices consist of tubing as well as one or more translucent PVC bag(s) which contain anticoagulants and preservatives. The tubing for collecting blood has a length of around 80 centimetres and the distal end is furnished with a large calibre intravenous cannula. The bag is furnished with an adhesive label for recording information on the blood group and donor etc. as well as a portal for attaching a blood giving set for transfusion.

Single bags hold volumes of 150, 250 or 450 millilitres. Multiple blood bags allow separation of blood components and their subsequent separate transfusion.

Sterile blood transfusion (giving) sets are sterile devices which are attached to blood bags for transfusing blood or blood products. The slightly tapered perforator at the proximal end is inserted into the port of the blood bag. The semi-rigid and transparent drop-counting chamber is fitted with a 200 µ polyamide mesh filter for retaining any coagulated blood. The transparent PVC tubing has a length of around 150 cm and is furnished with flow regulator which allows the complete interruption of the flow through the tube. A male Luer connector at the distal end of the tubing allows connection to an intravenous catheter.

The diameter of catheters, tubes and drains may be measured in millimetres or in Charriere (Ch) which is a synonym for French (FR) or French Gauge (FG). Charriere is simply the length of the circumference of the catheter in millimetres. Therefore dividing the Charriere number by π (or very roughly 3) gives the diameter. For example a thoracic drain of 36 Charriere has an outer diameter of about 12 millimetres.

Nelaton catheters are short, flexible, sterile urinary catheters with distal side windows but without a balloon made from PVC which are intended for immediate removal after drainage of

the bladder. Short (female) and long (male) catheters are available with diameters of around CH 10 in double sterile packaging.

Indwelling retention or Foley catheters are made from latex and can be coated with silicone for preventing injury to the mucous membrane especially during long-term use and are intended for permanent insertion into and drainage of the bladder. Urine is drained through side windows at the distal end and a urine collection bag is attached to the connector at the proximal end. The catheter is prevented from retracting by injecting a sterile liquid into a non-return valve with a Luer connection which is connected to an inflatable balloon at the distal end through a thin duct integrated into the catheter. These catheters commonly have a length of 30-40 cm, diameters of between 8 - 18 CH and are provided with double sterile packaging.

Urine collection bags are connected to urinary catheters for drainage and collection of urine in a closed system for preventing leakage as well as infection. The flexible PVC or EVA bags are made from transparent plastics and are furnished with eyelets or plastic straps for fastening to a hanger. They have a capacity of around two litres and graduations for every 100 ml are marked on the bag. The PVC tube is about one metre long, has a universal connector attached to one end which must allow a watertight connection to different sizes of catheters and is attached to the bag through a non-return valve which must prevent urine from flowing back into the urinary catheter. Bags may allow emptying through a drainage valve with a seal cap to prevent contamination. Reservoirs may also be made from rigid plastics and smaller devices with finer graduations are used for children.

Complete single use and sterile sets are used for supra-pubic bladder drainage. A thin, graduated semi-rigid polyurethane catheter is inserted through a trocar after puncturing the abdominal wall. The catheter of between 10 and 16 CH is held in place by a plastic plate which is sutured to the skin. The catheter which is closed and opened with a clamp is attached to a urine collection bag.

Sterile, single use thoracic drains are intended for insertion into the pleural cavity for drainage of air, blood and other liquids. Thoracic drains may be inserted after placing a surgical incision or be inserted with a stainless steel trocar which is removed and disposed of after insertion. The semi-flexible and transparent PVC drains have a blunt end with side windows and radiopaque markings. Thoracic drains have diameters from between 14 and 36 CH and are 25 to 40 centimetres long. Each unit is provided in a flexible or rigid sterile packaging.

Thoracic drainage non-return valves, commonly called Heimlich chest drain valves, are made from transparent polyurethane with an integrated rubber sleeve which allows drainage of liquids and gas out of the drain but prevents re-entry, particularly of air. The direction of the flow must be marked on the device. The connector on one end is attached to the thoracic drain while the other is connected to the collection system.

Single use, rigid and graduated chest drainage bottle are connected to thoracic drains and allow collecting as well as measuring the quantity of drained liquids, such as blood, in a collection chamber. A second compartment, the water seal chamber, is filled with a defined quantity of sterile water which acts as a one-way valve, allowing venting of air from the patient but prevents entry of air into the tubing and return to the patient. An optional third chamber allows connecting continuous suction and adjusting the strength of the applied vacuum which helps to drain air and liquids.

Complete sterile, single use thoracic drainage sets contain, among others, a sterile single use drape, sterile gloves, thoracic drain with trocar, sterile surgical drapes, compresses, scalpel, sutures, a non-return valve as well as a collection system.

Endotracheal tubes are inserted through the nose or the mouth into the trachea with a laryngoscope and left in place for preventing any obstruction of the airway and are necessary when using ventilators and anaesthesia machines. Endotracheal tubes are made from transparent PVC with longitudinal radiopaque markings and graduations indicating the distance (in centimetres) to the tip. The bevel (distal opening) must have smooth edges to prevent injury during insertion and placement and is cut at an angle. An elongated inflatable, low-pressure cuff (balloon) is integrated above the proximal end for creating an airtight seal which prevents gases from escaping from the lungs as well as aspiration of liquids into the lung while preventing necrosis by ischemia. The balloon is connected with a thin tube integrated into the tube to a pilot (indicator) balloon and a non-return valve with a Luer connector at the distal end for inflating and deflating the balloon. For children endotracheal tubes without cuffs are available as cuffs may damage the sensitive mucus membranes of the trachea which usually forms an airtight seal naturally. The distal end of the tube is fitted with a standard connector (15 mm diameter) which allows connecting a resuscitation bag, ventilator or anaesthesia circuit. Endotracheal tubes are available with inner diameters of between 2 and 10 mm diameter and lengths between 10 - 30 cm corresponding to the diameter.

Tracheostomy tubes are inserted into the trachea between the cartilage rings after a surgical tracheotomy and intended for similar purposes as endotracheal tubes but can be used for longer periods of time and are fitted with removable inner liners. Tracheostomy tubes are made from radiopaque PVC tubes angled at 90 degrees with a smooth bevel at the proximal and a connector at the distal end. A low pressure cuff near the proximal end is again connected through a thin tube to a pilot (indicator) balloon and a non-return valve with a Luer connector for inflating and deflating the balloon.

Gastric tubes (nasogastric tubes, Levin tubes) are semi-rigid tubes with a single channel made from PVC which are inserted through the nose or the mouth into the stomach for drainage of liquids and gases, irrigation or enteral feeding. The distal end has a conical tip with soft edges and side openings, a radiopaque strip is integrated along the tube and the proximal end is fitted with a cup connector for attaching a suction tube or a syringe with a nozzle. The commonly used sizes have a length of around 120 centimetres and diameters of CH 6 to 18 (in even increments).

Feeding tubes are made from soft and flexible PVC with a single channel and are inserted through the nose or the mouth into the stomach for feeding infants. The distal end is round and smoothed, has side windows, the tube itself is marked with radiopaque graduations from the distal end and the distal end is fitted with a Luer tip and a stopper. The commonly used sizes have a length of 50 cm and a diameter of CH 6 to 10.

Suction tubes are made from translucent and flexible PVC for removing secretions and other liquids from the pharynx or from endotracheal and tracheostomy tubes. The distal end is straight, has smooth edges and side windows while the proximal end has a cup connector which allows attaching the connector of a suction machine. The sterile and single use suction tubes have a length of about 50 centimetres and most commonly diameters of CH 6 to 18 are used.

The mucus extractor for neonates (newborns) is a manual suction device for removing mucus from the mouth and oropharynx of newborn children. The sterile, single use device consists of a closed, transparent, polypropylene container with a volume of around 20 ml, an integrated HIV filter and two PVC catheters. By sucking on one catheter the health professional creates a vacuum in the container while the second catheter is used to suck the mucus into the container.

Contamination of patients or breathing circuits of anaesthesia machines and ventilators can be prevented by separation with a special sterile and single use filter which is replaced every day or for each patient. A rigid polyurethane box with two standard connectors houses a hydrophobic membrane with a large surface to minimize resistance to air flow and which serves as a filter for particles as well as bacteria and viruses. The filters also serve as a heat and moisture exchanger (HME) which prevent losses from the respiratory system.

Penrose drains, for example 1 cm wide and around 20 cm long, are flexible silicone rubber tubes coated on both sides with silicone which are introduced into the body and drain off secretions passively by gravity or capillarity.

Multichannel corrugated sheets are made from natural rubber or silicone elastomer and have to be cut to the required size before use, the unused portion may be cleaned and sterilized. Corrugated sheets are used in surgery for draining liquids from wounds.

Redon drains are wound drainage systems which use a vacuum to suck liquids into a drainage bottle and consist of several parts. A slightly curved, pointed, stainless steel needle (Redon needle) which is sealed to the drainage tube is removed after inserting the drainage tube. The distal end of the PVC redon drain tube with diameters of CH 12 or 16 is perforated over a length of several centimetres and the entire tube of around 50 - 70 cm is marked. The proximal end of the redon drain tube is attached to a connecting tube with a non-return valve which in turn leads to a bellows-shaped, graduated polyethylene bottle with a capacity of 100 - 500 ml. A vacuum of around 100 mbar is created by squeezing and releasing the bottle.

Enterostomy collection bags of various sizes consist of a single device or two separate parts which can be detached and fastened together. The opening of the flexible and self-adhesive skin protection plate is cut to match the shape of the stoma before being attached to the skin for protection from the faeces emptying out of the colostoma or ileostoma into the bag. Remaining irregularities can be smoothed with special stomahesive pastes (karaya gum). A flexible plastic bag serves as a receptacle and is either fused to the protective plate or can be clipped onto the plate and removed if necessary. Integrated anti-odour filters allow gases to escape and prevent the bag from bursting while preventing unpleasant odours. Emptyable bags have an opening which is closed and must be completely sealed with a self-locking and removable clamp. The underside of the bags may be padded to prevent irritation of the skin from direct contact with the plastic.

Urostomy bags are similar except that the plates are smaller and the bags allow connection to a tube and a urine bag for drainage.

Single use and non-sterile (examination) gloves are ambidextrous (fitting left and right hands) and are used for protecting health professionals from infection and soiling during diagnostic, therapeutic as well as nursing procedures. These gloves are watertight, made from natural latex, are not powdered, available in different sizes (small, medium, large and extra large) and usually packaged in carton dispenser boxes of 100 pieces. They must break only after being stretched more than 600% of their length. The gloves must not be reused and cannot be sterilized.

Sterile (surgical) gloves are made from natural latex and intended for use in any procedure requiring aseptic conditions, such as surgery, for protecting the patient from infection by operating staff as well as protecting operating staff against infection and soiling. Surgical gloves are anatomically shaped, must be supple, allow an excellent sense of touch and are available in sizes between 6 and 8.5 (with increments of 0.5). Sterile gloves with long sleeves (up to the elbow) are intended for obstetrics and gynaecology.

Each pair of gloves is packaged separately in a double wrapping. The left and right glove, with their sleeves reversed (to allow doning without contaminating the outside) up to the thumb are folded in a sheet of paper, indicating the right and left glove as well as the size, which is in turn placed in a peel pouch.

Surgical masks cover the nose, mouth and chin for protecting the wearer against splashing fluids and aerosols (for example during operations) as well as to protect others from spreading of airborne infectious particles by the wearer.

The mask is made from three layers of polypropylene which withhold at least 98% of bacteria while allowing breathing but does not protect against viruses. The nose wire, a malleable strip of aluminium allows forming the mask on the nose and two attached straps allow fastening the mask by tying them at the back of the head. The non-sterile but single use masks are usually packaged in carton dispenser boxes of 50 or 100 pieces.

Caps are designed to completely cover all hair on one's head during surgical interventions to prevent contamination of wounds with dandruff and hair (particles) as well as to protect health professionals from splashing.

Caps are made from non-woven polypropylene, are impervious to liquids, lightweight and fitted with an elastic opening. The non-sterile but single use caps are usually packaged in carton dispenser boxes of 100 pieces.

Surgical gowns are worn by surgical staff over their workwear in order to protect patients from infection as well as staff from splashes of (body) liquids. The single use and sterile gowns are expensive but particularly useful in emergencies in order to reduce the workload of the sterilization department as well as the required capacities for sterilization.

They are made from soft and fluid repellent cellulose-polyester, available in various sizes and usually blue or green. The long sleeves allow a wide range of movement and are fitted with elastic cuffs. The chest area as well as the forearms are reinforced for greater strength and impermeability to fluids. The wraparound gowns provide a complete cover from the neck to the middle of the calf and are tied in the back with ties or Velcro fasteners.

Gowns are provided in peel pouches in double sterile packaging with aseptic folding which allow doning them without contamination of the outside surface.

Single use, sterile drapes are used to cover operating theatre furniture as well as the perimeter of operating sites in order to provide aseptic surfaces.

Drapes are made from non-woven, synthetic fibres and composed of at least one absorbent polypropylene layer and one impervious polyethylene layer. The must have a good absorption capacity but must not release particles or fluff and be absolutely impervious to damp as well as pathogens. They must be supple and easy to unfold and drape but highly resistant to tearing.

Surgical drapes are available in a large variety of sizes from around 40 by 40 centimetres up to 200 by 150 centimetres and are usually blue or green. The may be fitted with slits or round holes which are placed over the operating site as well as self-adhesive strips for attaching to the patient or (overlapping) to each other. Drapes formed as a sack are used for covering Mayo (instrument) tables in operating theatres.

Usually disposable scalpel blades are used together with reusable, metal scalpel handles with are sterilized after use. However, for sets and kits, individually packaged, single use, sterile scalpels with plastic handles and metal blades of different sizes and shapes may be used.

Single use and sterile scalpel blades are attached to reusable scalpel handles for cutting and making incisions during surgery. Scalpel blades are about 6 centimetres long and made from martensitic steel with a hardness of 50 to 58 HRC (Rockwell hardness scale).

The numbering of the blades indicates the shape rather than the size. Commonly, numbers 11 (oblique, straight, pointed end), 15 (rounded, small head) and 22 (rounded, large head) are used. Each scalpel blade is individually packaged in an aluminium-laminated sachet.

Single use, sterile and individually packaged dermatome blades are used with specially designed dermatomes for shearing off skin for autotransplantation.

The bevelled, sharp and rectangular blades are made from martensitic steel and fitted with two holes for firmly attaching them to the dermatome with screws.

Gigli saw wires are 50 centimetres long, made from woven, stainless steel with saw teeth and are fitted with a ring on either end for attaching Gigli saw handles before use for cutting bones during amputations.

Silicone-free instrument oil is used for lubricating the joints of surgical instruments made from stainless steel. The oil is applied for protecting joints from wear after disinfection and cleaning but before sterilization. An additive allows saturated steam to penetrate oil films.

Surgical sutures ("sutures" for short) are strands of thin filament(s) used for approximating and holding wound edges of various different tissues in apposition during healing or for ligating (tying) thin blood vessel for stopping bleeding.

Sutures and suture needles should meet the specifications laid down in internationally recognized pharmacopoeias and should minimize tissue reaction which they inevitably cause as a foreign body. Natural materials such as catgut are no longer used as sutures made from animal intestines bear the risk of transmission of BSE (bovine spongiforme encephalopathy) and are not as homogenous as synthetic sutures. Silk is no longer used as it causes tissue reaction.

According to the European Pharmacopoeia the diameter of sutures is measuring in DEC units which corresponds to a tenth of a millimetre. A suture with a diameter of 0.3 millimetres therefore has a diameter of DEC3. Another widespread measurement system uses a numbering from 10/0 (thinnest) to 4 (thickest).

Sutures have lengths of between 40 to 140 centimetres.

Monofilament sutures are made from a single, homogenous thread with a constant diameter. Braided sutures are made from several threads which are braided into a compact strand. In order to prevent the capillary effect of braided sutures which is similar to a wick, the surface of braided sutures are coated to prevent creating a conduit for microorganisms through sutured surfaces.

Absorbable sutures are completely broken down in the tissue either by enzymatic processes or by hydrolysis over a period of 10 days to 3 months depending on the characteristic of the individual suture and do not need to be removed by surgery. Synthetic absorbable sutures made from lactic polyglucolic acid, polygliconate or polydioxanone cause little tissue reaction, are absorbed at constant rates and show constant reduction in tensile strength as they are absorbed.

Nonabsorbable sutures are not absorbed or altered by body tissue, maintain their tensile strength and remain in the body until they are removed by surgery. Synthetic nonabsorbable sutures are made from polyamide, polypropylene, polybuster or polytetrafluorethylene (PTFE),

are uniform, have high tensile strengths and cause little tissue reaction. Stainless steel or silver wires are used for rigid fixation of bones.

Sutures without needles are called "ligatures" as they are used for ligating (tying) small blood vessel for stopping their bleeding. The ligatures may be cut into several pieces during surgery but are nevertheless packaged individually on small spools. In the past sutures were provided on spools for cutting and threading onto separate suture needles with eyelets. However, as the needle as well as two threads of the suture have to be pulled through the tissue, they cause more trauma and this system has been replaced by individually packaged sutures with attached needles.

Sutures with integrated suture needles are used for piercing tissues, approximating and holding their edges in apposition during healing. The suture threads are firmly attached to the suture needle by drilling a small hole into the shaft, inserting the strand and swaging the shaft around the inserted strand. Swaging provides a smooth junction and minimizes tissue trauma ("atraumatic sutures", eyeless) as only the diameter of the suture needles has to pass through tissues. Suture needles are removed after completing suturing by cutting the threads just below the needle with a pair of scissors.

Suture needles are made from stainless steel and available in a large number of sizes and shapes. Suture needles are defined by their length (in centimetres), their diameter (in millimetres) and their shape. The curvature of needles is described in fractions of a circle, for example 1/2 or 3/8 circle and depends on the type of the tissue and the depth of the suture.

Round bodied suture needles are used for soft tissues, gradually taper from their diameter to a sharp point and have circular cross sections. Triangular-bodied suture needles have a sharp point, a triangular cross section and therefore have three (cutting) edges along their body.

Despite the very large number of different surgical sutures which are available, essentially surgery can be carried out professionally with about 20 different types. Sutures are identified by the characteristics shown in table 15.13. Adding the manufacturer catalogue number to the respective suture descriptions greatly facilitates their identification by non-specialists.

- Diameter (thickness, gauge).
- Length (centimetres).
- Number of filaments: monofilament - braided (several filaments).
- Absorption: absorbable - nonabsorbable
- Suture needle: not included (ligature) - attached (suture).
- Needle length (centimetres).
- Needle diameter.
- Needle shape: curvature.
- Needle cross section: round, triangular.

Table 15.13 Characteristics of surgical sutures

All sutures are sterile and packaged individually in foil and overwrapped in peel pouches in order to allow handing them to surgical staff without contamination of the inner wrapping.

Umbilical cord thread is used as ligature for tying the umbilical cord tightly twice before cutting it between the two ties. The flat, braided thread is about 3 millimetres wide (to avoid cutting through the umbilical cord) and made from pure cotton. The rolls of thread, for example with a length of 100 metres, are not sterile but should be sterilized before use.

Before sterilization, many goods need to be wrapped in sterilization paper which allows penetration of (saturated) steam but is impervious to micro-organisms. Goods wrapped in two layers are protected from contamination for a maximum of 15 days if stored in adequate conditions and provided that the wrapping is not dampened.

Crepe paper is made from cellulose fibres with a grammage of 60 grams per square metre and must repel water for at least 20 seconds. The non-sterile but single use sheets are pre-cut in squares of between 75 and 120 centimetres.

Non-woven sterilization paper made from a blend of cellulose and synthetic fibres is stronger than crepe paper and used for wrapping large and heavy goods. The non-sterile but single use sheets are available in squares of about 150 centimetres.

Autoclave steam indicator tape is a special crepe paper tape which is used as tape for closing wrapped packages and also serves as an indicator. Steam-sensitive white ink which changes to black after exposure to steam at + 121° Celsius for 3 minutes or steam at + 134° Celsius for 30 seconds is applied to the crepe tape in hatched strips. However the autoclave steam indicator tape only shows that a certain temperature has been reached for a minimum time but does not measure whether the steam was saturated or how long the temperature was maintained and therefore does not guarantee sterility. However, if the hatched strips do not turn black, sterilization has certainly failed.

TST (time - saturated steam - temperature) indicators consist of small, reinforced, strips with coloured spots of about 1 centimetre diameter which change their colour to purple after 20 minutes of exposure to saturated steam at + 121° C or 7 minutes of exposure to steam at + 134° C. The TST indicator is placed inside and as near to the centre of the goods as possible in order to prove that steam has penetrated the entire package and to validate the sterilization process.

Single use lancets are small steel plates with a sharp, bevelled point (designed for being as painless as possible) which are used for pricking the skin for taking samples of capillary blood. Lancets are sterile and packaged individually in small sachets.

Specimen containers are used to collect, transport and temporarily store specimen inside health care facilities until they can be examined. Sputum containers are made from polyethylene or polystyrene crystal, have a tightly fitting screw cap, are rather flat with a diameter of 5 centimetres and have a capacity of around 30 millilitres. They are single use but non-sterile.

Containers for urine or stool are transparent bottles made from polystyrene crystal with tightly fitting screw caps and a capacity of about 60 millilitres. The inner side of the cap of stool containers is fitted with a small spoon for taking samples.

Blood sampling tubes are used for collecting, transporting, temporarily storing and processing blood samples at health care facilities. The closed system allows collecting blood directly from an intravenous catheter or hypodermic needle and eliminates the risk of contamination.

The single use, sterile PET tube is closed with a polystyrene plug with an elastomer stopper which will remain watertight after drawing the sample. The vacuum inside the tube allows drawing blood into the tube during collection without the need to open the tube or remove air. Tubes of about 8 centimetre length and with volumes between 3 and 7 millilitres are colour coded for different purposes and may contain various additives. Depending on the type of examination foreseen with the blood, tubes may contain reagents which cause clotting of the blood or the internal walls may be coated with EDTA which prevents blood from clotting.

Special holders and hypodermic needles are available for drawing blood directly into the blood sampling tubes without any risk of contamination and for discharging the hypodermic needle into a sharps container without touching it. The single use, sterile hypodermic needle which is used for puncturing the vein is screwed to the plastic holder and a spike protruding from the other end is used to puncture the stopper of the blood sampling tube. A rubber sleeve stops the blood flow when the blood sample tube is withdrawn and allows subsequently filling several tubes. The holder in principle does not come in contact with blood and can be reused after cleaning and disinfection.

Capillary glass tubes with a capacity of around 75 microlitres are used for determining the haematocrit of a blood sample. The 75 millimetre long tubes with an internal diameter of only 1.1 millimetres which are open on both ends are filled with blood and closed on one end with a special paste before placing in a centrifuge. The inside walls are coated with heparin to prevent coagulation of the blood sample. The capillary tubes are usually packaged in plastic tubes or boxes of 100 tubes.

Special past for sealing haematocrit tubes is similar to modelling clay and packaged in small trays. The haematocrit tubes are sealed simply by pressing one end vertically into the paste which fills the bottom end of the tube and remains in place when removed from the tray.

Unbreakable, polypropylene centrifuge tubes with a conical bottom and a cap are used for hold urine and other body fluids during centrifuging. The tubes must fit the centrifuge but commonly tubes with a length of 10 centimetres and a volume of 15 millimetres are used.

Non-sterile but single use pipette tips are attached to automatic pipettes for holding small volumes of 0.5 to 1,000 microlitres. Pipette tips are made from polypropylene and the different tips are colour coded (for example yellow or blue) according to the volume they can hold. The are usually packed in bags of 1,000 pieces.

Microscope slides hold samples for examination under a microscope and should not be reused. Microscope slides are made from ordinary glass, are 26 millimetres wide, 76 millimetres long, around 1 millimetre thick, have rough edges to facilitate spreading of smears and one end may be frosted for marking with a pen.

Single use microscope cover glasses (cover slip) are placed on unstained samples before examination. The square cover glasses have a length of 22 millimetres, a thickness of about 0.15 millimetres and are usually packaged in small containers of 100 pieces. Larger cover glasses are used for covering the entire smear for preservation.

Lens cleaning paper is used for cleaning the eyepieces as well as objectives of microscopes. The sheets of about 10 by 15 millimetres are usually packaged in pads of 100 pieces.

Filter paper "Whatman" is used for filtering various stains during preparation. The paper discs have various diameters and thicknesses and are usually packaged in 100 pieces.

A wide range of laboratory reagents are used for basic examinations of blood, cerebrospinal fluid, sputum, urine and stool. However, only few are needed if rapid tests (for example for glucose and haemoglobin) are used. Many other laboratory reagents are used for preparing staining solutions for blood cells or bacteria such as Giemsa solution (malaria, blood cell morphology), Ziehl Neelson solution (for tuberculosis mycobacteria in sputum) and Gram stain (differentiation of gram positive and gram negative bacteria). These may be replaced by ready for use solutions or complete staining kits.

Buffer tablets (pH 7.2) are used for preparing solutions for diluting Giemsa solution and methanol is used for preparing numerous reagents. Turck solution haemolyses erythrocytes and stains leucocytes allowing to count them under a microscope. Immersion oil, which must

have the same refractory index as the microscope slide, is placed between the microscope slide and the objective in order to reduce refraction of light and therefore makes specimen appear brighter. Xylene is used as solvent for removing grease from microscope slides and microscope objectives.

Blood grouping antisera anti-A, anti-B, anti-AB and anti-D are used for determining the blood group of a blood sample. The anti-A, anti-B and anti-D (Rhesus factor) reagents contain the antibodies against the respective antigens on the surface of red blood cells which lead to agglutination of a blood film placed on a special blood card, glass slide or special tile. The anti-AB antisera is in principle not needed but used as a control. The dropper bottles of usually 10 ml are sufficient for 150 - 200 tests and must be kept in a cold chain.

Blood group control cards allow testing for presence of the respective antigens in the donor and recipient blood on dedicated circles and documentation of the results.

Urine test strips contain several pads which change their colour after being dipped into a sample in urine and allow the qualitative determination of such parameters as glucose, protein, bilirubin, blood etc. in a urine sample. The result is determined by comparing the colour change with a colour scale printed on the packaging.

The qualitative determination of hCG with a urine test strip allows determining a pregnancy.

Blood glucose test strips change their colour according to the concentration of glucose in blood smeared on it and readings can be obtained by visual comparison with a colour scale or by reading in a glucometer.

Single use microcuvettes are specifically designed by the respective manufacturer to fit (only) their specific type of glucometer or haemoglobinometer. One end of the small slide is fitted with a rectangular cavity which holds a minute volume (for example 10 microlitres) and is open on the side to allow filling the blood sample by capillarity. After filling, the microcuvette is inserted into the respective analyser for obtaining the reading. Microcuvettes are usually packaged in plastic bottles of 50 pieces.

Various rapid diagnostic tests contain individually wrapped test strips which indicate a positive result by a colour change after applying blood or serum. Test kits may also include various reagents such as diluents, buffers, positive and negative controls as well as single use devices such as pipettes. They may require a cold chain but some also remain stable at room temperature throughout their shelf life.

Rapid tests are used for diagnosing such diseases as malaria, brucellosis, leishmaniasis in a blood sample or meningitis in cerebral spinal fluid obtained through a lumbar puncture.

Rapid tests for hepatitis B, hepatitis C, HIV 1+2 and Syphilis are compulsory for screening blood donors but are usually not primarily intended for diagnosing these diseases in patients. Often a second HIV rapid test product is used for confirmation.

X-ray films are available in sizes of 18 x 24, 24 x 30, 30 x 40 and 35 x 43 centimetres and must fit the respective x-ray cassette. X-ray films must be packaged in lightproof packaging which must only be opened in a special dark room before loading the x-ray cassettes. Some of the radiation is converted into visible light in the x-ray cassette and x-ray films can be sensitive to green or blue light which enhances the image.

After exposure, x-ray films are immersed in a developing solution. One plastic bag of developer powder is typically sufficient for preparing 22.5 litres of working solution and 1 litre is sufficient for developing about 1 square metre of x-ray films.

A fixer solution is also made from powder, typically packaged in quantities sufficient for preparation of 22.5 litres of solution.

Since air reflects more than 99% of the ultrasound beam (Stocksley, M. 2001, 7), conductive ultrasound (transmission) gel (coupling gel) must be applied between the ultrasound probe and the skin in order to eliminate any, even minute, amounts of air. Ultrasound gel should be aqueous (water soluble), have medium viscosity, be free of salt and alcohol, should be hypoallergenic and not irritate the skin, be non-staining and must not damage the transducer.

A tongue depressor is a non-sterile but single use spatula for depressing the tongue for examining the throat and the mouth. They are about 14 centimetres long, 2 centimetres wide, 2 millimetres thick and made from polished wood.

Non-sterile but single use razors are used for removing hair from the skin of an intended operating site. A plastic head holds a stainless steel blade and is attached to a plastic handle. Razors must not comply with any particular specifications and simple razors for everyday use are appropriate.

Small plastic bags are used for dispensing drug products at clinics which are taken home by individual patients. The transparent polyethylene bags are usually measure 6 by 8 centimetres and fitted with a watertight snap-lock closure. The bags may be printed with instructions and may have space for indicating the name of the drug product, daily dosage and duration of treatment.

15.3.3 Quality standards

Medical devices must be manufactured according to demanding standards in order to be effective for their intended purpose as well as protect the patient, the user and any other person against possible risks.

Standards differ from country to country and manufacturers are obliged to comply only with the laws which apply in the country of manufacture. Manufacturers in the European Union have to comply with Council Directive 93/42/EEC of 14 June 1993 concerning medical devices (European Commission 1993) which is also a requirement for using the "CE" (Conformité Européene) marking.

In Europe, the manufacturer determines the class of a new product which in turn determines regulatory procedures. Except for sterile devices, the conformity of Class I products with quality requirements can be assessed by the manufacturer himself. For Class IIa products the intervention of a notifying body is compulsory at the manufacturing stage and for Class IIb in addition at the design stage. In addition, Class III products require an authorization for design and production.

In less developed countries, regulatory control for domestic production as well as for importation are scarce as well as poor and create significant risks for patients (Cheng, M. 2003, V).

15.3.4 Packaging and sterilization

The functions of packaging listed in table 15.6 equally apply to single use medical devices. All single use medical devices must be packaged in paper (wrapping, bags), plastic (wrapping, cans, boxes) or cardboard boxes.

Sterile medical devices must be packaged in specific ways in order to allow effective sterilization after packaging by the manufacturer, maintaining sterility throughout the

expected shelf life as well as opening and aseptic removal without contamination. Packaging must be durable, easy to open and packaging material must open or tear only in the intended place. Packaging materials must be compatible with the packaged devices and must withstand the respective sterilization method.

Most single use devices are available in peel pouches (Reichert, M., and J.H. Young 1997, 62) which allow opening them and removing the device without contamination. Peel pouches may be made of two sheets of paper (for example with sterile gloves), one sheet of plastic composite and one sheet of paper (for example for endotracheal tubes, aluminium pouches (surgical blades) or blister packaging (for example for peripheral venous catheters). Sterile packaging must be non-reusable as well as tamper-evident and it must be impossible to close the packaging after opening as sterility is maintained only as long as the packaging is not opened.

Effective sterilization destroys all micro-organisms in or on the medical device or the packaging. However, in practice sterilization can ensure (only) the complete destruction of all micro-organisms only with a very high probability, for example leaving a probability of one in a million (devices) of detecting viable micro-organisms.

Sterilization can be achieved by physical methods such as moist heat, dry heat or irradiation as well as be chemical methods such as the use of gases or liquids.

Sterilization by saturated steam for a defined period of time, at a defined temperature and pressure in industrial autoclaves is a commonly used method. The use of paper packaging often in combination with plastic allows steam to easily penetrate into the packaging while preventing penetration of micro-organisms after sterilization and drying. However sterility of packaged devices is only ensured if the packaging is not damaged (punctured, torn, cut etc.) and if the packaging remains dry at all times.

Sterilization with ethylene oxide (EO) at a carefully controlled concentration, temperature, humidity as well as duration and in special ethylene oxide autoclaves is also a common method for sterilizing medical devices made from plastics, especially if they are damaged by heat and cannot withstand steam sterilization. All surfaces of the device must be in immediate contact with the gas in order to be sterilized.

Medical devices are commonly sterilized by electromagnetic radiation (gamma rays or x-rays) or particulate radiation in electron-beam sterilizers of defined doses and for a defined duration. The ionizing radiation destroys or inactivates micro-organisms by damaging their molecular structure and therefore their cells.

The time and conditions of the sterilization process of every batch must be recorded and traceable through a batch number. In any case the sterility of sterilized devices is never known with certainty as inadvertent and unnoticed contamination may have taken place, even after effective sterilization. For example paper packaging may have become wet allowing contamination but have subsequently dried again without leaving any visible trace.

The shelf life of sterilized medical devices stated by the manufacturer is only valid if the packaging is not damaged and if the required storage conditions have been maintained without interruption from the time of manufacture.

15.3.5 Labelling

As there are no universal standards, medical devices must be labelled according to the national legislation of the country of manufacture. However, Annex I of the Council Directive 93/42/EEC (EC 1993) can serve as a reference (see table 15.14).

Labelling of medical devices must indicate the name (or trade name) of the manufacturer and his address. The packaging must bear the name of the medical device as well as sufficient specifications such as the dimensions or volume for complete identification of the device. Manufacturers must also indicate their proprietary article reference number which is also used in catalogues and for ordering.

The word "STERILE" as well as a clear indication of the applied sterilization method must be printed on sterile medical devices.

Where applicable, the batch number preceded by "LOT", "BATCH" or an equivalent word must be printed on the label. All sterile medical devices must be labelled with a batch number in order to allow batch tracing in case a fault is detected in the sterilization process after release of the respective batch.

If no expiry date is printed on the label, (at least) the year of manufacture must be indicated although it may be integrated into the batch number.

The label must clearly indicate that the respective device is intended only for single use.

Wherever applicable, the required storage and handling conditions such as maximum storage temperatures must be clearly indicated, especially for maintaining sterility.

The number of units in every packaging should be printed on the outer packaging.

Any warnings and/or precautions which must be taken must be printed on the label.

- Name (or trade name) of manufacturer.
- Address of manufacturer.
- Name of medical device.
- Specifications (dimensions, volume, etc.) sufficient for the identification of the medical device.
- Article reference number given by the manufacturer.
- "STERILE" printed on packaging for sterile items.
- Clear indication of sterilization method.
- Batch number preceded by "LOT" or "BATCH" (or equivalent), if applicable.
- Expiry date (at least month and year) preceded by "EXP", "Exp. date" (or equivalent), if applicable.
- Year of manufacture (at least if there is no expiry date), may be included in the batch number.
- Indication that medical device is for single use only, if applicable.
- Required storage and handling conditions (temperature etc.).
- Number of units per packaging.
- Instructions for use, if applicable.
- Any warning and/or precautions which must be taken.

Table 15.14 Contents of labelling of single use medical devices

The intended purpose of the medical device must be indicated on the label if it is not obvious for users. Except for class I or IIa devices, as far as practical and where necessary, information required for the safe use of medical devices must be printed on the packaging of each device. If this is not practical, each (outer) packaging must be supplied with a leaflet.

In addition to the information on the label (except for the batch number and expiry date), leaflets must describe the performance intended by the manufacturer, as well as potential undesirable side effects. Moreover contra-indications for using the medical device as well as precautions in case devices fail to perform as intended. Medical devices intended for

administering drug products must indicate suitable uses as well as any limitations. The claimed accuracy must be included for any measuring devices.

Instructions must be given for the event of damage of the packaging and, if appropriate, methods for re-sterilization. Moreover any instructions as well as unusual risks related to the disposal of the medical device.

15.4 Health care equipment

Health care equipment covers a wide range of items, from a simple stethoscope to sophisticated anaesthesia equipment and surgical instruments. All electrical equipment should be protected by voltage regulators of sufficient capacity wherever fluctuations of the mains electricity supply or electricity from generator sets cannot be excluded.

15.4.1 Classification

Health care equipment (including their replacement parts) can be roughly divided into equipment for clinical services, clinical support services and non-clinical services.

Clinical services for diagnosis, nursing and treatment include diagnostic equipment, hospital furniture, physiotherapy equipment, anaesthesia, operating room and sterilization equipment, surgical clothing and linen, surgical instruments as well as surgical instrument sets (see table 15.15).

- Diagnostic and examination equipment: scale, measuring tape, brachial perimeter bracelet, thermometer, stethoscope, sphygmomanometer, pocket torch, ophthalmoscope**,** otoscope.
- Furniture and patient transport: examination table, delivery table, hospital bed, bed side locker, IV stand, stretcher, stretcher carrier, manual wheel chair, crutches, dressing trolley.
- Operating room equipment: operating table, mayo table, instrument table, bowl stand, OT-stool, operating lamp, surgical suction machine, electrosurgical unit.
- Sterilization equipment: autoclave, burner, sterilization drum/case, timer, packing table.
- Anaesthesia equipment: tourniquet, pressure cuff, Guedel airway, resuscitation bag, laryngoscope, Magill forceps, intubation stylet, suction machine, oxygen concentrator, oxygen cylinder, pulse oximeter, anaesthesia machine, ventilator.
- Surgical clothing and linen: cap, glasses, mask, tunic and trousers, gown, clogs, surgical apron, drape.
- Surgical instruments: scalpel handle, dermatome, scissors, curette, respiratory, osteotome and mallet, rongeur, shear, bone saw, Gigli saw handle, drill and chuck, needle holder, spatula, speculum, forceps, clamp, retractor, Steinmann pin and traction bow, external fixation, plaster shear, probe, suction tube, galipot, bowl, kidney dish, tray.
- Surgical instrument sets: minor surgery, wound excision, basic general surgery, paediatric surgery, craniotomy, thoracotomy, laparotomy, gynaecology, amputation of limbs, bone surgery, skeletal traction, external fixator, fine surgery, vascular set, E.N.T., dental, skin graft.
- Laboratory and blood bank: spatula, funnel, measuring cylinder, beaker, washing bottle, staining jar, staining rack, slide rack, grease and diamond pencil, tube rack, pipette, micropipette, glucometer, haemoglobinometer, haemocytometer, mechanical counter, scale, spirit lamp, centrifuge, microscope.
- Diagnostic imaging: radioprotective clothing, pocket dosimeter, x-ray cassette, x-ray machine, darkroom light, processing tank, film hanger, thermometer, darkroom timer, x-ray film dryer, x-ray viewing box, ultrasound machine.
- Miscellaneous equipment: nail brush, splint, urine bottle, bedpan.

Table 15.15 Classification of health care equipment

Clinical support services include the laboratory, blood bank and diagnostic imaging such as x-ray and ultrasound.

In addition non-clinical support services such as offices, kitchen, tailor's shop, laundry, cleaning, incineration and waste disposal as well maintenance and a workshop require equipment which are not specific to health care logistics. Furthermore security, telecommunication, lighting, water supply and waste water disposal as well as heating, cooling and ventilation equipment and facilities require installation, maintenance and servicing.

15.4.2 Types of items and specifications

The technical specifications are, again, mainly based on volumes 1 through 4 of the Medical Catalogue (Bretton, M., V. Cruyt, A.-F. Maes, and I. Verelst (ed.) 2008) published by Médecins sans Frontières.

Conventional bathroom mechanical scales with a maximum weight of 150 kilograms and graduations of 0.5 kilograms are used to determine the body mass (weight) of patients in clinics and hospitals. The scale must have a stable platform and must be made from anti-corrosive steel. There should be a possibility to reset (adjust) the dial which is connected to the spring mechanism to zero when the scale is not loaded. Mechanical scales are usually preferred to electronic scales as they are more robust.

"Salter scales" with a maximum weight of 25 or 50 kilograms and graduations of 0.1 or 0.2 kilograms are commonly used for determining the weight of children, especially in clinics and feeding centres. The scale is hung from the ceiling or a pole and the child is suspended in a harness ("trousers") from a second hook. Before measuring the scale must be tarred with the trousers and the dial then indicates the weigh on a large dial plate.

The height of patients can be measured with a simple 200 centimetre tape, graduated in millimetres or a wooden (foldable) measuring board with a measuring tape attached. Small children are measured lying down, other patients standing upright.

Brachial perimeter bracelets are used to measure the mid-upper-arm circumference (MUAC) of 6 months to 5 year old children and allow the rapid diagnosis of acute malnutrition without the need for measuring the weight or height. The 10 centimetre long polypropylene bracelet is graduated, marked with coloured sections and fitted with a window for reading the result. Another model can be used for measurement in adults.

Clinical thermometers are used to measure the body temperature of patients. Thermometers containing mercury should not be used as they are banned in some countries, this substance is harmful to the environment and subject to restrictions for air transportation. Instead glass gallium thermometers with protective cases, a measurement range between + 35 to + 42° Celsius and 0,1° Celsius graduations should be used. The gallium column indicates the highest measured temperature and must be reset before any further measurements by shaking the gallium column back. Alternatively electronic thermometers with the same range and accuracy with batteries which allow around 1,000 measurements may be used.

Stethoscopes are used for amplifying and auscultation of sounds from the surface of the body which originate inside the body such as cardiac, pulmonary or bowel sounds as well as sounds from (obstructed) vessels and are needed for measuring arterial blood pressure together with a sphygmomanometer.

One cup stethoscopes have a plastic or expoxy glass fibre diaphragm with a diameter of 40 millimetres (25 millimetres for children) which is secured on the chest piece made from chromed brass with a clip ring. Chest pieces may be fitted with two diaphragms of different

sizes which can be switched by turning the chest piece 180 degrees. The metal connector of the chest piece is connected to a rubber tube with a diameter of 10 millimetres and a maximum length of 40 centimetres (to minimize sound reduction) which is impervious to outside noise but ensures full transmission of sounds. A Y-tube with adjustable stainless steel arms connected by a spring makes the connection to two tubes fitted with earpieces which must be detachable for cleaning and disinfection. Stethoscopes should be provided with spare diaphragms and earpieces.

Obstetrical stethoscopes, commonly called Pinard stethoscopes, are conical aluminium tubes with a length of about 15 centimetres with a round and flat base which is placed on the abdomen of pregnant women and allows auscultation of fetal heart sounds at the funnel-shaped end.

Sphygmomanometers are mechanical devices used for measuring arterial blood pressure on extremities by blocking the blood flow by inflating a cuff and lowering the pressure until blood flow resumes intermittently (systolic blood pressure) and completely (diastolic blood pressure).

The flat, rectangular (approximately 10 x 22 centimetres for adults) and inflatable rubber bag which is fitted with a 60 centimetre long tube is washable and can be disinfected or even steam sterilized.

The rubber cuff is entirely covered by a robust, inelastic and washable nylon cuff with a wide Velcro strip which allows fastening the cuff tightly around the arm and safely prevents opening of the cuff during inflating of the rubber bag. A range of smaller cuffs is available for children and infants.

The rubber tube is connected to a pressure gauge which indicates the pressure from 0 to 300 mmHg (millimetre of mercury) with a needle on a dial scale and a rubber bulb with a one-way release valve which allows inflating the rubber bag as well as a pressure release (screw) valve. The entire device is usually kept in a plastic bag with a zipper.

Pocket torches without any particular medical specifications are used for testing the pupillary reflex (constriction upon stimulation of the retina by light), a basic but important neurological examination.

Ophthalmoscopes allow shining light inside the eye and simultaneously examining the eye through a lens, particularly the retina. The handle houses two batteries and a switch for the 2.5 volt halogen bulb which is fitted inside the head. The detachable screw-on head is fitted with a dial with several lenses and filters which can be switched and placed in front of the eye piece by turning the dial. The device must be robust, resistant to dust and should be provided in a rigid, protective case with spare bulbs.

Otoscopes are used for examining the inside of the ear with a light source. The handle contains two batteries and a switch for the 2.5 volt halogen bulb. The screw-on head is fitted with a bulb which allows shining light into the ear while observing and examining through a magnifying glass and reusable specula with diameters of 2 to 5 millimetres.

The device should be provided in a rigid, protective case with spare bulbs. Complete sets with a handle interchangeably fitting an ophthalmoscope or otoscope screw-on head are available.

All furniture is likely to be exposed to various liquids and must therefore be made from materials which are resistant to corrosion, easy to clean and to disinfect.

Examination tables are used in clinics and outpatient departments at hospitals for medical examinations as well as simple nursing and medical procedures. They should be foldable or easy to assemble and dismantle for transportation.

The frame of 80 centimetres height, 60 centimetres length and 190 centimetres length is made from stainless steel and the surface is fitted with a strong plywood or metal sheeting. The adjustable headrest should be self-locking. The entire surface is fitted with a 5 centimetre thick foam cushion and the cover should be easy to clean and must be resilient to disinfection.

Gynaecological examination tables which are used for gynaecological and obstetrical examinations are similar in size design. However they are made of three sections, a self-locking and adjustable back, seat and leg rest which can folded downward and is fitted with a pair of leg supports as well as a removable stainless steel pan.

Delivery tables, which are similar in design to but wider than gynaecological examination tables, are especially designed for deliveries in clinics or hospitals. The foot rest can be folded downward or be removed and the entire table can be tilted in the Trendelenburg position (head down) up to 30° backward. Side rails allow fitting various accessories such as leg supports and handles.

Hospital beds have a width of 90 centimetres, length of 200 centimetres and a height of approximately 60 centimetres, should be durable and long-lasting, especially in humid climates. The chromium plated steel frame can be made from one piece or three parts which can be slotted or screwed together. The metal grid base and the manually adjustable backrest should be coated with epoxy for protection from corrosion from cleaning, disinfection or exposure to other liquids.

Mattresses should be made from 10 cm thick (high density) foam and must be covered with resilient fabric which can be cleaned and disinfected. Likewise the same fabric should be used to cover pillows as they are very difficult to clean and disinfect. Mattresses may be protected by waterproof rubber draw sheets.

Bed sheets are approximately 180 centimetres wide and 290 centimetres long. The cotton fabric should be hemmed on all four edges, have a warp and weft of around 30 and a weight of 180 grams per square metre. The fabric must withstand repeated washing, disinfection as well as boiling and sterilization. The same fabric can be used for making pillow covers.

In countries where diseases transmitted by (flying) insects are endemic, every hospital bed must be fitted with a suitable and impregnated mosquito net.

Bed side tables or lockers may be placed bedside each hospital bed for keeping personal belongings of patients. They have a surface of approximately 40 x 40 centimetres, a height of 80 centimetres, may be fitted with a compartment and drawer and should be made from epoxy powder coated stainless steel.

Infusions stands are used in emergency rooms, operating theatres as well as in wards for suspending bottles or pouches of infusion solutions or blood during infusion and transfusion.

The stable base with 4 to 5 antistatic castor wheels of 5 to 10 centimetre diameter is made from stainless steel tubing (approximately 30 millimetre in diameter or cross-section) and allows easily moving the infusion stand. A support column holds a telescopic pole which can be adjusted between 140 and 200 centimetres and has 2 to 4 hooks for infusion bottles firmly attached (welded) at its tip.

Stretchers which are foldable only in width or in width and length are used mainly in first aid for transporting patients as well as (temporary) makeshift beds in emergency situations.

The rectangular aluminium frame with overall dimensions of approximately 230 by 60 centimetres is fitted with a foot on each corner to allow setting the stretcher on the ground while keeping the patient suspended. The two lengthways poles are fitted with handles on either end and may be fitted with straps for carrying patients over longer distances. A robust, reinforced, coated and washable canvas which can also be disinfected is firmly fitted between the two poles.

Stretcher carriers are used for internal transfers of patients inside hospitals especially to and from operating theatres and diagnostic facilities (for example x-ray department) and should have a capacity of around 180 kilograms.

The robust frame made from 30 millimetre stainless steel has a size of approximately 200 by 60 centimetres and a height of 80 centimetres and is fitted with four antistatic, rubber covered steel castors with a diameter of about 10 centimetres which can be safely arrested with 2 foot brakes. The headrest should be adjustable and the side rails on either side removable.

The mattress should be made of 5 centimetre thick, high density foam and be covered with a robust, water-resistant fabric which can be cleaned and disinfected.

Manual wheel chairs must be sturdy, durable, stable, ensure the safety as well as health of the user (Bardsley, G. et al. (ed.) 2008, 42) and must be suitable for indoor and outdoor use. They may be designed with three or four wheels, be foldable or rigid and are available for adults and children.

Two large inflatable or rubber rear wheels with push rings and brakes as well as one or two small turnable castor wheels in front must ensure high manoeuvrability.

The backrest must have push handles attached for movement by a care taker. Wheel chairs may be fitted with a flexible but stretch-resistant sling (slung) seat made from canvas or vinyl or a solid seat made from metal or plastic. Every wheel chair must be fitted with a pressure relief cushion as well as removable armrests and the design should facilitate transfer in and out of the wheelchair. A calf strap as well as adjustable and retractable footrests support legs and feet.

Crutches are gait aids used by patients with injuries or disabilities for walking and standing. The can be made from wood or aluminium, are available in different sizes and are adjustable in length.

Adjustable axillary (under arm) crutches are made from two uprights joined together at the top with a padded crossbar, are connected to an adjustable, rubber-tipped bottom with screws and fitted with a grip in the middle (Tan, J.C. 2006, 298).

Adjustable forearm (Lofstrand) crutches are made from a single telescopic upright which is fitted with a rubber-tip for preventing slippage, a padded hand bar for gripping and an open forearm cuff for support.

Dressing trolleys are used in hospital wards for transporting items for changing dressing as well as for transportation of medicines and other items.

Dressing trolleys should have a width of at least 50 centimetres as well as a length of at least 80 centimetres, must be robust and allow moving a load of 100 kilograms. The four antistatic castor wheels should have a diameter of 10 centimetres, the frame and two shelves should be made from stainless steel in order to be resistant against corrosion.

Operating tables accommodate patients in operating theatres while undergoing surgery. In order to avoid dependency on electrical power supply, operating tables should be fully mechanical and hydraulic. They should be multifunctional yet simple and require only a

minimal number of tools for assembly as well as be stable, robust and yet light weight (around 100 - 150 kilograms), long-lasting and require as little maintenance as possible.

Frames and support structures are made from stainless steel and operating tables have a width of about 60 centimetres, a total length of about 220 centimetres and the height should be adjustable with a crank or a hydraulic foot pump between 75 to 100 centimetres. Frames may be fitted with adjustable pods or castor wheels which can be arrested with breaks.

Operating tables are composed of a headrest, backrest, seat and separate leg supports, which are all fitted with antistatic cushions, and are connected but can be individually adjusted according to the patient position required for the operation. The entire operating table can be tilted 30° head down (Trendelenburg) or head up (reverse Trendelenburg) as well as up to 20° laterally.

Accessories such as an anaesthesia screen, shoulder rest, armrest, side support, pubic support, leg support and poles with hooks for holding infusions can be attached with special clamps to side rails which run along the entire length of the operating table.

Operating tables must be supplied with detailed user manuals and a reference for replacement parts.

A Mayo table is used for keeping surgical instruments and devices near to the operating site. As the table surface may be placed over aseptic areas, mayo tables must be covered on all sides which special covers shaped like a pillow cover. Therefore the table surface can be supported only by a single upright. Nevertheless the table must be stable even when loaded.

The table surface which is about 50 centimetres wide, 60 centimetres long and 1 centimetre thick as well as the frame which can be adjusted to heights between 80 to 150 centimetres with a screw are made from stainless steel. The base of the Mayo table may be rectangular with 4 antistatic, castor wheels or T-shaped with only 3 castors.

Instrument tables are used in the operating theatre for preparing and placing instruments and devices for surgery and should be to able to safely take a load of up to 80 kilograms.

The steel frame with a height of around 85 centimetres and with a diameter of about 25 millimetres as well as two approximately 120 by 60 centimetre shelves are made from stainless steel and fitted with 4 antistatic, castor wheels with a diameter of 5 to 10 centimetres. The shelves are plane and not fitted with border rails in order to allow covering them with sterile drapes.

Bowl stands hold one or two metal bowls with diameters of 30 to 40 centimetres and capacities of around 5 litres which are used during surgery for holding various goods such as liquids, used surgical instruments or waste.

The frame is made from tubular stainless steel with a diameter of around 25 millimetres and has a height of approximately 20 or 90 centimetres. The bowl stand must be stable but mobile and is fitted with 4 or 5 antistatic castor wheels with a diameter of 5 centimetres.

Mobile stools are used in the operating theatre for staff which need to wait or sometimes by surgeons during operations.

The base is made from 5 rectangular, stainless steel legs fitted with antistatic castor wheels with a diameter of 5 centimetres. The height of the seat with a diameter of about 30 centimetres is adjustable manually or hydraulically between 40 and 60 centimetres.

Operating lamps are used in operating theatres to illuminate the operating site, small lamps are also used in clinics or outpatient departments for examinations. Operating lamps with one or several bulbs can be fitted to mobile stands with articulating arms or be fastened to the

ceiling with mechanisms which allow moving and rotating them in all directions. Operating lamps should illuminate the operating site but should not radiate heat to the operating site as this will lead to an undesired increase in blood circulation (and therefore increase in bleeding) as well as evaporation.

Mobile operating lamps require a mobile base made from 3 to 5 stainless steel legs with antistatic castor wheels. The lamp is connected to the stand with an articulated arm which allows adjusting the height between around 120 to 220 centimetres.

The inside of the housing is fitted with a reflector which increases the light shined onto the operating site while absorbing infrared radiation. The height of the lamp and its angle is adjusted with a handle, usually in the centre of the lamp. As operating staff with sterile gloves adjust the lamp during operations, this handle must be fitted with a detachable cover which can be cleaned and sterilized after every operation.

Operating lamps may be operated on rechargeable 24 volt (car) batteries or 220 volts mains electricity supply. A single bulb should provide 80,000 to 100,000 lux and last for 500 - 1,000 hours of operation.

At the recommended distance from the operating site of 70 to 140 centimetres the light field should have a diameter of around 20 centimetres.

Equipment must be delivered with spare bulbs, spare handles as well as instructions for installation, operation and maintenance.

Surgical suction machines are used to remove blood and other liquids which obstruct the view from the operating site. The units are fitted onto mobile platforms for movement during and after operations. An electrical suction pump, usually operating at 220 volts, generates a vacuum in a receptacle which is fitted with valves which will safely prevent any humidity or liquid from entering and damaging the pump. An additional safety bottle with an automatic overflow valve provides additional protection in case the overflow valve of the receptacle fails. The receptacle is connected with a flexible plastic tube to the suction device, such as a single use Yankauer tube, manipulated by operating staff.

The surgical suction unit is fitted onto a rectangular platform with 4 antistatic castor wheels. The vacuum pump is operated with a switch which should be fitted with a power on light, the vacuum is adjusted with a control knob up to 800 mbar and the actual vacuum in the receptacle is indicated on a pressure gauge. In addition the suction pump may be operated by the surgeon with a pedal switch which is connected to the suction unit by an electrical cable.

Surgical suction units may be fitted with one or two graduated plastic receptacles which can each hold up to around 4 litres of liquid. Units with two receptacles have the advantage that a full receptacle can be emptied while using the second receptacle and therefore avoiding the need for any interruption. The lid of receptacles must be fitted with automatic valves which will prevent any liquids from overflowing. Receptacles must be easy to empty, disinfect, clean and must be autoclavable.

Suction machines must be provided with spare fuses, spare overflow filters as well as user manuals. A sufficient supply of 5 metre, flexible, plastic tubing with a diameter of around 7 millimetres, (reusable) biconical connectors as well as sterile, single use suction tubes (for example Yankauer suction tube) must always be available.

Electrosurgical units generate high frequency alternating currents between the patient body and an electrical scalpel which allow cutting soft tissue as well as stopping bleeding by coagulating (small) vessels in the operating site.

The device is protected by a metal casing and is fitted or placed on a stainless steel trolley with antistatic castor wheels. The panel includes the main power switch with a power on light as well as controls for adjusting the power for cutting and coagulation individually between 80 to 200 watt. Devices usually operate with 220 volts and are protected against defibrillator shocks.

The "neutral" electrode must be attached directly to skin of the patient, usually the thigh, must have a large surface in order to prevent skin burns and is connected to the main unit with a 5 metre long cable. The unit must be automatically disabled if the patient electrode is not connected at all, not connected correctly, the wire breaks, the connection becomes loose or the electrode is accidentally disconnected. Single use electrodes or reusable electrodes which must withstand cleaning and disinfection may be used.

A further cable connects the main unit with an autoclavable handle with the electrode holder. The handle is fitted with separate buttons for activating the electric current for cutting or coagulation which also switches on a buzzer in the main unit whenever a current is applied. Alternatively the device may be controlled by a foot operated switch.

The electrodes are shaped as blades, short rods with heads or sharp needles and are reusable but will withstand only a certain number of sterilization cycles after which they have to be replaced.

Electrosurgical units should be delivered with spare fuses, spare patient electrodes, spare electrodes and a comprehensive user and service manual.

The use of saturated, heated steam is the only practical sterilization method under the conditions humanitarian organizations work under. Dry heat sterilizers ("Poupinel") are not suitable as they require temperatures of + 180° C which have to be maintained without overheating, the temperature must be evenly distributed throughout the chamber, air must be able to circulate around the load, sterilization cycles last around 4 hours and they are difficult to monitor and control. The high temperatures causes deterioration of various items and materials such as sharp stainless steel instruments, plastics or linen. Boiling in water is also not an effective method.

Sterilization with saturated steam can be effectively carried out at + 121° Celsius (at 1 bar) for 20 minutes or + 134° Celsius (at 2 bars) for 10 minutes. The ability to destroy micro-organisms does not depend on the temperature alone but on the energy that is transferred from the condensing steam to the surface of individual cells. As the thermal capacity of air is much lower and therefore transfers little energy, all air must be removed from autoclave chambers before the actual sterilization cycle starts. As water a sea level evaporates at + 100° Celsius, the high temperatures which are required can only be achieved by increasing the pressure inside the autoclave.

Small autoclaves ("pressure cooker" type) with diameters of around 30 centimetres and capacities of 20 to 40 litres are used in clinics for sterilization of compresses and small surgical instruments at + 121° Celsius (at 1 bar).

The vessel is made from cast aluminium and fitted with two handles. The aluminium lid may be fitted with a high pressure and heat resistant rubber seal or seal directly with the vessel (metal to metal) and is secured with several screw clamps with knobs or wings.

The lid is also fitted with a graduated pressure and temperature gauge, a pressure regulator, a pressure safety valve which opens automatically if the maximum pressure is exceeded as well as a steam release valve which is used for removing air ("purging") before sterilization and releasing the pressure after sterilization.

The autoclave should be provided with an aluminium basket with feet, spare gaskets (if necessary), spare safety valves, spare steam release valves and operating instructions.

Vertical autoclaves with capacities of about 90 litres are used in sterilization departments of hospitals for sterilization of surgical linen and instruments. They usually operate on 220 volt (single or three phase) or 380 V (three phase) but compressed gas or kerosene may also serve as additional or alternative power sources.

The stainless steel vessel which has a diameter of around 40 centimetres and a height of around 70 centimetres, is fitted with a lid with a gasket and closed with screw clamps.

Several electric heating elements with together 3,000 to 4,500 watt allow operating at + 121° or + 134° Celsius. An automatic valve will switch off the autoclave if the water level is too low as the heating elements will burn if they are not entirely immersed in water.

The autoclave is fitted with a temperature and pressure gauge, pressure regulating valve, safety valve and a steam release valve which may be operated entirely manually or regulated semi-automatically through a thermostat and electronic controls.

Autoclaves should require a minimum of maintenance, be delivered with spare gaskets, valves and heating elements as well as installation, maintenance and operating manuals.

Automatic, horizontal autoclaves with electronic controls are more complex but are also are more reliable and ensure that all sterilization parameters remain within the required ranges throughout the entire sterilization cycle. They also allow using different preset programmes for sterilizing different types of goods. Digital displays as well as a printer record pressure, temperature and any alarms over time. Integrated vacuum pumps quickly and reliably remove all air from the chamber before the sterilization cycle ("purging") and allow drying the goods after the sterilization is completed. However these autoclaves require installation and regular maintenance by certified technicians.

Small autoclaves require an external heating source for operation and larger autoclaves may use burners as supplementary energy source. If a reliable electricity supply is available a conventional hot plate for cooking with around 1,500 watts can be used.

Portable kerosene burners are fitted with a tank with a capacity of about 2 litres as well as a small hand pump which allows increasing the pressure in the tank and therefore the temperature of the flame. They allow completing the sterilization cycle for autoclaves up to a capacity of 40 litres while modified burners can be used for heating 90 litre autoclaves.

An alternative are portable iron tripods with a pipe, pressure reducer, regulator valve and gas burner which can operate butane or propane gas and provide about 8,000 watt of energy.

Sterilization baskets are made from wire mesh (around 4 by 4 millimetres or finer), fitted with handles and used for placing goods into autoclaves, preventing direct contact with the floor or the wall of the autoclave as well as removing them after sterilization. Sterilization drums and cases are used for holding goods during sterilization and may also be used for storage until use in the operating theatre.

Sterilization drums are made from stainless steel, cylindrical containers. The lid is fitted with a handle and can be locked to the drum with a latch. The body is fitted with lateral eclipses which are left open during sterilization to allow complete penetration of the inside with saturated steam and which can be closed with a slide after drying in order to prevent contamination during storage. Sterilization drums are available in diameters of between 15 and 35 centimetres and heights of 10 to 30 centimetres and must fit the respective autoclave.

Sterilization cases are rectangular aluminium boxes which are fitted with perforations and special textile filters in the top and bottom surface which allow penetration of saturated steam but prevent contamination during storage.

A mechanical timer sets of an audible alarm after the time preset in increments of one minute and up to on hour and is used for controlling the duration of the sterilization cycle.

A large table is needed in the sterilization department for preparing loads for sterilization, wrapping them in sterilization paper and loading them into sterilization drums. Moreover for making various sizes and types of compresses and preparing them for sterilization.

Anaesthesia equipment may be used in emergency rooms, operating theatres, post-operative care etc.

Tourniquets made from natural rubber or fabric with a plastic clamp are used to compress a limb and reduce venous blood flow for facilitating the puncturing and catheterisation of peripheral veins. They are made of a rubber strip or hollow tube with a length of about 50 centimetres and a width of 2 cm.

Esmarch bandages are firmly wrapped around limbs in order to compress blood vessels and limit bleeding during certain operations. The elastic rubber bandages are around 1 centimetre thick, 6 centimetres wide and 5 metres long and need to resist cleaning and disinfection.

Pneumatic tourniquets are cuffs, similar to cuffs of sphygmomanometers, for arms and legs which are connected to a pressure gauge and allow completely interrupting the blood flow to limbs for certain types of anaesthesia and surgery.

Pneumatic pressure cuffs are used for rapid infusion or transfusion of 500 millilitre or 1 litre pouches in emergency rooms and operating theatres.

The pneumatic cuff has the shape of a sleeve with a fabric back and a transparent net on the front side, a fabric loop which is threaded through the pouch for holding it in position and a hook for suspending the entire device from an infusion stand. The pneumatic rubber bag which is integrated in the back has a size of about 25 by 12 centimetres and is connected to a rubber bulb with a 80 centimetre long tube, a pressure release valve as well as anaeroid pressure gauge. The rubber bulb allows inflating the bag and increasing the pressure exerted onto the pouch to up to 300 mmHg.

Guedel airways are commonly used oro-pharyngeal tubes which are inserted into the oral cavity for preventing the tongue of unconscious patients from occluding the airway and securing a safe passage for air through the tube.

Guedel airways are made from semi-rigid rubber and are shaped in a characteristic curve. A short straight proximal part, which is placed between the teeth, is fitted with an oval plate at its end. The size of the oval cross section depends on the size with ranges from number 00 (40 millimetres long) for neonates and size 6 (10 centimetres long) for adults. The tubes must withstand cleaning and disinfection as well as sterilization in an autoclave.

Self-inflating resuscitation ("Ambu") bags are used for manual, assisted or controlled ventilation of (unconscious) patients during resuscitation or anaesthesia through a face mask, endotracheal or tracheostomy tube. Large models are used for adults while bags with smaller volumes are used for (small) children and infants in order to prevent insufflation of too large air volumes which could damage the lungs.

The bags made of silicone and polypropylene are soft enough to be easily compressed but sufficiently rigid to inflate immediately after release and (re)fill with air. Large resuscitation bags may be compressed with both hands or a single hand which may be facilitated by a strap

along the outer surface which prevents the resuscitation bag from slipping. Bags for children must be operated only with one hand or even two fingers.

During inflation air is drawn into the resuscitation bag through a one-way air intake valve which is fitted with a connector which allows connection to an oxygen source. The optional 1.5 litre reservoir bag allows filling with oxygen during compression of the resuscitation bag and increases the oxygen concentration of the air mixture drawn into the resuscitation bag during inflation.

A transparent T-shaped valve allows monitoring the proper function, facilitates cleaning and is designed to offer minimal resistance to any air flows. During deflation of the resuscitation bag air flows through the patient valve to a 22/15 millimetre connector which fits onto any endotracheal or tracheostomy tube or into standard face masks. The non-rebreathing valve prevents return of air into the resuscitation bag and ensures removal of exhaled air with minimal resistance through a third opening.

The resuscitation bag must be easy to dismantle for cleaning and disinfection and must withstand sterilization in an autoclave.

Face masks with sizes between 0 (infants) and 5 (adults) may be used with resuscitation bags or with anaesthesia circuits. They consist of a rigid shell with a flexible, inflatable, rubber or silicon rim and are fitted with a standard 22 millimetre connector. For anaesthesia four metal hooks allow attaching an elastic rubber head ban with four straps and permanently fixing the mask to the patient. Masks for infants may be made entirely out of soft silicone with a round rather than oval shape.

Laryngoscopes are indispensable instruments for safe endotracheal intubation. The laryngoscope provides a light source for viewing the larynx and the blade allows pushing the tongue aside as well as lifting the epiglottis before introducing the endotracheal tube into the trachea.

The round, chromium-plated brass or stainless steel handle holds two batteries and is fitted with an electric contact as well as a fitting for attaching the blades and locking them into place.

Laryngoscopes of different sizes and shapes are fitted with a bulb and a protected electric cable for illuminating the small halogen bulb. The bulb is switched on as soon as the blade is properly locked into place. The blade must withstand cleaning and disinfection.

Most commonly curved Macintosh blades with sizes between 1 (90 mm long) to 5 (150 mm long) and straight Miller blades are used.

A Magill forceps is used for facilitating the introduction of an endotracheal tube (especially through the nose) into the trachea during intubation or of a gastric tube into the oesophagus.

The characteristically shaped forceps with a 30° bend is made of stainless steel, fitted with fenestrated and striated jaws and available in different sizes (24 centimetres for adults and 15 centimetres for children).

Intubation stylets are inserted into the endotracheal tube before intubation, increase its stiffness, allow shaping the flexible endotracheal tube and maintain the desired shape during intubation. They are made from malleable aluminium wires which are covered by a polyethylene outer sleeve.

Compact mechanical suction pumps are used during resuscitation and anaesthesia for suctioning the pharynx or endotracheal and tracheostomy tubes but are not suitable as surgical suction machines.

Twin pumps with two pistons can be operated by foot or hand in a sea-saw movement which allows more or less continuous suction and generating a vacuum of up to 800 mbar. The suction device is made from transparent plastic and connected to a receptacle with a maximum capacity of about 600 millilitres.

Small, portable electrical suction units are used in operating theatres for anaesthesia for suctioning the pharynx as well as endotracheal and tracheostomy tubes. They can operate on the mains electricity supply or on batteries which may also be rechargeable from a car battery.

Controls include a power switch, a flow regulator which allows adjusting flows up to about 35 litres per minute at a vacuum of around 800 mbar which can be monitored on a pressure gauge. The collection bottle with a capacity of 1 litre is fitted with an overflow safety valve and is connected to the singe use suction catheter with a flexible suction tube.

Oxygen concentrators or devices which allow extracting oxygen from ambient air. They consist of a robust plastic casing with a handle for carrying as well as castor wheels for mobility and are fitted with a power switch, an indicator for the oxygen concentrator as well as an alarm in case of low oxygen concentration or of power failure.

The air is drawn into the device through a serious of filters for protection against particles and dust as well as an antibacterial filter. Air containing more than 90% oxygen is continuously generated and the flow can be regulated between 1 and 5 litres per minute. However the generated pressure is low and does not allow operating anaesthesia machines or ventilators. A standard connector allows attaching single use oxygen tubes and oxygen masks with humidifiers or a resuscitation bag. Flow splitters allowing simultaneous administration of oxygen to two adults or up to 4 children.

Oxygen concentrators generate little noise, require little maintenance and should be delivered with a user and maintenance manual as well as replacement parts such as filters.

In general, anaesthesia machines cannot operate on oxygen concentrators as the generated pressure is too low. Bottled, pressurized oxygen is stored and transported in metal oxygen cylinders with volumes ranging from 1 to 80 litres and a weight of up to 90 kilograms. An oxygen cylinder with oxygen compressed at about 130 bar (13,000 kPa) can provide about 130 times its volume at atmospheric pressure.

Oxygen cylinders should be colour-coded (black body with white neck according to British standards) and labelled, among others, with the name of the gas, chemical symbol, hazard warnings and safety instructions, cylinder size, nominal cylinder contents (litres), maximum cylinder pressure (bars) as well as directions for storage and handling (Al-Shaihk, B., and S. Stacey 2002, 3).

Cylinder valves are permanently screwed into the neck of the cylinder, seal the contents of the cylinder and allow opening and shutting off the gas flow with a hand wheel or a spanner. Unless connected to equipment, cylinder valves must be protected with metal caps, especially during transportation.

Different types of cylinder connectors, such as bullnose or pin-index, are not compatible with cylinder valves of other types and allow connection with anaesthesia machines or attachment of regulators.

Regulators reduce the high and variable pressure from the cylinder and ensure a constant pressure at their outlet. The safety pressure relief valve automatically releases gas if the cylinder is over-pressurized. The pressure gauge indicates the pressure inside the cylinder which is proportional to the amount of gas remaining in the cylinder (Skeet, M., and D. Fear. 1995, 60).

A flow meter which allows adjusting the oxygen flow between 0 to 15 litres per minute and connection to an oxygen mask, is attached to the outlet of the regulator.

Pulse oximeters, which are used during anaesthesia, in critical care and during oxygen therapy, are non-invasive devices which allow measuring the arterial oxygen saturation as well as the pulse. Portable devices for operating theatres operate on the mains electricity supply while small hand-held devices run on batteries.

The device is fitted with a power switch and LED indicators displaying arterial oxygen saturation (SpO_2), the pulse rate (beats per minute) as well as alarm limits which set off visual and audible alarms. Reusable sensor which are clipped onto a finger or a toe or single use self-adhesive sensors which are attached to earlobes of children are connected to the pulse oximeter with a cable.

A simple anaesthesia apparatus allows connecting a halothan vaporizer, oxygen and nitrous oxide to an anaesthesia circuit during the manual ventilation of patients with a resuscitation bag. The apparatus may be fitted onto a special trolley.

Draw over vaporizer offer little resistance to airflow and consists of a metal container which allows precisely regulating the evaporation and therefore the concentration of a volatile anaesthetic such as halothan into a closed air circuit which is connected to a mask or an endotracheal tube. Vaporizers are sophisticated precision instruments which require regular calibration by qualified technicians.

The anaesthesia apparatus may include glass columns for measuring the airflow of oxygen and nitrous oxide which is added to the anaesthesia circuit, various valves as well as a container filled with carbon dioxide absorbing granules.

Ventilators are used for automatically ventilating patients during anaesthesia as well as in critical care and fitted on special trolleys for mobility.

They operate on the mains electricity supply and usually require a supply of compressed oxygen from an oxygen cylinder or a central medical gas supply system. Anaesthesia ventilators allow attaching or connecting an anaesthesia apparatus or circuit.

Depending on the design and model and number of different ventilation modes for assisted and controlled ventilation are available. The basic parameters which can be selected are the oxygen concentration, tidal volume (gas volume per insufflation), the frequency (number of ventilation cycles per minute) as well as the ratio between the lengths of inspiration and expiration (I:E ratio). The actual parameters are displayed and various limits which will trigger audible and visual alarms can be set.

The disposable or reusable patient circuits are supported by an articulated arm which will prevent any tension on the endotracheal or tracheostomy tube.

Ventilators must be supplied with detailed manuals for installation, operation and maintenance as well as spare parts such as fuses and filters.

Staff working in operating rooms require a range of surgical clothing. Instead of single use caps, caps made from cotton can be used which are tied at the back of the head with a knot and disinfected and washed after every use.

Safety glasses are worn in operating theatres, emergency rooms and laboratories for protecting staff against splashes of blood and other potentially infectious liquids. They are lightweight, made from plastic, furnished with an anti-mist as well as scratch resistant coating and the large glasses with drawn back ear pieces allow a large range of vision.

Likewise face masks made from cotton with four strings for tying behind the head may be used instead of single use masks.

Blue or green tunics and trousers of different sizes are often used as workwear by staff in the operating department as well as by nursing staff. The short-sleeved and V-neck tunics with side pockets can be made of pure cotton or a blend of cotton and polyester, can be disinfected and washed. The trousers are made of the same material, have a simple pattern and are tied around the waste with a string.

Surgical gowns are worn by surgical staff over their workwear in order to protect patients from infection as well as staff from splashes of (body) liquids.

Reusable gowns can be made from cotton or polyester-cotton with a strength of around 180 grams per square metre, are washable, can be disinfected and must withstand repeated steam sterilization. They are green or blue, available in different sizes, provide a complete cover from the neck to the middle of the calf and are tied in the back.

Protective shoes are advised for staff working in areas with high risks of infection such as operating theatres and delivery rooms and limit risk from splashes. The use of distinct footwear in certain departments is also a hygienic measure for reducing the risk of contamination by footwear worn in other departments or outside health care facilities.

Plastic clogs of different sizes are moulded in one piece with a non-slip sole and a back strap, are waterproof and antistatic. The are light and comfortable to wear, even during several hours of standing. They are washable and must withstand disinfection.

Surgical aprons covering the entire chest and legs are used as protective clothing during procedures with a high risk of infection such as orthopaedic surgery or deliveries. They are made from flexible nitril rubber which can be washed and disinfected, fitted with an adjustable neck strap and are tied at the waist in the back.

Reusable drapes are made from strong, woven cotton or cotton/polyester fabric with a weight of around 180 grams per square metre. The blue or green drapes of various sizes, with or without holes or slits are hemmed around all edges. They are washable, can be disinfected and withstand repeated sterilization.

The number of different surgical instruments which are usually available in several different sizes is vast and one manufacturer offers 30,000 different items.

Scalpel handles of different sizes are flat and fitted with a thin elongated tip with a groove into which disposable surgical blades are slid.

Manual dermatomes (such as Humby, Watson etc.) are used to remove a thin layer of healthy skin for grafting to a wound of the same patient. They are fitted with a handle, a small wheel with a knurled pattern on either end and a blade holder for inserting and securing sterile, single use blades.

Scissors (for example Metzenbaum, Mayo) of various sizes, shapes (straight, curved) and different shapes of tips (rounded, pointed) are used for cutting and dissecting tissue as well as cutting sutures and dressing material.

Curettes are formed like a spoon and fitted with sharp edges for scraping tissue. Rasparatories are sharp instruments which are used for rasping bones..

Osteotomes (chisels) are flat, triangular instruments with sharp, bevelled edges which are used to chisel bone. Mallets are double-headed metal hammers with a large head with a diameter of about 4 centimetres and a weight of about 500 grams which are used together with the osteotome.

Bone rongeurs have gouge-shaped, oval jaws and are used for removing bone fragments as well as trimming bones while shears are cutting tools for example for ribs.

Bone saws are shaped like hand saws with a straight blade with a length of about 20 centimetres and used for cutting bones during amputations.

Gigli saw handles are T-shaped handles with a hook for attaching a Gigli saw wire. A Gigli saw wire is attached to two Gigli saw handles and kept taut while alternately pulling on the handles for cutting bones.

Mechanical hand drills are used for trepanation of the skull as well as for perforating bones before introducing Kirschner wires or Steinmann pins. They may be operated by turning a crank or turning a handle. The shank of various types of drill bits are fastened in the chuck by tightening the jaws with a key.

Needle holders are pincer-shaped instruments with parallel, serrated jaws for grasping and holding surgical needles during suturing. They can be straight or curved and the suture needle can be locked with a ratchet fitted between the scissor handles.

Spatulas are fairly thin, broad, flat and nearly rectangular blades with blunt rounded edges which are used for pushing and holding back tissue after incisions. They are malleable and can be bent for adapting to the operating site.

Specula are blunt, often curved and sometimes angled blades which may be used alone or in combination of two pivoting and self-retaining blades which can be adjusted.

The two arms of a forceps can be permanently joined together at one end and allow approximation by their flexibility or the handles can be joined with a pivot like scissors. They are used for holding and grasping tissue. Dissecting, tissue, haemostatic, dressing, intestinal or bone holding forceps are around 12 to 26 centimetres long and fitted with a ratchet between the handles with allows locking them in different positions. Forceps can be straight or curved and the serrated or cross-serrated jaws may be fitted with teeth.

Clamps, such as vascular clamps, are similar to forceps but intended for clamping rather than gripping or holding. Towel clamps are fitted with two pointed teeth for attaching drapes around the operating site.

Retractors are curved blades which are used for pulling back and holding back tissue in order to expose the operating site. A simple retractor consists of a single blade attached to a handle. Self-retaining retractors consists of several blades of different shapes and sizes which can be adjusted and locked into the required position by fastening them to a frame.

Steinmann pins and Kirschner wires have diameters of 1 to 5 millimetres and lengths of 15 to 30 centimetres and are used to hold bone fragments together or are pierced through the bone for attaching to a traction device.

Traction bows (for example Boehler) of different widths and lengths are formed like stirrups and fitted with a tightening screw on either end for securing a wire or a pin. The hook in the middle is connected to a weight with a rope which ensures exertion of permanent and constant traction.

External fixation can be used for treating bone fractures. Metal pins with threads are screwed into bone fragments, aligned in the required position and firmly held in place by attaching them to external rods with specially designed clamps.

Plaster shears of different sizes are used for cutting plaster casts to allow their removal. One blade has a smooth and flattened tip which can be inserted underneath the plaster cast

without any danger of injury. Alternatively an electric saw with a special round blade may be used.

Probes are thin long instruments with a length of about 15 centimetres and a bulb-shaped end which are used for probing wounds and fistulas.

Suction tubes with a length of approximately 20 centimetres and diameters of around 10 millimetres are used for suctioning of blood and other liquids from the operating site.

Galipots and bowls are stainless steel receptacles which are shaped like cups or flat bowls and can hold between 50 and 2,000 millilitres of antiseptics or various materials during operations.

Kidney dishes are kidney-shaped, stainless steel receptacles, approximately 15 centimetres wide and 30 centimetres long which are used in operating theatres as well as in wards, for example for changing dressings.

Flat stainless steel trays for example 15 to 20 centimetres wide and 30 centimetres long and 3 centimetres high are used for holding and carrying various items such as a surgical instruments and dressing material.

A number of standard surgical instrument sets which are limited to essential instruments but sufficient for safe and professional surgery and which may be used in combination with each other, are commonly used.

For example surgical instrument sets for minor surgery, wound excision (wound debridement), basic general surgery, paediatric surgery (small instruments), craniotomy (trepanation of the skull), thoracotomy (chest surgery), laparotomy (abdominal operations), gynaecology (including curettage), amputation of limbs, bone surgery (for example treatment of osteomyelitis), skeletal traction, external fixator (pins, clamps, rods and tools), fine surgery (for example for nerves and plastic surgery), vascular surgery (repair of blood vessels), E.N.T. (ear, nose and throat), dental surgery (for example extraction of teeth) and skin grafts.

A wide range of equipment is used in laboratories. Stainless steel, one- or double-ended spatulas with a length of 15 to 25 centimetres are used for placing powders on a scale and accurate adjustment to the required mass (weight).

Polyethylene (or glass) funnels with an upper diameters of 9 to 12 centimetres and stem diameter of around 1 centimetre are used for channelling liquids into containers (bottles) as well as filtering liquids with special filter paper.

Polypropylene (or glass) measuring cylinders with volumes between 10 and 1,000 millilitres with around 100 graduations are used for accurately measuring liquids for preparing and diluting various solutions and stains.

Polypropylene (or glass) laboratory beakers have the shape of a cylinder, have volumes of 250 millilitres and a small spout for pouring liquids. They are used for stirring and mixing liquids but, despite some graduations, not sufficiently accurate for measuring volumes.

Washing bottles are polyethylene bottles with capacities of, for example, 250 millilitres which are fitted with a plastic tube that reaches all the way down to the bottom of the bottle. As the lid is air tight, pressure on the side of the bottle forces the liquid through the tube to the angled dispensing spout producing a steady stream of liquid for washing and rinsing.

The inside walls of rectangular glass staining jars with a volume of approximately 250 millilitres and a glass lid are fitted with grooves which allow vertically slotting microscopes slides and immersing them in various solutions.

Horizontal staining racks are made of two parallel stainless steel bars spaced about 6 centimetres apart, mounted on feet and used for placing microscope slides horizontally during staining.

Plastic slide racks allow placing several microscope slides separately (back to back or next to each other) for drying slides after staining.

Grease pencils (china marker, chinagraph pencil) allow writing on a glass surface such microscope slides and are resistant to water. Wooden or plastic handles with a diamond point allow permanently marking microscope slides.

Tube racks are made of horizontal and parallel metal or plastic plates with holes which allow securely placing (for example 50) centrifuge or tubes in a vertical position.

Pipettes are plastic or glass tubes with a tapered end, volumes of, for example, 1 or 10 millilitres and 100 marked graduations which are used for accurately measuring small volumes of liquids during preparation of laboratory reagents and solutions. They must be filled using special pipette fillers rather than by suction by mouth.

Variable volume air displacement micropipettes allow accurately drawing, holding and dispensing a specific preset but adjustable volume, for example of body liquids, for diagnostic tests. Micropipettes are made from polypropylen and can accurately measure liquid volumes between 1 and 1,000 microlitres. The tip of the pipette tip is immersed in the liquid, depressing and releasing a plungers creates a vacuum which sucks liquid into the attached single use pipette tip and depressing the plunger a second time dispenses the precisely measured volume of the liquid. A release mechanism allows dropping off the pipette tip after use without the need for touching it.

Small hand-held and battery operated glucometers (glucose meters) allow measuring the concentration of glucose in a whole blood sample with an accuracy of ± 10 - 15%. Glucometers usually require calibration with special control test strips or microcuvettes. The blood sample is either placed on a single use test strip and excess blood is wiped off or blood is drawn into a microcuvette before placing either into the glucometer. The result is displayed in millimol per litre (range up to 25) or milligrams per decilitre (range up to 500) in less than a minute on a small display. Usually several of the most recent test results can be stored in the memory.

Hand-held and battery operated haemoglobinometers allow determining the haemoglobin concentration of a blood sample with an accuracy of about ± 1 - 2%. A microcuvette is placed in the haemoglobinometer after filling with the blood sample and the result is displayed in less than a minute in millimol per litre (range of 0 to 15) or grams per decilitre (range of 0 - 25). Devices require regular calibration with control solutions.

Haemocytometers (often called counting chamber) consist of thick glass microscope slides with very precise rectangular indentations which create a chamber with a precise volume. The floor of the chamber is engraved with perpendicular lines which form a grid. The chamber is filled with a liquid, covered with a special (reusable) cover glass and the number of cells in part of the grid are counted visually through a microscope in order to extrapolate the concentration of cells in the liquid. A mechanical counter can be used which displays the number of times a button was pressed and which can be reset for further counts. Different types of haemocytometers with different grids are available. The Neubauer haemocytometer is commonly used for counting cells (erythrocytes, leucocytes and thrombocytes) in blood while the Fuchs-Rosenthal haemocytometer is often used for counting cells in cerebrospinal fluids.

Digital or mechanical analytical balances, which are more resilient, are used for accurately measuring the weight of powders for preparing stains and reagents. For example an analytical balance with a maximum capacity of 300 grams and an accuracy of 10 milligrams with a

weighing pan and a sliding mass for balancing. Precise and calibrated weights must be provided with the equipment for calibration and regularly checking the accuracy of the analytical balance.

Glass spirit lamps with volumes of about 100 millilitres are used for fixing stains and samples as well as sterilizing inoculating loops. A wick with a diameter of about 5 millimetres leads the methanol (methyl alcohol) fuel to the burner which is protected with a cap when the spirit lamp is not in use.

Hand-operated centrifuges are used in (small) laboratories for separating mixtures of particles and liquids according to their densities where no electricity is available but electrical centrifuges should be used wherever possible. The centrifuge is tightly fastened to a table with a bench clamp. A metal crank allows turning four pivoting aluminium buckets, which hold plastic tubes closed with a cap, with up to 1,500 rotations per minute.

Electrical centrifuges allow centrifugation of biological fluids (urine, blood or cerebrospinal fluid) with up to 6,000 rotations per minute inside a closed case. Centrifuges are fitted with swinging-bucket or fixed-angle rotors which hold four or more tubes. The speed can be adjusted and the centrifugation time can be preset with a timer. Haematocrit centrifuges are fitted with a special rotor which allows holding capillary glass tubes and turns at speeds of up to 14,000 rotations per minute. A lid prevents contamination of the centrifuge in case glass tubes break during centrifugation and can be replaced by an evaluation disk for determining the haematocrit value after centrifugation.

Optical microscopes with an electrical light source are used for viewing specimen of cells and micro-organisms under magnification. Several objectives allow changing the magnification between 4 to 100 times.

The use of x-rays for diagnostic imaging requires use protection of staff against any and patients against any unnecessary exposure to x-ray with radio-protective clothing.

Radiation protection aprons are made from lead-free composite materials which provide the same protection as about 0.35 millimetres of pure lead, can be cleaned and disinfected. The knee-length aprons which provide protection from the front are flexible and close in the back with crossover back straps. The thyroid x-ray shield has the shape of a collar, covers the neck as well as the upper part of the chest and is worn in addition to the apron.

Radiation protection gloves, which are used for protecting the hands, are around 40 centimetres long, flexible, seamless, made from lead rubber equivalent to 0.25 - 0.35 millimetres of lead and can be cleaned and disinfected.

X-ray gonad shields are wrapped around the pelvis of patients and secured with a Velcro closure during exposure to x-rays. The lead-free composite material offers the same protection as 0.35 millimetres of lead and is available for infants and adults in different sizes. They are flexible, can be cleaned as well as disinfected.

Personal dosimeters measure the occupational cumulative exposure of individuals to ionizing radiation (mainly x-rays) in order to ensure it remains within the prescribed limits as well as for measurement of exposure in case of accidents.

Film badge dosimeters contain radiation sensitive film in a snap-shut holder, are fitted with name labels and attached to the clothing. The level of absorbed radiation is indicated by a colour change on the surface of the badge or determined in a laboratory.

Pen sized direct read pocket dosimeters indicate the cumulative exposure on a scale which can be viewed through a system of built-in lenses and can be reset by the user any time.

X-ray cassettes protect the x-ray films from exposure to visible light, hold the x-ray film in place and allow positioning the film during radiography. They are made from metal or robust plastic and available in the standard sizes of 18 by 24, 24 by 30, 30 by 40 and 35 by 43 centimetres. They must be fitted with hinges which allow opening the cassettes at least 180° for loading and unloading as well as an indicator showing whether a film is loaded or not when the cassette is closed.

Two intensifying screens which are in direct contact with either side of the x-ray film are fitted inside the cassette on thin sheets of celluloid or plastic. Intensifying screens for blue-sensitive films are coated with a fluorescent layer of calcium-tungstate which converts some of the x-rays into visible, blue light which contributes to the exposure and intensifies the image. Intensifying screens for green-sensitive films are coated with gadolinium which converts some of the x-rays into green light. The type of intensifying screen which allows reducing the exposure of patients to x-rays, must be marked on the x-ray cassette.

X-ray machines are used for taking radiographs of bones, the chest and abdomen. The World Health Organization System for Radiography (WHIS-RAD) is a simple device which nevertheless allows making 95% of all radiographs made worldwide with high quality (Holm, T. 2000, 2).

A regular mains electricity supply is sufficient but x-ray machines must be fitted with batteries or capacitors for short-term energy storage of about 2 kWh for supplying the high tension generator during radiography.

X-ray machines should be pre-installed at the factory and be tested before delivery. The generator control panel must be fitted with a main switch, a kV-selector, mAs-selector, indicator for the anode rotation as well as an exposure button.

The examination stand with a base of 20 by 30 centimetres should allow radiographs of patients standing, sitting or lying on a special trolley. The swivel-arm, which is shaped like a question mark carries the x-ray tube and the cassette holder at opposite ends, is mounted on a vertical column and allows upward and downward movement as well as a 120° rotation to either side from the vertical position. The focus-film distance is fixed at 140 centimetres.

The examination trolley is about 70 centimetres wide, 200 centimetres long and 70 centimetres high, must support a weight up to 110 kilograms, has a rigid and radiolucent top and is fitted with four wheels with a diameter of at least 10 centimetres which can be arrested.

The x-ray tube has a voltage of between 60 to 120 kV, a minimum exposure time of 2 - 3 milliseconds, a total energy output of around 12-30 kWs (kilowatt-seconds) and should allow incremental adjustments between 1 to 250 mAs (milliampere-seconds). It should be fitted with a rotating anode with a focal spot with a surface area of no more than 1 square millimetre. Except for the opening which directs the beam towards the middle of the x-ray cassette, the x-ray tube must be completely shielded with lead to prevent any unnecessary exposure of staff and patients. An x-ray tube should last for about 50,000 exposures and is expected to have a lifetime of about 10 years.

The adjustable light beam collimator facilitates correct positioning of patients by indicating the path of the beam as well as limiting the extent of the beam to the format of the respective cassette which is being used.

The anti-scatter grid with 40 to 88 lines per centimetre is placed in front of the x-ray cassette and blocks x-rays scattered while traversing human tissue, ensures that only x-rays with the same direction as those leaving the x-ray tube reach the x-ray film and therefore prevent the film from becoming foggy.

The 49 by 49 centimetre cassette holder allows slotting in loaded x-ray cassettes and must be fitted with a radiation absorbing back of 0.8 millimetre lead equivalent in order to prevent exposure of the environment during radiography. The cassette holder should ensure a distance between the film and the patient of about 2 - 3 centimetres.

X-ray equipment must be delivered with detailed installation, maintenance and operating manuals as well as spare parts such as collimator bulbs sufficient for 10 years operation.

A safe-light is used during processing to provide some minimal lighting to radiographers while preventing any exposure of x-ray films to light which would make the image appear "foggy". Safe-lights consist of a 15 watt incandescent lamp with a filter which is coloured according to the type of x-ray films which are used. Amber (orange-brown) filters are used for blue-sensitive, and ruby red filters for green-sensitive films.

Processing tanks are used for manual processing which is recommended for dark rooms which develop less than 50 films per day.

Complete sets of PVC tanks fitted on a basin (drip tray) are available which allow processing films with sizes of up to 35 by 43 centimetres. The developer and fixer tank are of equal size, should hold around 20 to 25 litres and are fitted with valves at their bottom for drainage. The two tanks must be clearly marked to prevent confusion and be fitted with overlapping lids which prevent splashing and contain fumes. A third tank for rinsing is fitted between the developer and fixing tank.

Film hangers are metal frames with clips for holding films and lowering them into and retrieving them from the various tanks for processing.

A thermometer is needed for measuring the temperature of the developer and fixer as the optimal processing times also depend on their temperature.

Dark room timers allow setting times between 3 to 6 minutes for determining the exact developing and fixing time.

X-ray film dryers are small, ventilated cabinets used for drying films after processing.

X-ray viewing boxes are used for reviewing of radiographs by medical staff and usually fitted on the wall. The rectangular cases, which are about 50 centimetres high, 80 centimetres wide and about 10 centimetres deep, are made of metal or plastic and fitted with a light reflector in the back. They are fitted with a main switch and 4 to 6 warm-white, 15 watt fluorescent tubes which must homogenously light the white, opaque surface. A film grip rail made from chromed metal at the upper edge as well as a nylon wire in the middle hold the x-ray films in place during viewing and a drip tray at the bottom collects any liquids from the x-ray films.

Ultrasound scanners can complement x-ray machines but cannot replace them as the primary diagnostic imaging equipment. A simple device complying with the specifications of the World Health Organization's GPUS (General Purpose Ultrasound Scanner) allows carrying out 90 - 95% of the most common examinations (Palmer, P.E.S. 1995, 322) of the abdomen (kidneys, liver, spleen etc.), gynaecology, obstetrics and neonatal care.

Ultrasound machines may be fitted on mobile trolleys but must be portable. They operate on 220 volts and an internal voltage regulator should allow compensation for voltage fluctuations of up to 10%. The equipment and especially the transducer and its connecting cable must allow cleaning and disinfection.

The transducer should be convex with a linear array of 5 to 8 centimetres, have a sector angle of at least 40°, should be operating at a frequency of around 3.5 MHz and a frame rate of 5 to 30 Hz and fitted with simple controls.

The video monitor should measure at least 10 by 13 centimetres, have at least 16 grey levels, allow adjusting the brightness of the image and allow entering patient identification to the screen and the final record. Images should be stored electronically but in addition a printer must allow printing a hard copy of the image from the screen for recording. Biometric tables may be stored in the memory which may require adjustment.

The supplier must provide detailed operating instructions, service and maintenance manuals.

A range of miscellaneous items or commonly used in health care facilities.

Autoclavable polypropylene nail brushes with nylon bristles are used for scrubbing the nails by operating room staff before surgery.

Cramer splints are made from an epoxy-coated steel lattice with cross-wires every 2 centimetres and used for temporarily immobilizing joints and limbs during first aid. The 8 to 15 centimetre wide and 1 metre long splints can be bent into any shape and be individually adapted to each patient.

Bohler-Braun splints are made from metal strips and tubes and support the knee and lower leg during traction. The frame is adjustable in length and fitted with two bows with a wheel for guiding the traction rope.

Polycarbonate urine bottles with a volume of about 1 litre and a watertight lid are used by patients who are confined to their beds in hospitals. They must allow cleaning, disinfection and steam sterilization.

Polypropylene bedpans with a volume of about 2.5 litres are used by patients which are confined to their beds in hospitals. They are wedge-shape to facilitate placing under the patient and fitted with a handle for carrying. They must allow cleaning, disinfection and steam sterilization.

15.4.3 Quality standards

Unlike the pharmacopoeial standards for drug products, no internationally accepted standards are available for health care equipment. However, according to the Guidelines for Health Care equipment Donations published by the World Health Organization, only equipment which is approved by the regulatory authorities in the donor country should be donated (Heimann, P., A. Issakov, and S.Y. Kwankam (ed.) 2000, 18).

The Global Harmonization Task Force (GHTF) is a working group of representatives from medical device regulatory authorities and industry which develops guidance documents for harmonization of regulations and development of a regulatory model for medical devices.

The primary requirements for health care equipment are safety and reliability. Medical devices must not compromise the clinical condition or the safety of patients or the safety and health of users or other persons. Any potential risks should be minimized and manufacturers should consider the state of the art for all safety aspects (GHTF 2005a, 8).

The performance of health care equipment must not be adversely affected by transportation or storage under the recommended conditions and the safety must be ensured throughout the expected lifetime of equipment when maintained in accordance with the manufacturer's instructions. Any materials used should not be toxic or flammable and, where required, compatible with biological tissues (GHTF 2005a, 9).

Any risk of infection of patients, users or other person should be eliminated or at least reduced as far as possible (GHTF 2005a, 9). Likewise any risks from electrical devices,

accidental electric shocks, electrostatic discharge, fire or explosion as well as risks from contacts with substances or gases under normal conditions of use (GHTF 2005a, 12).

Health care equipment must be designed in a way that exposure of patients, users and other person to radiation is minimized (GHTF 2005a, 13). Alarm systems must be integrated into any electrical health care equipment if patient safety can be compromised by a power failure and as well into devices for monitoring clinical parameters of patients. Patients and user must also be protected from mechanical risks such as instability or moving parts and any accessible parts and their surroundings should not reach potentially dangerous temperatures (GHTF 2005a, 14).

The provisions of the "Council Directive 93/42/EEC of 14 June 1993 concerning medical devices" (EC 1993) which are binding for all member states of the European Union are very similar to the recommendations of the GHTF and the "CE" mark indicates full compliance with the directive.

Steel used for manufacturing surgical instruments must comply with specific quality requirements and standards. In order to ensure durability and resistance to corrosion despite constant exposure to liquids during surgery as well as cleaning, disinfection and sterilization, only high quality stainless steel must be used for manufacturing surgical instruments.

Martensitic stainless steel (martensite) which is produced by rapid cooling (quenching) of austenitic steel, is highly machinable, ferromagnetic, very hard, extremely strong and has a high tensil strength. Austenitic stainless steel (austenite) is non-magnetic and has a higher resistance against corrosion.

15.4.4 Packaging and labelling

Supplier packaging must protect health care equipment during handling, transportation and intermediate storage. For international transportation as well as final delivery to health care facilities, additional packaging may be necessary especially for road transportation on poor quality roads. If necessary breakable parts should be specially packaged for transportation and be assembled during installation.

The labelling of each piece of health care equipment must provide general information as well as detailed information which allows individually identifying each piece of equipment (see table 15.16). The labelling must comply with the regulations in the country of manufacture, will greatly depend on the type of device and, for example, differ significantly between a surgical instrument and an ultrasound machine.

Health care equipment should bear the name of the manufacturer and the country of manufacture. The type of equipment (its intended purpose), such as pulse oximeter or microscope, as well as the make (proprietary name) and model (number) should be indicated.

Often industrial norms (such as ISO), standards and certifications (such as CE marking) are indicated and the registration number with the regulatory authorities may be included. The manufacturer product (catalogue) number as well as the year of manufacture should be indicated. All sophisticated health care equipment must be labelled with a unique serial number which is individually attributed to each piece of equipment by the manufacturer.

Electrical equipment must indicate the voltage (range), mains frequency as well as the power rating which is important for selecting voltage regulators as well as ensuring sufficient capacities of cabling and mains electricity supplies.

Any important information on hazards such as danger from radiation or use in rooms with oxygen or danger of parts which reach high temperatures as well as precautions and safety instructions should be prominently displayed on the equipment.

Any restrictions on environmental conditions for operating such as temperature and humidity ranges should be indicated.

- Name of the manufacturer.
- Country of manufacture.
- Type of equipment (intended purpose).
- Make (proprietary name) and model (number).
- Industrial norms, standards and certification (such as CE or ISO).
- Registration number (where applicable).
- Product (catalogue) number (according to the manufacturer).
- Serial number (including manufacturing year).
- Voltage and frequency (electrical devices).
- Power rating (electrical devices).
- Any important information on hazards and precautions.
- Any important safety instructions.
- Restrictions on environmental conditions for operating (temperature, humidity).

Table 15.16 Contents of labelling of health care equipment

15.4.5 Documentation

All health care equipment should be furnished with detailed documentation (see table 15.17) although the type and extent will greatly differ according to the type of equipment.

The manufacturer document must contain detailed technical specifications, detailed information on any certification such as the EC type-examination or ISO certificate and declaration of conformity. Where applicable, detailed warranty documentation indicating the coverage as well as the time period must be provided.

A detailed catalogue with the names, specifications and supplier part number of all maintenance, repair and operating supplies as well as replacement parts is essential for future ordering.

Storage instructions for the time before installation may be needed.

The installation manual must provide a list of required tools, inform on the skills required for installation, the requirements for and preparation of the site such as the (minimum) size of the room, floor strength, ventilation or cooling as well as required utilities such as electricity and water supply. The manual must also cover installation of any required software. Any risks of incorrect installations should be described.

If applicable, special instructions before the first use and detailed instructions for (initial) calibration must be provided. Moreover the procedures for testing and commissioning must be described in detail. Separate instructions may be needed for configuring and using installed software.

Where applicable, training manuals for technicians, operators and users should be provided. Detailed manuals for operators and users must cover all features and aspects, provide comprehensive safety information and give warnings. Any alarms and required measures need

to be explained. The potential risks of using the equipment, contraindications and precautions as well as possible risk of operating errors, malfunctioning, technical errors and faults, equipment failures, power failure and defects as well as the required (emergency) measures must be explained.

Detailed information on cleaning schedules and procedures, appropriate and inappropriate cleaning agents, suitable disinfection methods and agents as well as sterilization methods are of particular importance.

The maintenance and service manual must indicate scheduled and preventive maintenance measures and procedures. Repairs which can be carried out by a qualified technician need to be explained in detail.

Schedules and procedures for (regular) calibration and testing need to be documented.

The name, address and contact of customer service centres, technical support centres and authorized agents should be provided.

Finally, instructions for the safe disposal of health care equipment should be provided.

- Detailed technical specifications.
- Certification (where applicable).
- Warranty documentation.
- Catalogue of maintenance, repair and operating supplies as well as replacement parts.
- Storage instructions.
- Installation manual (technical and software).
- Instructions for (initial) calibration.
- Instructions for testing and commissioning.
- Instructions for configuration and use of software.
- Training manuals (for users, operators and technicians).
- Operating instructions and manual.
- User manual.
- Warnings and safety information.
- Cleaning, disinfection and sterilization instructions.
- Maintenance, service and repair manual.
- Instructions for (regular) calibration and testing.
- Name, address and contact of customer service centres, technical centres and authorized agents.
- Disposal instructions.

Table 15.17 Contents of documentation for health care equipment

The documentation must cover the equipment as well as any accessories. The language of the manuals and guidelines must be adapted to the respective audience such as operators, users and technicians and any symbols and abbreviations must be explained.

15.5 Kits

Kits are standardized assortments of pre-selected drug products, single use medical devices and health care equipment in predefined quantities which are usually designed for providing a specific and clearly defined service to a certain number of patients or a certain population size. Their content must be carefully selected for ensuring universal and flexible use throughout the

world and should only be changed for adjusting to worldwide accepted changes to treatment protocols.

The size of kits can vary from a single parcel to an entire field hospital and be used individually, in combination with each other or in combination with additional individual item.

Kits should contain either health care equipment or drug products and/or single use medical devices in order to allow re-supplying established health care facilities without repeatedly providing (the same) health care equipment.

15.5.1 Classification

Medical kits can be classified by the services which they are intended to provide into first aid (or pre-hospital care), primary health care and hospital care (see table 15.18). Surgical instrument sets were already considered in the previous chapter.

First aid kits may be designed for internal use such as in vehicles or field trips or for treating injured patients encountered on field trips or in disaster or conflict areas.

Dressing kits contain sufficient supplies such as disinfectants, dressing material, gloves and scissors for making, for example, 50 (minor) dressings.

The Interagency Emergency Health Kit (IEHK) 2006 (WHO 2006n) was designed by the World Health Organization together with leading humanitarian organization to meet the primary health care needs of a displaced population or in situations where the health care system is disrupted. The kit is intended for use in a health centre (dispensary) for serving a population of 10,000 people for 3 months. The kit is designed to treat the most commonly encountered medical conditions and symptoms such as anaemia, pain, diarrhoea, fever, respiratory tract infections, measles, some skin diseases as well as provide preventive care for pregnant woman according to standard treatment protocols.

Ten basic units contain stationery, drug products (oral and external), basic single use medical devices (dressing material) as well as some simple health care equipment (thermometer, scissors) which can be used by health workers. One complimentary kit contains additional (injectable) drug products, infusions, injection material, tubes and catheters, examination equipment as well as a small autoclave.

Immunization kits are designed for mass immunization campaigns such as against measles, meningitis and yellow fever. They contain, among others, disinfectants, auto-disable syringes, safety containers as well as cold chain equipment for immunization of 10,000 people but do not contain the respective vaccine.

Nutrition kits are designed for registering, weighing, measuring, feeding and providing medical care to, for example, 50 malnourished children during a period of 3 months.

Cholera kits are designed for treating a certain number of patients in a refugee camp and contain disinfectants, oral rehydration salt, infusion solutions, antibiotics, gloves, injection and dressing material as well as various equipment.

The examination equipment kit is designed for clinical examinations by health professionals in health centres and includes, among others, a pocket torch, thermometer, stethoscope and sphygmomanometer.

Glove kits contain examination gloves as well as various sizes of sterile surgical gloves.

Injection kits contain gloves, disinfectants, hypodermic needles and intravascular catheters, syringes and safety containers for performing, for example, 1,000 injections.

Infusion sets contain basic infusion solutions such as Ringer lactate, sodium chloride and dextrose.

Surgical drainage kits contain abdominal drains, penrose drains, thoracic drains and colostomy bags as well as tubing and collection bags.

Urine drainage kits contain various sizes of Foley catheters, lubricating jelly as well as urine bags.

Suture kits contain a range of essential sutures sufficient for example for 100 operations.

Surgical linen kits include single use drapes, caps, masks and gowns sufficient for example for 50 operations or reusable linen sufficient for furnishing an operating theatre.

Sterilization kits contain mainly disinfectants, sterilization paper, tape and sterilization indicators for (re)supplying sterilization rooms in hospitals.

Resuscitation kits contain Guedel airways, a laryngoscope, a resuscitation bag as well as a manual suction pump for intubating and manually ventilating a patient. Some single use endotracheal tubes and suction tubes may be included or need to be provided separately.

A) First aid

- First aid kit.
- Dressing kit.

B) Primary health care

- IEHK (Interagency Emergency Health Kit) 2006.
- Immunization kit.
- Nutrition kit.
- Cholera kit.

C) Hospital care

- Examination equipment.
- Glove kit.
- Injection kit.
- Infusion kit.
- Surgical drainage kit.
- Urine drainage kit.
- Suture kit.
- Surgical linen kit.
- Sterilization kit.
- Resuscitation kit.
- Anaesthesia kit (drug products and single use medical devices).
- Surgical kit (trauma, wounded).
- Laboratory kit.
- Transfusion kit.
- Refrigeration kit.
- X-ray kit (equipment and single use medical devices).
- Field hospital kit.

Table 15.18 Classification of kits

The anaesthesia equipment kit contains mainly diagnostic and resuscitation equipment, an anaesthesia machine with or without ventilator and oxygen concentrator and allows to perform general anaesthesia.

The anaesthesia kit with drug products contains anaesthetics and various essential drug products for pre-medication, performing anaesthesia and postoperative care on, for example, 100 patients.

The anaesthesia kit with single use medical devices contains, among others, endotracheal tubes, gastric tubes, suction tubes as well as spinal needles and needs to be complemented by glove, injection and infusion kits.

Several of the kits mentioned above may be combined into surgical, trauma or disaster kits which are sufficient for 100 operations.

Laboratory kits are designed to carry out basic and essential laboratory tests such as malaria tests, testing of blood, urine and stool.

Transfusion kits contain all necessary equipment for sampling, testing and safely administering, for example, 100 units of blood in a hospital.

Cold chain kits contain all necessary equipment such as thermometers, cold boxes, packs, refrigerators and freezers for setting up a cold chain.

X-ray kits contain, among others, an x-ray machine, radio-protective clothing, x-ray cassettes as well as various equipment for setting up a darkroom. X-ray kits with expendable items contain various sizes of x-ray films as well as x-ray developer and chemicals for 500 x-rays.

Complete hospitals contain hospital furniture, tents, a combination of the kits above and may be complemented by kits for water and electricity supply. However, field hospitals should only be deployed (temporarily) if local capacities are exceeded and wherever possible, humanitarian organizations should assist existing health care facilities (The Sphere Project 2004, 263).

15.5.2 Quality standards

For the individual components of the kits the same quality standards as for drug products, single use medical devices and health care equipment apply.

As kits are mainly used for emergencies which occur irregularly, the shelf live of kits, which is determined by the shelf life of the item with the earliest expiry date, should be as long as possible, ideally at least two years.

15.5.3 Packaging and labelling

The contents of individual kits should be packed in sturdy cartons with a maximum weight of 25 kilograms per parcel in order to allow handling by an individual or 50 kilograms for manual handling by two persons. Heavy parcels should be fitted with loops or handles to facilitate handling.

Health care goods requiring different transportation and storage conditions (for example cold chain) as well as which are subject to different custom clearance procedure (for example internationally controlled drug products) must be packed separately.

As far as possible parcels should be commensurate and allow stacking on standard (Euro)pallets without wasting any space.

Each parcel must be clearly identifiable and bear a label with the type of kit (item code and description), preferably in several languages. Sub-kits (modules) must be marked with the item code and description of the kit as well as the sub-kit. The parcels of kits which are composed of several parcels must each be marked with consecutive numbers as well as the total number of parcels in the kit, for example "7 / 25" (parcel number 7 out of a total of 25 parcels). Colour coded labels can be helpful for distinguishing different types of health care goods (for example drug products, single use medical devices and health care equipment) or different kits.

Each parcel should also be marked with the name of the kit manufacturer, the country of origin as well as the dimensions, weight and volume. Moreover each parcel should be clearly marked with special requirements for storage (for example the maximum temperature) as well as any instructions for transport (for example indicating breakable contents).

On the outside, every parcel must be labelled individually with all items, quantities as well as their expiry dates contained in the kit. Otherwise the kits have to be opened for checking the expiry date of each item.

A complete list of all items, quantities and parcel numbers contained in the entire kit must be attached or be included in the first parcel.

15.5.4 Advantages and disadvantages of kits

If humanitarian organizations have taken the strategic decision to include kits in their standard item catalogue their suitability, advantages and disadvantages (table 15.19) have to be considered for each country and each heath care programme where humanitarian organizations provide assistance.

Kits are used for emergency preparedness and emergency response planning when the needs have not been assessed yet (Quick, J.D. (ed.) 1997, 408), no accurate data for an assessment is available and the destination of kits is not known yet. Moreover in acute emergencies (WHO 1999c, 11) until stocks of individual items have been established. Kits designed for special purposes such as a cholera outbreak or an immunization programme are more efficient than using individual items even if the supply network is established and stocks are available. Kits may also be used as a simple and cost-efficient long-term distribution strategy (Quick, J.D. (ed.) 1997, 408).

Kits should also be used where logistical capacities such as medical stores and information systems as well as skills are not (yet) sufficient for handling a large number of separate items.

Kits are also useful for supplying specific programmes such as vaccination campaigns or management of a cholera epidemic.

The use of kits has several advantages for assisted health care facilities, encourages the use of standard treatment protocols and improves the quality of care. As the contents of kits are designed by specialists and are based on extensive field experience, all contained goods are essential, suitable for the context of humanitarian assistance and the contents covers all essential needs. Kits allow a swift response with health care goods which allow addressing the main health needs (WHO 2006n, 3) with limited resources.

Health staff which lacks the experience and knowledge for selecting individual items and determining quantities can provide appropriate assistance simply by selecting the correct kit. As kits are designed for a specific purpose and a defined number of treatment episodes (Quick, J.D. (ed.) 1997, 408) or for the needs of a certain population, health programme managers only need to determine the kind of need and the number of customers which require assistance rather than forecasting demand for separate items. For example the Interagency Emergency

Health Kit is designed to provide primary health care services to a population of 10,000 people during three months (WHO 2006n, 4). For the same reason budgeting of humanitarian assistance programmes is far easier with kits than with separate items.

Humanitarian assistance can easily be adapted to the level of skills of health professionals by selecting kits with the appropriate contents and variety of goods. For example the Interagency Emergency Health Kit is intended for use by basic health workers and therefore does not contain any injectable drug products (WHO 2006n, 4). The contents can be designed according to standard treatment protocols (Hanquet, G. (ed.) 1997, 136) and providing essential drug products encourages rational prescription and drug use. The universal contents allows shifting or redistributing kits which are not needed at one health care facility, area or country to another.

The possibility to handle a large number of separate items as a single item (Quick, J.D. (ed.) 1997, 416) and therefore reduce complexity has many advantages for logistics and supply chain management and greatly increases the effectiveness and efficiency of humanitarian assistance.

Kits can be handled by inexperienced logistics staff with a low level of professional skills. The small number of different items which need to be handled throughout the supply network greatly facilitates information management, record keeping and documentation as well as tracking of distributions and donor reporting.

Forecasting a small number of items is easy for individual medical distribution centres as well as at the country level and can be done manually if electronic information systems are not yet available. The aggregation of goods increases forecasting accuracy (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 35) and therefore allows reducing safety stock levels (Quick, J.D. (ed.) 1997, 413). Moreover health programme managers need only to forecast the morbidity, the population or the number of affected people they want to serve and can easily and accurately calculate the appropriate number of required kits. Historic demand of the number of distributed kits can be used for forecasts at the line item level if these later replace the use of kits.

The ease and efficiency of purchasing is increased with kits and they can be managed in a simple store without the need for special storage equipment. As several items are densely packed in a kit and do not need to be stored separately, the required storage space is greatly reduced. Multiple put-away, order picking and packing of separate line items throughout the supply network becomes unnecessary and the resources required for warehouse and stores management are greatly reduced.

The known weight and volume of kits facilitates planning of transport requirements and capacities. Logisticians can keep track of a few different kinds of kits much more easily than for a large number of separate items and visibility of stocks throughout the supply network and across different humanitarian organizations is enhanced.

The use of kits reduces pilfering and generally improves availability of health care goods at assisted health care facilities (Quick, J.D. (ed.) 1997, 413).

The numerous advantages have to be balanced against some disadvantages. Providing kits instead of separate items reduces flexibility in tailoring humanitarian assistance programmes to the regional climate, prevailing medical conditions and morbidity patterns, to different health care programmes and different health care facilities (Quick, J.D. (ed.) 1997, 410). However, the great majority of medical conditions are determined by poverty and the main public health problems are very similar in many less developed countries. While regional and

seasonal differences may be perceived, differences concern mainly the quantities but much less the type of required and used health care goods (Haak, H., and H.V. Hogerzeil 1991, 62).

Advantages

- Ensures that all goods are essential.
- Usefulness of contents proven for its purpose.
- Designed to cover essential needs.
- Ensures completeness.
- Encourages the use of standard treatment protocol.
- Improves quality of care.
- Facilitates selection (by inexperienced staff).
- Easy to adapt to level of skills.
- Universality of use.
- Promotes rational prescription and drug use.
- Facilitates budgeting of programmes.
- Facilitates ordering.
- Allows handling by less skilled staff.
- Increases effectiveness of supply chain management.
- Reduces complexity.
- Smaller number of items to manage.
- Facilitates record keeping and documentation.
- Facilitates information management.
- Facilitates donor reporting.
- Facilitates forecasting and inventory control.
- Lower safety stock level need (aggregation).
- Facilitates purchasing.
- Greatly reduces resources needed for warehouse and stores management.
- Reduces picking and packing time.
- Can be managed with simple storage equipment.
- No need for put-away, picking and packing.
- Requires less storage space.
- Facilitates contingency stock management.
- Facilitates stock visibility throughout the supply network and among humanitarian organizations.
- Facilitates tracking of goods.
- Known weight, volume and value.
- Facilitates distribution.
- Easy to transport.
- Reduces pilfering.
- Improves availability of health care goods.
- Allows immediate response to emergencies.

Disadvantages

- Reduces flexibility.
- Regional differences of needs not considered.
- Differences of health care programmes not considered.
- Not adapted to staff training and practices.
- Need for familiarization.
- Requires training of staff.

- Possible wastage of surplus goods.
- Possibly unsuitable ratio of items.
- Shortage or lack of certain items.
- Prescriptions based on supply.
- Smaller number of suppliers.
- Long supplier lead times.
- Stockout of goods with highest demand.
- Can disrupt existing inventory control systems.
- Loss of inventory control skills.
- Seasonal changes cannot be considered.
- Combines goods with different expiry dates.
- Difficulty in monitoring expiry dates.

Table 15.19 Advantages and disadvantages of kits

The contents may not be adapted to the national treatment protocols, the training health professionals have received and their practices. Therefore health professional need to familiarize themselves with the contents quickly and may even require some training.

As the contents of kits is pre-determined there is a danger that some health care goods are unnecessary for a specific context (Quick, J.D. (ed.) 1997, 409), will not be used at the assisted health care facility and might be wasted. However, the problem of surplus tends to be exaggerated as in most countries there is a general lack of health care goods and the financial loss in one study was estimated at 4% (Haak, H., and H.V. Hogerzeil 1991, 62). The surplus can be distributed to other health care facilities or stocks of essential health care goods will simply last for a longer period of time (Haak, H., and H.V. Hogerzeil 1991, 53). Moreover, a surplus may also accumulate because standard treatment protocols are not adhered to.

The ratio of health care items may be unsuitable for the context. Consequently increasing the number of distributed kits in order to avoid shortages of items with the highest turnover will lead to accumulation of other goods with a lower turnover.

Health professionals may be tempted to prescribe or administer drug products which are available rather than selecting the most suitable drug product.

Since kits are not routinely used by health care facilities in either developed or less developed countries, the number of suppliers offering medical kits is limited (Quick, J.D. (ed.) 1997, 411) and sourcing may be difficult. Especially in emergencies where a large number of humanitarian organizations want to purchase from the same few suppliers. If suppliers do not keep kits in stock, lead times will be long.

Health care goods with the largest demand will stock out while others will accumulate and eventually expire before they can be used. The use of inventory control systems may be interrupted and staff may lose their skills (Quick, J.D. (ed.) 1997, 410). Seasonal changes in demand cannot be accommodated and health care goods, especially drug products, with higher seasonal demand will quickly stock out.

Since health care goods with different expiry dates and therefore different remaining shelf lives are combined, the item with the shortest remaining shelf-life dictates management of the entire kit. Consequently entire kits may have to be distributed quickly although the majority of their contents still have long remaining shelf lives. During the transition from using only kits to using individual items, a small number of individual items with high demand can be added to standardized kits to overcome the lack of flexibility.

As transition but also to simplify long-term assistance to health care facilities, kits can be customized for a specific programme or area. Health programme managers only need to determine the frequency of delivery and quantity of these prepacked kits for each health care facility.

Once the supply network has been established and a thorough assessment of the needs of health care facilities has been carried out, individual goods can be provided to health care facilities to meet their individual needs (WHO 2006n, 7).

15.6 National standard list

The standard item catalogue significantly reduces the number of health care goods which logistics services need to manage. Nevertheless managing several thousand different health care goods in the context in which humanitarian organizations work would require complex operations and large resources. Consequently programme managers need to narrow down the standard item catalogue further and select a few hundred essential health care goods which cover basic needs and are most suitable for the context and programmes in a specific country.

Reducing the number of (regularly) distributed health care goods facilitates quality assurance and reduces the overall complexity of logistics and supply chain management (PAHO 1983, 20). Effectiveness, reliability and consistency are increased as a smaller number of health care goods reduces demand variability and makes it easier to provide higher customer service levels. The smaller number of goods which need to be managed throughout the supply network increases efficiency and facilitates tracking of distributions and accurate donor reporting. Providing a limited number of essential health care goods also ensures that the most urgent health needs are covered first (PAHO 1983, 49). For example 5 - 15 different drug products should suffice for a small health care centre (health post), 20 - 40 drug products for a health centre (Dörner, G. (ed.) 1992, 7) and 120 for a district hospital (Tigretti-Berthoud, Th. 1998, V).

Health programme managers must also decide whether to order and distribute individual health care goods or supply health care facilities with prepacked kits.

The essential drugs concept as well as the principle of establishing standard lists of drug products and equipment according to the prevailing epidemiological situation is part of the primary health care concept (WHO 1978, 66). No public or private health care system, neither in developed nor less developed countries, could afford providing all health care goods available in the market and standardization is a an effective means of controlling expenditure (WHO 1999f, 11). An essential drug list allows concentrating available resources on the most efficacious and cost-effective drug products for treating the prevailing medical conditions (WHO 1999f, 11). Moreover, without standardization, the list of requested health care goods tends to be long (Quick, J.D. (ed.) 1997, 152). The principle of standardization equally applies to humanitarian organizations (Health Action International 1998).

"The first strategic objective is that all organizations responsible for procurement whether they are public private non-profit-making or private for-profit should develop an essential drugs list to make sure that only the most cost-effective drugs are purchased" (WHO 1999f, 7).

For establishing a national standard list the effectiveness and efficiency of managing a small number of health care goods (WHO 1988a, 6) must be balanced against the quality and level of

health care services which can be provided with a larger number of items. Consequently national standard lists need to be developed systematically and adapted to changes of health programmes. However, frequent and extensive changes should be avoided since they make reliable supply chain management more difficult and may require additional training of health staff (WHO 1998e, 26 ff.).

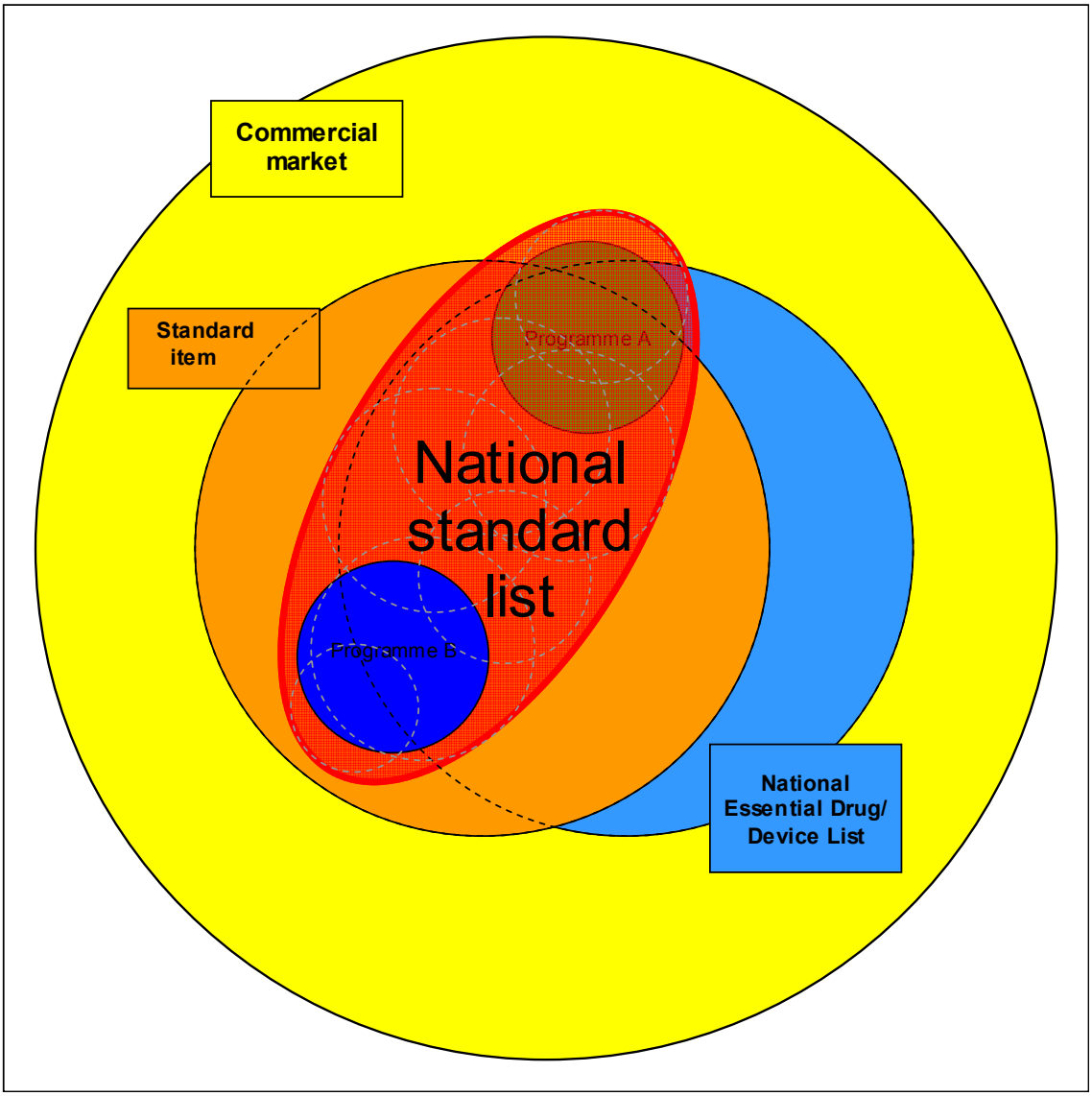

Figure 15.4 Development of national standard lists

Developing national standard lists also ensures coherence and consistency when assisting several health care facilities of the same type and avoids changes of health care goods based merely on personal preferences of health professionals which may difficult to resist (Quick, J.D. (ed.) 1997, 152).

National standard lists should be considered as formal documents which are approved and validated by health programme managers. They should be reviewed, and if necessary updated, at regular intervals, for example every three months, as well as whenever health programmes change but must not be changed too frequently.

The selection of health care goods first depends on the most prevalent (Quick, J.D. (ed.) 1997, 122) and most commonly treated medical conditions in the respective country, in health

care programmes as well as assisted health care facilities, at the level of health care the humanitarian organizations wants to provide (Dörner, G. (ed.) 1992, 9). Moreover the experience, training as well as level of health staff must be considered (Griffiths, A. 1988, 4.8). Standard treatment protocols (Quick, J.D. (ed.) 1997, 122) developed by national authorities, international organizations such as the World Health Organization or by humanitarian organizations also determine essential health care goods.

National health policies and national essential drug lists (WHO 1998e, 2) also provide a framework for selection of the most suitable health care goods and ensure that health professionals are familiar with provided health care goods (PAHO 2001a, 149). Finally the "WHO Model List of Essential Medicines" (WHO 2007n) as well as inventory lists from assisted health care facilities can be consulted as a further reference.

The median of the number of drug products on the essential drug lists of 105 countries lies at 356 (Creese, A., N. Gasmann, and M. Mariko 2004, 138 - 145).

All health care goods should be approved for use in the recipient country and health professionals should be familiar with presentation, strength of dosage unit and formulation (PAHO 2001a, 149). Depending on the development of national drug legislation, the importation of drug products requires a notification, authorization or full registration procedure by the national drug regulatory authorities (WHO 1988a, 51).

- Item is essential.
- Item included in the standard item catalogue of the humanitarian organization.
- Item complies with the national drug policy as well as national treatment protocols.
- Item is needed for providing the level of care offered at the assisted health care facility.
- Item is regularly used.
- Item cannot be substituted by another item already included in the national standard list.
- Item is efficacious for treating prevailing medical conditions (according to standard or established treatment protocols).
- Health staff is competent and qualified for using the item.
- Item is needed for emergencies (even if not used regularly).
- Replacement parts for essential health care equipment.
- Item part of contingency stocks.

Table 15.20 Criteria for including items in the national standard list

In a similar way model lists for essential medical devices and equipment (WHO 2003a, 18) can be developed for countries or individual health care facilities. Determining appropriate health care interventions for the prevalent medical conditions as well as the appropriate level of technology allow selecting equipment which is necessary to provide the required medical care (Temple-Bird, C. et al. 2005, 77).

As far as possible, health professionals should already be familiar with health care equipment and maintenance and repair services should be available domestically. A VEN analysis (Quick, J.D. (ed.) 1997, 630) can be performed to ensure that only essential items are held in stock. It categorizes items as vital (V), essential (E) and non-essential (N). Vital and essential items need to be kept in stock while non-essential items can be ordered from higher level as needed.

Stock lists or essential drug lists from assisted health care facilities can be helpful for establishing stock lists at the medical distribution centres. However erratic use of drug products must be considered and treatment protocols by the humanitarian organization taken

into account to ensure that poor medical practices are not encouraged. Stocking a regularly used drug product or other health care product may not be warranted if the item is misused or not used according to established medical practices and treatment protocols. An available alternative may be more suitable. For example the misuse of sophisticated antibiotics which may be considered as indispensable by certain health professionals is notorious.

After health care facilities have been supported for at least a few weeks, reviewing stock records will allow distinguishing health care goods which are regularly ordered and those which can be removed because of low demand. A Pareto analysis can help in determining fast moving items. However care must be taken that slow moving items are not automatically discarded as they may nevertheless be essential.

15.7 Determining contingency stocks

It is the responsibility of logistics managers to develop strategies which ensure that the required contingency stocks are permanently available (PAHO 1983, 20) and can be delivered rapidly to any location where they are required. Positioning of contingency stocks follows the push-pull principle. Contingency stocks are positioned throughout the supply network according to a forecast (push) and "pulled" from contingency stocks according to actual demand at health care facilities and orders placed by health programme managers.

However, it is the responsibility of health professionals and health programme managers to determine the contents and quantities of contingency stocks. The composition of contingency stocks at international and regional distribution centres will mainly be determined by the contingency plans of the countries with ongoing operations. In addition, head offices need to prepare for sudden outbreaks of conflicts in other countries.

The decision on size and contents of contingency stocks must be carefully considered and should be part of a country wide, regional as well as global strategy. The contents of contingency stocks should be formally documented and not changed without careful consideration. The periodic review of risks of emergencies and the most appropriate contingency stocks may require changes in the kind of stocked items as well as the stock levels. Arbitrary and frequent changes which are not based on a rational must be avoided.

- Epidemics (measles, cholera, meningitis).
- Displacement of a large number of people.
- Large number of war-wounded patients.

Table 15.21 Emergencies for which contingency stocks may be held

Health programme managers must first consider the possible types of emergencies for which contingency stocks may be held (see table 15.21).

The cost of establishing and maintaining contingency stocks must be balanced against the probability of the respective emergency.

Not every emergency is likely to require assistance from any particular humanitarian organization. The health system may be expected to cope with the demand for health services, the government may have sufficient contingency stocks and other humanitarian organizations may already be prepared for the same contingency.

Humanitarian organizations must also consider their priorities in term of geographical regions, countries as well as types of emergencies in which they are willing to provide assistance.

The expected target population in terms of geographical area and type as well as the number of affected population will determine the type and number of health care facilities which are likely to require assistance. If the capacity of current health services is sufficient, the additional number of people requiring health services in case of an emergency needs to be determined.

Determining the likely as well as essential needs which would have to be met immediately, allow selecting the most appropriate kits. Finally the quantity for each type of kit needs to be determined.

- Possible types of emergencies
- Probability of the respective type of emergency.
- Probability of need to provide assistance.
- Willingness of humanitarian organization to provide assistance for specific types of crises.
- Expected target population and number of affected people.
- Type and number of health care facilities likely to require assistance.
- Additional number of people expected to require health services.
- Determine likely material needs.
- Identify needs which will have to be met immediately.
- Determine suitable kits.
- Estimate quantities.

Table 15.22 Considerations for determining contingency stocks

16 SOURCING

Within the strategic sourcing framework of humanitarian organizations a market assessment needs to be carried out and tactical decisions concerning supplier registration, the tender format, supplier selection as well as the type of purchase contracts need to be taken

The primary concern is ensuring the reliable supply of high quality health care goods. Moreover commercial laws and regulations in the country of purchase must be adhered to. Another important consideration is the need for transparency as well as accountability towards donors. The selection of suppliers must ensure purchasing the best possible overall value for the resources provided by donors and the entire purchasing process must be transparent and well documented to allow later auditing by donors.

18.1 Market assessment and supplier registration

Before any purchasing can take place, information on the domestic, regional and possibly international market needs to be collected and analysed through a market assessment.

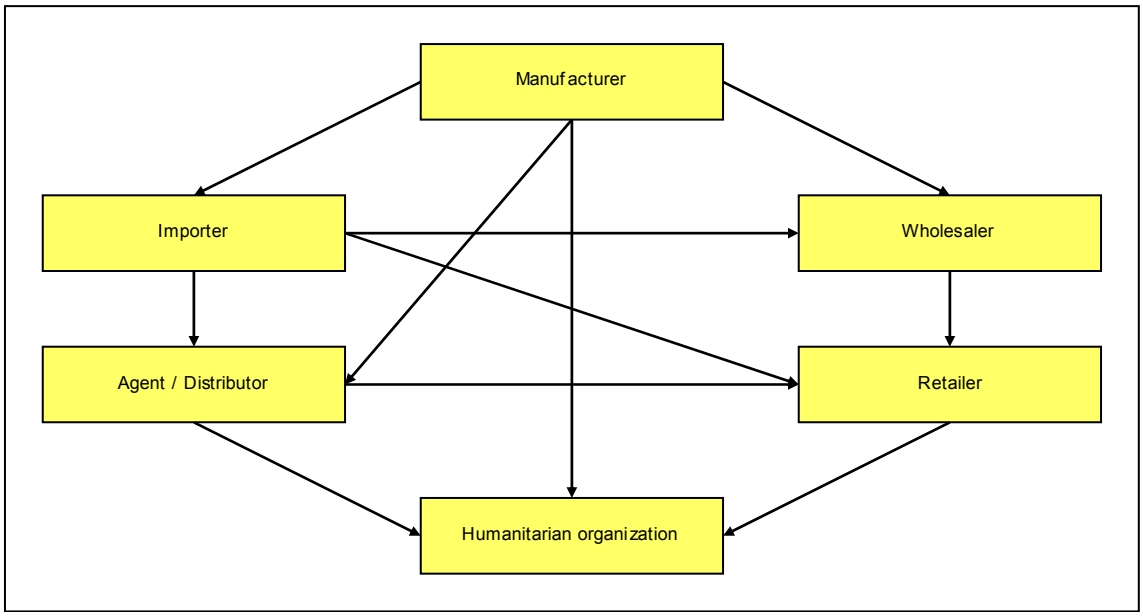

Figure 16.1 Types of commercial suppliers

Market assessment are necessary for a number of reasons (see table 18.1). As part of the contingency planning, market assessments need to be carried out in countries (and possibly in neighbouring countries) where an acute or chronic crises is anticipated. In general, a market assessment needs to be carried out, or at least be updated, in preparation of any tender. Moreover before starting the first health programmes as well as before extending the range of health care goods provided to assisted health care facilities.

In case of decreasing competitiveness of current commercial suppliers (for example increasing prices or decreasing services), a market assessment may be needed to extend the supplier base. Finally market assessment should be carried out regularly, for example annually, in order for the purchasing department to follow changes in the domestic, and perhaps regional, market.

- Contingency planning (anticipation of an acute or chronic crisis).
- Preparation of tender.
- Starting (new) health programmes.
- Extending range of provided health care goods.
- Need to extend supplier base.
- Need to replace current commercial suppliers.
- Regular update of market knowledge.

Table 16.1 Reasons for carrying out a market assessment

Market assessment intend to gain an overview of available manufacturers, commercial suppliers as well as health care goods without (yet) considering whether they fulfil the quality requirements. The market assessment then serves as a basis for selecting required and suitable health care goods.

The market assessment must cover domestic manufacturers of health care goods, authorized agents (representatives) of domestic manufacturers as well as for any imported health care goods. Furthermore any commercial suppliers (importers, wholesalers etc.) as well as possibly non-commercial suppliers such as governmental central medical stores or not-profit-making suppliers.

The complete list of health care goods holding valid marketing authorizations allows quickly determining what health care goods are available in the country without having to piece together information from several manufacturers commercial suppliers. Any health care goods which do not hold a valid marketing authorization must not be on offer from any commercial or non-commercial supplier.

The market assessment allows obtaining detailed information on the type, specifications as well as quality of health care products from the respective suppliers. Moreover which health care products are held in stock by suppliers or are only available on request as well as indicative prices for a preliminary comparison.

Obtaining or updating information on

- Manufacturers of health care goods (primary sources).
- Domestic authorized agents of (multinational) manufacturers abroad.
- Commercial suppliers (secondary sources).
- Non-commercial suppliers (government, not-profit-making suppliers etc.).
- Health care goods with valid marketing authorization.
- Available health care goods (type, specifications, quality).
- Health care goods stocked by commercial suppliers.
- Indicative prices.

Table 16.2 Objectives of market assessments

In case of (periodically) repeated market assessments, the most recent supplier register should be used as a starting point. In case domestic purchase was carried out in the past and has been suspended, previous supplier registers are likely to still be a valuable source of information.

Names, addresses and telephone numbers of manufacturers as well as commercial suppliers can be found in publicly accessible records such as telephone books and yellow pages. Internet search engines will quickly direct users to websites of (large) commercial suppliers.

Commercial trade associations and trade directories as well as professional associations of pharmacists or manufacturers of health care goods can be consulted for advice.

The national drug regulatory authorities are able to provide information on all manufacturers and commercial suppliers which are registered and have received licenses for manufacturing or trading of health care goods. Governmental (central) purchasing departments, central medical stores as well as the ministries of commerce and trade can also provide information.

The purchasers or purchasing departments of other humanitarian organizations can be contacted for sharing their market assessments without divulging any confidential details. The website of the World Health Organization provides information on prequalified manufacturers of antimalarials, antiretroviral and antituberculosis drug products. Pharmacists and management staff at health care facilities as well as (retail) pharmacies can be contacted.

The head offices of multinational manufacturers of required health care goods can be contacted for information on their authorized agents (representatives) in the respective country.

Finally commercial suppliers may take the initiative to contact humanitarian organizations for presenting their organization and may publicly advertise their products.

- Current supplier register.
- Previous supplier register.
- Public records (telephone book, yellow pages).
- Internet search engines.
- Commercial (trade) associations and trade directories.
- Professional associations (pharmacists, manufacturers).
- List of suppliers registered with the national drug regulatory authorities.
- Governmental purchasing department and central medical stores.
- Ministry of commerce and trade.
- Purchasing departments of other humanitarian organizations.
- World Health Organization website of prequalified manufacturers.
- Staff (pharmacists, management) at health care facilities.
- Retail pharmacies.
- Head offices (abroad) of multinational manufacturers.
- Contacts made by commercial suppliers.
- Public advertising.

Table 16.3 Sources of information

Any suppliers which offer the range of required products and which appear to comply with the quality requirements should be formally registered for further inquiries and possible consideration for future invitations to tender. All suppliers must comply with national legislation and regulations and hold valid authorizations for manufacturing and/or trading health care goods.

All suppliers should be requested to fill in a standardized registration form (see table 18.4) and attach the required documents. The supplier registration should include information on

the company, its registration, offered products, sales turnover and customer, offered customer service as well as copies of relevant documents.

A) Company

- Name.
- Year or establishment.
- Name of managers and sales representatives.
- Contact details (address, telephone number, fax, email, website, business hours).
- Owner(s), type of business entity.
- Type of supplier (manufacturer, importer, wholesaler, authorized agent etc.).
- Number of employees.

B) Registration

- Registration status with national drug regulatory authorities.
- Inspector, date and results of last (GMP) inspection.

C) Products

- Catalogue of offered products and prices.
- Manufacturer(s).
- Countrie(s) of origin.
- Valid marketing authorization.

D) Sales

- Manufacturing capacity (units per year).
- Annual sales turnover.
- Primary customers (health care facilities, government, humanitarian organizations).

E) Customer service

- List of products which are permanently stocked.
- Lead time for products which are not held in stock.
- After sales services.

Table 16.4 Information required for registration of suppliers

16.2 Purchasing method

The four main methods for purchasing health care goods (WHO 1999f, 14) comprise direct negotiation as well as the competitive methods restricted tenders, open tenders and competitive negotiation (figure 18.2).

In general, tendering increases transparency and competency of purchasing but can tempt suppliers to cut costs by all means in order to win the tender (Dörner, G. (ed.) 1992, 14) and provide poor quality products.

The choice between open and restricted (selective, closed) tenders is one of the most important decisions in purchasing (Quick, J.D. (ed.) 1997, 234) and must consider national legislation as well as donor requirements.

In open tenders all interested suppliers can participate (Quick, J.D. (ed.) 1997, 234) and submit their bids. Unsuitable suppliers are eliminated through postqualification which reviews their registration status and qualifications as well as the quality of their products and, where applicable, past performance (Kaur, M., et al. 2005, 179).

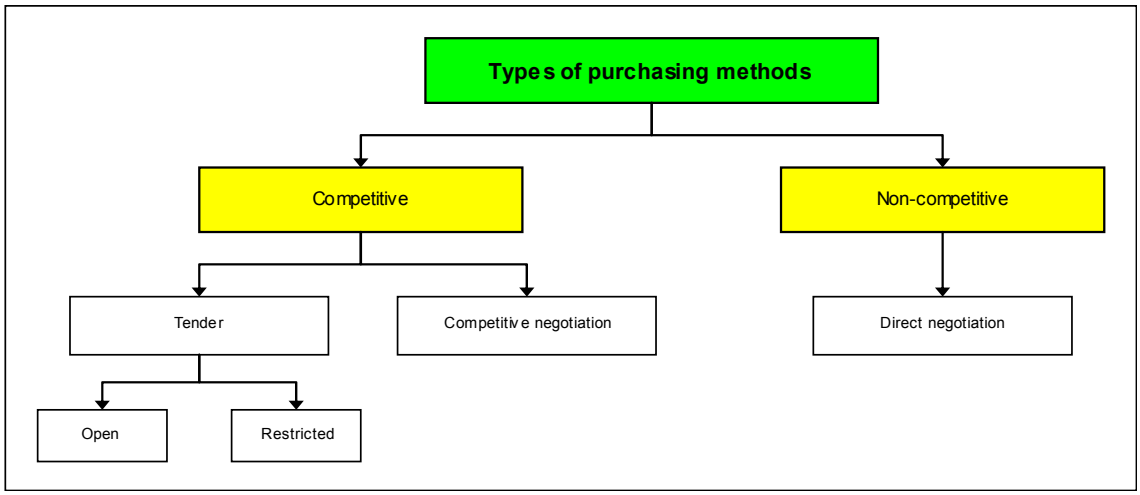

Figure 16.2 Types of purchasing methods

Compared to restricted tenders, open tenders may attract unknown suppliers, increase the number of potential suppliers as well as offered health care products and therefore increase the competitiveness among suppliers which is likely to result in lower prices. However since no preconditions are set, the participation of unreliable suppliers as well as the risk of receiving bids for poor quality health care goods increases.

The main disadvantages of open tenders are the potentially large number of suppliers and samples of health care products which have to be assessed. Since the quality of health care goods, especially drug products, is difficult to asses only by evaluating a sample, the qualification should include visits of manufacturing facilities, which are time-consuming and require specialists. Consequently open tenders should be limited to health care products which do not require visiting and validating suppliers and where significant savings can be expected by the competition among suppliers.

While in principle any supplier can participate in the prequalification process, only those who have been evaluated approved and registered (Kaur, M., et al. 2005, 114) or which are registered with the national drug regulatory authorities can participate in restricted (closed, selective) tenders. Since prequalified suppliers have been carefully audited, humanitarian organizations can be sure that all their products fulfil the quality requirements (Kaur, M., et al. 2005, 114). A thorough prequalification procedure ensures that all participating suppliers comply with the required quality standards and avoids that substandard health care goods are purchased (Quick, J.D. (ed.) 1997, 234). The smaller number of participating suppliers reduces the resources required for purchasing and increases the transparency of the purchasing process. Moreover the tender process can be completed faster (Kaur, M., et al. 2005, 100).

However, the prequalification process is time consuming and also bears the risk of corruption, favouring suppliers and excluding competitive suppliers. Moreover purchasing departments must proactively search for new potential suppliers in order to maintain competitive pressure on already prequalified suppliers (WHO 1999f, 17).

The prequalification of suppliers can be limited to the country carrying out the purchase or be extended to include regional and international distribution centres. Many multinational companies sell their goods through authorized traders in the respective country who often have exclusive rights. Consequently there is often no justification to issue tenders internationally, especially for fairly small purchasing values.

While pre- as well as postqualification both require considerable time, prequalification procedures can be completed before a tender is issued and lead times for purchasing are reduced. Moreover prequalification of suppliers is recommended by the World Health Organization (WHO 1999f, 10) and will therefore be the method of choice for humanitarian organizations.

Where the resources for completing an entire tender process are not warranted because of the low value of health care goods or because of lack of time but quality of health care goods is important, a small number of known potential suppliers can be approached with competitive negotiation (Kaur, M., et al. 2005, 94). Typically quotations are requested from three known and registered suppliers, possibly followed by bargaining. Competitive negotiation requires little time and resources but lacks transparency, bears the danger of favouritism and may tempt suppliers to inflate prices if they know that only a limited number of suppliers were invited for quoting.

	Advantages	**Disadvantages**
Open tender	• Any interested supplier can participate. • Larger pool of potential suppliers. • Possibility of attracting unknown suppliers. • Larger number of potential products. • Wider choice from which to select. • Greater competitiveness. • Transparency and fairness. • Higher probability of lower prices.	• More time for preparation. • Larger number of suppliers to validate. • Possible delay by qualifying new suppliers. • Potentially invites suppliers with known poor performance. • Greater risk of unqualified suppliers among participants. • Large number of product samples to assess. • Potential for manipulation of postqualification.
Restricted tender	• Known and higher quality of suppliers. • Higher quality of products. • Smaller number of (unsuitable) bids to review. • Faster completion of tender process. • Shorter purchasing lead times.	• No immediate access for new suppliers. • Exclusion of poor quality suppliers which have improved their performance. • Less competition. • Danger of favouritisms.
Competitive negotiation	• Less time and resources required. • Only (well) known suppliers are considered.	• Less transparent process. • Less competition. • Suppliers may be tempted to inflate prices. • Danger of favouritism.
Direct negotiation	• Fastest method. • Supplier known and qualified.	• Potentially lower quality of products. • Usually higher prices. • Poor transparency. • Greatest danger of favouritism.

Table 16.5 Advantages and disadvantages of different purchasing methods

Direct negotiation with a single supplier is the fastest method and is preferred in emergencies (Kaur, M., et al. 2005, 94) provided that the importance of quality for the required health care goods is not high. Although direct negotiations usually result in higher prices, the overall purchase costs are low and may therefore be the cheapest purchasing method, especially for low contract values.

Despite the lack of transparency, donors will usually accept direct purchasing for purchases up to a clearly defined limit (ECHO 2003, 13). Direct purchasing is indispensable where a single manufacturer offers the health care product with the required specifications, for example for single-source drug products. Direct negotiation can be effected either by buying directly from a supplier and paying in cash or by requesting a written quotation and then issuing a purchase contract.

The framework presented in figure 18.3 proposes criteria for selecting appropriate tender formats. For health care goods with high annual purchasing values donors will insist on following a detailed tender process in order to ensure that the best possible use is made of donated funds. For goods which must comply with high quality standards, restricted tenders should be used in order to limit the resources required for validating suppliers while health care goods with lower quality requirements can be purchased through open tenders since no resources are needed for supplier visits.

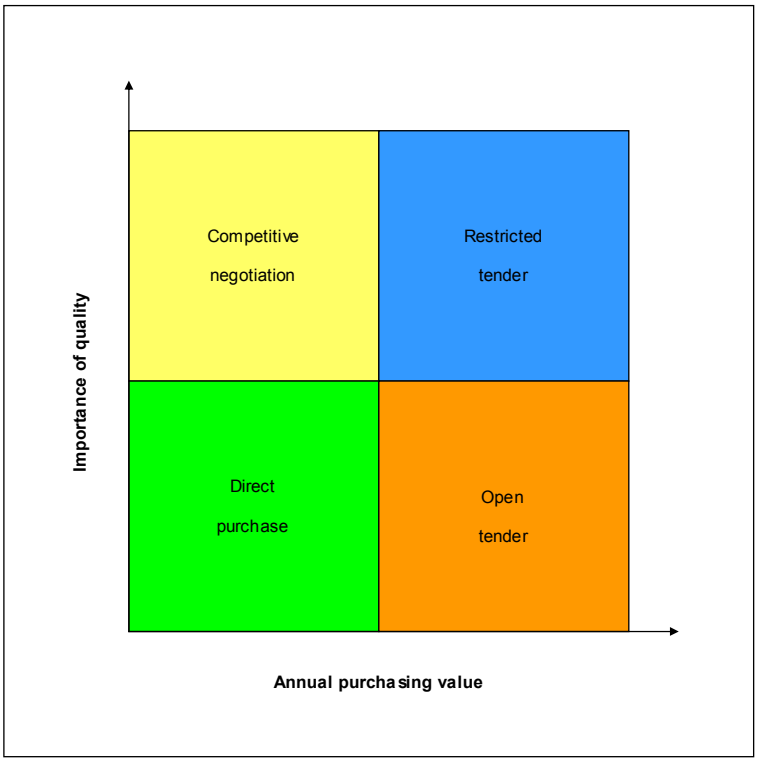

Figure 16.3 Framework for selecting purchasing methods

Allocating significant financial and human resources is not economical for one-off purchases and purchasing low value items (Kaur, M., et al. 2005, 179). Health care goods with low annual purchasing value which must be of high quality can be purchased from known suppliers through competitive negotiations. Direct purchasing increases the risk of purchasing low quality goods, has the least transparency, carries the greatest risk of favouring suppliers and must therefore be restricted to health care goods with low annual purchasing value.

16.3 Product and supplier selection

The selection of products and suppliers must consider the quality of products and services provided by the supplier as well as total costs (WHO 2006r, 246) and fulfil a range of criteria (see table 18.6).

The specifications and quality of health care goods must generally comply with the requirements laid down by humanitarian organizations in their standard item catalogue and the criteria discussed in chapter 15. In all countries where national drug regulatory authorities are established, only products which are licensed (authorized, registered) in the country of purchase as well as the country where humanitarian organizations are importing the goods can be selected (WHO 1997a, 12).

An important criterion is the remaining shelf-life upon delivery and for drug products suppliers must provide Certificates of Analysis (WHO 2002c, 4) for each batch.

Commercial suppliers must be reliable, viable and financially sound. Suppliers should be easily accessibly and available during holidays in case of emergencies, flexible in responding to special requests and changes at short notice. Ordering should be convenient and suppliers should respond quickly to any inquiries. Availability of a worldwide network of authorized distributors allows domestic purchase and therefore reducing transportation costs as well as order lead times for assisted health care facilities.

Suppliers must be able to provide detailed information and documentation on their products, documentation on their manufacturing process as well as accurate shipping documents.

Especially for highly critical items, one of the key criteria is stock availability (Chopra, S., and P. Meindl 2007, 450) and the ability and willingness to provide suitable substitutes in case of stockouts. The absolute order lead time, variability of lead times as well as on-time performance are important criteria which determine the safety stock levels humanitarian organizations need to maintain as well as the quality of services they can provide to their customers. Commercial suppliers should also have the capacity to deliver and expedite shipments in case of emergencies.

Other service criteria are the ability to provide special packaging such as for dangerous goods, the capacity to delivery directly to assisted health care facilities or at least national distribution centres worldwide as well as maintaining accurate documentation on shipments which allows tracing individual batches and products in case of their recall.

The purchase price of health care goods, which comply with required quality standards, is only part of the costs incurred by humanitarian organizations and acquisition, ownership and post-ownership costs need to be considered. The total cost of ownership (Schary, Ph.B., and T. Skjøtt-Larsen 2001, 204) considers additional costs for supplier selection, quality management, warehouse management, supplier management, inbound transportation, communication with suppliers as well as final disposal of goods. For health care equipment the cost of installation, testing, training, operations, maintenance, servicing, repairs and savings from costs covered by warranties as well as downtime and expected lifetime of equipment must also be considered. The purchase price accounts only for an estimated 20% of the overall cost of ownership of health care equipment (Kaur, M., et al. 2005, 50).

For health care equipment worldwide availability, quality, reliability and cost of after-sales services are important selection criteria (Kaur, M., et al. 2005, 59). Since health care equipment must be sustained for many years after being purchased, availability of a worldwide network of qualified technicians who can install, calibrate, test, service and repair equipment as well as train staff at assisted health care facilities are key criteria for supplier selection.

- Compliance with specifications of the standard item catalogue.
- Compliance with quality standards and requirements of humanitarian organization.
- Valid marketing authorization in the country of purchase and importation.
- Remaining shelf life at the time of delivery.
- Provision of quality certificates.
- Reliability, viability and financial standing of supplier.
- Availability and ease of access to suppliers (including holidays).
- Convenience and ease of ordering.
- Quick response to any kind of inquiries.
- Availability of a worldwide network of authorized distributors.
- Availability of product information and documentation.
- Availability of documentation on manufacturing process.
- Provision of accurate shipping documents.
- Stock availability of health care goods and lead time.
- Availability of substitutes in case of shortages.
- Capacity of suppliers to expedite shipments.
- Ability of suppliers to provide special packaging (dangerous goods).
- Maintaining accurate records which allow batch tracing.
- Purchase price.
- Total cost of ownership.
- Availability of after-sales services for health care equipment.
- Warranty coverage and conditions for health care equipment.
- Response of suppliers to complaints and quality of their follow-up.

Table 16.6 Criteria for product and supplier selection

Operating materials such as lubricants or calibration solutions as well as service and replacement parts should be available in the country receiving humanitarian assistance since otherwise health care facilities will remain dependent on humanitarian organizations for operating equipment.

The coverage and conditions as well as length of warranties are important factors for the overall costs as well as for the costs which will be incurred by health care facilities after equipment is handed over to them.

The speed of responding to claims, complaints and handling returns as well as final disposal of equipment by suppliers are also important criteria.

18.4 Counterfeit and substandard products

As far back as the first century, the Greek physician Dioscorides identifies and advises on detection of counterfeit drug products (WHO 1999a, 7). In classical antiquity drug fraud was common (Nutton, V. 1985, 144) and the detection of counterfeit opium was one of the duties of physicians (Porter, R., and M. Teich (ed.) 1995, 16). The production, distribution and use of counterfeit and substandard drug products, single use medical devices and health care equipment pose a serious danger and global public health problem.

Because counterfeiting willingly and deliberately endangers the health of people, causes injury, disability and death it must be considered as serious criminal offence (WHO 2006f, 1) and has been termed manslaughter (Newton, P.N. et al. 2006, 752).

According to the World Health Organization, counterfeits are drug products which are deliberately and fraudulently mislabelled with respect to their identity and/or source (WHO 1997a, 216). However the exact legal definition varies from country to country (Primo-Carpenter, J. 2004 39).

The working text agreed upon during the Third General Meeting of the International Medical Products Anti-Counterfeit Taskforce in Hammamet defines counterfeits as health care products with a deliberate, fraudulent and false representation of the identity and/or source of the product, any of its components (active pharmaceutical ingredients or excipients) its composition, containers or other packaging as well as labelling (WHO 2008b, 3). Misrepresentations of the source include false or misleading statements with respect to the manufacturer, country of manufacturing, marketing authorization and its holder as well as distribution of the product. Health care products which are authorized for marketing in one country are not considered counterfeit in another country where their marketing is not authorized.

Substandard drug products are manufactured by legitimate manufacturers with the intent of producing a genuine product (Seiter, A. 2005, 1) but due to poor manufacturing practices, negligence, human error or improper storage conditions fail to meet quality standards or their defined specifications.

"Lookalikes" are strictly speaking not counterfeit products (WHO 1998d, 10). However packaging designs which are very similar to another (branded) product can be deceptive.

Counterfeiting concerns starting materials (active pharmaceutical ingredients and excipients) as well as finished drug products, innovator (branded) products as well as multisource products and drug products, single use medical devices (for example contact lenses, syringes) as well as health care equipment (for example surgical instruments). Counterfeited products may be distributed separately or be mixed with the genuine product somewhere throughout the supply network (Seiter, A. 2005, 2) possibly making detection more difficult as confirming the genuineness of samples from a box or consignment does not exclude the presence of counterfeits.

Genuine products which were rejected by genuine manufacturers after having failed quality control or genuine packaging and labelling material might be stolen and diverted for sale. Counterfeit products or their parts might also originate from a genuine manufacturer but have been manipulated for example be (re)using original packaging material for counterfeit products.

Usually the source of counterfeit drug products are illegitimate manufacturers. However, legitimate and licensed manufacturers may forge manufacturing records to conceal that the manufacturing process was flawed or a batch does not conform to the required quality requirements (WHO 2008b, 2). Fully licensed and legitimate manufacturers may also manufacture counterfeit drug products as a "sideline" for making extra profit (Schofield, J. 2001, 1564 and Chatterjee, P. 2001, 1776).

Another source of counterfeits are products which are repackaged after salvaging them from the waste stream.

The different types of substandard and counterfeit drug products are summarized in table 18.7.

A drug product is only genuine if the starting materials are of the required specifications and quality, it contain the correct quantity of the correct active pharmaceutical ingredient as well as excipients of the required quality, is manufactured in the correct way and is contained in genuine packaging which has not been manipulated in any way.

Packaging / source	Quantity of ingredients	Ingredients	Product
genuine	correct	correct	genuine
genuine	incorrect (unintended)	correct	substandard
genuine	correct	correct but wrong formulation	counterfeit
fake	correct	correct	counterfeit
genuine	incorrect (deliberate)	correct	counterfeit
genuine	no API (deliberate)	(not relevant)	counterfeit
genuine	(not relevant)	wrong (deliberate)	counterfeit
genuine, changed expiry date	correct	correct	counterfeit
fake	incorrect	correct	counterfeit
fake	no API	(not relevant)	counterfeit
fake	(not relevant)	wrong	counterfeit

Table 16.7 Types of substandard and counterfeit drug products

Simply "mixing" the correct amounts of the correct active pharmaceutical ingredients and excipients alone is by no means sufficient for manufacturing a genuine product. Rather each manufacturing step for example filtration, mixing, granulation, drying, tabletting, encapsulation, sterilization or packaging must be carefully performed and controlled. For example a solid dosage form which does not meet the requirements for dissolution might pass the digestive system without being absorbed (Seiter, A. 2005, 1). A counterfeit antibiotic tablet contained the active pharmaceutical ingredient from the injectable dosage form which is hardly absorbed by the digestive system and therefore is not efficacious (Primo-Carpenter, J., and M. McGinnis 2007, 12).

Drug products which comply with the quality, safety and efficacy of the original product are still counterfeit if the packaging is counterfeited and falsely states another manufacturer or country of manufacture. Moreover if empty containers from genuine manufacturers are salvaged and refilled.

The quantity of ingredients in counterfeit drug products may be higher (super-potent) or lower (subpotent) than in the stated pharmacopoeial standard, counterfeit drug products may contain no active pharmaceutical ingredients at all or harmful impurities. Incorrect active pharmaceutical ingredients are any other than declared on the packaging and accompanying information and counterfeits may contain excipients which are not part of the original composition. Ingredients may be harmless (flour, starch, chalk, talcum, sugar), toxic (diethylene glycol) or genuine (cheaper) active pharmaceutical ingredients but which are not indicated on the product. In Ghana cassava powder was sold as ampicillin (McGinnis, M. 2008, 3) and in South East Asia counterfeit artesunate tablets were found to be contaminated with a wide variety of (wrong) active pharmaceutical ingredients such as erythromycin, chloramphenicol, metronidazole and chloroquine (Newton, P.N. et al. 2008, 9). In Vietnam hospital staff discovered that ceftazidime vials had been refilled with the cheaper antibiotic streptomycin (Primo-Carpenter, J., and M. McGinnis 2007, 23). In China distilled water, starch and other ingredients were used to manufacture many different products, among others rabies vaccine and miconazole nitrate, an antifungal (McGinnis, M. 2009, 17). In Indonesia used syringes were salvaged from the waste of hospitals, filled with water, marked with forged expiry dates and repackaged (McGinnis, M. 2009, 24).

Counterfeiters usually imitate existing drug products but may also randomly mix ingredients or "invent" bogus products (WHO 2008a, 2).

Counterfeiting of medical devices such as syringes or gauze has also been discovered (Morris, J., and Ph. Stevens 2006, 3). Single use medical devices which are labelled as sterile might have not been sterilized at all or the sterilization process might have been inadequate. Another way of counterfeiting is to manipulate expiry dates and distribute expired devices with a "new" expiry date. Again batches which have not passed quality control and been rejected by the manufacturer may be stolen and distributed. Already used single use medical devices may be cleaned and repackaged (Cheng, M. 2003, V).

Although the extent and scope is impossible to determine exactly (WHO 2010, 1), counterfeiting of health care products is certainly a widespread, global and increasing problem. A large proportion of counterfeit drug products originate in Asia (Morris, J., and Ph. Stevens 2006, 3) and Mexico is also a major global source with an estimated 10% of traded drug products being counterfeit (Morris, J., and Ph. Stevens 2006, 4).

Counterfeit health care products have been detected in most countries (Forzley, M. 2006, 14) and even in countries with the best regulatory control systems. Less developed countries are generally more affected than developed countries and the majority of counterfeit drug products originate in less developed countries (Morris, J., and Ph. Stevens 2006, 3).

The World Health Organization estimates that counterfeit drug products represent significantly less than 1% of sales in developed countries with highly developed and effective regulatory control systems such as the European Union, Canada or Japan (WHO 2006e, 1). However even in these countries the problem is increasing.

The percentage of counterfeit drug product is estimated at above 20% of sales in countries of the former Soviet Union (WHO 2006e, 1).

In many less developed countries in Africa, Asia and Latin America the percentage of counterfeit drug products exceed 30% of sales while in other less developed countries the estimates are 10% of sales (WHO 2006e, 1). Within countries the differences in percentage can be very significant. Because it is more difficult to enforce drug regulations in rural areas, the percentage of counterfeits can be significantly higher than an urban areas (WHO 2008a, 3).

Drug products purchased over the Internet from illegal sites which do not disclose the actual physical address of their company are counterfeited in 50% of cases (WHO 2006e, 1) and the Internet is there a major source of counterfeits (WHO 2008a, 4).

In 2006 olsetamivir (Tamiflu) without any active pharmaceutical ingredient was discovered in the Netherlands (WHO 2008a, 4).

A study in Botswana found that 31% of antituberculosis drug products were substandard, contained no active or toxic ingredients (Forzley, M. 2006, 8).

In 2004 the prevalence of counterfeit drug products in Nigeria was estimated at between 40 - 50% of the market (Morris, J., and Ph. Stevens 2006, 3).

One director of a pharmaceutical company estimated that 30 - 40% of drug products sold in Saudi Arabia are counterfeit (McGinnis, M. 2009, 32).

The Ministry of Health in Iraq estimated the prevalence of counterfeit drug products at approximately 20% (McGinnis, M. 2009, 26).

The Federal Service for Health Sphere Supervision reported in 2006 that 10% of the drug products sold in Russia were counterfeit (WHO 2006e, 2).

In 2007, according to the Associated Chambers of Commerce and Industry of India, 20% of sold drug products were counterfeit, of which 60% had no active pharmaceutical ingredient, 19% had wrong ingredients and 16% had inappropriate or harmful ingredients (McGinnis, M. 2009, 22).

The World Health Organization estimated in 2006 that 40-50% of drug products in the Pakistani market were counterfeit (McGinnis, M. 2009, 28).

Of 133 randomly selected vendors in Cambodia, 71% sold counterfeit artesunate and 60% sold counterfeit mefloquine (Rozendaal, J. 2001, 890).

The International Pharmaceutical Manufacturer Group estimated that in 2008 around 40% of drug products in the Indonesian market were counterfeit (McGinnis, M. 2009, 25).

In the Philippines the Department of Health estimated the prevalence of counterfeit drug products in 2008 to be 10% (McGinnis, M. 2009, 31).

According to the Council of Europe and statistics of the World Health Organization, 40% of all drug products distributed in Mexico are counterfeit (McGinnis, M. 2009, 42).

Any kind of drug products such as analgesics, antineoplastic (against cancer), antibiotic, antiretroviral, antituberculosis, antimalarial, anti-inflammatory, antihypertensive, lipid-lowering hormones or vaccines can be and have been counterfeited (WHO 2008a, 2). Also medical devices such as contact lenses, surgical mesh, blood glucose test strips and syringes have been counterfeited (WHO 2008b, 1).

An analysis of antimalarials in eight African countries found concentrations of active pharmaceutical ingredients ranging from 20 - 67% of chloroquine tablets, 5 - 38% for sulphadoxine and pyrimethamine tablets and dissolution failures ranging up to 100% (Maponga Ch., and C. Ondari 2003, ix).

In Brazil over two hundred woman became pregnant after taking contraceptive pills made from pure wheat flour (Bate, R. 2008, 14).

A selection of studies on the percentage of counterfeit and substandard drug products collected by the U.S. Pharmacopeia Drug Quality and Information Program (McGinnis, M. 2009,) are presented in table 18.8.

A number of factors related to national legislation, the counterfeiters, economics and logistics as well as end-users can favour and facilitate or even enable counterfeiting (table 18.9).

Counterfeiting is favoured by poor legal security, lack of law enforcement and weak sanctions against identified counterfeiters and makes it less risky than the narcotics trade. Enacting laws is neither effective nor a deterrent if laws are not enforced and violators are not prosecuted and convicted. The lack of national and international cooperation and exchange of information between different stakeholders such as national drug regulatory authorities, customs officials, the judiciary as well as the police decreases chances of apprehending counterfeiters.

Especially in countries without (functioning) governments and state authorities counterfeiters have little to fear. The absence of intellectual property laws in a country makes it impossible for trademark owners to protect their rights (Morris, J., and Ph. Stevens 2006, 5). Weak and inefficient judicial systems as well as lack of civil liability prevent consumers from filing a suit against manufacturers or commercial suppliers selling counterfeit products (Morris, J., and Ph. Stevens 2006, 5). The lack of political will to curb this illegal form of trade as well as

corruption of regulatory authorities, law enforcement officials and judges encourage counterfeiting.

Country	Year	Drug products	Samples	Counterfeit or substandard
China	2002	Various	14,980	8%
Senegal	2002	Ampicillin capsules	22	95%
Senegal	2002	Antimalarials	67	29%
Tanzania	2002	Sulfadoxine-pyrimethamine tablets	145	50%
Bangladesh	2003	Various	5,000	6%
Cambodia	2003	Antimalarials	451	27%
Gabon	2003	Chloroquine tablets	17	29%
Ghana	2003	Antimalarials	46	35%
Kenya	2003	Antimalarials	34	59%
Mali	2003	Antimalarials	32	63%
Mozambique	2003	Antimalarials	45	53%
Sudan	2003	Antimalarials	46	39%
Tanzania	2003	Antimalarials	33	36%
Zimbabwe	2003	Antimalarials	39	51%
Cambodia	2004	Quinine sulphate tablets	39	77%
Nepal	2004	Various	359	27%
Cameroon	2004	3 different antimalarials	284	39%
Burkina Faso	2006	Antimalarials	77	42%
Cambodia	2006	Antimalarials	451	27%
Vietnam	2006	Various	29,336	3%
China	2007	Various	110,426	3%
India	2007	Paracetamol	10,743	31%
Vietnam	2007	Various	25,460	3.3%
India	2008	Various	~ 40,000	8%
Thailand	2008	Sildenafil citrate (Viagra)	217	93%
Uganda	2008	Antimalarials	237	0%

Table 16.8 Studies on counterfeit and substandard drug products (McGinnis, M. 2009)

The lack or weakness of national drug regulations as well as national drug regulatory authorities is particularly conducive to the counterfeit trade. Less than 20% of the members of the World Health Organization are estimated to have well developed drug regulatory systems, 50% have drug regulatory systems of varying quality and capacity and 30% have no or barely functioning systems (Ratanawijitrasin, S., and E. Wondemagegnehu 2002, 11). Combating counterfeiting requires strict systems for licensing, production, importation, distribution and trade of health care products as well as the power to inspect manufacturing sites and impose sanctions.

Even in countries where regulatory systems are in place and enforced, the requirements for products destined exclusively for exportation may be less stringent than products intended for sale in the domestic market (WHO 1997a, 30), effectively legitimizing double standards. In Cyprus drug products manufactured by state agencies do not require registration and are not subject to regulatory controls and in Australia drug products manufactured for exportation are not subject to the same standards as those sold domestically (Ratanawijitrasin, S., and E. Wondemagegnehu 2002, 134). In Germany thousands of "grandfather drugs" which have not undergone regulatory procedures can be exported to less developed without any restrictions (E. Wondemagegnehu 1999b, 13).

Even in countries were (strict) regulatory controls are in place, national drug regulatory authorities lacking competence, qualified laboratories as well as sufficient human and financial resources are unable to enforce them (WHO 1999a, 15). The reluctance of the pharmaceutical industry as well as sellers to report (suspected) cases hampers detection and combating counterfeiting (WHO 1999a, 16).

Adequate national drug regulatory authorities may also lack the power to enforce measures which would prevent counterfeiting (Forzley, M. 2006, 3). For example in India the capacities of the national drug regulatory authorities are not sufficient to control 20,000 manufacturers (Chatterjee, P. 2001, 1776).

The production of counterfeit drug products does not require special knowledge, skills or complex facilities and most counterfeiting is carried out in ordinary households, small (cottage) industries or in backyards (WHO 2008a, 4). For example in Egypt ingredients for counterfeit sildenafil citrate (Viagra) tablets were processed in a cement mixer (Primo-Carpenter, J., and M. McGinnis 2007, 3).

Counterfeiters may use sophisticated equipment to imitate packaging and security features such as holograms or purchase them from the same suppliers as legitimate manufacturers, making detection very difficult.

Counterfeit drug products have a high value density, the relatively small volumes are fairly ease to transport and the "suitcase trade" even allows transporting counterfeits worth thousands of dollars by commercial transport in a single person's luggage (WHO 1998d, 13).

Counterfeiters are attracted by the low production costs and the potentially huge profits fairly small quantities of drug products can make while risking small penalties (Bate, R. 2008, 26) compared to other criminal activities (FIP 2003, 1).

Globalization, deregulation of markets, free trade as well as (unregulated) e-commerce facilitate access to (counterfeit) components as well as free movement of counterfeit products across international borders (Forzley, M. 2006, 4). Regulatory control in free trade zones is often poor and counterfeiters take advantage by repackaging and re-labelling products (WHO 1999a, 17).

The high complexity of supply networks with many stages as well as a large number of intermediaries and other actors increase the opportunities to introduce counterfeit products (WHO 1999a, 16). The existence of unlicensed commercial suppliers in poorly regulated markets facilitates distribution of counterfeit products.

In markets where demand exceeds supply of (genuine) products, counterfeiters can expect higher sales and larger profit margins (WHO 1999a, 16). Shortages of health care products can be caused, among others, by price controls which reduce the profit margins of licensed suppliers and particularly make distribution to remote and rural areas financially unviable (Morris, J., and Ph. Stevens 2006, 6). Likewise imposing taxes and tariffs, possibly to protect

domestic markets, reduce the profit margins of licensed sellers or increase market prices (Morris, J., and Ph. Stevens 2006, 6).

Populations which have to rely on their own resources rather than social security systems and health insurance will favour purchase of cheaper products.

In rural and poor communities genuine products may not be (easily) available as authorized suppliers incur higher costs for transport and distribution (WHO 2008a, 2).

Higher prices of genuine products and greater price differentials to counterfeit products are an incentive to supply cheaper, counterfeit products (WHO 1999a, 16).

Health professionals but especially consumers and patients may be unaware of the problems and dangers of counterfeit products. The low level of literacy in some less developed countries makes detection of counterfeit products more difficult.

Compared to other products such as food or perhaps household goods, the assessment of the quality, efficacy and safety of health care products as well as associated risks is much more difficult or impossible. Patients taking counterfeit drug products may nevertheless be cured and patients taking genuine drug products may nevertheless not recover. The quality of drug products cannot be readily assessed by lay persons or even experts and detection of counterfeit drug products requires sophisticated quality testing laboratories (Seiter, A. 2005, 1).

A) National legislation

- Lack of rule of law, law enforcement and weak sanctions.
- Lack of national legislation, drug regulation and national drug regulatory authorities.
- Double standards for exportation.
- Lack or weakness of enforcement of national drug regulations.
- Difficulty of detection by health professionals, consumers and patients.

B) Counterfeiters

- Ease of manufacture.
- Ease of transportation.
- Potentially huge profits.

C) Economic and logistical

- Globalization and free trade.
- Transactions involving many intermediaries throughout the supply network.
- Unauthorized suppliers.
- Demand exceeding supply.
- Taxes and tariffs.

D) Patients, consumers and health professionals

- Lack of access to adequate health services.
- Lack of access to genuine products.
- High prices.
- Lack of awareness
- Low levels of literacy.
- Difficulty to assess quality and distinguish genuine and counterfeit products.

Table 16.9 Factors which favour and facilitate counterfeiting

While detection of counterfeit packaging and labelling is difficult even if they can be compared to genuine samples, detection without a genuine samples is far more difficult. Sophisticated counterfeit packaging and labelling may require specialist equipment such as microscopes as well as specialized and experienced staff for detection. Determining that a single use medical device is sterile is literally impossible without sophisticated laboratory equipment.

Substandard and counterfeit health care products have a wide range of possible detrimental effects on public health, confidence in the public in the health care system, the economy as well as legitimate manufacturers (see table 18.10).

The inappropriate or insufficient treatment of patients with drug products with an insufficient quantity of active pharmaceutical ingredients or the wrong active pharmaceutical ingredient deny patients treatments which can alleviate suffering and save lives (FDA 2004, i). They can delay recovery and prolong the medical condition (Forzley, M. 2003, 1) which in turn may lead to preventable disabilities or even preventable death (Morris, J., and Ph. Stevens 2006, 4). As a consequences suffering of patients is prolonged.

The distribution of counterfeit and substandard antimalarials is probably a major cause of morbidity and mortality in Cambodia (Rozendaal, J. 2001, 890).

In 2004 an Internet site in India sold counterfeit contraceptive transdermal patches which contained no active pharmaceutical ingredient (McGinnis, M. 2008, 22).

In 1999 at least 30 people died in Cambodia after treatment with counterfeit artesunate tablets which contained a less effective antimalarial (Primo-Carpenter, J. 2004, 7).

Nine poisoning epidemics with diethylene glycol, a colourless and odourless but toxic liquid which is used as industrial solvent in antifreeze solutions, lubricants, glues and paints are known (Rentz, E.D. et al. 2008, 749).

The first and largest mass poisoning with the excipient diethylene glycol took place in 1937 in the United States where 105 patients died from renal failure after ingesting Elixir Sulfanilamide, an antimicrobial liquid (Wax, P.M. 1995, 456). In Bombay 14 patients died after receiving the cheaper diethylene glycol instead of medicinal glycerine in 1986. 40 children died in Nigeria in 1990 after ingesting acetaminophen syrup in which propylene glycol had been substituted with diethylene glycol (Wax, P.M. 1995, 460).

Between 1990 and 1992 more than two hundred children died in Bangladesh from acute renal failure after poisoning with paracetamol elixirs containing diethylene glycol which was substituted for glycerol (White Junod, S. 2000, 79).

In 2006 more than one hundred children were confirmed to have died as a result of ingesting government-made cough and anti-allergy syrups contaminated with diethylene glycol (McGinnis, M. 2008, 43).

88 children died from acute renal failure in Haiti in 1996 after glycerine imported into Haiti from China through Europe which was contaminated with diethylene glycol was used to manufacture acetaminophen (paracetamol) syrup. (O'Brien, K.L. et al. 1998, 1175).

In 2005 a man died in Burma of cerebral malaria after treatment with counterfeit oral artesunate which contained mainly paracetamol and only a fifth of the stated quantity of artesunate (Newton, P.N. et al. 2006, 197).

Persons which receive an ineffective vaccine are not protected in case of a future infection and may develop a preventable illness or even die as a consequence. For example a newborn child could die from neonatal tetanus if the mother was not immunized during her pregnancy

or a person could die from a wound infection after a harmless injury. Moreover, in general, decreased immunization coverage increases the likelihood of an epidemic.

The treatment of infectious diseases with counterfeit or substandard drug products with insufficient strengths or inadequate formulations can lead to development and subsequent transmission of strains of bacteria, parasites and viruses which are resistant against the respective active pharmaceutical ingredient (Forzley, M. 2006, 2). As a consequence new and more expensive drug products need to be developed.

The use of counterfeit artemisinin could result in the emergency and spread of resistance of this vital drug product (Newton, P.N., et al. 2008, 754). Counterfeit and substandard antimalarials were a contributing factor to the doubling of malaria deaths in Nigeria over the last 20 years (Morris, J., and Ph. Stevens 2006, 5). Drug resistance resulting from the counterfeit antiretroviral drug products in Congo could render first line therapies against HIV/AIDS useless (Morris, J., and Ph. Stevens 2006, 5).

Ineffective drug products against tuberculosis will not only prolong the suffering of inappropriately treated patient but also increase the number of healthy people infected by the untreated carrier, possibly with drug resistant tuberculosis strains.

Counterfeit drug products could undermine the ability to contain a potential avian flu pandemic by facilitating development of drug resistant viruses (Morris, J., and Ph. Stevens 2006, 5). In 2006 the Dutch Healthcare Inspectorate warned against purchase of oseltamivir (Tamiflu) through the Internet after detecting counterfeit capsules containing lactose and vitamin C but no active pharmaceutical ingredient (WHO 2008a, 4).

The transfusion of blood or blood products falsely negative testing for malaria or HIV could cause illness and death of the recipients.

False negative diagnostic tests, for example for malaria or haemoglobin determination, can leave medical conditions undetected or lead to inappropriate treatment while false positive test results would prompt unnecessary treatments with their possible side effects. In 2006 counterfeit blood glucose test strips were detected (WHO 2008a, 4) which could lead to over- or under-dosing of antidiabetics.

Patients falsely testing negative for communicable diseases could infect other people.

Even if counterfeit and substandard products do not cause immediate harm, the lack of traceability makes a recall impossible (WHO 1999a, 13). Quality problems can also occur with high quality products but labelling with genuine information on the manufacturer, the country of manufacture, the manufacturing date as well as the batch number allow to quickly locate and retrieve them. For example the national drug regulatory authorities in Argentina were unable to recall a counterfeit drug product for treatment of iron deficiency which had killed a health young woman (WHO 2008a, 3).

Patients as well as health professionals can be contaminated by single use medical devices which were salvaged from the waste stream and recycled.

Counterfeit or substandard health care equipment could cause burns and electrocution or over-exposure to x-ray radiation from diagnostic imaging equipment.

The occurrence of counterfeiting can damage the public confidence in the health care system, including the national drug regulatory authorities, and even risks undermining and eroding its credibility (Wondemagegnehu, E. 1999a, v).

Counterfeit and substandard products damage public confidence in quality of health care products available in the market (WHO 1998d 13). The mistrust of the quality of multisource

drug products and the preference for purchasing more expensive innovator (branded) products instead impedes the implementation of rational drug policies (Seiter, A. 2005, 1). Likewise the public may be reluctant to support import preventive public health measures such as immunization campaigns.

The purchase, transport and distribution of counterfeit and substandard products is a waste of economic resources.

Apart from the harm and suffering inflicted on individuals the public has to carry the unnecessary cost of the increased morbidity, disability and mortality caused by substandard or counterfeit products.

Substandard and counterfeit health care products can erode public confidence in manufacturers and suppliers of genuine products in general and of the manufacturers whose name, and reputation, was abused in particular (WHO 1999a, 13).

The purchase of substandard or counterfeit health care products causes an economic loss to legitimate manufacturers who invested into their development, licensing and marketing (Newton, P.N., et al. 2008, 1).

A) Health and safety

- Leaving medical conditions untreated (inefficacious drug products).
- Causing (unnecessary) suffering.
- Unwanted pregnancies.
- Illness, disability and death caused by toxic substances.
- Illness, disability and death caused be ineffective immunization.
- Insufficient treatment of infectious diseases leading to or favouring resistance.
- Infection of others from untreated or insufficiently treated carriers.
- Undermining the ability or effectiveness in containing epidemics and pandemics.
- Transfusion of contaminated blood products.
- Leaving medical conditions which are undiagnosed because of false negative tests untreated.
- Inadequate or wrong therapeutic measures based on false results of diagnostic tests.
- Loss of traceability of batches.
- Infection of health professionals and patients by contaminated, reused medical devices.
- Harm caused by poor quality health care equipment.

B) Loss of confidence

- Reduced confidence in the public health care system.
- Reduced confidence in the quality of health care products.
- Reluctance of the public to participate in preventive public health measures.

C) Economical

- Waste of resources (transportation, distribution and disposal).
- Resulting costs of illness, disabilities and deaths caused.
- Damage to the credibility of legitimate manufacturers.
- Lost sales for legitimate manufacturers.
- Reducing revenue and viability of manufacturers of high quality products.
- Depriving legitimate manufacturers of revenue required for further research.
- Undermining incentives for research and development of high quality health care products.

Table 16.10 Possible detrimental consequences of counterfeit and substandard products

As a consequence the revenue and viability of legitimate manufacturers is reduced, depriving them of incentives as well as of the required resources for research and development of new products of high quality (Morris, J., and Ph. Stevens 2006, 5).

Like all other actors in the distribution of health care goods, humanitarian organizations need to contribute to increasing awareness of the problem (Kelesidis, Th., et. al. 2007, 230) and minimize the risk of purchasing substandard and counterfeit products.

In addition some pertinent measures discussed earlier are summarized in table 18.11.

- Raising and maintaining awareness of the problem among health and logistics staff .
- Placing quality, safety and efficacy above cost.
- Ensuring accurate and complete traceability of all batches throughout the supply network.
- Ensuring full compliance with national legislation and regulations.
- Establishing and implementing a policy for qualification of products and manufacturers.
- Careful registration of all (new) commercial suppliers.
- Applying the same quality standards to all donations received in kind.
- Source products directly from manufacturers or at least as far upstream as possible.
- Purchasing only from inspected manufacturers and suppliers.
- Wherever possible, purchasing from WHO prequalified manufacturers.
- Ensuring that all products have a valid marketing authorization in the country of manufacture.
- Inspection of all consignments received from commercial suppliers by a qualified pharmacist.
- Careful inspection of accompanying documentation.
- Rigorously investigating any doubts raised concerning the quality of products.
- Reporting any suspicions to the national drug regulatory authorities.

Table 16.11 Measures against counterfeit and substandard health care products

16.5 Purchase contracts

Humanitarian organizations need to consider the unpredictability of demand as well as the required resources when evaluating the advantages and disadvantages of different purchase contracts (table 18.12).

Volume contracts allow combining the purchasing requirements over a certain period of time, for example one year, and negotiating lower purchase prices (Lambert, R.S., and J.R. Stock 1993, 506). In order to reduce annual storage costs of the buyer, partial (scheduled) deliveries over the period of the contract can be agreed on. Since the purchasing volume is determined in the contract, buyers carry the risk of overstocking or shortages (Quick, J.D. (ed.) 1997, 235).

With system contracts (Lambert, R.S., and J.R. Stock 1993, 507) the purchase price is negotiated for a certain quantity over a specified time period but the supplier makes partial deliveries of the quantities and at the time requested by the buyer. This allows humanitarian organizations to negotiate overall lower purchase prices and to reduce purchase costs (for example with annual tenders) but replenish stocks according to varying demand of their customers. Stock levels can be minimized or even eliminated with stockless purchasing, where the required quantities are "called off" from the supplier as needed.

The greatest flexibility for the purchaser is achieved by negotiating a fixed purchase price but without determining the purchase quantity over the period of the contract (Quick, J.D. (ed.)

1997, 235). The contract is based on an estimate of the expected annual purchase quantity without a commitment of the humanitarian organization to purchase a specific quantity. Suppliers carry the risk of selling at a low price even if the annual purchase value eventually is lower than estimated but have the advantage of being the only supplier during the entire contract period. Buyers can order any quantity at any time at a fixed price, do not risk overstocking if demand decreases and can quickly react to sudden increases in demand. Regular ordering of smaller quantities reduces average stock levels and therefore increases remaining shelf-life of goods.

Humanitarian organizations can also negotiate consignment stocks which are stocked at the warehouse of the buyer but remain the property of the supplier (Steinbuch, P.A. 2001, 237). The buyer has the right to withdraw any quantity at any time and only pays the supplier for the quantities which are shipped to customers. Stocks are available to humanitarian organizations any time and immediately without the risk of overstocking and without the need to purchase goods they hold in stock (Schulte, Ch. 1999, 180).

	Advantages	**Disadvantages**
Volume contracts	• Lower purchase costs. • Higher contract value allows negotiating lower prices. • Higher contract value incentive for suppliers to bid (reducing prices). • Protection against price fluctuations. • Protection against inflation. • Facilitation of budgeting. • Planning by suppliers increases reliability.	• Requires large amounts of cash at the time of purchasing. • Unbalanced workload of purchasing department and warehouse staff. • Possible inability of suppliers to deliver large quantities. • Higher average stock levels. • Additional purchases needed if demand increases. • Risk of decreasing demand lies with buyer. • Inflexible to new suppliers or falling prices.
System contracts	• Same as volume contracts. • Greater flexibility in reacting to demand fluctuations. • Reduced risk of overstocking. • More balanced stock levels. • Cash requirements spread over time. • Higher stock availability at the supplier.	• Requires issuing several purchase contracts.
Fixed purchase price	• Same as volume and systems contracts. • High flexibility in reacting to changes of demand. • No risk of overstocking.	• Higher price (compared to volume and system contracts).
Consignment stocks	• Outsourcing of storage to the supplier. • Risk of damage or loss remains with the supplier. • No risk of overstocking.	• Control of stocks remains with supplier. • Stocks may not be available when needed.

Table 16.12 Advantages and disadvantages of different purchase contracts

Because humanitarian organizations need to provide a fairly large number of health care goods with often highly uncertain demand, system contracts with estimated purchasing volumes are the most favourable purchase contract.

18.6 Domestic purchase

Within the strategic purchasing framework and in light of the conditions and constraints in a given country, logistics managers will have to initially decide whether to set up a purchasing department and, if so, regularly review whether domestic purchase should be maintained.

Domestic purchase may be difficult or impossible for various reasons (see table 18.13).

Health care goods need to be purchased abroad if they are unavailable in the host country or the range of available products does not allow covering all essential goods (Kaur, M.,, et al. 2005, 112).

More complex and sophisticated health care goods, especially equipment, and the selected standard items are less likely to be available in less developed countries and will therefore require centralized purchasing. Moreover the need for quality assurance increases with the complexity of health care goods which also favours centralized purchasing.

Likewise domestic availability only of health care goods, either manufactured domestically or imported, which do not comply with the quality assurance policy defined by the humanitarian organization, necessitates purchase abroad.

The risk of acquiring substandard or even counterfeit health care goods is generally higher in less developed countries because of lower manufacturing standards as well as a higher risk of importing counterfeit drug products. Consequently humanitarian organizations need to purchase health care goods where quality is critical centrally at least until a domestic source of equal quality is identified.

If health care equipment is included in the standard item catalogue for which manufacturers do not provide a worldwide service network, the principles of standardization runs contrary to the need for ensuring sustainability. Consequently humanitarian organizations must decide on a case by case basis whether they follow, possibly lower, domestic standards or accept that the provided health care goods are only provided for the duration of humanitarian assistance programmes.

- Unavailability of required health care goods in the country.
- Unavailability of health care goods which comply with the required quality standards.
- Unavailability of supplier services in the receiving country.
- Higher prices for domestically available health care goods.
- Lack of legal security in the host country.

Table 16.13 Circumstances which discourage domestic purchase

Depending on the mark-up of domestic importers, centralized purchasing may be more cost-efficient than domestic purchase, even when international distribution costs are considered. Especially where domestic importers have reserved exclusive rights for health care goods, the competition among suppliers is likely to yield lower prices by centralized purchasing. On the other hand importers are likely to benefit from economies of scale for transportation and are more likely to be able to use slower surface transportation for replenishing their stocks.

Moreover multinational manufacturers may sell the same product at lower prices in less developed countries than in developed countries.

Lack of legal security in the host country makes domestic purchase risky and will strongly favour purchase abroad.

On the other hand, several circumstances favour domestic purchase (see table 18.14).

Short lead times requested by customers will generally favour domestic purchase. However the lead time for health care goods which are not in stock with domestic importers or authorized suppliers may be longer than lead times from regional or even international distribution centres.

Centralized purchasing in developed countries is likely to be unsustainable (Kaur, M., et al. 2005, 112) when assisted health care facilities or national health care systems eventually resume their self-sufficiency. Domestic purchasing services may lack the contacts to international manufacturers, or where health care goods are available through importers, products may be too expensive.

Unpredictability of demand favours domestic purchase as centralized purchase may incur high costs for expediting shipments.

Restrictions on and delays for importation of health care goods into recipient countries favour domestic purchase. High costs for registration of standard health care goods in the host country, which have not been registered by domestic importers with the national drug regulatory authorities, also favour domestic purchase.

Rigorous national drug legislation may hamper importation, especially of not registered health care goods, and is likely to increase the quality of domestically available health care goods which both favour domestic purchase.

Where national drug regulatory authorities require labelling in national languages, centralized purchasing may be impossible. For example multilingual labelling, including Arabic or Asian languages, is unlikely to be available in the European market and consequently domestic or at least regional purchasing may be necessary.

Highly developed and stringent national drug legislation as well as highly competent national drug regulatory authorities in host countries favour domestic purchase. The safety of imported as well as domestically manufactured health care goods increases and the cost of quality assurance decreases for humanitarian organizations. Moreover the likelihood that importation, even of high quality health care goods, is refused increases as the number of registered products is limited in any market. Domestic purchasing also furthers the domestic economy and improves relations with local authorities (WHO 1999e, 19).

Although, unlike food purchase, domestic purchase of health care goods is unlikely to have a significant impact on the national economy, domestic purchase may be desirable for political reasons and for showing respect for the host country.

Generally speaking small-scale local production is the most unlikely option because of the technical difficulties as well as the complex quality assurance system which is required. However if a small scale manufacturing facility, for example of infusions (Quick, J.D. (ed.) 1997, 291) exists, supporting and maintaining this facility might be an option. Qualified pharmacists may be able to prepare a limited range of creams or ointments. Oxygen can also be produced with special units at hospitals which eliminates the need for providing oxygen in medical gas cylinders and exchanging them. Providing assistance to or even establishing such a facility requires supervision by a specialist and strict compliance with national legislation and regulations.

- Expected handing over of assisted health care facilities and need for sustainability.
- Unpredictable customer demand.
- Restrictions on importation.
- Delays for importation.
- Rigorous national pharmaceutical legislation and regulations.
- Requirement for labelling in national language.
- Highly developed and stringent national drug legislation.
- Desire of humanitarian organizations to support the national economy.

Table 16.14 Circumstances which favour domestic purchase

16.7 Incoterms

The Incoterms (international commercial terms) are the official set of rules of the International Chamber of Commerce (ICC) for interpreting trade terms, primarily where goods are sold for delivery across national borders (ICC 2000). This worldwide contractual standard is regularly updated and avoids the problems associated with different interpretations of trade terms by contract parties. The Incoterms intend to facilitate international trade by avoiding misunderstandings, disputes and litigation which can be caused when contract partners refer to different practices or rules applying in their respective countries.

The Incoterms clearly define the rights and obligations of sellers and buyers concerning transportation and delivery of goods as well as distribution and passage of risks related to a sales contract. The Incoterms concern only the obligations which the two parties of a sales contract owe each other and do not concern insurance (with exceptions) or financing, do not apply to contracts of carriage and should not be confused with shipping terms. However agreement on a certain term of trade may have implications for other contracts, for example concerning the mode of transportation. Moreover, Incoterms by no means define all the obligations but are limited to the aspect of transportation as well as delivery and do not deal with important issues such as transfer of ownership, breaches of contract or their consequences. Incoterms by no means intend to cover all relevant issues of a sales contract but are merely an important complement.

Since Incoterms may be changed when they are updated from time to time, whenever Incoterms are used in a sales contract an explicit reference to the version must be made, for example "Incoterms 2000". Moreover all Incoterms require precisely specifying a named place, named port of shipment, named port of destination or named place of destination in order to make sense.

The Incoterms do not provide any explanation or interpretation of any terms which contract parties may add to the standardized Incoterms. Therefore contract parties must specify any additions in their sales contract to ensure that both parties agree on their interpretation, in particular whether they relate only to costs or risks as well.

Some Incoterms (see figure 18.4) apply only to maritime and inland waterway transport while the others apply to any mode of transportation.

It is generally recommended that the exporter should be responsible for clearing goods for exportation while importation should be carried or contracted out by the contract party which is present in the country where goods are being imported.

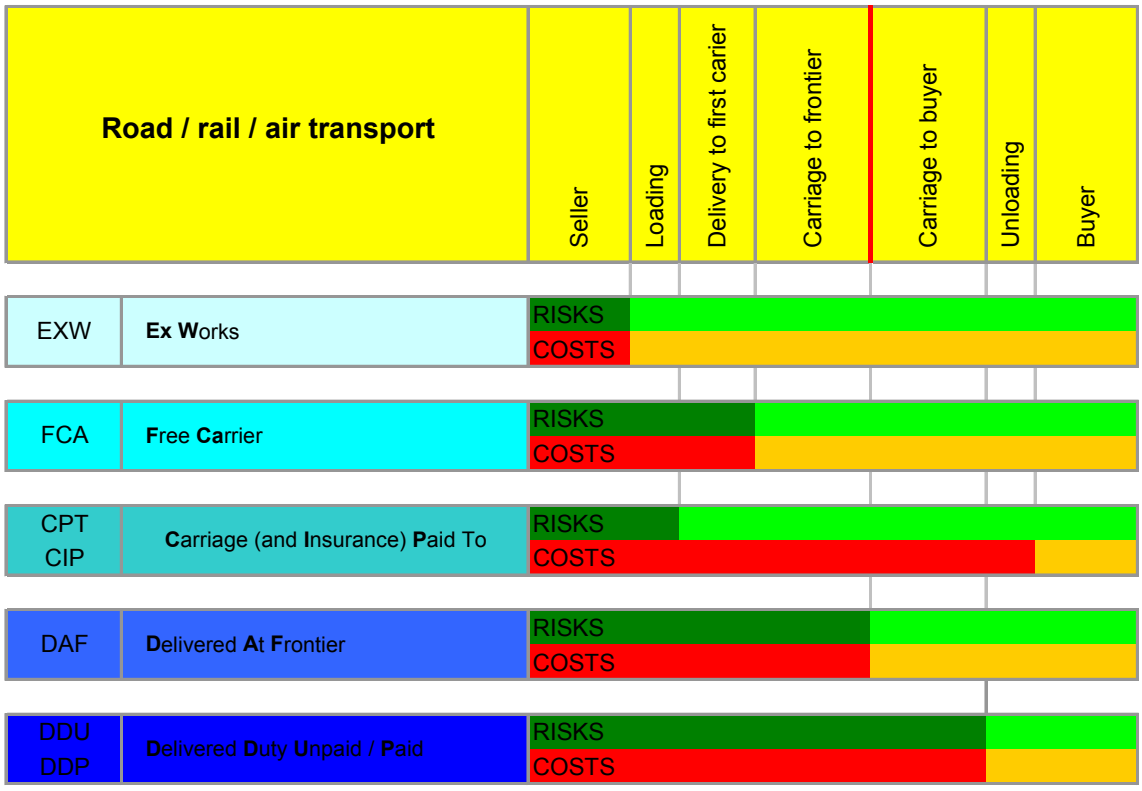

Figure 16.4 Incoterms for all modes of transportation

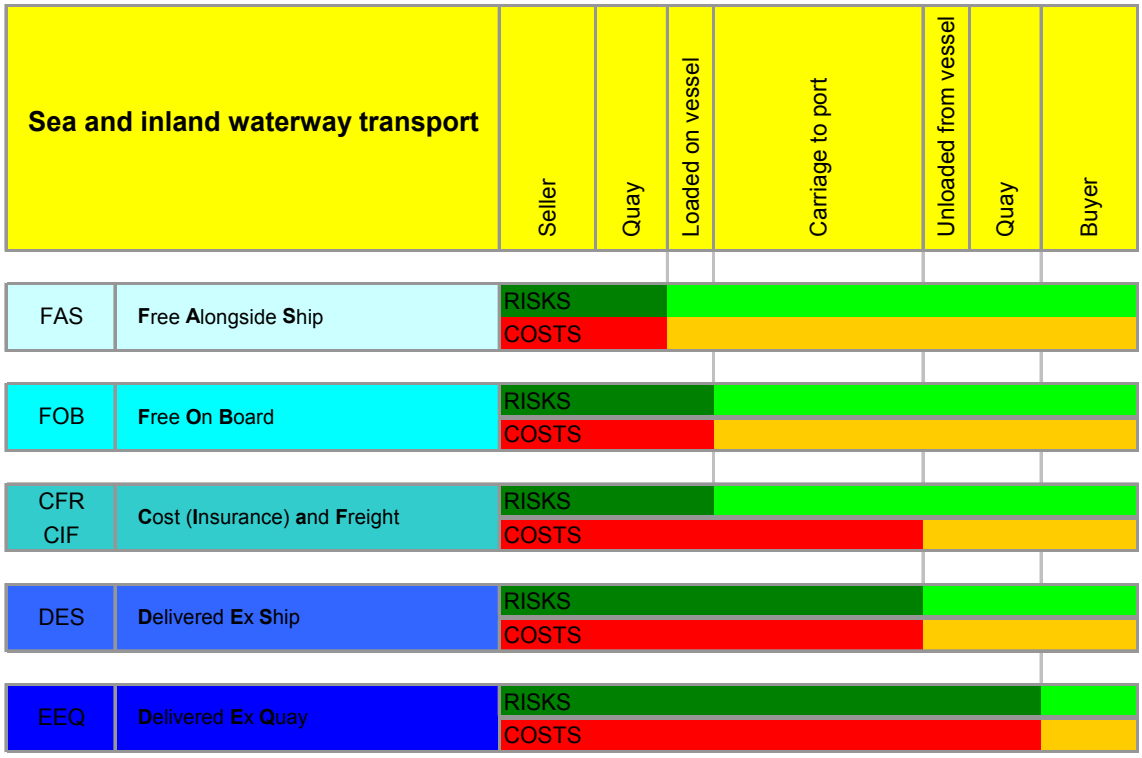

Figure 16.5 Incoterms for sea and inland waterway transport

It is important that the risk of loss or damage of goods as well as the obligation to bear any resulting costs, passes from the seller to the buyer when the seller has fulfilled his obligation according to the respective Incoterm. This transfer of risk from the seller to the buyer does not necessarily coincide with the receipt of goods at the buyer. Moreover the risk transfers to the buyer even if he does not take delivery as agreed.

The risks and their insurance can be agreed upon by the buyer and seller independently of any Incoterm.

The Incoterms are structured into four categories from minimum seller's obligations in group E to maximum seller's obligations in group D. In the first group "E", which contains only the Incoterm "Ex Works", the seller only has the obligation to make the goods available to the buyer. In the second group (F-group) the seller is obliged to deliver the goods to a carrier appointed by the buyer. Under the C-group the obligations of the seller are extended to contract carriage but without the seller assuming the risk of loss or damage of goods after their dispatch and shipment. Finally under the D-group Incoterms the seller must bear all costs and risks of bringing goods to the place of destination.

Group E

EXW - Ex Works (named place)

The seller delivers when he places the goods, properly packed for overseas transport, at the disposal of the buyer at an agreed place, usually the seller's premises as well as at an agreed time.

The buyer is responsible for exportation and transportation of goods to the final destination. The seller has minimum obligation and the buyer bears all the costs and risks after taking delivery of goods at the seller's premises.

In practice, the seller will often assist the buyer in loading the goods on a vehicle provided by the buyer and the responsibilities concerning risks and costs of loading can be agreed upon separately in the sales contract.

Group F

*FCA - **F**ree **Ca**rrier (named place)*

The seller must deliver the goods, cleared for exportation, and place them at the disposal of the carrier or another person chosen by the buyer, at the named place and at the agreed date or within the agreed period of delivery.

The buyer has to bear any costs for loading as well as any costs incurred if, for whatever reason, the goods are not or cannot be loaded on the means of transportation. The buyer also has to arrange for carriage as well as importation into the destination country.

*FAS - **F**ree **A**longside **S**hip (named port of shipment)*

The seller delivers when the goods have been cleared for exportation and are placed alongside the vessel chosen by the buyer at the named port of shipment and at the agreed date or within the agreed period of time. The buyer is responsible for loading, carriage and importation of goods in the destination country.

*FOB - **F**ree **O**n **B**oard (named port of shipment)*

The seller delivers when the goods have been cleared for exportation and the goods pass the rail of the ship chosen by the buyer, at the named port of shipment at the agreed date or within the agreed period of delivery. The buyer has to contract carriage and is responsible for

importation of goods in the destination country. Moreover the buyer has to bear any costs incurred if the vessel fails to arrive on time or is unable to take the goods.

Group C

The Incoterms of the C-group oblige the seller to contract for carriage at his own expense. However the seller fulfils his contractual obligations in the country of dispatch (and not in the country of importation) and at the time of shipping the goods with the contracted carrier and therefore, in principle, does not bear the risk during transportation. Therefore the C-group Incoterm are departure contracts.

However, the seller is responsible for taking out an insurance for the benefit of the buyer under the CIF and CIP Incoterms. For contracts under the CFR and CPT Incoterms the seller and buyer must agree on which party is responsible for insurance.

*CFR - **C**ost and **Fr**eight (named port of destination)*

The seller delivers the goods cleared for exportation when they pass the ship's rail in the port of shipment at the agreed date but bears the costs for loading and carriage in a vessel to the named port of destination. However the risk of loss and damage of goods is transferred to the buyer at the time of delivery at the port of shipment not at the time of arrival in the port of destination.

*CIF - **C**ost, **I**nsurance and **F**reight (named port of destination)*

The Incoterm corresponds to CFR but the seller has to contract and pay marine insurance only on minimum cover against the buyer's risk of loss or damage to goods during carriage. Any increase of insurance above the minimum coverage would have to be agreed upon in the sales contract or the buyer can make his own additional insurance arrangements.

*CPT - **C**arriage, **P**aid **t**o (named place of destination)*

The seller delivers the goods cleared for exportation to a carrier chosen by himself at the agreed date but must in addition pay the cost of carriage to transport the goods to the named destination. The costs for unloading must be paid by the seller if they are part of the contract of carriage, otherwise they are paid by the buyer. The buyer must clear goods for importation.

*CIP - **C**arriage and **I**nsurance **P**aid to (named place of destination)*

The CIP Incoterm corresponds to the CPT Incoterm but in addition the seller must insure the goods against the buyer's risk of loss or damage of the goods during carriage. However the seller is obliged to obtain insurance only on minimum cover. The seller and buyer can agree on a better insurance coverage or the buyer can take out additional insurance.

Group D

Under the D-group Incoterms the seller is responsible for the arrival of goods at the agreed place or destination at the border or within the country of importation and bears all costs for carriage and as well as all associated risks. Therefore the D-group Incoterms are arrival contracts.

*DAF - **D**elivered **A**t **F**rontier (named place)*

The seller delivers the goods cleared for exportation when they are placed at the disposal of the buyer on the arriving means of transportation (not unloaded) at the named point and place at the frontier, but before the customs border of the adjoining country. The frontier may be that of the country of exportation or any other one. The seller must bear the costs for carriage but the buyer must clear goods for importation.

*DES - **D**elivered **E**x **S**hip (named port of destination)*

The seller delivers the goods cleared for exportation when they are placed at the disposal of the buyer on board the vessel at the named port of destination and must bear all costs for and risks of carriage. The buyer must clear goods for importation.

*DEQ - **D**elivered **E**x **Q**uay (named port of destination)*

The seller delivers the goods cleared for exportation when they are placed at the disposal of the buyer on the quay (wharf) at the named port of destination. The seller bears all costs and risks for bringing the goods to the named port of destination. The buyer has to clear the goods for importation.

*DDU - **D**elivered **D**uty **U**npaid (named place of destination)*

The seller contracts the carriage at his own expense and delivers the goods cleared for exportation but not cleared for importation at the named place of destination when they are placed at the disposal of the buyer on any arriving means of transportation but not unloaded. The buyer has to bear all costs for importation.

*DDU - **D**elivered **D**uty **P**aid (named place of destination)*

The seller delivers the goods to the buyer, cleared for exportation as well as for importation on the arriving means of transportation, but not unloaded, at the agreed date and at the named place of destination and bears all costs and risks. This term should not be used if the seller is unable to clear goods for importation.

18.8 United Nations Convention on Contracts for the International Sale of Goods

Sales contracts between a seller and a buyer which have their places of business in the same state are, as a general rule, governed by their respective domestic sales law while uncertainty concerning applicable legislation arises when the two parties have their places of business in different countries. As the convention is complex, the following chapter will be limited to important issues which may be relevant for the purchase of health care goods.

Part I: Sphere of application and general provisions

Part II: Formation of the contract

Part III: Sale of goods

- Obligations of the seller (delivery, conformity, remedies).
- Obligations of the buyer (payment, taking delivery, remedies).
- Remedies for breach of contract.
- Passing of risk.
- Suspension of performance and anticipatory breach.
- Damages.
- Exemption from liability to pay damages.
- Avoidance.
- Preservation of goods.

Part IV: Final clauses

Table 16.15 Parts of the CISG

The United Nations Convention on Contracts for the International Sale of Goods (CISG) is a binding agreement between states which undertake to adopt the rules of the convention as

part of their domestic law. However some contracting states have made reservations or declarations that certain articles do not apply.

The convention which was developed by the United Nations Commission on International Trade Law (UNCITRAL) offers a uniform international sales law and is divided into four parts (see table 18.15).The convention applies only to contracts of sale of goods between parties whose places of business are in different states which are both party to the convention or where the rules of private international law determine the applicability of the law of a contracting state (Art. 1). The convention does not apply to service contracts and does not contain definitions of delivery terms. The nationality of the parties or the place where the buyer takes delivery is not relevant.

Unless agreed otherwise, in principle the applicable laws are determined by the international private law in the country of place of business of the seller.

The convention is limited to the formation of contracts of sale as well as the rights and obligations of the seller and buyer (Art. 4) but does not cover the liability of the seller for personal injury or death caused by the goods (Art. 5). Rather these are governed by the respective applicable national laws.

While the convention in principle applies automatically the parties may exclude the application altogether or may derogate from or vary any of its provisions (Art. 6) by including a statement in their contract.

The provision that sales contracts do not have to be concluded in writing (Art. 11) may be abrogated by any contracting state (Art. 12) and contracts evidenced in writing do not require any specific format.

Offers must indicate goods, quantities and prices and be addressed to one ore more specific persons (Art. 14). Such offers are binding in case of acceptance as soon as they reach the offeree (Art. 15). However until a contract is concluded an offer may be revoked by the offeror if the revocation reaches the offeree before he dispatches an acceptance (Art. 16) and offers are terminated as soon as a rejection by the offeree reaches the offeror (Art. 17).

The acceptance of an offer becomes effective as soon as a statement or other indication of assent reaches the offeror while silence or inactivity does not amount to acceptance (Art. 18) unless other practices have been established between the parties. Any reply to an offer containing additions, limitations or other modifications which materially alter the terms (for example price, quality and quantity of goods) of the offer constitutes a rejection (Art. 19).

An acceptance may be withdrawn if the withdrawal reaches the offeror before or at the same time the acceptance would have become effective (Art. 22).

As soon as the offer becomes effective, a contract is concluded (Art. 23).

A contract is avoided (rejected and cancelled) if the breach of contract by one of the parties substantially deprives the other party of what he is entitled to expect under the contract (Art. 25) but is effective only if the other party is notified (Art. 26). Contract parties can agree on modifying or terminating contracts (Art. 29).

The main obligation of the seller is delivery of the goods and transfer of property according to the contract on a certain date, within a specified period of time or within a reasonable time after the conclusion of the contract (Art. 30).

The seller must deliver the goods in the quantity and quality specified in the contract (Art. 35), which possess the qualities of samples provided by the seller and are packaged in the manner usual for such goods.

The seller is liable for any lack of conformity at the time the risk passes to the buyer, even if this lack of conformity only becomes apparent later (Art. 36) as well as after this time if the goods are guaranteed to retain specific qualities or characteristics for a certain period of time.

The buyer must take delivery and examine the goods or have them examined within as short a period as is practicable in the circumstances (Art. 38). He loses any rights resulting from the lack of conformity if he does not give notice to the seller within a reasonable time and provides details of the faults (Art. 39). The maximum time period depends on the discretion of national courts and varies.

However, the buyer does not lose his rights if the seller knew or could not have been unaware of the lack of conformity and which he did not disclose to the buyer (Art. 40). If the seller delivers a quantity larger than specified in the contract, the buyer may refuse the excess quantity or take delivery and pay for the excess quantity according to the price specified for the initially contracted quantity (Art. 52).

If the lack of conformity of delivered goods constitutes a fundamental breach of contract, the buyer can require repair or delivery of substitute goods provided he makes his request together with the notice of lack of conformity to the seller. The buyer may declare the contract avoided (cancelled) in case of non-delivery.

The buyer must pay the price for the goods which is specified in the contract (Art. 53) at the time the seller places them at his disposal or within a time period specified in the contract (Art. 58) but does not have to pay until he has had an opportunity to examine the goods.

The seller may avoid (cancel) the contract if the failure of the buyer to perform amounts to a fundamental breach of contract (Art. 64).

If the buyer fails with his obligation to provide specifications of goods on time, the seller may determine the specifications himself according to the requirements of the buyer that he may know. However, the seller must inform the buyer and allow a reasonable period of time during which the buyer may provide the required specifications. However, if the buyer fails to provide these specifications, the specifications determined by the seller are binding (Art. 65).

After the risk has passed to the buyer, he is obliged to pay the (full) price even if the goods were lost or damaged, unless the loss or damage is due to an act or omission of the seller (Art. 66).

The risk passes to the buyer when he takes over the goods or when the goods are placed at his disposal and he fails to take delivery (Art. 69).

The seller as well as the buyer may claim damages equal to the loss if the other party fails to perform (Art. 74). A party relying on a breach of contract must take all reasonably possible measure to mitigate the loss resulting from the breach (Art. 75).

Avoidance (cancellation) of the contract releases both parties from their contractual obligations although they may still be liable to pay or receive damages.

The buyer loses the right to avoid the contract or require the seller to deliver substitutes if he is not able to make restitution of the delivered goods substantially in the condition in which they were received (Art. 82).

Both parties have the duty to preserve any goods in their possession which belong to the other party for example goods retained by the seller awaiting delayed payment by the buyer or goods rejected by the buyer and awaiting return to the seller.

Parties are not liable for any failure to perform any of their obligations if they can prove that this failure was due to circumstances beyond their control ("force majeure") and could not

have reasonably been expected (Art. 79). Courts are restrictive in accepting invocation of force majeure which cannot be used for excusing negligence. However the party remains liable for the damages if he does not give notice to the other party within a reasonable time after failing to perform.

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17 SETTING UP MEDICAL STORAGE FACILITIES IN THE FIELD

Medical distribution centres are crucial links in the supply network. The terms medical stores and medical warehouses refer to the purely physical function of storage of health care goods while the term medical distribution centre refers to a variety of other activities and services provided to customers.

This chapter will focus on the practical aspects of setting up medical storage facilities in less developed countries rather than on building large commercial distribution centres in developed countries which requires specialists. In humanitarian assistance medical storage facilities as well as the number of stocked items are much smaller than in commercial logistics.

The terms stores and stocks are sometimes used as synonyms. However a store is a facility for keeping stocks of goods and stocks are physical goods which are kept in a store.

The same principles for planning and setting up a small medical store in a clinic also apply to setting up a large regional medial distribution centre. The principles which apply to planning a facility which is built from scratch are the same as the selection criteria for choosing between different options of available storage facilities.

In practice, ideal medical storage facilities will rarely be available and compromises will often have to be made. Sometimes humanitarian organizations will have to make due with the best available facilities and try improving them as much as possible. Making compromises however should not go so far as to make due with any building and being content with "making the best of it". Medical storage facilities are indispensable elements of the supply network and logistics managers must be aware that their establishment and maintenance inevitably requires resources.

As far as possible the principles for planning and designing warehouses outlined below should be applied. In any case, national legislation as well as regulations must be complied with and operating a medical storage facility may be conditional on obtaining a licence from the national drug regulatory authorities.

In this chapter a medical warehouse will be considered as a separate building while a medical store may be part of a medical warehouse (cold store, store for drug products etc.) or one or several rooms within a health care facility or another building.

The main purpose of medical storage facilities is preventing deterioration and protecting health care goods from adverse environmental conditions such as heat and cold, humidity, rain and snow, dust and dirtying. Likewise infrastructure, storage as well as materials handling equipment is protected.

Moreover storage facilities provide security and protect health care goods as well as equipment against theft.

- Protection of goods from the environment (wind, sun light, rain, snow, heat, cold).
- Protection of infrastructure and equipment from the environment.
- Protection of goods and equipment from theft.
- Providing appropriate (environmental) working conditions for staff (temperature, humidity).
- Allow systematic organization and arrangement of stocks.

Table 17.1 Functions of storage facilities

Storage facilities also provide an appropriate environment and working conditions for staff such as appropriate temperatures and protection from rain, snow, wind, dust and sunlight.

Medical storage facilities also allow systematically organizing and arranging stocks in order to allow finding and retrieving them quickly when needed.

However medical storage facilities also have a large number of significant disadvantages (see table 17.2) and the need for establishing medical storage facilities must therefore be considered very carefully.

Medical storage facilities require significant financial, human and organizational resources for establishing, maintaining as well as operating and tie up funds which could otherwise be used for assistance programmes. Annual stock holding costs of commercial organizations typically range from 20 - 30% of the average stock value (Lewis, C. 1997, 21).

While the location of customers might change quickly and frequently, medical storage facilities can be moved only at a high costs. Consequently medical storage facilities can decrease the flexibility of the supply network.

Demand distortion as well as the total stocks held in the supply network increases with every medical storage facility which is added. Moreover whenever customers add a new item to their national standard list, several medical storage facilities have to stock this new item. Likewise all stocks of an item have to be cleared from the supply network when it is removed from the national standard list.

On average, the remaining shelf-life of any batch of health care goods is reduced by the cumulative average stocking time at all medical storage facility. Moreover goods are exposed to the risks of expiry, theft, looting, damage and destruction.

Benefits

- Protection from environmental conditions (weather and climate).
- Security (protection from theft).
- Organization of stocks.

Disadvantages

- Resources for setting up.
- Resources for maintenance.
- Tying of funds which are unavailable for humanitarian assistance programmes.
- High costs for moving storage facilities.
- Reduction of the flexibility of the supply network.
- Increase of demand distortion.
- Increase of total stocks in the supply network.
- Delays for stocking new items and depleting items which are no longer needed.
- Reduction of remaining shelf-life.
- Risk of expiry, theft, looting, damage and destruction.
- Warehouse operations in itself add no value to customers.
- Discouragement of efficient supply network management.
- Stocks hide inefficiencies.

Table 17.2 Benefits and disadvantages of stores

While warehouse operations at every medical storage facility are indispensable, they do not add any value to the final customer. At every stage of the network, goods have to be unloaded, inspected, recorded, put away, maintained, counted regularly, picked, packed, loaded and

shipped. None of these processes adds any value to the end-user. For the patient who receives a drug product on time it makes no difference whether it has been processed through only three or ten stages. Therefore establishing intermediate medical storage facilities is a waste of resources, provided that the required lead times could be efficiently achieved by other means. This wastage is often overlooked because accounting in humanitarian assistance usually does not allow accurate calculation of stock holding costs.

Large stocks and a large number of stages discourage efficient supply network management and discourage reduction of lead times. Large stocks hide inefficiencies in the supply network. Especially in emergencies where no stocks are available, theses inefficiencies will cause long lead times.

Therefore before establishing medical storage facilities in the field, the benefits as well as disadvantages must be carefully weighed up. In any case establishing an (additional) medical storage facility can only be justified by directly or indirectly improving customer service.

The most important question before setting up a medical storage facility is:

Is the medical storage facility really needed?

Medical storage facilities are an (often inevitable) waste of resources.

If possible avoid them!

Especially when new medical storage facilities are set up in the field they should be planned very carefully as they are often maintained for years or even decades. Poor planning will inevitably result in inefficient stores management and lead to repeated needs for changing the layout of stores and storage equipment.

Although this may appear counterintuitive at first site, medical stores and warehouses should be planned "inside out" (see table 17.3). If the storage equipment is set up without considering types and quantities of goods which need to be stored, eventually the store might turn out to be too small. If storage equipment is set up without planning the materials handling equipment, counterbalanced forklift trucks may not be able to operate in too narrow aisles. If the building is selected first, the rooms might not be able to accommodate the most appropriate storage equipment and the materials handling equipment may be unsuitable for operating in the building.

An "inside out" approach to planning medical stores and warehouses

- Determine whether the medical storage facility is really needed.
- Define reasons for setting up the medical storage facility.
- Determine the type and quantities of health care goods which should be stored.
- Identify suitable unit load systems.
- Estimate maximum stock levels for each item.
- Identify suitable storage equipment.
- Estimate the annual turnover in terms of stock volume.
- Identify materials handling equipment suitable for handling the estimated (peak) flows of goods.
- Plan an appropriate layout for storage equipment and other facilities.
- Plan the required size of the building for storage, offices and ancillary areas.
- Plan an appropriate layout of the site.

Table 17.3 Planning process for medical storage facilities

Therefore, after the need for a medical storage facility has been ascertained and the reasons have been clearly documented, the type of goods, their quantities and volume need to be calculated or at least estimated. The type of goods and their unit loads will determine the type and capacities of required storage equipment. The storage equipment as well as the (peak) flows of goods will determine the type and capacity of materials handling equipment.

The storage equipment and its layout together with the ancillary areas will determine the required size and layout of the building. Finally the layout and size of the site will depend on the layout and size of the medical storage facility or the building in which it is accommodated.

An ideal set-up is probably only possible if the medical storage facility is purpose built, which will rarely be the case. If existing storage facilities are chosen, in practice many compromises will have to be made. However if the "inside out" approach is not followed, there is a danger of selecting, building or adapting a medical storage facility which turns out to be too large or too small. Especially when the medical storage facility is too small, another site should be selected in order to avoid all the problems that locating stocks in different buildings or sites can cause.

Medical storage facilities must not be too small since otherwise they can impossibly be set up or managed appropriately or efficiently.

The stock volume which determines the size of the required storage area as well as the overall capacity of the storage equipment, is of course an important consideration in planning medical storage facilities. However, when planning medical storage facilities the estimated (peak) flows of goods are just as important.

Medical storage facilities with large flows require more docks as well as larger receipt and dispatch areas. Moreover the materials handling equipment must be appropriate for managing large flows and more staff will be needed for receipt, put-away, order picking, packing, dispatch as well as general stores management. For example, even large contingency stocks which may not be used for months or even years, require little resources for managing.

From the very beginning, considering the possibility that medical storage facilities will have to be expanded, possibly only years after being set up, is important. This must be taken into consideration for planning storage equipment, materials handling equipment, the building as well as the site.

Storage volume - static aspect	Flow of goods - dynamic aspect
• Size of the required storage area. • Capacity of storage equipment.	• Number of docks. • Size of receipt and dispatch area. • Type and quantity of materials handling equipment. • Number of staff.

Table 17.4 Planning factors determined by storage volumes and flows of goods

As far as possible, the set-up and layout as well as the storage and materials handling equipment should be standardized in order to allow setting up stores quickly and efficiently as well as avoiding (non-value adding) changes according to personal preferences.

17.1 Storage requirements

If an assessment and analysis of provided and required services has shown that establishing a medical storage facility is necessary for improving services, the next step is to determine storage requirements. Determining the items which need to be permanently held in stock as well as their respective storage quantities in turn allows determining the required storage capacity.

17.1.1 Establishing the stock list

The stock list is a list of all items which are, or should be, permanently held in stock and are regularly replenished. These items are sometimes also called "stock items". All other items are "non-stock items". All items should either be clearly designated as stock item or non-stock item.

The health programme manager is responsible for taking decisions concerning the contents of the stock list which should correspond to the national standard list. In order to ensure a regular stock turnover and avoid expiry, only regularly used items should be stocked.

Despite of their possibly very low turnover, contingency stocks must be included in the stock list to ensure immediate availability.

17.1.2 Determining stock levels

After all stock list items have been determined and laid down in a formal stock list, the stock level for each item has to be determined.

The stock levels are determined by the inventory control system and its parameters.

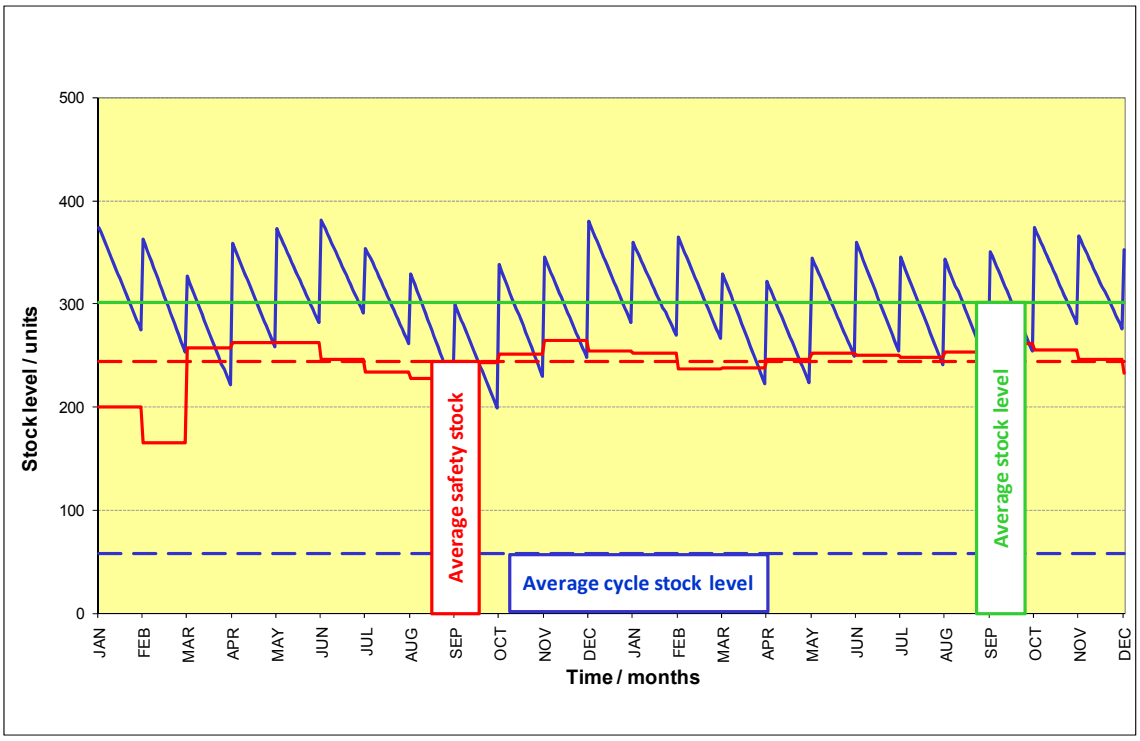

Figure 17.1 Average stock level of an individual item

In principle two kinds of stocks must be kept. The cycle stock covers forecasted demand during the review period as well as during the expected replenishment lead time. In addition a safety stock must be carried to hedge against uncertainty of demand as well as supply.

The average stock level is calculated as the average stock on hand which corresponds to the sum of the average safety stock level and the average cycle stock (see figure 17.1).

However, the storage capacity must be sufficient to accommodate the maximum expected stock levels. In a periodic review system total stock levels will reach their maximum after (monthly) stock replenishment orders have been received and been put away. If customer demand suddenly decreases or even ceases, stock levels will increase as long as stock on order from previously placed stock replenishment orders is received. Moreover customer demand may increase in the future and therefore, eventually, lead to increased total stock levels.

In a period review system, the stock of many items will be at their lowest level just before the consignments ordered for stock replenishment are received. In theory, if all items have identical lead times, the stock level of all items will reach the safety stock level plus cycle stock level at the same time. Therefore the store must have the capacity to accommodate the maximum stock level (safety stock as well as the cycle stock) of all items at the same time.

In a continuous review system different items will reach the reorder level at different times. Consequently at any given time, some items will reach their highest stock level while others will be reaching their lowest level. The total required storage capacity can then be based on average stock levels as items with high stock levels can use some of the space that is vacated by items with low stock levels at the same time.

17.1.3 Calculation of stock volume and required storage capacity

After the stock list has been established and the maximum stock levels have been calculated, detailed calculations of the stock volume as well as the required storage capacity can be made.

The required storage capacity depends on a number of factors (see table 17.5). First of all it depends on the type of stored health care goods, the volume of each packaging unit as well as the geometry of its packaging.

For example round bottles and cans will require more storage volume than the sum of their volumes because they cannot be stacked or packed as tightly as square containers. Bottles of infusion solutions will require more storage volume than infusions packaged in plastic pouches. Moreover, small items with odd shapes such as syringes cannot be packed without leaving gaps but can be packed more tightly than for example small tubes which are each packed in a cuboid carton.

For determining the required storage volume per unit of item, the total occupied storage volume of primary as well as secondary packaging and possibly additional supplier master cartons must be measured and divided by the number of units the packaging contains. For example, tablets in blister packaging require significantly higher storage volumes than the same tablets in hospital packaging. Likewise small quantities, for example 2 - 10 ampoules in individual blister packaging require significantly higher storage volumes than larger packaging, for example of 100 ampoules.

The required storage capacity for each unit can be calculated most accurately by measuring the volume of a large quantity of the item with all its outer packaging and dividing the total volume by the quantity of product it contains. The storage volume per unit should be available from the standard item catalogue or database used by the humanitarian organization.

The required storage volume per unit of each item is multiplied with the maximum stock level to determine the required storage volume of each item. The volumes calculated for each of the items on the stock list are then added up to calculate the total required storage volume.

The result of these calculations is the minimum space that would be required if all stock could be mixed and neatly stacked in a cube. However, since every item as well as every batch of every item has to be stored separately, the actually required storage volume will be higher.

If small containers are used for all small packaging, the minimum volume for any batch will be at least the volume of one small container. Moreover if the entire batch of a item does not fit in one small container, the volume of an entire second small container will be required, even if the later holds only a single unit of the respective product. The same principle applies to the separate storage of bulky items such as infusions or dressing material on floor pallets.

Therefore the total required storage volume will increase, possibly significantly, with the total number of batches held in stock.

Finally the required storage volume will also depend on the storage place allocation system. In a fixed storage place allocation system an empty space is kept reserved for batches of the same item which may arrive in future rather than using the space for other items. Therefore a certain percentage, for example 20%, of all available storage space will remain unused at any time.

- Volume of product itself.
- Occupied volume (shape and geometry).
- Safety stock levels.
- Cycle stock levels.
- Number of different batches per item.
- Number of different items stored.
- Storage place allocation system.

Table 17.5 Factors determining overall stock volume

Generally speaking it is better to have too much than too little storage space and capacity as it is impossible to keep an (over)crowded store clean and orderly. It is also inefficient to repeatedly have to relocate stock within a store because of lack of storage capacity or even have to move the medical store to another storage facility.

The possibility of a future increase in required storage capacity because of increasing demand from assisted health care facilities or because of an increase in the number of assisted health care facilities must also be considered.

The calculation or estimation of number of small containers allows calculating the number of required shelves and the estimation of required storage volume on floor pallets allows calculating the number of required pallets.

In addition storage capacities for contingency stocks must be considered. As these should consist only of sets and kits and be stocked according to an imprest system, calculation of required storage volumes and capacities is straight forward.

17.2 Storage systems

The selection of appropriate storage systems, unit load systems and storage equipment, is essential for maximizing space utilization of the store, keeping the stock in good order,

facilitating stock rotation and using materials handling equipment as efficient and economical as possible. In order to ensure efficient stock management and eliminate the need for repeated "reorganizations", medical storage facilities in general and storage equipment in particular must be set up in a systematic way from the very beginning.

In order to avoid the need for future "reorganizations", storage systemsshould be carefully chosen when medical storage facilities are set up.

The selected storage systems should be appropriate for the type of stored health care goods and allow future expansion.

Unit load systems and storage equipment are sometimes considered as a luxury and an unproductive expense. However storage systems are indispensable for efficient warehouse management and should be considered as a long-term investment. They should be seen as an asset which can be used for many years and transferred to another medical storage facility if a site is closed down. Purchasing expensive storage equipment such as adjustable pallet racking may reduce the overall storage cost as space can be better utilized and the size of required medical storage facilities can be reduced.

The storage system should be simple and yet allow efficient management. Medical storage facilities are often established for temporary use although they usually end up to be in use for many years or even decades. However the poor security situation with the danger of damage by effects of war as well as theft preclude setting up expensive and sophisticated storage systems.

17.2.1 Types of storage facilities

The selection of unit load systems, storage equipment and materials handling equipment are interdependent (see figure 17.2). The choice of unit load systems affects and limits the options for suitable storage equipment and vice versa. For example small containers have to fit on shelving and adjustable pallet racking has to be suited to the selected pallets.

Likewise the unit load system affects and determines possible choices of materials handling equipment. For example the use of pallets requires suitable pallet trucks.

Finally the selection of materials handling equipment and storage equipment are also interdependent. For example aisles between storage equipment have to be wide enough for manoeuvring materials handling equipment and pallet trucks have to be able to reach all stages of adjustable pallet racking.

In the context of humanitarian assistance in less developed countries the level of sophistication of storage and materials handling equipment will be limited and three types of medical storage facilities can be distinguished (see table 17.6).

- Facilities using manual materials handling.
- Facilities using non-powered (mechanized), manually operated materials handling equipment.
- Facilities using powered materials handling equipment.

Table 17.6 Types of storage facilities

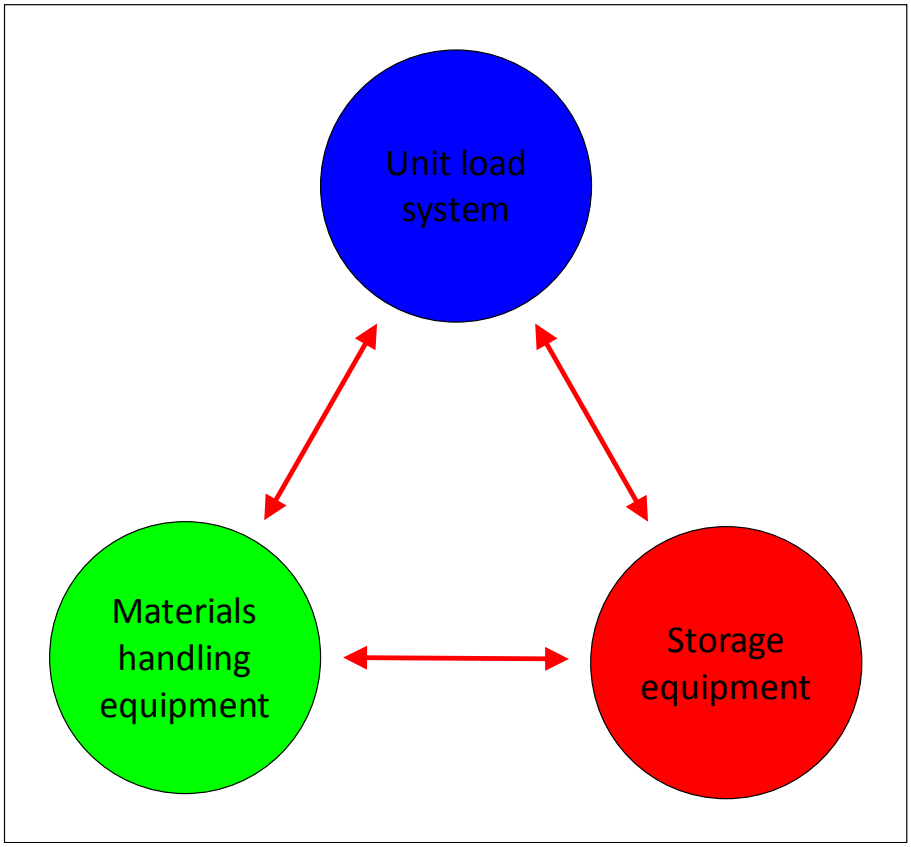

Figure 17.2 Interdependence of unit load systems and equipment

The distinction is based on the type and sophistication of used materials handling equipment which in turn limits and determines suitable storage equipment.

The choice of the type of medical storage facility will depend on the type of stored health care goods, their volumes as well as the (expected) average and maximum flows.

The simplest type of medical storage facility relies solely on manual handling rather than on any materials handling equipment.

Such medical storage facilities are suitable for hospital pharmacies or very small medical stores with small quantities of a small amount of health care goods with fairly small flows.

Simple shelving and cupboards are sufficient as storage equipment and all health care goods are carried and placed on or removed from shelving manually.

This type of medical storage facility can be set up very quickly as well as at low cost and incurs little maintenance costs. However it is suitable only for storage of very limited quantities and is not suitable for large flows of health care goods.

The efficiency of materials handling in larger medical storage facilities of medium stock volume and a medium flow of health care goods can be greatly improved by using non-powered, manually operated materials handling equipment.

In additional to handling goods on shelves manually, floor pallets are set up which can easily be moved with hydraulic hand pallet trucks. This allows a single person to move up to two tonnes of goods with great ease and to quickly rearrange stocks. The use of floor pallets allows a maximum of flexibility as no storage equipment is installed permanently. Instead floor pallets can be moved and rearranged as needed and as appropriate.

Shelves and floor pallets are cheap and can be set up very quickly. Hand pallet trucks are cheap, readily available, easy to maintain and can be used for loads of up to 2 tonnes.

The only possible disadvantage is that only floor pallets rather than adjustable pallet racking can be used, the warehouse surface has to be sufficiently large and available shelving height above 2 metres is not utilized.

Generally, this type of medical storage facility is the best choice for the field. Despite the simplicity of the materials handling as well as storage equipment, goods can be stored and handled appropriately and efficiently.

Facilities using non-powered materials handling equipment, are appropriate for medium volumes and flows. However if enough space is available, large stocks can also be managed very efficiently only with mechanized materials handling equipment although travelling distances will increase and require more staff. However operating a large warehouse with more staff is likely to be more economical than setting up expensive adjustable pallet racking and purchasing counterbalanced forklift trucks or reach trucks.

The operation of large medical distribution centres may justify the use of powered materials handling equipment, especially the use of counterbalanced forklift trucks. However the significant investment as well as maintenance costs must be justified by large stock volumes as well as high flows. The regular supply of fuel as well as the dependency on powered materials handling equipment must also be considered.

	Manual materials handling	**Mechanized materials handling equipment**	**Powered materials handling equipment**
Stock volume	small	medium	large
Flow	small	medium	large
Storage equipment	shelves, cupboards	shelves, cupboards, floor pallets	shelves, cupboard, floor pallets, (adjustable pallet racking)
Materials handling equipment	none	mechanized (hydraulic, manually operated)	powered (electric, gas, diesel)
Advantages	- low cost for setting up - quick to set up - low maintenance cost	- low cost for equipment - quick to set up - low maintenance costs	- high storage capacity
Disadvantages	- low storage capacity - manual handling only	- limited storage capacity	- high equipment costs - high operating costs - long time for setting up - requires fuel - dependency

Table 17.7 Characteristics of different types of medical storage facilities

The ability of counterbalanced forklift trucks to lift loads vertically allows the use of adjustable pallet racking. However higher warehouses are usually more expensive, this type of storage equipment is expensive and requires wide aisles. Therefore, compared to the use of floor pallets, the overall storage capacity may only increase if at least several stages of adjustable pallet racking are set up. If only floor pallets are used, the counterbalanced forklift truck is still useful for reducing the time for transferring pallets with goods as well as for very significantly reducing the time for unloading and loading vehicles.

In commercial warehouses a large variety of storage systems such as small parts live storage, horizontal and vertical carousels, cabinet and drawer systems, live storage of bins, palletized live storage or pallets, drive-in pallet racking and automated pallet storage are used. However they require considerable investment, and require careful planning. The required storage systems are unlikely to be readily available in less developed countries and are not economical for humanitarian assistance.

17.2.2 Standardization of storage systems and equipment

A pragmatic approach to storage equipment is to simply select a storage facility and use whatever storage equipment may be available. Often a variety of different sizes of pallets, shelves and cupboards can be found. Using this equipment may initially save time and money but does not allow efficient stores management in the long run.

A single size of shelves and pallets respectively as well as small containers should be selected and used for the entire storage facility. Selecting one size of pallet and one size of shelf allows setting up the storage facility in a systematic way, facilitates expansion and allows eventually using the storage equipment at another site. The requirements for storage equipment can be easily calculated and stores can be set up in a systematic and standardized way.

Standardization of unit loads as well as all storage equipment allows optimizing utilization of storage equipment. In order to maximize space utilization, ideally the dimension of unit load systems should exactly fit the storage systems.

Standardization facilitates purchasing storage equipment and allows using the same unit loads throughout the entire supply network without the need for repacking. For example if the same pallets are used along the entire supply network, the need for re-palletizing because arriving pallets are too small or too big for the storage equipment is eliminated. Using standard shelving allows storing standard unit loads at any store without the need for repacking.

When large quantities of health care goods are purchased the required specifications of the unit loads should be included in purchase contracts, for example the size of pallets. This will allow using the unit loads delivered by suppliers without any need for repacking.

17.3 Unit load systems

A unit load can be defined as ". . . an assembly of individual items or packages usually of a like kind, to enable convenient composite movement, whether mechanical or manual movement" (Rushton, A., J. Oxley, and Ph. Croucher 2000, 238).

Load unitization allows consolidating a large number of small packaging into larger units which can be handled, stored and transported easier. For example loose syringes or bandages could not be stacked and would be cumbersome to handle. They are therefore usually packed in cardboard boxes which can easily be handled and stacked.

Health care goods can be placed on storage equipment openly (for example cans of tablets), in tertiary manufacturer packaging (transport packaging) or in unit loads.

In principle small containers, various types of pallets and containers can be distinguished (table 17.8).

- Shrink-wrapped cardboard trays.
- Corrugated cardboard boxes.
- Tote bins, open front stock boxes, trays.
- Crates (plastic, metal, wood).
- Cassettes.
- Cages.
- Bags (plastic, jute etc.).
- Bales.
- Drums.
- Pallets.
- Cage pallets.
- Roll-cage pallets.
- ISO shipping containers.

Table 17.8 Commonly used unit loads

Goods either arrive from the supplier in the appropriate unit loads or are repacked once they are received at the storage facility. Then the goods can be handled and moved in this unit load from the time of entering the storage facility until they are dispatch or even throughout the supply network without the need for repacking.

Unit loads have several advantages (see table 17.9).

- Protection of goods and reducing the probability of damage.
- Facilitating handling of larger quantities of goods (by moving boxes and pallets rather than items).
- Reducing time for loading and unloading.
- Stacking of unit loads allows maximizing the available storage capacity.
- Allows standardizing of materials handling equipment.

Table 17.9 Advantages of unit loads

Using a standard unit load facilitates FEFO management and reduces the need for manual handling. Rather than moving larger numbers of small packages all packages of one batch can be held as a unit load and moved together.

Using the same unit load throughout the entire supply network greatly reduces the need for packing and repacking and allows to maximize utilization of storage space on pallets and shelves.

Standardization of unit loads allows ensuring their commensurability. If, for example, cardboard boxes placed on a pallet do not cover the entire surface, transportation capacity is wasted. On the other hand, if they overhang the edges of the pallet, the (wider) pallets will not fit into their pallet positions and the boxes may be damaged.

Standardization of unit load systems also allows standardizing storage equipment as well as maximizing space utilization by ensuring commensurability. Moreover, unit load systems can be exchanged between sites ("recycled").

Standardization of unit load systems allows standardizing materials handling equipment and also facilitates planning of new as well as extension of existing storage facilities.

17.3.1 Small containers

Small containers are used for very small items or small quantities of items and can be made from polypropylene, corrugated cardboard, wire mesh or timber. Small containers can be designed for stacking or nesting and can have facilities for internal sub-division. They may have provisions for label holders and can be coloured to facilitate identification.

Polypropylene cannot rust and has the advantages of being light, robust and easy to clean. However small containers made of polypropylene are more expensive than containers made from cardboard. Cardboard containers are cheap and very light but are not as robust. Small containers made from timber are quite heavy and expensive while wire mesh is light and transparent but can rust.

Advantages

- Protection of goods-
- Improvement of space utilization.
- Facilitation of handling.
- Facilitation of FEFO and FIFO management.

Disadvantages

- Cost.

Table 17.10 Advantages and disadvantages of small containers

A special form of small containers is the open front stock box which can be made from metal, polypropylene or cardboard. It has the advantage that the contents is visible without having to open the container and goods can be picked without having to remove the container from the shelf and opening it.

Stock boxes are robust, can be stacked, are easy to clean and can be fitted with a lid and sealed if necessary. Dividers allow storing several batches of a item or different sizes of a item in one container, thereby maximizing utilization of storage space. Empty stock boxes can be nested to reduce their volume for transport.

Small containers allow holding and handling small items with odd shapes such as surgical instruments or spherical objects such as bulbs. These containers hold the packages together and allow better utilization of available storage equipment. In order to improve space utilization, several different batches of the same item can be held in a single container with separators. Placing small items in containers prevents them from falling behind shelves, prevents accidental mixing of different batches and facilitates materials handling.

Especially when batches of goods need to be moved from one place to another for ensuring storage by FIFO or FEFO, the complete container rather than individual items or packages can be moved. A further advantage is that a small container can be taken off a shelf for picking items rather than having to search for items on a shelf.

Figure 17.3 Open front stock box

If health care goods are placed in standard sized containers on arrival at the warehouse, these containers can be used for storage as well as for onward shipment without the need for repacking.

Standard cartons (for example corrugated cardboard boxes of 600 x 400 x 350 mm) can be economically stacked on pallets and be used as master cartons for shipment of goods. The same cartons used for shipment can be used for storage of goods on shelves or pallets.

Cartons are cheap, stable, stackable, protect goods from dust and light and can be sealed with plastic straps before shipment for added security. Empty cartons can be folded for transport which greatly reduces their volume.

17.3.2 Pallets

According to the British Standards Institution a pallet is a "A load board with two decks separated by stringers, blocks or feet or a single deck supported by stringers, blocks or feet constructed with a view to transport and stacking, and with the overall height reduced to a minimum compatible with handling by forklift trucks and pallet trucks" (Jessop, D., and A. Morrison 1994, 260).

Pallets are used for large and heavy items (more than 30 kg per parcel), large quantities of small items or bulky items and can hold up to two metric tonnes.

Pallets are fairly inexpensive, can keep a large amount of goods together, allow handling of large volumes, can be handled efficiently with inexpensive mechanical materials handling equipment and are widely available.

Pallets keep goods off the floor, insulate goods from hot or cold floors, protect the goods from moisture and water, allow air circulation around the goods and provide ventilation.

Pallets allow easy horizontal as well as vertical movement of heavy and bulky loads inside storage facilities with simple materials handling equipment and a minimum of effort and time.

They also allow loading and unloading large quantities of goods from trucks, aircraft and trains as well as transhipment throughout the supply network.

The use of materials handling equipment greatly reduces the risk of occupational injury to warehouse staff caused by lifting and carrying heavy loads.

Timber pallets can be made from locally available materials and are easy to repair. Pallets beyond repair can easily be disposed of or used for heating.

Pallets can be stored on the floor and do not require any additional storage equipment. Pallets are extremely flexible and can be used in almost any size and shape of storage facility. Unlike shelves they do not require installation and the layout of the store can therefore be easily changed at any time.

Pallets keep goods together, allow keeping the store in good order and maintaining a good overview of stocks. Physical stock counts can be facilitated by storing a defined quantity of an item, for example infusions, on each pallet. Pallets can easily be moved to ensure storage according to FEFO or FIFO or in a semi-fluid or fluid storage place allocation system.

Pallets can be used for storage as well as transportation of goods. Goods which are delivered on pallets do not require repacking before put-away and can be picked and shipped without repacking as well. Some pallet sizes are used as an international standard. Packing goods on pallets facilitates estimation of the required transportation capacity.

Advantages	Disadvantages / Risks
• Inexpensive. • Readily available and easy to manufacture. • Sturdy and robust, cannot be overloaded. • Allow keeping large quantities of goods together. • Allow handling of large volumes and bulky items. • Allow handling of heavy goods. • Allow use of inexpensive materials handling equipment. • Allow horizontal as well as vertical movement. • Reduce risk of occupational injury from lifting goods. • Very flexible. • Do not require additional storage equipment. • Allow keeping a good overview of stock. • Facilitate keeping stores in good order. • Internationally standardized. • Allow loading and unloading of large quantities.	• Cost. • Weight. • Reduction of storage capacity. • Materials handling equipment is mandatory. • Require horizontal and even floors. • May not fit through doors. • Timber pallets can cause injuries from splinters and protruding nails. • Not efficient for storing small goods or small quantities of goods. • Loads stored on pallets may exceed the maximum permissible floor load.

Table 17.11 Advantages and disadvantages of pallets

Pallets are not efficient for storing small items or small quantities of goods and must therefore be combined with another type of storage equipment such as shelves. Another disadvantage is that materials handling equipment is mandatory. Especially when stores are set up on short notice, hand pallet trucks may not (yet) be available. Floors must be level and even (smooth) and there must be no obstacles such as thresholds or steps. In improvised stores the width of doors may not allow pallets to pass. Fully loaded pallets may exceeds the maximum permissible floor load, especially when they are not stored at the ground level.

Especially timber pallets can cause injury from splinters and protruding nails and therefore require regular maintenance.

Pallets can be made from timber (wood), aluminium, steel, fibre or plastic and usually have a height of around 10 - 20 centimetres. The main trade-off between the different materials are weight, cost, robustness and durability.

Figure 17.4 Wooden pallet

The most commonly used size is the timber whole pallet which measures 800 x 1,200 x 144 mm and is also called the 'EURO pallet' (also called CEN pallet) because it is the standard in most European countries (figure 17.5).

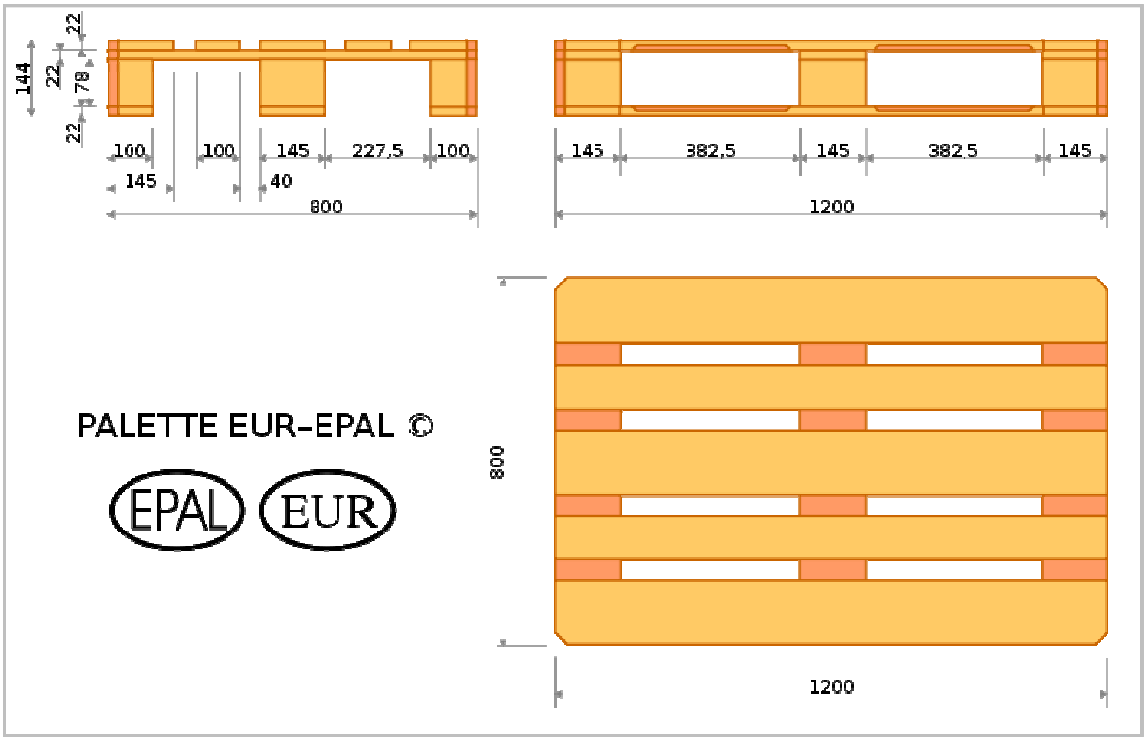

Figure 17.5 Dimensions of a EURO pallet (Timberwolf, W. 2011)

The upper deck is made from 3 timber boards of 145 mm width and 2 timber boards of 100 mm width, all of them 22 mm thick with gaps of around 40 mm between boards. The height from the bottom of the lower deck to the under side of the upper deck for access by pallet trucks is 102 mm.

Half-size pallets (80 x 60 cm) are not as common but used for very heavy goods such as vehicle spare parts. The stringers are often set back slightly to facilitate strapping. Square 120 x 120 cm pallets are also used.

Pallets can be furnished with single or double decks. Double deck pallets are more stable against bending when heavy loads are lifted and they are reversible (both sides can be used). However a major disadvantage is that pallet trucks cannot be used for handling because the lower deck blocks the front rollers. They can nevertheless be handled by forklift trucks.

Single deck pallets are less sturdy but allow handling with pallet trucks.

Open boarded pallet decks have gaps between the deck boards, are lighter and facilitate ventilation but can be dangerous when stepping or walking on them with heavy loads. Closed boarded pallet decks have no gaps between the deck boards and are heavier but provide a smoother surface for storage.

Two-way entry pallets are cheaper and more sturdy but limit the handling to only two sides. Four-way pallets can be handled from any side and are more flexible for storage and loading. Especially single deck four-way pallets are less robust than two-way entry pallets.

Figure 17.6 Box pallet and post pallet

When manufacturing pallets locally it is important to ensure that the supports are high enough for forks of mechanical and mechanized handling equipment to fit underneath the decks.

Various accessories have been developed in order to protect the load, permit stacking and facilitate more efficient storage.

Pallet collars can be made from timber or plastic, are 20 or 40 cm high, can be collapsible or non-collapsible, are fitted around the outer edge of the pallet and are removable. This allows storing goods with irregular and odd shapes (for examples shoes or crutches) which cannot be stacked onto pallets. Pallet collars also protect goods during transportation and allow stacking

pallets on top of each other which cannot be block stacked because the goods would otherwise be crushed. Several rows of pallet collars may be placed on top of each other for increasing the overall height. Pallet collars can also be fitted with lids which allow completely enclosing and protecting goods.

Figure 17.7 Pallet collars

A number of special types of pallets are available. The box pallet consists of a conventional pallet at its base and a timber or metal frame as superstructure which resembles a box which is open at the top. It may be possible to open or remove one or more sides to gain better access to the goods, especially when several box pallets are stacked upon each other. The superstructure may be collapsible to reduce the volume of empty box pallets during return transportation. Box pallets may have 'bell' feet which allow stacking box pallets only on the vertical supports without the need for the lower box pallet to have a flat surface.

The cage pallet is very similar to the box pallet but the superstructure is made from wire mesh. This material offers less protection but is lighter and allows seeing inside the cage pallet without having to open it.

Another special form of pallet is the roll cage pallet which is similar to a cage pallet with castors and allows handling of loads of up to about 200 kilograms. They consist of about a half pallet size base with castors and a high wire mesh cage. The cage might have horizontal supports and can be opened in the front for inserting and removing goods.

Roll cage pallets are mainly used for transportation and distribution, especially to retailers, rather than for storage as such. They are particularly convenient for order picking and transportation of goods with varying sizes and with odd shapes.

They are expensive but greatly facilitate loading and unloading of vehicles as well as movement within the store to which goods are delivered. Unlike conventional pallets they do not require any materials handling equipment for movement and allow horizontal transportation of considerable loads by a single person. However they can also be handled

vertically with forklift trucks for loading or unloading. When empty, the wire mesh sides can be folded which allows nesting several roll cage pallets and reducing their volume for return transportation.

17.3.3 Transport crates

Metal or timber cages and crates are used for transporting and storing large and expensive goods such as health care equipment, for example operating lamps, refrigerators or x-ray machines. Cages and crates enclose goods and protect them from damage as well as pilferage during transportation.

Large crates can also be used for transporting and storing medical kits and modules of field hospitals.

Cages and creates are sturdy and robust and can hold considerable loads. They can be stacked on top of each other without the need for additional storage equipment such as shelves or racks. Unlike box and cage pallets, cages and crates can have any size to fit their contents.

Cages and crates can be placed on pallets to facilitate their handling.

Figure 17.8 Wooden transport crates

17.3.4 Unit load flows

Ideally secondary or tertiary manufacturer packaging or complete pallets would flow through the supply network from the manufacturer to the end-user without the need for any opening

and re-packing. Handling of larger unit loads is more economical, reduces damage and greatly facilities order picking and especially physical stock counts.

However, in practice these quantities will be larger than required and packaging will have to be split at one or several stages of supply network.

Nevertheless, the type of packaging should correspond to the flows of goods and the opening and splitting of cases should be avoided as much as possible according to a system such as presented in figure 17.8.

In some cases movement of full ISO shipping containers of the same product, for example infusions, syringes or dressing material, directly from manufacturers to international or regional distribution centres is possible.

Wherever possible, international and regional distribution centres should ship stretch wrapped full pallets (of the same item) to national distribution centres. Items for which the quantities of full pallets are too large, tertiary manufacturing packaging should be shipped. As national distribution centres keep considerable (safety) stocks, they should be able to round up quantities for replenishing their stocks in most cases.

As assisted health care facilities require relatively small quantities and providing them with larger than requested quantities has a number of disadvantages, national distribution centres will rarely be able to ship entire pallets (of the same item). Rather, they will ship tertiary packaging (supplier transport packaging containing a single item) wherever possible as well as secondary packaging.

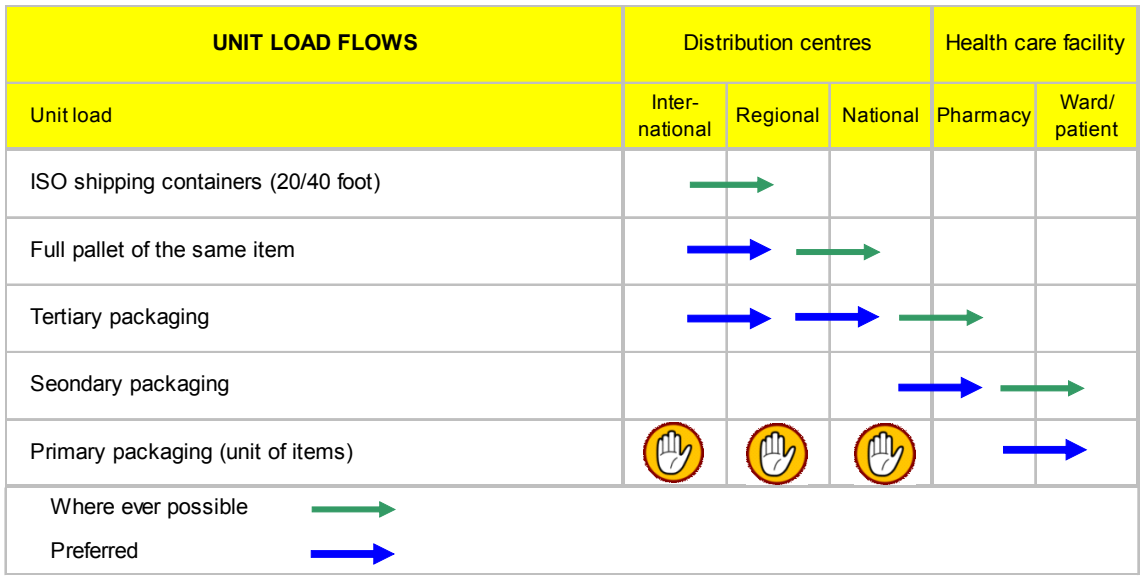

Figure 17.9 Unit load flows

17.4 Storage equipment

From the large number of available storage systems the most practical and simple systems which can be used in the field are adjustable steel shelving and metal cupboards as well as floor pallets and adjustable pallet racking (table 17.12). In addition refrigerators are needed for storage of cold chain goods. Block stacking of pallets may be permissible in exceptional case where the nature and packaging of health care goods will prevent damage.

- Adjustable steel shelving.
- Cupboards.
- Refrigerators.
- Floor pallets.
- Adjustable pallet racking.

Table 17.12 Storage systems

Other storage systems which are used in large commercial warehouses are drive in racks, drive through racks, live storage of pallets, live storage of containers, mobile shelving and cantilever racking for storage of long loose goods.

In any case, health care goods must never ever be stored directly on the floor, regardless of the packaging. Storage of health care goods on the floor leads to dirtying and possibly soiling and health care goods can be severely damaged by water entering the storage facility during rain fall or from ruptured water pipes. Moreover health care goods stored on the floor rather than in or on unit loads cannot be moved with manual, mechanized or powered materials handling equipment but have to be moved by hand instead.

Never ever store any health care goods directly on the floor!

17.4.1 Adjustable steel shelving and cupboards

Adjustable steel shelving and cupboards are appropriate for storing small and medium-sized items or small quantities of health care goods and allow efficient storage and order picking. All goods on shelves are easily accessible and can handled without the use of any materials handling equipment.

Shelving is not economical for storage of large quantities and moving batches to maintain them in order of their expiry dates when new batches are put away or picked can be cumbersome. If larger quantities are stored on shelves, they must nevertheless be handled manually as mechanized or powered materials handling equipment cannot be used.

The size of individual items that fit on shelves is limited, the maximum weight is limited by the maximum load a shelf panel can carry and shelves can break if they are overloaded. The maximum weight of items is also limited by the maximum load storekeepers can handle manually.

Compared to the storage capacity, shelving is more expensive than pallets. Unlike pallets, good quality shelving is not as widely available and even good quality material for local manufacture may not be available.

Shelves require level and even floors for setting up to ensure they do not tilt.

Compared to floor pallets, shelving requires more time for moving and changing the layout and significant space is needed for aisles in front of each shelf.

In high rooms the overall space utilization is poor as the height of shelves is limited to 200 centimetres. Put-away and order picking from low and high shelves can be cumbersome.

Timber shelves, which are not recommended, may rot or be damaged by insects (termites) while metal shelves may rust.

Advantages

- Allows storage of small items and small quantities.
- Allows keeping stock in good order.
- Easy access to any item.
- No materials handling equipment required.

Disadvantages

- Uneconomical for storage of large quantities.
- Moving large quantities, which may be needed for FEFO management, is cumbersome.
- Items must be handled manually, even if they are heavy or their quantities are large.
- The size of items which can be stored is limited.
- The maximum load is limited by the strength of shelves which can break if overloaded.
- The weight of items which can be stored is limited because they can only be handled manually.
- Expensive (compared to floor pallets).
- May not be available domestically.
- Material for local manufacturing may not be available domestically.
- Require level and even floors for setting up.
- Less flexible for changing the layout than floor pallets.
- Requires aisle in front of each shelf.
- In high rooms space utilization is poor (because the useful height of shelves is limited.
- Put-away and order picking from low and high shelves is cumbersome.
- Timber shelves may rot.
- Metal shelves may rust.

Table 17.13 Advantages and disadvantages of shelves

Some health care goods such as internationally controlled drug products or hazardous goods have to be stored in closed and lockable cupboards rather than on open shelves. Cupboards which should be kept permanently locked can be fitted with a red light which automatically switches on when the door is opened. Cupboards also provide good protection from dust and light.

Shelves can be made from timber, plywood, metal or a combination of these materials.

Timber is often available locally and easy to process but can also be expensive. Timber shelves are heavy and timber may be damaged by humidity and insects such as termites. Timber is difficult to clean and keep clean and splinters can cause injuries and damage health care goods. Therefore the use of timber shelves should be avoided.

Shelves made from metal (angle iron) can be very heavy but are sturdy and durable. Unlike timber, metal cannot be damaged by insects and does not rot although it can rust if shelves are not protected by a coat of paint. Rusting can also be prevented by using galvanized steel.

Angle iron is widely available and can be assembled by welding or with screws. Welding makes shelves far more sturdy but requires welding equipment and either electricity or welding gases which may not be available locally. Metal shelves have the disadvantage that they suddenly buckle when they are overloaded rather than indicating their overload by bending like timber shelves.

Aluminium shelving is very light but cannot be made locally. Rather shelving kits will have to purchased and transported to the store.

Wherever possible, commercially available adjustable steel shelving should be purchased. The quality is far better than locally manufactured shelving and local production is often not cheaper than purchasing. Moreover purchased steel shelving is adjustable while locally manufactured shelving is usually welded and cannot be adjusted or changed.

Each shelving bay consists of vertical uprights (posts) or end frames with feet and horizontal shelf panels. The vertical height between shelving panels should be adjustable either by attaching them to the uprights or end frames with bolts or by slotting them into slots. Shelves may be fitted with retaining stops on the front or back edges to prevent goods or containers from being pushed off the shelves.

The stability of the vertical posts can be greatly increased by attaching horizontal or diagonal braces on all surfaces except the front. Side braces and posts can be replaced by side and back panels which also increase stability. Diagonal back braces should be attached to shelving bays according to the manufacturer's recommendation but a back brace must at least be attached to one shelving bay in each row of shelves to prevent shelves from tilting sideways.

Shelves should carry a sign stating the maximum load per shelf as well as per bay. However this sign indicates the maximum load which can be spread across the entire shelf. If a single item with the maximum load is placed in the middle, the shelf will probably nevertheless be damaged.

A stand-alone shelving bay with four posts or two end frames can be extended by adding shelf panels and posts or end frames on either side. Connecting shelving bays together increases their stability. Shelving bays can also be placed back to back and connected to each other for increasing stability.

Shelves may be separated by vertical dividers and shelves may allow attaching doors to convert them into cupboards.

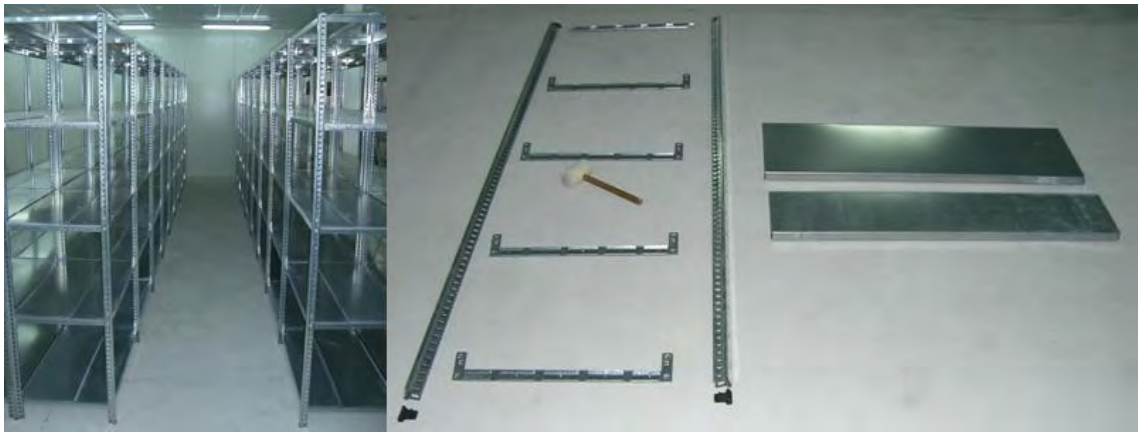

Figure 17.10 Adjustable steel shelving

Truck guards protect shelving from damage by materials handling equipment.

Shelves should fulfil a range of requirements. Shelves should be easy to transport, easy to set up, easy to dismantle, light, adjustable and flexible, strong and stable, durable, rust proof, resistant to insects (termites) as well as inexpensive.

Short span shelving should be preferred over long span shelving as the former is more flexible. Individual shelving units whether purchased or made locally should have a width of no more than 100 cm in order to maximize the flexibility of setting them up and later changing the layout of the store if necessary. Moreover the maximum weight capacity of each shelf panel

decreases with increasing distance between uprights or end frames. Open-type shelving should be preferred simply because of the lower cost.

The ideal measurements for a standard adjustable steel shelving unit is 100 cm wide, 50 cm deep and 200 cm height, where the upper most shelf is not used for storage. The lowest shelf should be placed a least 10 cm off the floor to protect health care goods in case the storage facility is flooded and to allow cleaning floors underneath shelves.

The width and height of shelves should match the unit loads (containers, tot bins, stock boxes etc.) which are used in the store in order to maximize space utilization. All shelving panels should be mounted with equal vertical spaces in order to allow moving any goods or containers between any of the shelves.

Assuming a constant width of the aisles (of 1 metre) and a fixed height, the percentage of area used for storage increases with the depth of the shelf (see figure 17.10). Therefore it is more economical to use deep than shallow shelves. However, as the depth of shelves increases, especially items on the upper and lower shelves are more difficult to access. Moreover, as the depth of the shelf increases, the relative increase of storage capacity which can be gained by increasing its depth, decreases. A good compromise between accessibility and storage capacity is a depth of about 50 centimetres.

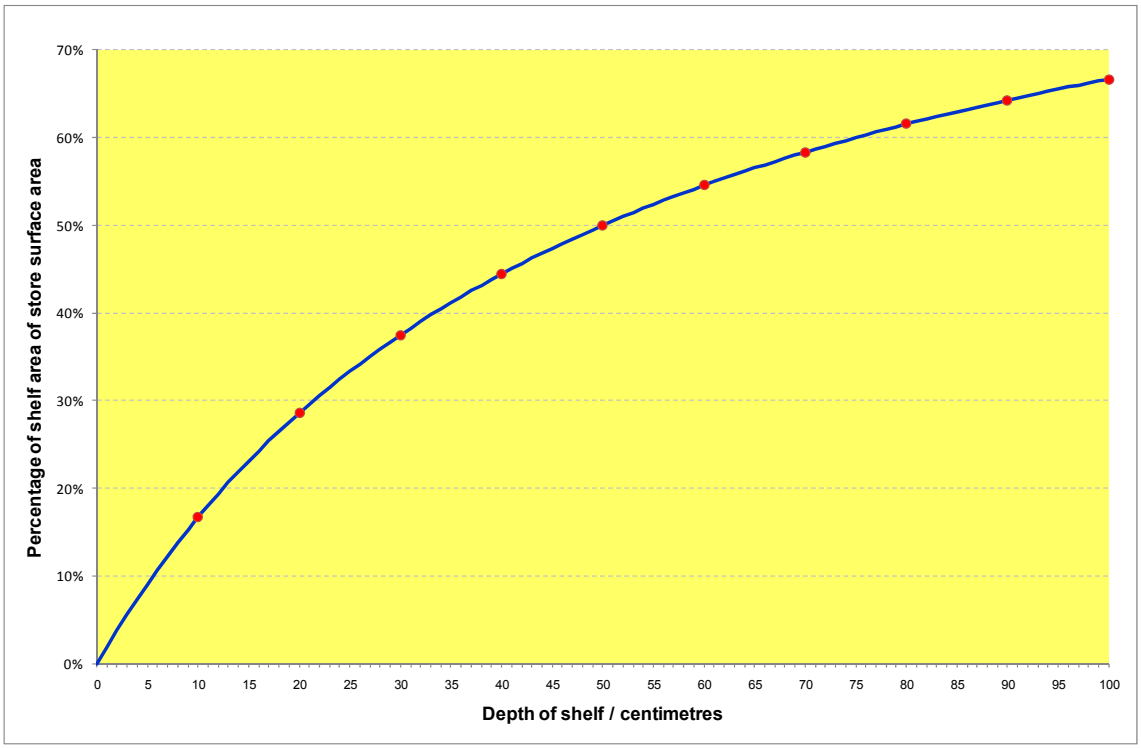

Figure 17.11 Relation between depth of shelves and percentage of storage area

Each shelf panel should support around 80 kilograms of load spread evenly across the shelf panel.

Only one size of shelf should be used throughout the storage facility and if possible standardized throughout the organization. Standardization greatly facilitates planning of the stores layout, setting up of the storage equipment and allows transferring storage equipment from one storage facility to another.

- Easy to transport.
- Easy to set up.
- Easy to move.
- Easy to dismantle.
- Light weight.
- Adjustable.
- Flexible.
- Strong and stable.
- Durable.
- Rust proof.
- Resistant to insects (termites).
- Inexpensive.
- Support loads of approximately 80 kg per shelf panel.
- Short span (100 cm width).
- Depth of (approximately) 50 cm.
- Maximum height of 200 cm.

Table 17.14 Requirements for shelving

Ready to assemble shelving kits are ideal for setting up medical storage facilities and a standard piece of equipment should be included in the standard item catalogue. Adjustable steel shelving kits are comparatively expensive but should be considered as an asset which can be moved to another programme and used for many years. Shelving kits are flexible, can be adapted to any size of store and can be used in large medical warehouses as well as in hospital pharmacies.

Ready to assemble shelving kits can be assembled quickly and allow setting up a medical storage facility within hours while it may take days for manufacturing shelving locally.

Shelves are only economical until a height of 200 cm. Higher shelves require the use of steps or ladders which are time consuming and cumbersome to frequently move and to use.

In stores with an internal height of more than 4.5 metres, a mezzanine can be installed. A mezzanine is a second level which is installed around 2 metres above the ground floor. On the upper floor shelves can be installed allowing to double the storage capacity of a given area.

Mezzanines are expensive, inflexible and not accessible for forklift trucks. All goods have to moved upstairs during put-away and downstairs during order picking by a crane or an elevator.

Therefore a mezzanine should only be considered if only high storerooms are available and the storage capacity on the ground floor is insufficient.

17.4.2 Floor pallets

Floor pallets are an inexpensive, simple and efficient means of storage. They are widely available in less developed country and are easy to manufacture locally.

Floor pallets are easy to set up and are very flexible in case their layout needs to be changed.

Floor pallets require no other storage equipment and in principle any size of pallet can be used without being constrained by adjustable pallet racking for example.

Stock arranged on floor pallets can be easily accessed and provides a good overview of stock.

Advantages

- Inexpensive.
- Simple.
- Widely available.
- Easy to manufacture locally.
- Can be set up very quickly.
- Very flexible.
- Require no other storage equipment.
- No restrictions on type and size of pallets.
- Easy access to stock.
- Provides a good overview of stock.

Disadvantages

- Requires even and level floors.
- Poor vertical space utilization.
- Requires aisle to access pallets (individually).

Table 17.15 Advantages and disadvantages of floor pallets

Floor pallets have the disadvantage that they require level and even floors in order to allow use of materials handling equipment. The space utilization in high stores will be poor as goods are only stacked up to a maximum height of about 2 metres.

The layout of floor pallets requires aisles of 2 metres width to ensure access of materials handling equipment to each floor pallet.

17.4.3 Block stacking

In block stacking several pallets are stacked next to, in front of and on top of each other with no aisles in between.

By stacking goods on pallets on top of each other the storage capacity of a store can be increased very significantly without the need for expensive storage equipment such as adjustable pallet racking. Compared to floor pallets, much less space is needed for aisles.

However, this method is strictly limited to goods with strong packaging which are not in danger of being crushed by placing another pallet on top. A further precondition is that the surface of the lower pallet must be level and even and all pallets must be of equal size. Floors must also be even and level to prevent stacks from toppling over and staff can be seriously injured if block stacks topple over.

This storage method should be used only for items without expiry dates and with relatively high turnover. As the pallet arriving first will be stored on the floor and later arriving pallets on top, strict FEFO or FIFO management is impossible unless the block stacks are restacked every time a pallet arrives or is removed.

The main disadvantage of block stacking is the need for counterbalanced forklift truck.

Block stacking provides a poor overview of stocks and is only practical if large quantities of one batch are stored. However block stacking may be used for different batches and even different health care goods for short-term storage of large consignments for transhipment.

Figure 17.12 Block stacking of pallets

Advantages

- Inexpensive.
- Simple.
- Can be set up very quickly.
- Very flexible.
- Requires no other storage equipment.
- Significantly increases space utilization.
- Does not require as many aisles as floor pallets.

Disadvantages

- Limited to goods which are not in danger of being damaged.
- Requires even and level surfaces of goods stored on pallets.
- Pallets must be of equal size.
- Requires even and level floors.
- Danger of injuring staff from falling goods.
- FEFO and FIFO management greatly impeded.
- Requires a counterbalanced forklift truck.
- Useful only for large quantities of goods.
- Poor overview of what goods are in stock.

Table 17.16 Advantages and disadvantages of block stacking

17.4.4 Adjustable pallet racking

Adjustable pallet racking (APR) is made from steel and consist of uprights (vertical beams) with feet which form the end frame, braces and at least two horizontal bearer beams at each

level which can be adjusted in height and upon which the pallets are placed. The pallet rack can have several tiers and the uprights should be anchored or bolted to the floor.

Each pallet rack bay is limited by two uprights, usually has a height of around 1.5 metres and holds two to three pallets next to each other. In order to increase stability, horizontal or diagonal side braces may be fixed to the adjustable pallet racking. The horizontal bearer beams must be fastened tightly to the uprights so they cannot be accidentally dislodged by counterbalanced forklift trucks during movement of pallets. The back of each adjustable pallet rack bay must be fitted with a device to prevent pallets from being pushed back too far and falling off the back (or through the bearers). If horizontal bearer beams are placed above gangways, additional protection is needed to prevent goods from falling through the rack and injuring people passing through below. Open ends of pallet racks should also be furnished with a protection to prevent goods from falling off.

Compared to simple floor pallets, adjustable pallet racking allows improving vertical space utilization of storerooms.

The bearer beams can be adjusted to the respective height of stored goods, large volumes of goods can be stored efficiently and each pallet is accessible individually for retrieval.

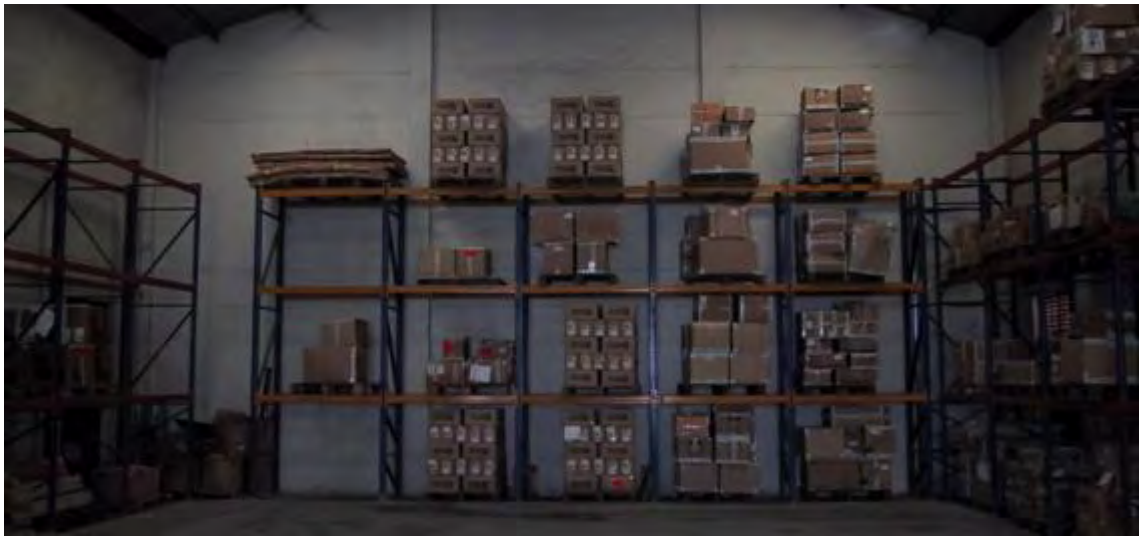

Figure 17.13 Adjustable pallet racking

One of the main disadvantages of adjustable pallet racking is its high cost. Floors must be level and even and support the weight of the storage equipment as well as the high loads placed on the adjustable pallet racking.

In order to ensure safety of the storage equipment, adjustable pallet racking must be planned and installed by professional technicians. Changing the layout and set-up requires significant resources and time.

Goods can be stored on adjustable pallet racking only if they are placed on standardized pallets or in sufficiently large boxes. While the height of the bays can be adjusted, the depth and width is fixed by the storage equipment.

The second main disadvantage of adjustable pallet racking is the need for expensive counterbalanced forklift trucks for put-away as well as retrieval. If the materials handling equipment fails, manual retrieval of goods is very cumbersome and dangerous. Moreover in order to be accessible by counterbalanced forklift trucks, much wider aisles are needed than for floor pallets.

Except for the pallets stored at ground level, the pallets are not readily accessible and identifiable. Because of the need for horizontal as well as vertical movement, pallets cannot be easily rearranged and keeping goods in systematic order and FEFO/FIFO management becomes difficult.

The possibility of large weights of goods on floor pallets falling off adjustable pallet racking poses a serious danger to staff working in the storage facility.

A range of accessories are available for adjustable pallet racking. Base plates distribute the weight evenly over a larger floor area. Truck guards are placed in front of the uprights and prevent damage from materials handling equipment.

Pallet stops or netting prevent pallets from being pushed through the rack and falling off the backside.

Inserts for half pallets allow storage of half pallets on adjustable pallet racking designed for whole pallets. Shelving sections can be used to span the bearer beams and provide a flat surface for storage of cartons and boxes of various sizes.

Advantages

- Improves space utilization.
- The heights of pallet rack bays can be adjusted to the height of goods.
- Large quantities can be stored efficiently.
- Each pallet rack bay is accessible individually.

Disadvantages

- Expensive.
- Requires high floor strength.
- Requires level and even floors.
- Requires installation by a professional technician.
- Inflexible, difficult to change the layout.
- All goods must be placed on pallets which may be difficult for bulky items.
- Requires use of standardized pallets.
- The width and depth of pallet rack bays cannot not be adjusted.
- Requires powered materials handling equipment.
- Requires wide aisles between pallet racks.
- Above the ground level, goods are not immediately accessible.
- Difficult to move pallets to ensure storage of goods by FEFO.
- Danger of injury from goods falling off pallet racks.

Table 17.17 Advantages and disadvantages of adjustable pallet racking

17.5 Cold storage

Some drug products, vaccines (and possibly diluents), diagnostic tests as well as samples for laboratory analysis and units of blood require refrigeration. Cold chain goods usually require storage at temperatures between + 2° to + 8° C. Vaccines are stored at various different temperatures according to the manufacturer's recommendation and some must or can be frozen. Ice-pack freezers are needed for freezing ice-packs which are loaded into cold boxes for transporting cold chain consignments.

It should be kept in mind that in very cold climates, cold chain items may require heating rather than cooling to maintain temperatures of between + 2° to + 8° C during storage as well as during transportation.

Cold storage	+ 2° to + 8° C
Freezer	- 25° to - 15° C

Table 17.18 Temperature ranges of cold chain equipment

Cold boxes and vaccine carriers are included in this chapter although they are used for transportation rather than storage of cold chain goods.

17.5.1 Cold chain equipment

The large variety of cold chain equipment can be divided into refrigerators and cold rooms, ice-pack freezers as well as cold boxes.

- Digital minimum/maximum thermometers.
- Cold boxes.
- Vaccine carriers.
- Ice-packs.
- Refrigerators (with baskets).
- Refrigerator rooms.
- Ice-pack freezers (with baskets).
- Voltage regulators.

Table 17.19 Types of cold chain equipment

Storage temperature
- Refrigerators (+ 2° to + 8° C).
- Ice-pack freezers (below 0° C).
- Refrigerator/freezer combinations.

Size
- Cold boxes.
- Refrigerators and ice-pack freezers.
- "Reach-in" cold rooms (small).
- "Step-in" cold rooms (large).

Type of loading
- Front-loading.
- Top-loading.

Refrigeration technology
- Compression.
- Absorption.

Power supply
- Electricity (mains).
- Solar power.
- Gas (compressed gas).
- Combination (kerosene/electricity, kerosene/ gas).

Insulation
- Conventional.
- Ice-lined.

Table 17.20 Specifications of cold chain equipment

Refrigerators and ice-pack freezers can hold small cold chain loads of up to 250 litres. The smallest "reach-in" cold room has a storage capacity of around 1,000 litres. Up to around 5 refrigerators are practical to maintain. If the cold chain load exceeds 1,000 litres, a cold room should be considered (WHO 1996b, 13). However installing a single cold room is risky since if

the cooling equipment fails or breaks down, the entire stock of cold chain goods is in danger of being damaged or spoiled. Conversely several smaller refrigerators are unlikely to break down simultaneously and therefore reduce the risk. The risk of spoilage due to power failure is the same for both strategies.

Refrigerators are made in varies sizes of up to 250 litres storage capacity and may be combined with a freezer compartment. Refrigerators without a freezing compartment maintain more steady temperatures. When warm goods are placed in the freezer compartment, the temperature in the refrigerating compartment can increase above the maximum limit.

In principle front-loading and top-loading refrigerators can be distinguished.

When front-loading refrigerators are opened, the cold air falls out.

Front-loading refrigerators and ice-pack freezers are opened like domestic refrigerators. They allow storing goods on horizontal shelves which provides a good overview and fairly good access.

	Advantages	Disadvantages
Front-loading refrigerators	• Better overview of stored goods. • Goods can be handled easier. • Less surface for installation. • Readily available. • Inexpensive.	• Cold air is lost every time the refrigerator is opened. • Cold air will leak out if seal is defective or the door is not closed tightly. • Doors tend to fall open if refrigerates are not level.
Top-loading refrigerators	• No loss of cold air during opening. • Lower power consumption. • More efficient. • Better insulated. • Ice-lined models are available. • Often cheaper. • No loss of cold air through defective seals.	• Requires a larger surface area. • Poorer overview of contents. • FEFO management is more difficult.

Table 17.21 Advantages and disadvantages of front- and top-loading refrigerators

The big disadvantage of front-loading refrigerators is that when they are opened, the cold air falls out and is replaced by warm ambient air. This warm air has to be cooled down after every opening of the refrigerator, a process which consumes energy. Especially when the refrigerator is frequently opened, the stored goods may be exposed to temperatures higher than the storage requirement. Because front-loading refrigerators are higher than top-loading refrigerators, the temperature gradient inside the refrigerator is larger. The top of the refrigerator may be too warm and the bottom to cold, freezing the stored goods. Goods tend to be packed against the back of the refrigerator and will freeze if they touch the evaporator.

Top-loading refrigerators and ice-pack freezer have a horizontal lid. When they are opened the cold air remains inside because cold air is heavier than the warm ambient air and they therefore require less energy. The main disadvantage is that it is more difficult to have an overview of its contents and to find items.

Overall top-loading refrigerators have more advantages and only top-loading refrigerators should be used for storage of health care goods requiring refrigeration.

Exclusively use top-loading refrigerators for health care goods requiring refrigeration.

Often domestic refrigerators are used for storage of health care goods. However domestic refrigerators are not suitable as they have very short holdover times. If the power supply fails, they will hold the temperature within the required range of + 2° to + 8° C for as little as 30 minutes only. If the power failure is not noted, for example during the night, or if no standby generator set or alternative power source is available, the cold chain items will quickly be spoiled.

Advantages

- Widely available.
- Inexpensive..
- Maintenance, service and repair readily available (if purchased domestically).
- Freezer compartment can be used for freezing ice-packs for cold boxes.

Disadvantages

- Not designed for cold chain loads.
- Poor insulation in general and of doors in particular.
- Short holdover time.
- Unsuitable egg and butter compartments in the door.
- Door fittings encourage storage of health care goods in the doors.
- Usually designed for food with respective accessories.
- No ice lining available.
- Interior temperature of the refrigerator may quickly increase during freezing of goods in the freezer compartment.
- Temperatures in the refrigeration compartment near the freezer compartment can drop below 0° C.
- Will not operate in high ambient temperatures (above + 43° C).

Table 17.22 Advantages and disadvantages of domestic refrigerators.

The thermal insulation between the freezing and refrigeration compartment is often poor. Consequently goods stored in the refrigeration compartment below the freezing compartment may freeze.

"It is strongly recommended that standard domestic refrigerators should not be used for bulk vaccine storage at national, regional or district Ievel. This is especially true in hot climates. *Domestic refrigerators are not suitable for vaccine storage* because they are not designed to maintain the temperature range required and they warm up quickly when the electricity fails" (WHO 1996b, 17).

The World Health Organization has developed kits for improving the performance of domestic refrigerators and adapt them to the requirements of vaccine storage (WHO 2000b, 60).

Never use domestic refrigerators for storage of health care goods requiring refrigeration.

The speed at which the internal temperatures of refrigerators increase after a power failure can be significantly decreased by using ice-lined refrigerators. Apart from the thermal

insulation, the surfaces of these refrigerators are lined with water filled tubes or packs. If the power fails the ice can absorb significant amounts of thermal energy before melting and therefore protects the load from warming. Ice-lined refrigerators must have a minimum holdover time of 20 hours and some models have holdover times of up to 49 hours at + 32° C ambient temperature, compared to a minimum requirement of only 4 hours (WHO 2007h, 5) for conventional vaccine refrigerators.

Ice-lined refrigerators are also the only choice if electric power is only available intermittently for example from solar panels or a generator set which does not run day and night. Internal temperatures can be safely maintained below + 8° C even if electricity is available for a minimum of 8 hours a day only (WHO 2004a, 74). During the remaining time the ice keeps the interior cool like a cold box.

If energy is available only intermittently, the compressor has to work extensively to cool the interior and freeze the ice lining. Consequently the temperature at the bottom of the refrigerator may drop below 0° C and freeze stored health care goods. The areas where goods may potentially freeze may be marked inside the ice-lined refrigerator. Direct contact of the cold load with the bottom as well as sides can and must be safely prevented by placing them in baskets which are hung inside the ice-lined refrigerator. Such baskets also allow free circulation of air around cold chain loads.

Ice-lined refrigerators can maintain temperatures below 8° Celsius

for up to 48 hours in case of a power failure.

If refrigerators are purchased for medical stores, ice-lined refrigerators are strongly recommended (WHO 2000b, 59).

Ice-lined refrigerators in principle must maintain temperatures between + 2° to + 8° C. However brief excursions are allowed as long as over a five day period a temperature of + 8° C is not exceeded for more than 12 cumulative hours, a temperature of + 20° C is never exceeded, the cumulative temperature below + 2° C does not exceed 12 hours and the temperature never reaches 0° C (WHO 2007c, 3). The thermostat must be set by the manufacturer to prevent freezing in any part of the refrigerator compartment at any time and at any loading or ambient temperature conditions. The thermostat must be designed in a way that it cannot be adjusted by the user but the possibility of adjustment by a technician is acceptable.

The control panel must be positioned at the front of the unit and the on/off switch must be recessed or otherwise protected from being switched off inadvertently. Ice-lined refrigerators must be fitted with an externally readable cabinet-mounted gas or vapour pressure dial thermometer or electronic maximum/minimum thermometer positioned at the front of the unit and as close to eye level as possible.

The lid of top-loading ice-lined refrigerators must be fitted with a lock as well as with non-removable labels designed to last for the lifetime of the appliance indicating vaccine storage instructions as well as the temperature zones for which the unit is designed.

The internal and external cabinet must be corrosion resistant, units must be designed to achieve a maintenance-free lifetime of at least 10 years and must be covered by a two year warranty.

Domestic refrigerators usually have a small freezer compartment. However, refrigerator/freezer combinations should be avoided and instead separate refrigerators and ice-pack freezers should be installed.

Various types of domestic front- and top-loading freezers are available which can be used for freezing ice-packs. Wherever possible, top-loading ice-pack freezers should be preferred to front-opening devices as the former contain the cold air when opened.

If large quantities of ice-packs are needed repeatedly for cold boxes, a larger dedicated ice-pack freezer should be used. If large amounts of ice-packs are needed and a high turnover is expected, for example during a vaccination campaign, specially designed ice-pack fast freezers should be used.

Ice-pack freezers must have a freezing capacity of at least 7.2 kg per 24 hours (WHO 2007m, 3) and must maintain temperatures between - 25° to - 15° C. No standards for holdover time in case of power failure have been set.

The internal and external cabinet, lid and frame must be protected against corrosion, units must be designed to achieve a lifetime of ten years and must be covered by a two year warranty. The lid must be fitted with a lock. Units must be furnished with either an externally readable cabinet-mounted gas or vapour pressure dial thermometer or electronic maximum/minimum thermometer. The on/off switch must be recessed or otherwise protected in order to prevent inadvertent switching off.

Figure 17.14 Ice-pack freezer

In order to prevent inadvertent freezing of cold chain loads, all freezers should be clearly marked as freezers as well as with large labels "for ice-packs only". Some manufacturers (unfortunately) offer refrigerators and ice-pack freezer with identical external cabinets.

Ice-pack freezers which can operate on natural gas, propane gas or kerosene and must have an ice-pack freezing capacity of at least 2.4 kg per 24 hours can be used in places where continuous electricity supply is available for less than 8 hours per day (WHO 2007e, 3).

Two technical principles are used for cooling of refrigerator and freezer compartments: compression-cycle and absorption-cycle.

The compression technology is used most commonly. It is about four times more efficient than the absorption technology. With the same input of energy, the compression technology produces four times as much cooling (WHO 2000b, 59). Wherever more than 8 hours of electricity supply is available per day, the compression technology should be preferred. Unlike in absorption refrigerators, the temperature can be regulated by a thermostat and compression refrigerators provide more stable internal temperatures. Compression refrigerators require less maintenance than absorption refrigerators.

Refrigeration technology	Advantages	Disadvantages
Compression cycle	• More efficient (about four times). • Temperature can be regulated by thermostats and is more stable. • Less maintenance than absorption refrigerators.	• Requires a motor which can break down. • Requires regular maintenance. • Cannot be run on kerosene or gas.
Absorption cycle	• No moving parts. • Can be driven by any power source (electricity, kerosene, gas).	• Use high temperatures and are a fire hazard. • Equipment can catch fire and explode. • In kerosene refrigerators the temperature can be regulated only manually which is less reliable. • Require regular monitoring and attention during operation. • Require regular and frequent maintenance. • Require training. • High maintenance costs

Table 17.23 Advantages and disadvantages of different types of refrigerators

One or two electrically powered compressors, drive a refrigerant through a system of pipes. The resistance of the pipes leads to an increase in pressure which in turn heats up the refrigerant. It is a natural property of gases and liquids to heat up when they are put under pressure in the condenser. The heat is radiated and conducted away from pipes attached to the outside of the refrigerator, while the compressed refrigerant passes through. This is the reason why the side of refrigerators are warm or hot. The compressed refrigerant is conducted to the evaporator in the inside of the refrigerator where it is allowed to expand by reducing the pressure. Like all gases and liquids, the expanding refrigerant cools down. While it flows through pipes inside the refrigerator it absorbs thermal energy and cools the interior. The refrigerant is then led outside where it is compressed again and enters a new cycle.

A control circuit which is connected to a thermometer inside the refrigerator switches the compressor on and off automatically to maintain the preset temperature.

Compression refrigerators can only be powered by electricity.

Until 1995 the CFCs R11 and R12 were used as the major refrigerants as well as foaming agent in the insulation of refrigerators and ice-pack freezers. The production, importation and exportation of CFCs has been banned by the Montreal protocol (Art. 2A) as of January 1st 1996 since these substances cause severe damage to the earth's ozone layer. They have been replaced by more environmentally friendly CFC-free hydrofluorocarbons (HFC) and hydrocarbons (HC) refrigerants such as HFC 134a or R134a.

Absorption refrigerators are driven by a constant heat source which can be generated by electricity, an open gas flame, a kerosene wick burner or a solar thermal panel.

The main advantage of absorption refrigerators is that they do not have any moving parts. Another advantage is that some models can operate on different power sources.

The main disadvantages are poor efficiency and high maintenance costs. Absorption refrigerators cannot handle large cooling loads and are most suitable for use in health care facilities rather than for bulk storage (WHO 1996b, 15).

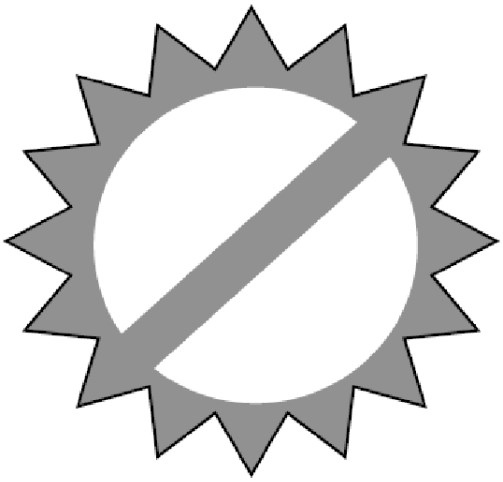

Figure 17.15 CFC-free symbol for refrigerators

The inside temperature of kerosene refrigerators must be controlled manually by adjusting the flame and cannot be maintained within the required limits by a thermostat. A study in Mali over 15 months showed that the temperatures were above + 8° C during at least 20% of the time and reached up to + 25° C despite good management. Temperature control was found to be particularly poor where daytime peak temperatures are high and where the outside temperature vary widely (WHO 1992b, 25).

Electric and gas absorption refrigerators however have control circuits for automatically maintaining the required temperature. The thermostats in gas refrigerators can increase the inside temperature by reducing the size of the gas flame. However thermostats cannot decrease the "pilot" flame below its minimum. When gas refrigerators are operated in low ambient temperatures, the "pilot" flame may be sufficient to decrease the internal temperature below the desired level and can damage goods by freezing.

Electrical powered absorption refrigerators require frequent replacement of the heating element if the voltage fluctuates widely.

Kerosene refrigerators are sensitive to fuel impurities, must be attended carefully and require frequent maintenance. The burner must be adjusted frequently to compensate for changes in ambient temperature. The flame must also be increased when ice-packs are being frozen and reduced again when freezing is completed to avoid a drop of the temperature in the refrigeration compartment. Kerosene refrigerators are a fire hazard and can explode.

If the flame of a kerosene refrigerator goes out, the refrigerator will stop working but not cause any danger since the wick stops drawing kerosene from the tank. Gas operated refrigerators must be fitted with safety devices which automatically shut off the gas supply if the flame extinguishes.

17.5.2 Power supply

Before setting up refrigerators a sufficient, reliable and sustainable power source must be ensured. If a mains electricity supply is not available or not reliable electric power from a generator set can be used. Alternatively kerosene or gas refrigerators can be used but require meticulous maintenance. Solar powered refrigerators can also be considered. However they require several hours of guaranteed sunshine every day, are expensive and require maintenance.

The energy source should be sustainable and reliance on a single source should be avoided. In any case a contingency plan must be developed both for a temporary as well as longer lasting failure of the primary power source. Refrigerators with dual energy sources such as kerosene/electricity and gas/electricity refrigerators increase flexibility.

A continuous (or at least regular) and reliable mains electricity supply with a stable voltage is ideal. At least 8 hours of electricity daily are necessary for operating electric ice-lined refrigerators properly. If electricity supply is irregular, unreliable and shows large voltage fluctuations, a generator set can be used instead. A standby generator set should also be considered if mains electricity supply is available but not reliable. The mains electricity supply may fail because the supply network is overloaded, because of a breakdown of generator sets, lack of fuel or lack of water for hydroelectric power plants. An alarm should alert staff or guards when the mains electricity supply fails.

Electric power plants and power lines may be damaged during armed conflict.

Generator sets must be carefully maintained and kept in working condition. A sufficient, reliable and sustainable fuel source must be available.

Photovoltaic system can provide electric energy for driving electric compression refrigerators and ice-pack freezers if the insolation (average daily solar radiation) is at least 5 kWh/m^2/day. One or two compression-cycle units are driven with 12 volt DC from batteries recharged from solar panels (WHO 2007h, 4).

The solar energy is free of charge and especially advantageous in (remote) places where no mains electricity supply is available. The technology itself is well developed and reliable. Although solar energy may not be the most economic solution it may nevertheless be the most practical one. If solar energy is available it can also be used for essential services such as emergency lighting, small laboratory equipment (centrifuges, microscopes) and radio transceivers.

The main disadvantages of solar photovoltaic refrigerators and ice-pack freezers are that solar insolation depends on the geographic location, may be unreliable and depends on the season. Even under the best conditions, solar systems cannot provide energy continuously since there is no insolation during the night. To bridge the night either batteries or ice-lined

refrigerators which can run on 8 hours electricity supply daily, have to be used. Ice-packs can only be frozen during day time when electricity supply is sufficient. The storage capacity is limited to 60 litres and solar technology is therefore not recommended for bulk storage.

Energy source	Advantages	Disadvantages
Electricity - mains supply	• No installation required. • Cost efficient .	• Dependency on infrastructure. • May be unreliable. • Likely to be disrupted during conflict.
Electricity - generator set	• Independent of infrastructure.	• Expensive equipment required. • High operating costs. • Requires regular maintenance. • Requires a reliable fuel source. • Fuel may be diverted for other purposes.
Electricity - solar (photovoltaic)	• Free source of energy. • Independent of local infrastructure. • Independent of fuel supply. • No fire hazard.	• Storage capacity limited to 60 litres. • Not recommended for bulk storage. • Dependent on duration and intensity of solar radiation. • Solar insolation unreliable. • Seasonal variability of insolation. • Available only during day time. • High equipment costs. • High maintenance costs. • Photovoltaic arrays are prone to damage. • Skilled technicians for maintenance not widely available. • Solar electricity may be misappropriated.
Kerosene	• Independent of mains electricity supply. • Fuel can be stored (unlike electricity). • Usually widely available. • Easy to transport.	• Fire hazard. • Danger of explosion. • Danger of misappropriation.
Gas	• Independent of mains electricity supply. • Fuel can be stored (unlike electricity). • Easy to transport..	• Requires a reliable source of gas bottles. • Dangerous to transport. • Fire hazard.

Table 17.24 Advantages and disadvantages of different energy sources

In order to ensure continuous operation during the night as well as periods of reduced insolation, photovoltaic arrays must be connected to batteries which are continuously charged and provide energy during the night. In case of a disconnection or technical failure refrigerators must have a holdover time of at least 3 hours (WHO 2007h, 5). The alarm system will usually be part of the battery charge regulator. If integrated into the refrigerator casing the control panel must include a voltmeter as well as a green LED indicating array charging, a

orange or yellow LED indicating a low battery charge as well as a red LED indicating a load disconnect. An acoustic alarm may be included which warns of a low battery charge and/or load disconnect.

A survey in Uganda has shown that the lifetime costs of solar refrigerators are higher than other technologies. Although solar system have low failure rates the maintenance costs are high (WHO 1992b, 23).

Initial investment for the photovoltaic array, battery and refrigerator as well as maintenance costs are higher over a 10 year period than for example gas operated refrigerators (WHO 2000b, 64).

Regulators and batteries have an average lifetime of five years. If funds are not available, the technology is unsustainable. Maintenance has to be carried out by skilled, qualified and competent technicians which are not widely available.

If solar electricity is available it may be misappropriated for other purposes (unnecessary lighting, radio, TV etc.) which can empty the battery and stop the refrigerator or ice-pack freezer from working. During operation, priority must be given to maintaining the cold chain.

Solar power systems must be purpose-designed to fit the specifications of the connected refrigerator as well as site-specific climate conditions such as ambient temperature and available solar radiation (WHO 2007l, 4). Solar power systems must be used exclusively for the connected refrigeration or freezer unit and no other loads such as lighting must be connected.

The crystalline or thin film solar modules must have a minimum warranty of 80% of the initial power rating for 20 years and must withstand extreme weather conditions characteristic for the installation site such as intense hail, snow, ice or dust storms.

The support structure for the photovoltaic array must be constructed from anodized aluminium, stainless or galvanized steel and suitable for mounting on pitched or flat roofs, walls, on poles or on the ground and should be supplied with theft deterrent fasteners.

The battery set must have a capacity sufficient to meet a five day autonomy period, have a battery life of 1,000 cycles and a warranty of 5 years. Sealed batteries are preferred although flooded batteries are also acceptable.

The battery charge regulator must be adjusted to the installed battery type, disconnect the load when the battery is discharged while leaving the solar array connected and automatically reconnect the refrigerator when the battery is sufficiently charged (again). The regulator unit must be fitted with voltmeter, a green LED indicating array charging, an orange or yellow LED indicating a low battery as well as a red LED indicating disconnection of the load. An acoustic alarm indicating low battery and/or disconnection of the load is optional. A power switch must be available for disconnecting the refrigerator from the solar power system.

The system must protected from damage by short circuits and (inadvertent) reversed polarity connections by fuses as well as by a lightning surge protector.

Photovoltaic panels must be designed to withstand exposure to temperatures ranging between - 40° and + 90° C and battery sets and battery charge regulators must be able to withstand temperatures ranging from - 10° to + 43° C.

A technician who has received only basic training must be able to assemble and commission the entire solar power system using only normally available hand tools. Spare parts sufficient for the first five years of operation should be supplied with the equipment.

Solar direct drive refrigerators without battery storage must have a holdover time of at least 20 hours as well as an autonomy of five days (WHO 2007k, 5). Autonomy is defined as the time

period that a solar refrigerator can maintain the required temperature under low solar radiation conditions, for example rain.

Absorption-cycle refrigerators driven by kerosene have the advantage that they are independent of the mains electricity supply which may be unreliable or destroyed during the conflict. Kerosene is widely available in many countries and easy to transport and store. Kerosene refrigerators can be used in remote areas where no mains electricity supply is available.

The failure rate of kerosene refrigerators is higher than solar refrigeration equipment but on the other hand, kerosene refrigerators are easier to repair locally (WHO 1992b, 23).

The regulation of refrigerator temperatures is difficult and kerosene refrigerators are difficult to maintain (WHO 2004a, 75). A major disadvantage of kerosene refrigerators is that they present a fire hazard and may cause damage or destruction of health care goods stored in the same room or building.

Several fires and explosions of kerosene refrigerators and ice-pack freezers, among others in Indonesia and Ghana have been reported. They have caused deaths and destruction of several health centres (WHO 1993, 97 f.). The model which caused problems was modified but these incidences do indicate the potential problem.

Liquid propane (LP) gas can be used for powering absorption refrigerators if a reliable source of bottled gas is available. Gas bottles must be handled carefully since they can cause fires and explode.

Only the type of gas specified by the manufacturer of the equipment must be used. The pressure of the gas bottles must also comply with the required specifications (Sibir International, n.d., 5).

Refrigerator type	Electricity kWh/24 hours	Kerosene l/24 hours	LP Gas kg/24 hours
Compression refrigerator	0.3 - 1.9	-	-
Compression freezer	1.6 - 5.8	-	-
Absorption refrigerator	1.6 - 3.5	0.5 - 1.4	0.4 - 0.8
Absorption freezer	2.5 - 3.5	0.5 - 0.9	0.4 - 0.9

Table 17.25 Energy consumption of refrigerators and freezers

The most appropriate power supply for refrigerators can be selected according to the recommendations by the World Health Organization (WHO 2000b, 55) and in the order of preference in table 17.26.

- Mains electricity supply (if reliably available for at least 8 hours a day).
- Diesel generator set (if reliably available for at least 8 hours a day).
- Bottled gas (provided it is not more expensive than kerosene).
- Kerosene.
- Photovoltaic (provided that more than 4.5 kWh/m2/day of solar energy is available).

Table 17.26 Order of preference for power supply for refrigerators

In general, electric refrigerators are the least costly to run and easiest to maintain (WHO 2004a, 74).

When energy sources for cold chain equipment are selected, contingencies for temporary as well as permanent failure of the primary energy source should be considered.

The risk of spoilage of cold chain loads can be reduced by using storage equipment with long holdover times, especially ice-lined refrigerators. Another measure is to freeze a significant number of ice-packs for lining cold boxes which can be used for temporary storage since they have longer holdover times than refrigerators.

If electric refrigerators are used, a backup generator set must be available. In case of the failure of the main generator set, a standby generator set must be available. Generator sets must be regularly serviced and well maintained. A sufficient quantity of fuel must be available and staff and security guards must be able to switch on and operate generator sets, including during the night and weekends. The same measures must be taken in case insolation is not reliable and solar refrigerators are used.

If refrigerators or ice-pack freezers with dual energy sources are used, the energy source can be switched if one of them fails.

17.5.3 Required specifications and selection criteria

Cold chain equipment should be carefully selected according to defined criteria rather than using domestic refrigerators and (ice-pack) freezers which happen to be available.

The World Health Organization (WHO) has elaborated standard equipment specifications and test procedures in great detail (WHO 1998b). Although they were developed mainly for vaccines used in the expanded programme on immunization, they apply to cold storage in general.

The rigorous testing procedures include installation of several temperature sensors in different places inside the refrigerators and ice-pack freezers and recording temperatures during five day/night cycles during which the ambient temperature is varied between + 15° and + 43° C (WHO 1998b, 29).

All equipment should be robust and the refrigerator or ice-pack freezer cabinet should be corrosion resistant, be well insulated and be fitted with tightly closing door or lid seals. External reading thermometers which indicate the internal temperature but which can be read without opening the refrigerator or ice-pack freezer should be fitted.

Ideally refrigerators and ice-pack freezers should be fitted with audible alarms which will sound an alert if the internal cabinet temperature is outside the required limits. Alarms should be fitted with batteries so they can alert staff even in case of the failure of the mains electricity supply.

The first step is determining or estimating the required storage capacity (volume) for refrigerators and ice-pack freezers based on a sound forecast and inventory control system. When ice-pack freezers are selected, a distinction between storage of ice-packs and the daily capacity for freezing ice-packs should be made. For the later, fast ice-pack freezers may be needed. Spare capacities should be planned to accommodate additional cold chain loads in case one of the refrigerators or ice-pack freezers breaks down or has to be shut off for servicing, repair, defrosting or cleaning.

Dedicated ice-pack freezers rather than freezing compartments of domestic refrigerators should be used for freezing and storing ice-packs. Either special ice-pack (fast) freezers or domestic freezers of good quality are suitable.

- Robust.
- Good insulation.
- Compliance of the equipment with the temperature zone in which it is used.
- Storage capacity of refrigerators sufficient for storage of cold chain loads.
- Storage capacity of ice-pack freezers sufficient for storage of ice-packs.
- Sufficient ice-pack freezing capacity.
- Required holdover time.
- Ease of repair.
- Ease of servicing.
- Availability of replacement parts.
- Availability of maintenance and repair services.
- Life-time costs.
- Availability of training of maintenance and repair staff.
- Availability of operating instructions, maintenance, service, repair as well as training manuals.
- Language of documentation.
- CFC-free refrigerant compliant to the Montreal Protocol.
- Equipment must comply with national legislation and regulations

Table 17.27 Required specifications/considerations for cold chain equipment

Based on the total required storage capacity ,the total number of pieces of equipment and their individual capacities can be determined. In order to hedge against technical failure of equipment, several smaller refrigerators and ice-pack freezers are more advantageous. This also allows shifting cold chain loads during maintenance, servicing, cleaning and defrosting.

Taking the temperature zone into consideration, finally the most suitable energy source needs to be determined.

The WHO has developed the concept of temperature zones (see figure 17.15).

- Cold zone: - 5° to + 32° C
- Temperate zone: 0° to + 32° C
- Hot zone: 0° to + 43° C

Figure 17.16 WHO temperature zones (WHO 2000b, 70)

Determination of the zone is based on the average temperature during the hottest and coldest months respectively. This allows selecting appropriate equipment according to the prevailing ambient temperatures rather than selecting the highest quality and therefore most expensive equipment for all places. Hot climates prevail in many less developed countries but this cannot be generalized globally (WHO 2000b, 69).

All equipment should be labelled with the temperature zone for which it is appropriate. Hot zone equipment may be used in temperate zones but not vice versa. If the temperature in rooms where refrigerators and ice-pack freezers are installed can reliably and continuously be maintained below + 32° C, then temperate zone equipment may be used in hot zones (WHO 2000b, 70).

Drug products requiring refrigeration and most vaccines should be stored between + 2° to + 8° C and must be protected from freezing. Vaccines should be stored according the recommendations of the manufacturer. Depending on the vaccine, diluents must either be kept in the cold chain or at least cooled before constituting the vaccine.

The longer the holdover time the better the protection against the risk of damage to cold chain loads caused by a temperature increase during a power failure. The holdover time is defined as the time period the internal temperature of a refrigerator will remain below + 10° C after the energy supply has been cut. The no sun autonomy of solar refrigerators without a battery ranges from 5 to 72 hours.

Refrigerators and refrigerators are available with gross volumes of up to 250 litres and ice-pack freezing capacities of up to 20 litres per 24 hours.

Refrigeration equipment should be robust, reliable, require little maintenance and should be easy to repair by non-specialist technicians. The cost for repairs and replacement parts account for 40 - 50% of the total lifetime cost of a refrigerator (WHO 2000b, 53). A set of essential spare parts should be purchased together with the equipment to ensure operation for several years without dependency on supply of replacement parts from abroad.

Equipment should comply with the Montreal Protocol and be CFC-free. The type of refrigerant used should be clearly indicated on the equipment by a permanent label to avoid contamination during servicing. Equipment must comply with any relevant national legislation or regulations such as concerning electrical safety.

From all refrigerators or ice-pack freezers which fulfil the required criteria the model with the lowest lifetime costs should be selected. Capital as well as recurring costs should be considered. The purchasing and transportation costs are only part of the total cost equipment will incur over its lifetime and the cost of energy as well as maintenance and repairs must also be considered.

Suppliers must provide operating, maintenance, service, repair and training manuals in a language commonly understood in the area or at least the country where the equipment will be used. The user manual must include instructions for installation and adjusting the temperature. Service and maintenance manuals should include daily, weekly and monthly maintenance tasks. Instructions for periodic preventive maintenance as well as for small repairs should also be provided.

The long-term availability of replacement parts as well as qualified technicians which can carry out servicing and repair of the equipment must be ensured.

Suppliers should also be able to provide training to users as well as to technicians for repair and servicing of the equipment. Service technicians must be provided with appropriate tools to carry out servicing and repairs.

All equipment should be packed in timber crates to protect equipment during transportation.

Electric refrigerators and ice-pack freezers may run on 12 V, 24 V, 120 V or 220 V. Input leads should be at least 2 metres long. The electric cable should be PVC insulated and fitted with a plug which is used in the country where the equipment will be set up. Electric refrigerators should be fitted with earth connections.

The size of photovoltaic systems must be planned to allow safe and reliable operation of all equipment during the periods of lowest insolation in the year. Solar refrigerators and ice-pack freezers must have dedicated batteries which are not used for any other purpose. Otherwise batteries might be exhausted by lighting etc. and the cold chain loads will be spoiled. A fully charged battery should allow continuous operation during at least five days when the photovoltaic array is not delivering any electricity.

Many problems in solar refrigeration have been caused by using different components which were not adapted to each other and did not match. "The best solar systems are those which are designed as a whole by a single company which has a thorough knowledge and understanding of the various components and the performance of available models" (WHO 1993, 33).

Photovoltaic arrays should withstand wind loads of 200 kg/m². Fixings should be available for installation either on the ground or for mounting on a roof. The equipment must be fitted with lightening (surge) protection.

Battery-free (ice-lined) units which do not require batteries and chargers should be preferred since the entire system is simpler and less prone to breakdowns. They also reduce capital as well as running costs (WHO 1993, 34). "A significant proportion of the breakdowns in photovoltaic refrigerators being used in the EPI today are caused by a failure of the battery and charge regulator pair -- the remaining weak link of this technology" (WHO 1990a, 23).

Cables connecting the photovoltaic array and charger must have sufficient capacity to carry the full current when the photovoltaic array is producing the maximum energy.

If batteries are used, they must be of good quality and suitable for solar refrigeration systems (WHO 1990a, 24).

Dry cell batteries should not be used and the acid (electrolyte) must be supplied in a separate, sealed container. Batteries should withstand at least 1,000 cycles to 50% discharge. An alarm should give a warning when the state of charge of the battery is low and also indicate that no ice-packs should be frozen. Batteries should be placed in a lockable and ventilated place and should require maintenance no more than every six months.

Battery charge regulators must disconnect the photovoltaic array from the battery when it is completely charged. The electric installation should be fitted with fuses and ten spare fuses should be purchased with the equipment.

Equipment should be fitted with an alarm which warns of any disconnection of the compressor from the regulator.

According to WHO/UNICEF standard performance specifications, solar arrays should have 10 years, batteries 5 years and other components 2 years of warranty (WHO 2000b, 61).

The wicks of kerosene refrigerators can be made from cotton or fibreglass (WHO 1990c, 9).

For gas refrigerators, pressure regulators must be fitted to gas bottles which reduce the gas pressure to the maximum pressure prescribed by the manufacturer.

Generally, refrigerators and ice-pack freezers can be fitted with various accessories. Level indicators and adjustable feet facilitate installation and ensure that equipment is set up correctly. Locks on doors protect equipment against unnecessary opening and theft.

External reading thermometers allow monitoring and recording temperatures regularly without the need for opening the refrigerator or ice-pack freezer.

Visual and audible alarms can be preset to alert users as soon as the internal temperature falls below or exceeds the required storage temperature. The alarms must work independently of the mains electricity supply so they still work in case of a power failure.

Voltage regulators control voltage fluctuations from mains electricity supply or generator sets and should be used wherever the voltage is not stable and fluctuates more than +/- 7% (WHO 2000b, 28). Voltage fluctuations and power surges can damage compressors and controls.

In electronic servo regulators the input voltage controls a motor which adjusts a transformer to provide the required output voltage. These devices are sensitive but accurate, can regulate a wide range of voltages and are usually inexpensive.

Solid state regulators have no moving parts and are therefore very reliable.

Pure transformer type devices regulate the output voltage by controlling the magnetic field which is induced by the input voltage. These devices are very simple and reliable but the most expensive type.

The input voltage must correspond to the voltage of the mains electricity supply or generator set. The output voltage should not fluctuate more than +/- 5% and match the required voltage for the equipment.

Figure 17.17 Voltage regulator

17.5.4 Set-up and installation

Refrigerators and ice-pack freezers must be set up in an appropriate place according to the manufacturer's instructions to ensure safety, reliability and maximum lifetime.

Rooms must be protected from intrusion and locked when the store is closed. Refrigerators and ice-pack freezers produce heat and must therefore be installed in well ventilated rooms. In order to avoid overheating, rooms should have a minimum of 4.5 m³ of room volume per 100 litres of stored cold chain loads and there should be some means of permanent ventilation in the room (WHO 1996b, 18).

Air must be able to circulate freely around the cooling unit (condenser) which is usually fitted to the rear of equipment. Refrigerators and ice-pack freezers must also be placed at a distance of at least 10 centimetres from walls and any furniture or other equipment (WHO 1996b, 18) or at a greater distance according to the manufacturer's instructions. Any ventilation grating fitted to refrigerators or freezers must also not be blocked or obstructed and air must be able to circulate freely through the grating.

In hot climates refrigerators should be set up in rooms which are as cool as possible since the efficiency of refrigeration equipment decreases at high ambient temperatures.

Equipment must be set up on a flat and level floor but should be raised about 10 cm off the floor to prevent corrosion from water swept underneath the cabinet during cleaning, water damage as well as for improving ventilation (WHO 1996b, 18). Refrigerators can be mounted on the pallets they are shipped on or a timber pallet can be made.

A water level should be used to ensure that the refrigerator or ice-pack freezers is placed in a level position. If the floor is not level, any supports should be sound and permanently attached to the floor to prevent accidental dislocation and tilting of the equipment.

Refrigerators must not be exposed to heat radiation from the sun or from heating equipment (stoves, ovens, radiators etc.).

Batteries and battery charge regulators must be mounted in protective cases which must be firmly attached to the wall, floor or refrigerator or ice-pack freezer cabinet.

Competent staff must be trained in maintenance and repair of equipment as well as in measures to be taken in case of equipment failure (WHO 2000b, 65).

All wiring as well as electric equipment for compression refrigerators and ice-pack freezers must be installed by a qualified technician. The power circuit must be rated for the running as well as maximum starting loads of refrigerators and ice-pack freezers. The maximum loads, which can be 5 - 6 times higher than the rated running load, occur when the compressors start up. If several refrigerators and ice-pack freezers are installed, their compressor will usually be working and resting at different times. However, after a prolonged power failure all appliances will start up as soon as power is restored and the electric wiring must be rated to carry the load of all refrigeration appliances simultaneously.

Every refrigerator and freezer should be connected to a separate voltage regulator which protects the equipment against electric power surges. Plugs must fit electrical sockets properly and accidental disconnection of equipment as well as voltage regulators must be prevented by fastening plugs to electrical sockets and wall plates with tape. Alternatively, appliances can be permanently wired into the electrical socket or voltage regulator.

Electric circuits should be earthed and only earthed electrical sockets should be used. The mains electricity supply must match the required input voltage of the equipment. If the voltage is not stable, voltage regulators should be used.

All electrical leads must be routed and secured so that they cannot come into contact with hot or sharp parts of the refrigerator (Sibir International, n.d., 5). Power leads should not be longer than necessary and should never be coiled up since coils generate heat which could cause a fire.

Solar refrigeration and freezing equipment must be set up and installed by a qualified and competent technician who has received specific training rather than by a general electrician.

The photovoltaic array modules can be installed on the ground or mounted to the roof or a pole. If photovoltaic arrays are installed on the ground, they must be protected from people and animals by a fence. In any case the photovoltaic array must be safely accessible and if mounted on a roof, a safe ladder should be available for maintenance.

All cables must be firmly attached to prevent dislocation and damage.

The batteries and battery charge regulators can be integrated in the refrigerator or ice-pack freezer cabinet or be set up next to the refrigerator or ice-pack freezer in a protective case (WHO 1988b, 2).

Kerosene and gas driven absorption refrigerators and ice-pack freezers should be installed by authorized technicians (Sibir International, n.d., 5).

Rooms should have a volume of at least 20 m^3, have an outside window or door and must be well ventilated. However draughts should be avoided since they may blow out the flame. Clearance between the refrigerator and ice-pack freezer and side walls should be at least 25 mm and above the refrigerator at least 100 mm. Air should circulate freely around the cooling unit fitted to the rear and the ventilation opening at the top must not be covered (Sibir International, n.d., 4).

Refrigerators and ice-pack freezers must be installed on flat and level floors in a perfectly upright vertical position. This requires to level the base of the refrigerator in two directions. This is particularly important to ensure that the fuel tank is level since otherwise the fuel may not reach the burner.

Installation of gas absorption refrigerators and ice-pack freezers as well as the gas supply must be carried out by authorized and qualified technicians. Hoses and hose connections must be suitable for gas installations and hoses should not be longer than 1.5 m (Sibir International, n.d., 6).

Gas bottles, hoses and inlet valves must be safely connected and connections secured with hose clamps. All connections must be checked with soapy water for detecting leaks. Flames must never be used for detecting gas leaks in the system.

A clearance of at least 400 mm should be left above the refrigerator and air should be able to freely circulate around the equipment.

A clearly marked wall- or floor-mounted shutoff valve must be visible and easily accessible.

17.5.5 Thermometers

Thermometers are used for measuring and recording storage temperatures in refrigerators and freezer, cold rooms and freezer rooms as well as in cold boxes and vaccine carriers.

Except for kerosene absorption refrigerators, the temperature of refrigerators and ice-pack freezers is controlled by a thermostat. Nevertheless the internal temperature must be monitored to detect technical faults and adjust thermostat settings if necessary. In some equipment the internal temperature cannot be preset directly but rather the internal temperature can be reduced and increased by manually adjusting the thermostat setting. Especially the temperature of kerosene absorption refrigerators must be monitored very closely.

If simple thermometers are used, the temperature reading only reflects the current temperature although the temperature may have been significantly higher or lower since the last reading. For example the internal cabinet temperature may have increased significantly during a power failure in the night but dropped to the required + 8° C again before the temperature reading the next morning. The internal cabinet temperature may also fluctuate with the ambient temperature. Therefore digital minimum/maximum thermometers should be preferred. These mark the minimum and maximum temperature since they were reset the last time.

Integrated electronic maximum-minimum thermometers, with factory programmed alarms, are intended for monitoring storage conditions in vaccine refrigerators and freezers (WHO 2006i, 2). They can operate on replaceable batteries or on rechargeable back-up batteries which must be capable of powering the devices for at least 72 hours during a power failure. A digital temperature read-out as well as a visual alarm must be integrated into the control panel of the refrigerator or freezer cabinet.

For refrigerators a visible (and optional audible) low breach, factory programmed alarm should be set at - 0.5° C and a high breach alarm at + 10° C which remains activated (even if the alarm condition is no longer met) until it is cancelled and reset with a switch by the user. For ice-pack freezers an alarm must be activated if the temperature exceeds - 15° C.

The 30 day electronic refrigerator loggers with an integrated or remote sensor device is intended for monitoring storage conditions in vaccine refrigerators as well as a secondary back-up device in cold rooms (WHO 2006a, 3). The device must measure and log temperatures at intervals no longer than 10 minutes and overwrite older data after 30 days. A temperature read-out with a visual alarm display must be integrated into the device and the minimum and maximum temperatures for every day must be accessible. A low breach alarm at - 0.5° C as well as a high breach alarm at + 10° C must be factory-programmed. The operating life of replaceable batteries must be at least one year, that of non-replaceable batteries at least two years. The device must withstand five drops from a height of one metre onto a concrete floor.

Programmable electronic temperature and event logger systems with integral alarm and auto-dialler options are intended for monitoring storage conditions in vaccine stores (WHO 2006m, 3). The specifications may be customized to the individual requirements of the vaccine store. The system comprises several temperature sensors which are connected to a logger unit or a base station (which may be connected to a personal computer) as well as a "door open" and voltage sensor. Logging intervals must be programmable between 1 and 60 minutes. The system must be fitted with an alarm sounder and/or flashing light signal as well as a device which automatically dials a pre-programmed telephone number when an alarm is triggered and alerts the recipient(s) with a recorded voice message or SMS text message.

Fixed gas or vapour pressure dial thermometers are intended for use in vaccine stores (WHO 2006h, 2). On a dial thermometer the needle, like the hand of a clock, turns clockwise when the measured temperature increases and counter-clockwise when the temperature decreases. They must be furnished with a circular centigrade scale indicating the range from + 2° to + 8° C as safe range for cold rooms and the range from - 15° to - 25° C as safe range for freezer rooms.

These thermometers must be either furnished with alarm contacts or with "lazy pointer" needles which record maximum and minimum temperatures and must be re-settable without tools.

Dial thermometers tend to lose their accuracy over time (WHO 2004a, 81) and require recalibration by comparing the indicated temperature with the temperature reading of a stem or bulb thermometer and adjusting a facility screw on the back of the thermometer.

Wall-mounted pen recording thermometers are designed for use in cold rooms and freezer rooms where electronic logger systems are not appropriate because of lack of technical support or unreliable electricity supply (WHO 2006q, 2).

The system comprises one or two remote electronic or gas/vapour pressure temperature sensors, alarm contacts (outside the range of + 2° to + 8° C for vaccine stores) as well as a "door open" sensor.

The temperature is recorded by a refillable or inkless blue or black pen on a replaceable paper disc or fanfold paper strip with a white background for at least seven days without changing and must be legible for at least three years. A digital display of the current temperature at the sensors may be included. Blank charts and (if necessary) ink refills sufficient for five years of normal operations must be supplied with the device.

Portable alcohol stem thermometers are suitable for measuring storage temperatures in vaccine refrigerators and freezers as well as in cool rooms cold rooms and freezer rooms (WHO 2006k, 2).

The sensor consists of coloured alcohol which expands in a glass column marked with a centigrade scale and indicating the temperature ranges from - 15° to - 25° C as well as + 2° to + 8° C with solid bars. The thermometers must be fitted with some sort of mounting device and must withstand five drops from a height of one metre onto a concrete floor without being damaged.

The internal sensors or one or two detachable probes of portable electronic thermometers are intended for measuring the air temperature in cold rooms and freezer rooms as well as refrigerators, ice-pack freezers and cold boxes (WHO 2006l, 2).

Devices must be able to operate on rechargeable or replaceable batteries for at least 100 hours and withstand five drops from the height of one metre onto a concrete floor.

Type of thermometer	Lower limit	Upper limit	Acura-cy	Resolu-tion	Logging interval	Intended for vaccine
Integrated electronic maximum-minimum thermometer	- 30° C	+ 50° C	± 0.5° C	0.2° C	less than 10 minutes	refrigerators and freezers
30 day electronic refrigerator logger	- 20° C	+ 50° C	± 0.5° C	0.2° C	not more than 10 minutes	refrigerators and stores
Programmable electronic temperature and event logger	-30° C	+ 50° C	± 0.5° C		1 - 60 minutes	stores
Fixed gas or vapour pressure dial thermometer	- 30° C	+ 50° C	± 1° C	0.5° C	none	stores
Wall-mounted pen recording thermometer	- 30° C	+ 50° C	± 1° C	0.5° C	continuous	stores
Portable alcohol stem thermometer	- 30° C	+ 50° C	± 1° C	0.5° C	none	refrigerators, freezers and stores
Portable electronic thermometer	- 30° C	+ 50° C	± 0.5° C	0.2° C	none	refrigerators, freezers, cold boxes and stores

Table 17.28 Specifications of thermometers

Alarm units connected to fixed gas or vapour pressure dial thermometers with alarm contacts or wall-mounted pen recording thermometers may feature acoustic or visual alarms or both and be mounted inside buildings or outside in a weatherproof housing (WHO 2006c, 2). Acoustic alarms must be intermittent and must not be confused with fire alarm sounders and visual alarms must feature coloured flashing lights which are clearly visible in full sunlight. Devices must be able to operate on back-up batteries for at least 48 hours and alarms must continue until cancelled by an operator.

17.5.6 Cold rooms

Refrigerators and ice-pack freezers will provide sufficient storage capacity for drug products, diagnostic tests and vaccines in most cases. However if large amounts of vaccines and diluents are stored for national immunization programmes, "walk-in" cold rooms may be necessary for storage at national, provincial or district level. Equipment failure may jeopardize the entire national programme and cold rooms must therefore be built to high standards and be as reliable as possible (WHO 1991, 1).

Cold rooms are expensive, can only be installed in safe places and must be planned for long-term use. The cost per cubic metre of cold chain load is constant when using refrigerators or ice-pack freezers while the cost per cubic metre decreases with the increasing size of cold rooms.

Figure 17.18 Cold room

An alternative to setting up large vaccines stores is outsourcing storage to private companies or making an agreement with the manufacturer to store vaccines for immunization programmes.

Vaccine stores should be located in a place which minimizes the overall transportation distances and transportation costs to lower level stores.

Cold rooms should be planned and installed only by specialists. A square foot print (that is equal width and length) of the cold room minimizes the total external surface and therefore minimizes energy consumption for cooling (see figure 17.18). The internal height should not exceed 2.2 metres to facilitate materials handling (WHO 1996b, 25).

Cold rooms and its equipment should be located on concrete slabs and the building must be designed to withstand floor loads of around 500 - 700 kg/m² (WHO 1996b, 20). Especially in moderate and cold climates, freezer rooms may freeze the floor beneath and cause the supporting concrete slab to crack or cause condensation in upper floor locations. This can be prevented by placing electric resistance heater mats between the freezer room and the concrete slab or the ceiling.

For planning cold rooms, first the type and quantities of required vaccines or other cold chain loads must be determined.

The required storage capacity depends on the volume of the individual products which may differ from supplier to supplier depending on the packaging.

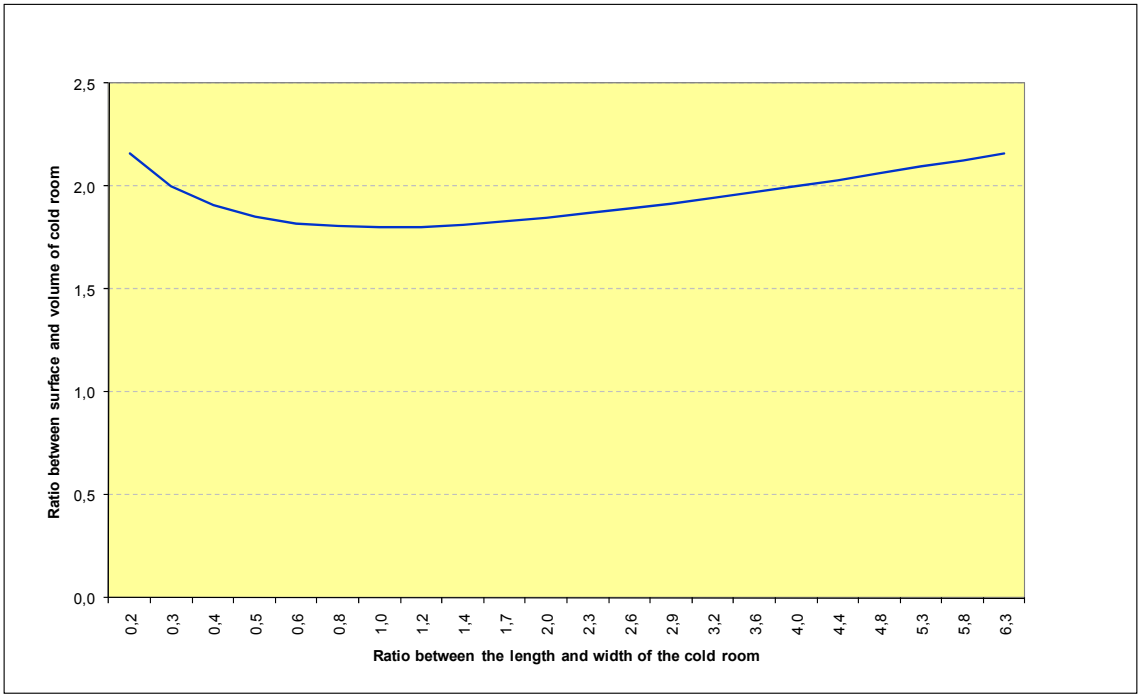

Figure 17.19 Relation between shape and external surface of cold rooms

Demand may peak during national immunization days which requires larger storage capacities than for accommodating stock to cover average demand. The demand for vaccines may be very seasonal depending on the accessibility of remote areas.

The quantity of required ice-packs and their turnover is determined by the number of supplied stores and delivery schedules. Demand for ice-packs can be reduced by using refrigerated vehicles rather than cold boxes.

Cold rooms can be built on a site, set up from prefabricated modules or be transportable.

Temperatures must be maintained steadily at between + 2° to + 8° C or - 25° to - 15° C for freezer rooms at the prevailing ambient temperatures. Some equipment allows using the cold rooms for either refrigeration or freezing. The required storage temperature must also be maintained in low ambient temperatures. Depending on the temperature zone, the thermal transmittance (U-value) of insulation of the roof, wall and floor panels must not exceed between 0.17 - 0.25 W/m²K (WHO 2007b, 6).

Insulation panels must be made from zinc coated steel sheets without any structural members or stiffeners between the two skins and designed for minimizing cold-bridging when fitted together. Floors must be furnished with hard-wearing non-slip finishing.

Cold rooms must have a holdover time of at least 8 hours when empty and be furnished with a timer-operated electric or hot-gas defrosting system as well as a condensate drip tray connected to a drain.

No outside part of the cold room or machinery should be exposed to direct sunlight. If necessary shades can be installed.

The insulation of doors must be equivalent to the insulation of the wall and ceiling panels. Doors must be 60 - 80 cm wide and furnished with an internal, clear plastic strip curtain to reduce cold air loss when the door is opened. The door must be lockable with 100% fail-safe provision for opening the door from the inside. Cold rooms in humid climates as well as all freezer rooms should be fitted with door frame heating elements to prevent freezing of the door to the frame (WHO 2007b, 6).

Freezer rooms must also be fitted with pressure relief valves since warm air which has entered and is cooled down will contract and lead to a vacuum inside the freezer room which may prevent opening of the door.

The cold room must be fitted with incandescent lamps connected to an external switch and pilot light. Fluorescent tubes must not be used as they can damage certain vaccines. The cold room must be furnished with wall-mounted or free-standing galvanized steel, stainless steel or aluminium, adjustable shelving units with a depth of 45 - 60 cm, a maximum span of 100 cm and with the lowest shelf mounted 20 cm above the floor (WHO 2007b, 7). No goods must be stored within 20 cm below the ceiling and goods should be stored 5 cm away from walls of the cold room to allow free movement of air between the stored goods.

The cold room should be cooled by two refrigeration units which each have the capacity to provide 100% cooling, operate alternately (100% standby capacity) and change over automatically. This ensures uninterrupted operations even if one refrigeration unit fails. The condenser units can be installed inside the building, usually next to the entrance door of the cold room or on the ceiling, be mounted to the wall of the cold room or be mounted externally on the roof or outside wall. The refrigerant must be CFC-free and comply with the requirements of the Montreal Protocol.

Cold rooms must be fitted with evaporator plume guards (mesh cage or deflector) which protect shelving from air flows with temperatures below + 2° C.

The available electrical power supply must be sufficient for the cooling equipment. If voltage fluctuations are expected, voltage regulators and surge protectors should be used with all equipment.

If heat from the condensers is discharged inside the building, the waste heat must be removed by ventilation or air-conditioning. However it is preferable to use split systems with

separate condenser and evaporator units which allow mounting the condenser on the outside of the building.

A thermostat must maintain the internal temperature between + 2° and + 8° C when measured in any part of the room under any loading condition (whether empty or full).

As drug products and some vaccines may be damaged or destroyed by freezing, in cold climates cold rooms may need to be fitted with cold climate freeze prevention.

Cold rooms must be fitted with mains-operated audible alarms with a automatically recharged battery backup, which are triggered in the event of mains failure or when temperatures are outside the set limits.

Temperatures must be recorded with a wall-mounted pen recording thermometer fitted with alarm contacts as well as a door-open sensor or a programmable electronic temperature and event logger system with auto-dialler. In both cases a gas or vapour pressure dial thermometer should be mounted on the wall of the cold room as a backup.

Tender specifications should refer to standards defined by the World Health Organization (WHO 1996b, 40).

Turnkey contracts, where the supplier should be responsible for delivery, installation as well as commissioning of cold rooms, should be preferred. A set of basic spare parts for two years should also be included in the purchase contract. Maintenance and repair services must be available domestically and a service contract should be made.

Suppliers must provide detailed operating, maintenance, service, repair and training manuals in a language commonly understood in the country. Training courses for maintenance technicians should be provided by the supplier on request (WHO 1991, 4).

Cold rooms should be housed in sound and permanent buildings which are in good condition. If no suitable building is available, transportable units should be preferred. Cold rooms as well as generator sets and fuel tanks should be installed inside a safe and guarded compound.

Installation of the cold room inside a building may require clearances on all sides as well as above the roof of the cold room. The concrete floor must be even, level and support the load of the cold room.

Prefabricated units are preferable, site-built cold rooms should be considered as an exception and only if the necessary skills are available. Lower building costs for site-built units are likely to be outweighed by higher maintenance and running costs (WHO 1996b, 22). Cold rooms must be planned by qualified engineers and built to exacting standards.

Prefabricated cold rooms are assembled from prefabricated modular insulated panels with widths of 60 - 200 mm which are mounted on a flat, level and solid concrete base. Walls as well as the ceiling may be faced with steel and the floor panels should be made from a non-slip finish (WHO 1996b, 19). Installation requires only a few days.

Self-contained, waterproof and transportable cold room units which are often built into standard ISO shipping containers can be set up outside or inside a building and may be furnished with their own electrical power supply.

Transportable cold rooms are more expensive but incur lower installation costs. They can be moved to the location where they are needed and must be set up in the shade.

Installation of cold rooms and freezers rooms requires a reliable mains electricity supply or a reliable backup power supply such as sufficiently powerful generator sets (WHO 1996b, 7).

Vaccines are usually expensive and if large quantities are spoiled their replacement may not be readily available from suppliers. The loss of large quantities can also disrupt immunization programmes and cause loss of confidence.

If voltage fluctuations exceed 15%, compressor motors can be damaged and equipment should be protected by voltage regulators. The nominal power of the voltage regulator should be about five times greater than the nominal power of the compressor since the starting load is much larger than during operation (WHO 1996b, 36).

Diesel or petrol generator sets may be used as a permanent or backup power supply. Generator sets must have a sufficient capacity to supply the entire energy needs and standby generator sets should be automatically switched on in case the mains electricity supply fails. Generator sets should be de-rated 1% for each 100 meters above sea level and 1% for each 5.5° C above 20° C (WHO 2000b, 23). For continuous operations power requirements should only require 80% of the maximum output of generator sets. Suppliers usually state output power for continuous as well as standby operations during mains electricity supply failures.

Generator sets should be fitted to a concrete foundation on anti-vibration mounts. The fuel tank must ensure at least 24 hours of continuous operation, sufficient fuel must always be available for refilling the tank and fuel consumption should be monitored. The generator set as well as fuel tank should be kept locked to prevent theft of fuel. Standby generator sets should be tested at least once per week and staff and security guards should now how to start them manually (WHO 1996b, 35).

Generator sets should be sited in a separate building, be protected from the weather and must not pose a fire hazard for the cold room. The fuel tank should be separated from the generator set and be surrounded by a wall to prevent fuel spills from spreading. Fire fighting equipment for electrical as well as fuel fires must be available and functional.

Diesel generator sets are usually more robust and more suitable for continuous operation than petrol generator sets. Hand starting generator sets are cheaper and more robust. However automatic starting may be necessary if permanent presence of staff or guards cannot be ensured. Air-cooled units are easier to maintain than water cooled units.

Depending on the siting of the generator set, soundproofing may be necessary. Enclosures made locally with brick walls may be cheaper.

The selection of a generator set should consider capital as well as running costs which depends among others on the fuel consumption.

Maintenance and replacement parts should be available domestically and generator sets should be delivered with operating, maintenance, service and repair manuals as well as spare parts and tools (WHO 2000b, 19).

Generator sets are expensive and should be selected by a qualified and experienced technician.

17.6 Storage of dangerous goods

Health care facilities require only small amounts of dangerous goods such as medical gases, pesticides as well as corrosive, toxic and flammable chemicals. Nevertheless they must be stored carefully to prevent injury of staff, harming the environment as well as damage of storage equipment and other health care goods stored in the same storage facility.

Ideally dangerous goods are stored in a separate building (Quick, J.D. (ed.) 1997, 349) or at least in a separate store room. Shelves, cupboards or containers holding dangerous goods

must clearly indicate the danger (flammable, toxic etc.). This allows staff to protect themselves and take the necessary measures in case of an accident.

Volatile	Halothane, enflurane
Flammable	Methanol, fuel (bottled gas, kerosene, diesel)
Explosive	Fuel
Corrosive	Chlorine
Oxidizing	Calcium hypochlorite, hydrogen peroxide
Toxic	Carbol Fuchsin powder, ammonium oxalate, mercury

Table 17.29 Possible safety hazards of health care goods

17.6.1 Medical gases

Compressed oxygen and nitrous oxide gas are used in anaesthesia. Oxygen can be produced at the hospital but will usually be provided in oxygen cylinders. Liquid propane gas cylinders may also be used for gas refrigerators.

Medical gas cylinders must be clearly marked with their contents and are usually colour coded. Medical gas cylinders must be stored on a level and even floor in an upright position. Placement on metal should be avoided as this can increase corrosion.

They must be secured to the wall or a rack by two chains at two different heights. In any case toppling of gas cylinders, which can damage the valve, must be prevented. Rapidly escaping gas can then turn the gas cylinder into a dangerous rocket. In addition flammable gases might lead to explosions.

Leaking medical gas cylinders such as nitrous oxide can lead to harmful concentrations or may cause explosions (oxygen). Therefore they are ideally stored in a separate building or container which is clearly marked with the appropriate hazard warning signs and will prevent damage to other health care goods in case of a fire. Access should be restricted to authorized staff and medical gas cylinders must be kept locked. Smoking as well as the use of open flames inside or in the vicinity of medical gas stores must be prohibited.

17.6.2 Chemicals

In health care facilities chemicals are mainly used for disinfection, diagnostic imaging and in laboratories. Some health care equipment may contain dangerous chemicals such as mercury. Chemicals may also be used in medical storage facilities for pest control.

Drug products	Volatile liquid anaesthetics (halothane, enfluran)
Disinfectants	Chlorine, hydrogen peroxide
Scabicides and pediculicides	Permethrin powder
X-Ray chemicals	X-Ray developer and fixer
Laboratory reagents	Alcohol and solutions containing alcohol
Health care equipment	Mercury (thermometers, sphygmomanometers)

Table 17.30 Dangerous chemicals used in health care programmes

Dangerous chemicals which may be volatile, flammable, explosive, corrosive, oxidizers or toxic, require special storage conditions.

Volatile liquids evaporate easily and must therefore be stored at room temperature and in bottles with tight lids or stoppers.

Flammable goods must be stored in sturdy glass bottles or Jerry cans with tight closures. They must be placed in a plastic receptacle which will contain the liquid in case the primary packaging cracks or breaks. The plastic receptacle must have the capacity to hold the entire volume of liquid placed in it. Both must be stored in a closed, but well ventilated and lockable metal cabinet. Ideally flammable substances should be stored in a separate building in order to prevent any fire from spreading throughout the medical storage facility. The cabinet should be stored away from any sources of open fire or electrical installations which could cause sparks and ignite a fire. Flammable goods should be stored separately and not below corrosive liquids which could damage packaging in case of leakage.

Even small amounts of fuel (kerosene, bottled gas, diesel, petrol) for refrigerators and generator sets must be stored in a separate building at least 20 metres away from other buildings. One wall of the building or the roof should be of lightweight material to reduce damage to the building in case of an explosion (AHRTAG 1994, 11). For example one side of the building can be constructed as a "timber blast wall". In case of an explosion this wall will be torn away but the explosion will not destroy the entire building.

In general fuel should be stored in drums which are locked in a dedicated building or in fuel tanks which are locked to prevent theft. In order to protect the environment as well as reduce a fire hazard, fuel tanks should be placed in an enclosure, for example concrete, which will contain the entire contents of the tank in case of a leak.

Corrosive chemicals should be stored at low levels so they cannot damage other goods or storage equipment in case of spillage. Packaging must be placed in corrosive proof receptacles which can contain the liquid in case the packaging breaks or cracks.

Goods should be stored in corrosion resistant plastic containers on stone or concrete floors.

Figure 17.20 Dedicated dangerous goods store

Oxidizing substances should be stored away from organic material, reducing agents (for example potassium permanganate) and flammable chemicals.

Toxic substances should be stored in a safe place, preferably a locked cupboard.

Chlorine products are used for disinfecting water, surgical equipment etc. and are highly corrosive. Small amounts can be stored in sealed plastic containers. Larger amounts should be stored in a separate well ventilated facility outside the medical storage facility.

17.7 Materials handling systems

Loads have to be handled in several places and for several reasons as they flow downstream through the supply network from the manufacturer to the end user. They must be picked from stock, moved inside stores to the dispatch area, loaded on vehicles, perhaps moved to another mode of transportation, unloaded, moved inside the receiving warehouse and put away. This process may have to be repeated several times throughout the supply network.

Materials handling equipment is used for:

- Loading and unloading
- Movement inside the warehouse or store
- Order picking and put-away

A great variety of materials handling equipment is available. However in this chapter only simple equipment which is appropriate for the environment in which humanitarian organizations work in the field will be discussed.

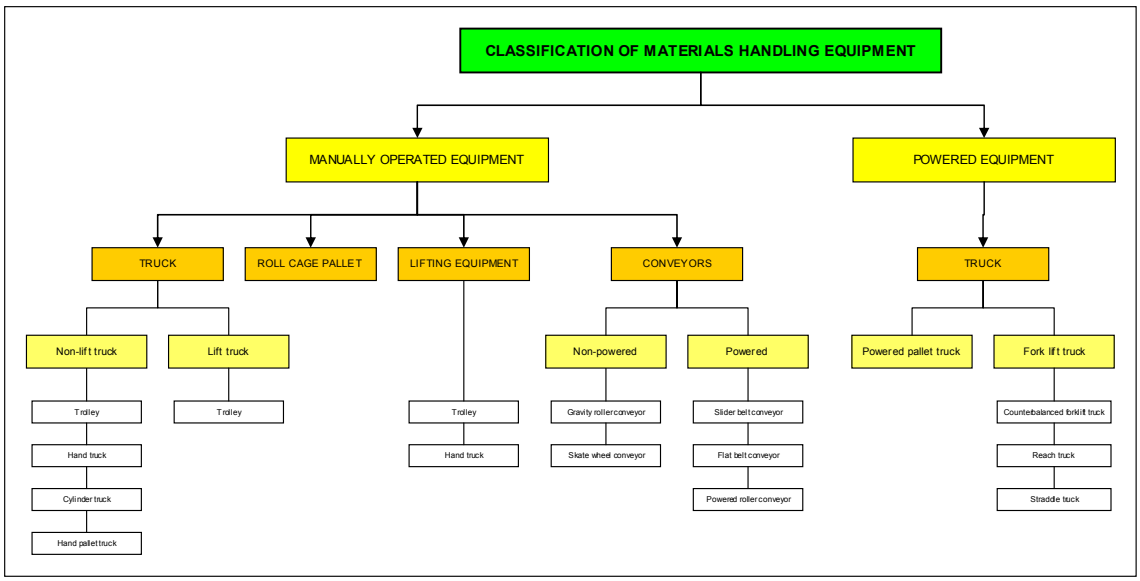

Figure 17.21 Classification of materials handling equipment

The placing of appropriate and sufficient materials handling equipment at the disposal of staff is sometimes neglected although it is usually not expensive. Materials handling equipment can increase the efficiency of materials handling very significantly, facilitates keeping the stock in order and reduces the probability of occupational injuries caused by lifting and moving heavy loads. Providing at least mechanical materials handling equipment as soon as a medical storage facilities are set up should be considered as a priority.

Materials handling method	Advantages	Disadvantages
Manual	• Readily available. • Requires no investment. • Flexible.	• Slow and Inefficient. • Danger of occupational injury. • Exhausting. • Requires more staff.
Mechanized	• Inexpensive. • Ease of use. • Requires little training. • Very efficient.	• Requires level and flat floors. • Requires maintenance.
Powered	• Very efficient. • Reduces need for staff.	• Expensive. • Requires fuel. • Requires maintenance.

Table 17.31 Advantages and disadvantages of materials handling equipment

Although materials handling equipment requires capital investment it may be cheaper than employing (additional) staff for moving goods. Moreover it should be considered as an asset which can be used for many years if it is properly maintained.

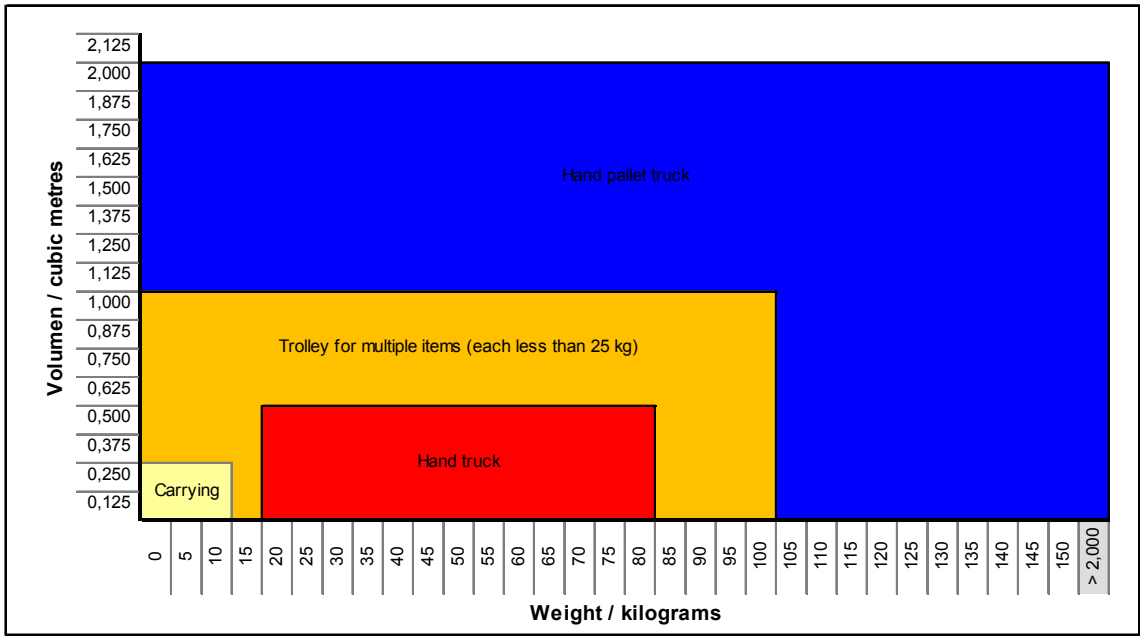

Figure 17.22 Criteria for selection of materials handling methods

Staff should not have to carry and lift heavy goods all day since this work is exhausting especially in hot climates. Moreover if goods are handled efficiently staff is freed up for more important work.

On the other hand materials handling equipment should be carefully selected and expensive equipment should only be purchased if it is really needed.

The selection of materials handling equipment depends on a number of criteria (see table 17.32). Some of the criteria are interdependent. For example the aisle width determines the selection of materials handling equipment and vice versa.

- Type of goods being handled.
- Average weight and size of loads.
- Flow of goods (volume and weight of goods handled per day).
- Distance loads need to be transported.
- Packing and load unitization (boxes, bags, pallets, drums, roll-cage pallets etc.).
- Type of storage equipment (floor pallets, pallet racking, shelves).
- Height of storage equipment.
- Width of aisles.
- Requirement for horizontal or vertical movement (especially during loading and unloading).
- Capital cost of equipment.
- Operating cost of equipment.

Table 17.32 Criteria for selecting materials handling equipment

Load unitization, materials handling equipment and storage equipment are interdependent.

The type of materials handling equipment is mainly determined by the type of goods while the number of pieces of equipment is mainly determined by the throughput of the store.

17.7.1 Safety

The primary concern with the use of materials handling equipment must the safety of staff. Materials handling equipment must be appropriate and well maintained. Staff must be trained and know how to use it properly.

Possible dangers are:

- Injury by materials handling equipment
- Goods falling off handling equipment

All materials handling equipment must be used in accordance with the operating instructions of the manufacturer and materials handling equipment must not be overloaded.

17.7.2 Manual handling

Manual handling (lifting and carrying) does not require any materials handling equipment and is a flexible and efficient means of handling of goods of limited size and weight over small distances. Manual handling is the most versatile method for materials handling as people can lift, lower, turn, stack and unstack goods. People can climb up and down steps, step over small obstacles, move on uneven surfaces and work in narrow aisles.

The weight that can be handled safely by one person is limited to 35 kilograms. The main disadvantage is that handling large amounts, for example of infusions, is time consuming and prone to cause occupational injury without adding any value. Carrying goods by hand requires much more energy than moving the same goods on trucks or trolleys.

Dropping of parcels cannot only injure staff but also cause damage of goods, especially health care equipment. Especially in hot climates, handling heavy loads can quickly lead to

exhaustion. Manual handling of heavy goods requires a sound grip, especially on heavy equipment, which may not be available on some loads.

Unloading vehicles manually is not only time consuming and inefficient in terms of labour costs, it also means that vehicles cannot be used for other purposes during this time.

Lifting, stacking and carrying loads all day is cumbersome, boring and staff is unavailable for more important work. Consequently manual handling should be limited to loads which are small, handled infrequently and moved over short distances.

17.7.3 Manually operated materials handling equipment

Manually operated materials handling equipment should be considered whenever heavy loads or large quantities of goods need to moved frequently over greater distances.

Manually operated materials handling equipment is inexpensive, easy to use and requires little training and maintenance. It increases the efficiency of materials handling considerably and eases the burden of warehouse staff.

One major advantage of materials handling equipment in general is that unit loads can be moved rather than moving individual items or packaging. Especially palletized goods can be unloaded, moved in the warehouse and loaded without the need for removing any goods from the pallet.

Materials handling equipment	Load capacity	Unit loads	Use
Trolley / platform truck	150 - 500 kg	Boxes.	Put-away. Order picking.
Roll cage pallet	200 - 500 kg	Boxes.	Put-away. Order picking.
Hand truck	100 - 300 kg	Boxes.	Loading and unloading. Put-away. Order picking. Horizontal movement. Movement over ramps and steps.
Cylinder truck	100 - 250 kg	Medical gas cylinders.	Horizontal movement. Movement over ramps and steps.
Hand pallet truck	2,000 - 3,000 kg	Pallets, large boxes.	Horizontal movement of pallets. Loading and unloading. Put-away. Order picking.
Hand stacker truck	500 - 2,000 kg	Pallets, large boxes.	Horizontal movement. Vertical movement up to 2 metres.
Conveyors	20 - 400 kg / m	Small boxes.	Loading and unloading. Packing of kits.
Cranes and hoists	200 - 500 kg	Large boxes.	Loading and unloading.

Table 17.33 Types of manually operated materials handling equipment and their application

Manually operated materials handling equipment usually does not require any specific warehouse layout. Most equipment can be used in aisles which are conceived for access by staff.

Even though inexpensive, manually operated materials handling equipment requires a capital investment and floors of storage facilities must be flat and level. Use of mechanical materials handling equipment may be impossible if there are steps or thresholds. Most mechanical materials handling equipment is conceived for horizontal movement only. Equipment for vertical equipment, such as stacker trucks, are available but cumbersome to use.

Trolleys consist of a square base with wheels, an elevated handle and may be fitted with shelves, baskets or cages etc. Trolleys with a single platform and raised handle are also called platform trucks. Their width varies from 50 to 80 centimetres, their length from 80 to 150 centimetres and they carry 200 to 400 kilograms. Wheels should have diameters of around 10 cm to prevent getting stuck in small cracks or bumps in the floor. Two fixed wheels and two swivel wheels allow great flexibility and facilitate straight movement. Trolleys with four swivel wheels are more difficult to direct.

Trolleys are inexpensive, very flexible and can be used in narrow aisles. They are most appropriate for transporting small quantities and small loads. They are particularly useful for put-away and order picking from shelves. Trolleys can be fitted with (folding) ladders to give access to goods which are out of reach from the floor.

Figure 17.23 Platform truck

Roll cage pallets allow movement of large quantities of goods. They are suitable for order picking and especially useful for moving goods of various different and odd sizes. Unlike pallets, they do not require any additional materials handling equipment and can easily be loaded. The main disadvantage is their high cost.

Hand trucks consist of a small base with two wheels and two handles. Hard rubber wheels are preferable to pneumatic tyres since the later are more likely to be damaged.

Several boxes can be stacked on them or they can be used for moving heavy or bulky loads such as health care equipment packed in boxes.

Hand trucks are inexpensive, very manoeuvrable and can be used in narrow aisle. Heavy loads can be moved onto the hand truck without lifting them but simply tilting the load slightly and shoving the hand truck underneath.

Hand trucks can be used to move loads over ramps, steps and uneven floors.

One disadvantage is that the hand truck has to be held in balance and prevented from tilting during movement of goods.

Specially designed hand trucks can be used for moving large drums.

These are similar to hand trucks but have circular fixtures to prevent round gas cylinders from moving or falling during transport. Cylinder trucks are available for transportation of one or two medical gas bottles at a time.

Wherever medical gas cylinders are stored, cylinder trucks should be used since the loads are very heavy (up to 90 kilograms). Toppling over of bottles can lead to severe injuries but also damage the valve of the gas cylinders which can lead to rapid escaping of highly pressurized gas.

Figure 17.24 Hand truck

Whenever medical gas cylinders are moved, they must be tightly fastened to the cylinder truck with chains.

Of all materials handling equipment, the hand pallet truck must be the most versatile and efficient. Hand pallet trucks consist of a fork and a hydraulic lifting unit which are specifically designed for handling pallets. Manually moving the steering arm up and down, pumps the hydraulic system which lifts the fork a few centimetres off the floor to allow horizontal movement. Two small wheels can be turned with the steering arm and allow a very small turning circle which make hand pallet trucks extremely manoeuvrable.

The hand pallet truck should be fitted with a lever to disengage the hydraulics for lowering the forks as well as a break for stopping the moving hand pallet truck.

Hand pallet trucks are inexpensive and simple but nevertheless allow a single person to manually move loads of up to 2,000 kg with great ease.

Hand pallet trucks can be used for unloading and loading of vehicles as well as internal movement of palletized goods in medical storage facilities.

Hand pallet trucks require level and flat (concrete) floors for effective operations. Especially when heavy loads are moved, a small bump in the floor will prevent further movement. Stone or brick floors must be levelled with a layer of concrete or asphalt. Moving heavy loads on inclined surfaces, even if they are even, is difficult and can be dangerous.

Figure 17.25 Hand pallet truck

Hand stacker trucks are similar to hand pallet trucks but allow vertical hydraulically lifting of up to 2,000 kg to a height of a maximum of 2 metres. Horizontal as well as vertical movements are powered manually.

Stacker trucks consist of a straddle frame (outrigger legs) with wheels which remains on the floor at all times and prevents the stacker truck from tilting. Two forks which can support a pallet, can be moved vertically with a hydraulic device.

Stacker trucks allow improving vertical utilization of the storage space as well placing pallets on adjustable pallet racking. However the vertical movement is cumbersome and time-consuming, at least for manually powered equipment, and is therefore not appropriate for handling large quantities of pallets.

Because the straddle frame must remain on the floor at all times and cannot always be pushed underneath a vehicle, stacker trucks may not be appropriate for unloading or loading pallets from or onto trucks.

Pallets can be placed on adjustable pallet racking but the straddle frame must be able to enter the space below the pallet rack, either in an empty bay or below a pallet placed on the floor.

Conveyors allow continuous movement of unit loads such as cases and cartons between two specific points and are suitable where throughputs are high.

A large variety of gravity as well as (electrical) powered conveyors are available for various applications. Conveyors allow horizontal and vertical movements as well as movement around corners and up and down inclines. Conveyors can be mobile or installed permanently.

A 'slider bed' consists of a belt sliding on a sheet metal bed and can be used for light loads. Such powered conveyors can be used for loading vehicles. The friction increases with the weight of loads and for heavier loads the belt requires support by rollers. The belts can be made from rubber, plastic, fabric, steel, steel mesh or composites.

Figure 17.26 Hand stacker truck

Gravity roller conveyors consist of parallel rollers over which parcels glide down an incline. The rollers should be spaced so that at least three rollers are in contact with the load at all times. Loads must have a flat, smooth and firm bottom. Gravity roller conveyors can be used for unloading large amounts of medium sized parcels from vehicles. The incline must be carefully selected to avoid excessive speeds and the end of gravity roller conveyors are usually fitted with stops to prevent goods from dropping to the floor.

Powered-roller conveyors are similar to gravity roller conveyors but the rollers are driven by a motor. They can have various widths and can carry loads of up to 1,500 kg/metre. Powered-roller conveyors should be used only for horizontal movements and not be inclined.

Skate wheel conveyors consist of discs fitted on to spindles which are mounted between side channels and are suitable for light loads with rigid bases. These conveyors are faster than skate gravity roller conveyors and therefore require less incline. Skate wheel conveyors can be fitted with a pantograph framework which allows to extend or shorten them as needed and are often used for unloading vehicles.

Conveyors have the advantage that they require handling only at the end points and movement in between is automatic. Conveyors are quiet, handle goods gently and can operate at high throughputs. They are efficient and reduce the need for lifting and lowering goods, especially during unloading. They are comparatively expensive but require little maintenance and incur little operating costs. Conveyors can be used across uneven floors, in confined spaces and for moving loads through narrow doors.

Advantages	Disadvantages
• Low operating costs. • Handling only needed at end points. • Quiet. • Handle goods gently. • Require little maintenance. • Can be used across uneven floors. • Can be used in confined spaces.	• Mainly for straight movements. • Fairly inflexible. • Expensive. • Difficult to control speed (gravity powered conveyors). • Only for light loads. • Loads must have flat and firm bottom.

Table 17.34 Advantages and disadvantages of conveyors

The disadvantages of conveyors are that they are only suitable for fixed routes and mainly intended for straight movement. In unpowered conveyors the control of speed may be difficult. The position of mobile conveyors can be changed but requires changes every time the end points change. Conveyors can become obstacles for people and other materials handling equipment.

The low throughput and small size of most medical storage facilities will generally not justify the use of conveyors, especially since they are quite expensive. However they may be used for unloading and loading vehicles. Fixed horizontal roller conveyors may also be used for manufacturing kits.

Cranes and hoists are used for regularly lifting and lowering heavy loads in a defined area. They are usually fixed in a location and are therefore less flexible than other materials handling equipment but can also be mobile.

Equipment can be operated manually but for heavy loads powered equipment is more appropriate. It is mainly used for unloading and loading heavy loads such as large equipment (autoclaves, OT-table etc.) from vehicles and ships.

17.7.4 Powered materials handling equipment

Powered materials handling equipment allows moving heavy goods and large quantities of boxes or pallets quickly and efficiently over long distances. It is especially useful for loading and unloading vehicles or aircraft. Use of powered materials handling equipment reduces the danger of occupational injury from lifting and carrying. Especially heavy loads and equipment are less likely to be damaged than by manual handling.

As powered materials handling equipment usually allows horizontal as well as vertical movement, space utilization of storage facilities can be increased considerably, for example by using adjustable pallet racking. Two tiers can be served by manually operated stacker cranes but for higher tiers powered materials handling equipment is necessary.

Powered materials handling equipment is expensive, incurs operating costs and requires maintenance. Floors must be level and even and must be able to support heavy equipment as well as the carried loads.

Staff need to be trained, especially to ensure their safety and the safety of other warehouse staff.

Areas should be dedicated to the operations of powered materials handling equipment, be separated from surfaces dedicated for pedestrians and marked on the floor to avoid accidents. Special care must be taken when driving through doors.

Materials handling equipment	Load capacity	Travelling speed	Use
Pedestrian electric pallet truck	1,300 - 2,000 kg	4 - 6 km/h	Horizontal movement of pallets. Loading and unloading. Put-away. Order picking.
Order picking truck (rider truck)	2,000 - 3,000 kg	5 - 13 km/h	Horizontal movement of pallets. Loading and unloading. Put-away. Order picking.
Powered pedestrian stacker truck (straddle truck)	1,000 - 2,000 kg	4 - 6 km/h	Horizontal movement. Vertical movement up to 5 metres. Loading and unloading. Put-away. Order picking.
Reach truck	1,000 - 3,500 kg	10 - 12 km/h	Horizontal movement. Vertical movement up to 8 metres. Put-away. Order picking.
Counterbalanced forklift truck	1,000 - 5,000 kg	10 - 22 km/h	Horizontal movement of pallets. Vertical movement of pallets. Loading and unloading. Put-away. Order picking.

Table 17.35 Types of powered materials handling equipment and their use

Pedestrian electric pallet trucks, also called pedestrian low lifter, resemble hand pallet trucks, but they are fitted with small platforms for the driver and horizontal as well has vertical movements are electrically powered by a battery.

This equipment, which lifts pallets around 20 cm off the ground is used for the same purposes as hand pallet trucks but is warranted when high volumes or heavy loads have to be transported over long distances.

In large warehouse low-level order picking trucks can significantly increase efficiency of warehouse staff. Picking staff can travel faster by riding on the order picking truck and does not need to pull or push a trolley or truck.

Intermediate and high-level order picking trucks for picking from adjustable pallet racking are available but expensive.

Powered pedestrian stacker trucks are the simplest type of high-lift materials handling equipment, can handle up to 2,000 kg and have a vertical range of about 5 metres. They are most appropriate for lighter loads and stores with low throughputs. Vertical and horizontal movements are powered electrically and staff have to walk behind the equipment while it is moving although stand-on and rider versions are available.

Figure 17.27 Pedestrian electric stacker truck

During lifting and movement with an elevated load, the powered stacker truck must be stabilized by straddle legs (outrigger legs) which remain on the floor at all times. When approaching the adjustable pallet racking for lifting or placing a pallet, the outrigger legs must run below the storage equipment. This can be accomplished by outrigger legs being positioned

underneath a pallet or below an elevated beam on which the lowest pallet is placed. In straddle trucks (wide track stacker), the outrigger legs are placed left and right of the pallet which is placed on the floor.

Powered pedestrian stacker trucks allow handling of entire pallets on adjustable pallet racking at lower cost and in less wide aisles than with other materials handling equipment.

Lifting with powered pedestrian stacker trucks is less efficient than for example with a counterbalanced forklift truck. However it is suitable for stores with low throughput which requires infrequent handling of goods at tiers above the floor level.

The flexibility is limited by the protruding straddle legs which preclude use on docks and for loading or unloading vehicles.

Reach trucks are usually electrically powered and similar to counterbalanced forklift trucks. However the whole mast can be retracted to move the centre of gravity nearer to the centre of the base during horizontal movement. Therefore reach trucks are shorter and can operate in more narrow aisle. Since they do not require a weight to counterbalance the load, they are lighter.

Figure 17.28 Counterbalanced forklift truck (diesel)

Before the load is placed on or picked up from the adjustable pallet racking, the whole mast is moved outward to place the forks above the adjustable pallet racking. Therefore the straddle legs do not have to enter underneath the pallet racking and reach trucks can also be used for loading and unloading vehicles. However because of the complexity of the mechanism

to move the mast, reach trucks are more expensive than straddle trucks or counterbalanced forklift trucks.

Reach trucks can travel at around 10 - 12 km/h and are slower than counterbalanced forklift trucks. They can handle between 1,000 to 3,500 kilograms and lift them up to 8 metres. Depending on the equipment, the load size and the lift height, aisles need to be 2.5 - 3 metres wide. Compared to counterbalanced forklift trucks they require less space for manoeuvring and can operate in more narrow aisles.

Counterbalanced forklift trucks (CBFLT) have two forks protruding in front of the front wheels for lifting and carrying pallets.

The force exerted by the load carried on the forks which tends to tilt the truck is balanced by the trucks own weight behind the front axle as well as a heavy counterweight set over the rear wheels. Because they need no outriggers to stabilize the truck, they can approach storage equipment and vehicles.

Counterbalanced forklift trucks are available in a wide variety of sizes and capacities. Electrical powered models can be fitted with three or four wheels. Their lifting capacities range from 1,000 kilograms for small models up to 45,000 kg for handling containers. They can lift loads up to around 8 metres high.

The maximum slope an electric forklift truck can negotiate, also called the gradeability, depends on the manufacturer specifications but is not more than 15% (Mulcay, D.E. 2007, 112) under ideal conditions and under general conditions the slope should not exceed 10% (that is one metre height over a distance of 10 metres). The maximum gradeability for forklift trucks with internal combustion engines is 20 - 25% (Mulcay, D.E. 2007, 112) under ideal conditions but, again, depends on the manufacturer's specifications.

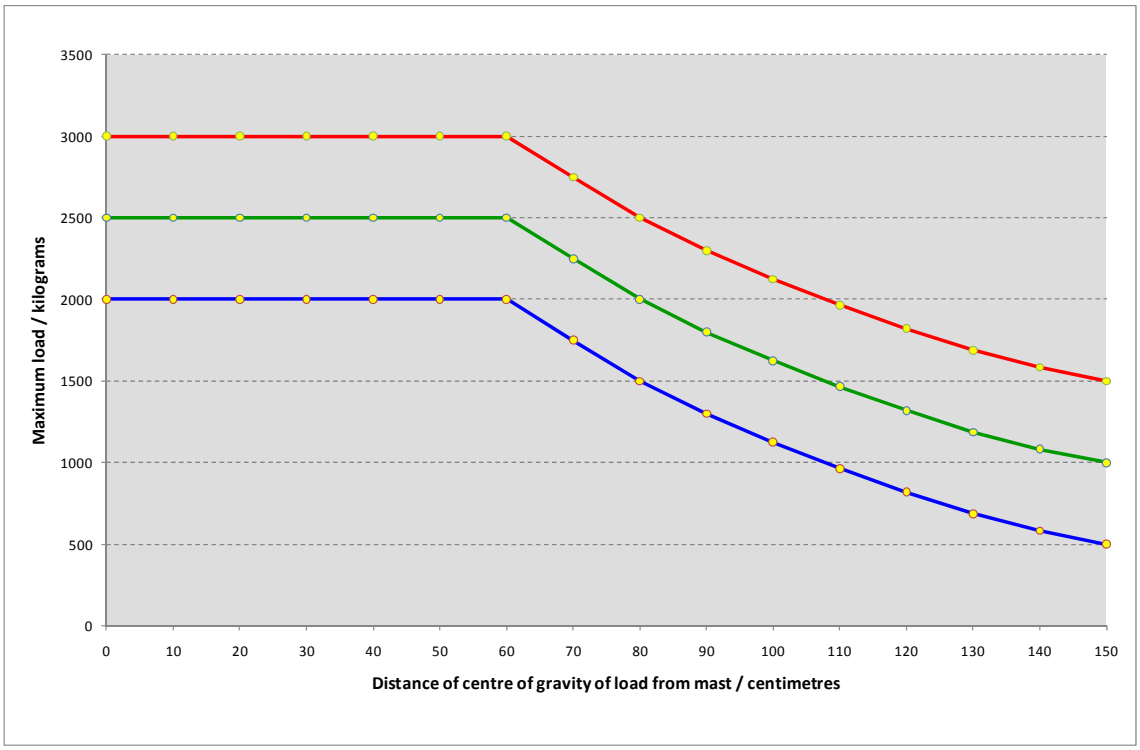

Figure 17.29 Example of a load capacity chart

The maximum weight that can be lifted depends on the size of the load, its centre of gravity as well as the lifting height. Manufacturers quote the maximum capacity in relation to a

specified distance of the centre of gravity of the load from the heel of the forks. An example of a load capacity chart, which must be displayed on every forklift truck, is shown in figure 17.28. The larger the distance between the heel of the forks and the centre of gravity of the load and the higher the load is lifted, the lower the maximum weight that can be lifted safely without risking the counterbalanced forklift truck to tip over.

In addition counterbalanced forklift trucks are "de-rated" depending on the height the load is lifted. The higher a load is lifted, the less stable the truck becomes and the lower the maximum load that can be carried is.

The operator rides on most counterbalanced forklift trucks but some pedestrian-operated versions are available where slower horizontal movement is sufficient.

Counterbalanced forklift trucks can lift loads up to 7 metres and are available with single stage, two stage (duplex) and three stage (triplex) masts. Generally the mast extends when the forks begin to rise. The maximum lift height increases and the total closed height decreases with the number of stages. The "free lift" counterbalanced forklift truck allows lifting and lowering the forks without extending the mast. These special trucks are needed for operating inside containers for loading and unloading as well as when working in stores with low headroom.

Masts can usually be tilted forward about 5 degrees to facilitate picking up and setting down pallets and about 12 degrees backward to stabilize the load during horizontal movement.

Figure 17.30 Electric counterbalanced forklift truck

Some counterbalanced forklift trucks allow adjusting the width of the forks to the load. Counterbalanced forklift trucks are designed for lifting and moving pallets and large loads with

flat bottoms such as equipment in timber boxes. Various powered and non-powered truck attachments allow additional movement or handling loads for which the use of forks are inappropriate. Since all attachments have a weight of their own, they reduce the capacity and the counterbalanced forklift truck must be de-rated accordingly.

Non-powered attachments include clamps for moving drums and coils. Forks can be replaced by booms or poles for moving reels and coils.

Powered attachments such as side shifts, allow moving the forks and the loads by about 8 cm left and right and are useful for accurately positioning goods on adjustable pallet racking or while loading containers.

Hydraulic operated clamps allow handling cartons, bales, reels and drums. Rotating heads allow changing the orientation of loads such as reels.

Small models may have only three wheels for increased manoeuvrability but most counterbalanced forklift trucks have four wheels. There are also pedestrian controlled models in the smaller sizes. Most counterbalanced forklift trucks use rear wheel steering to decrease the turning cycle.

Counterbalanced forklift trucks can be powered by combustion engines run on diesel, gasoline, compressed or liquefied bottled gas or be powered by electric motors and can have dual power systems.

Because combustion engines develop toxic exhaust fumes, only electric motors should be used indoors. Electric powered counterbalanced forklift trucks are also compact, reliable, clean and quiet. They provide high initial acceleration and are suitable for intermittent work. One disadvantage is the large weight of the batteries and the long time needed for recharging batteries. Electric powered counterbalanced forklift trucks have capacities of up to only 5,000 kg and can travel at speeds of up to 25 km per hour.

Gas operated counterbalanced forklift trucks produce fairly little amounts of exhaust and can be used indoors provided the store is sufficiently ventilated. Counterbalanced forklift trucks powered by combustion engines are suitable for outdoor work on docks, airports and seaports. They are more robust, can move heavier loads can travel faster and be refuelled quickly.

Compared to other powered materials handling equipment, counterbalanced forklift trucks are moderately expensive. They can travel at fairly high speeds and are excellent universal and flexible machines which allow horizontal movement as well as lifting to considerable heights. They are efficient and allow handling large volumes of goods with high throughputs. The vertical movement allows considerably increasing the utilization of warehouse capacities by block stacking or use of pallet racking. They can be used for loading and unloading vehicles as well as movement of goods in stores. Large wheels allow operation on uneven surfaces as well as outdoors.

Because they handle whole pallets, they are an efficient means of materials handling. Pallets can be handled from the short as well as the long side.

Compared to manually operated materials handling equipment, counterbalanced forklift trucks have the disadvantage of being dependent on fuel and maintenance. In places where services and workshops are not available, dependence on counterbalanced forklift trucks can be risky.

Because this equipment is powerful it is also dangerous. Counterbalanced forklift trucks can travel at fairly high speeds with heavy loads and are therefore a risk to pedestrian staff working in the warehouse.

Powered Materials handling equipment	Advantages	Disadvantages
Motorized trolleys	• Low capital cost. • Low operating cost. • Very flexible. • High efficiency.	• Low capacity. • Requires individual loading and unloading of each parcel.
Order picking trucks	• Order picker can travel on equipment (does not need to walk).	• High capital costs. • Rider has to step on and off at every location.
Pedestrian-controlled electric pallet truck	• Movement of goods far easier than with hand pallet trucks. • Flexible. • Fast. • Can carry large and heavy loads.	• Capital costs. • Requires maintenance. • No facility for staff to ride on.
Powered pedestrian stacker	• Allows lifting of goods. • Can operate in more narrow aisles than other equipment.	• No facility for staff to ride on. • Limited lifting height. • Limited lifting capacity.
Reach truck	• Shorter than counterbalanced forklift trucks. • Can operate in narrow aisles.	• Low horizontal travelling speed.
Counter-balanced forklift truck	• Can move large and heavy loads. • Horizontal as well as vertical movement.	• Expensive. • Requires fuel. • Operating costs. • Maintenance costs.

Table 17.36 Advantages and disadvantages of powered materials handling equipment

Because of its construction and because the forks cannot be retracted, counterbalanced forklift trucks require wide aisles of 3 - 4 metres for turning before setting down or taking up loads. These wide aisle reduce space utilization of the warehouse and reduce the amount of storage equipment which can be installed.

17.8 Other warehouse equipment

Besides storage and materials handling equipment, a range of other equipment (see table 18.38) is essential for setting up medical storage facilities as well as for allowing effective and efficient warehouse operations.

Protective clothing such as heavy duty gloves and safety shoes should be available for staff in order to reduce the risk of occupational injuries and a complete first aid kit must be available to assist staff in case of injury.

Smoke detectors must be installed in store rooms as well as offices for early detection of fires, ideally a complete fire alarm system should be installed and appropriate and sufficient fire fighting equipment must be installed.

Various forms such as bin cards and stock cards as well as temperature control charts should be available in the office.

Figure 17.31 Safety shoes

The office or office area should be equipped with basic furniture, office equipment and a calculator should be available for each storekeeper.

The respective logistics handbook as well as the standard item catalogue of the humanitarian organization should be readily available as a reference for warehouse staff. The national Essential Drug List of the respective country, the WHO Model Formulary as well as standard references such as "Essential Drugs" (MsF 2005) or the "British National Formulary" (British Medical Association and Royal Pharmaceutical Society, 2010) should be available as reference for warehouse staff as well as advising customers. The National Drug Act of the respective country as well as copies of any other pharmaceutical legislation or regulations should also be available as a reference.

a) **Safety**

- Protective clothing (gloves, safety shoes).
- First aid material.
- Smoke detectors.
- Fire alarm system.
- Fire fighting equipment.

b) Administration

- Bin cards.
- Stock cards.
- Temperature control charts.

c) Office equipment and Stationery

- Furniture (desk, chair).
- Calculators.
- Scissors.
- Stapler, staples and stapler remover.
- Office hole punch.
- Ruler.
- Paper (writing pads, printer paper).
- Pens, pencils, permanent markers, highlighters.

- Adhesive tape and glue.

d) Library

- Logistics handbook (of humanitarian organization).
- Logistics and supply chain management books.
- Standard item catalogue.
- National essential drug list.
- WHO Model Formulary.
- Essential Drugs (MsF).
- British National Formulary (or similar publication).
- National Drug Act.

e) Packing equipment

- Master cartons (three different sizes, empty).
- Tape dispensers.
- Packing tape (good quality).
- Stretch wrap film.
- Adhesive packing tape (for example 50 mm wide).
- Box cutters.
- Stickers.
- Industrial electronic floor scale.

f) Cleaning equipment and materials

- Rubbish bins (100 litres).
- Safety containers.
- Bucket (20 litre, for cleaning).
- Mop.
- Brooms (industrial).
- Brooms (house hold).
- Hand brush.
- Brush and dust pan.
- Clothes (for cleaning).
- Detergent (house hold).
- Plastic bags (150 litres).

g) Tools

- Rechargeable light.
- Level (approximately 40 cm).
- Measuring tape (50 metres).
- Crowbar (50 cm).
- Carpenter hammer (with nail claw).
- Saw.
- Pliers.
- Nails.

Table 17.37 Other warehouse equipment

For opening parcels box cutters are needed and for packing consignments at least three different sizes of master cartons, tape dispensers of good quality and high strength packing tape must be available. Adhesive stickers for marking parcels with consignee and destination as well as marking required storage and handling conditions should be available. An electronic

industrial floor scale is needed to accurately weigh each parcel, especially if they are being shipped by air.

Large rubbish bins with a volume of at least 100 litres must be set up in the receipt and dispatch area as well as throughout the storage area and large plastic bags should be available for final disposal. Safety containers must be available to collect broken glass or sharps from health care goods damaged during transport or during storage. For cleaning a range of brushes, brooms, mops, buckets, clothes and detergent must be available.

A rechargeable lamp should be available to allow working in the warehouse in case of a power failure. A level is needed for setting up and checking the appropriate positioning of refrigerators and ice-pack freezers. A long tape measure (50 metres) should be available for measuring the warehouse and drawing a plan.

Some basic tools such as a saw, carpenter hammer, pliers, crowbar and nails should be available for opening, repairing and closing timber boxes as well as for repairing floor pallets.

17.9 Other warehouse facilities

Apart from the storage equipment and the respective storage area, some other warehouse facilities are necessary for allowing efficient warehouse operations and accommodating warehouse staff.

Depending on the conflict and type of weapons in use, a (bomb) shelter (see chapter 5.2.8) which is large enough to accommodate all staff must be available at the warehouse.

a) Security

- Shelter (against conflict related risks).

b) Warehouse operations areas

- Receipt area.
- Quarantine area.
- Storage area.
- Packing area.
- Staging and dispatch area.
- Equipment parking and service area.

c) Office (area)

d) Amenities

- Lockers.
- Changing rooms.
- Staff rest area.
- Cooking facilities.

e) Sanitary facilities

- Bathrooms.
- Washing facilities.
- Waste disposal.

Table 17.38 Other warehouse facilities

17.9.1 Warehouse operations areas

While allocation of space for storage equipment is obvious, the great importance of other essential areas is sometimes overlooked or underestimated. However for effective and efficient warehouse operations additional areas are indispensable.

A dedicated receipt area is required for temporary storage of unloaded and received consignments which need to be counted, inspected, recorded, possibly sorted and repacked, placed on or in unit load systems and put away. A dedicated area for storing empty unit loads such as small containers as well as floor pallets is also essential.

A dedicated quarantine room, area or at least lockable cupboard is needed for storing health care goods which are damaged, expired or have been recalled by the manufacturer.

An area with large packing tables (approximately 1 x 2 metres) dedicated to checking, counting, recording and packing consignments, as well as marking and labelling of cartons and boxes is also essential. In the packing area dedicated shelves should be set up for storing packaging material such as tape and empty master cartons as well as packing equipment such as tape dispensers.

Figure 17.32 Packing table

Finally, an area needs to be dedicated for consolidating consignments by customers, staging (temporary storage) and for loading as well as dispatch of consignments.

A dedicated area should be foreseen for parking, maintaining and servicing materials handling equipment. For electrical powdered counterbalanced forklift trucks an area for charging and servicing must be available. Battery charging areas for electrically powered materials handling equipment should be well ventilated since batteries vent hydrogen during charging which is explosive when it is mixed with air. Floors should be protected from accidental spillage of acid.

However, any materials handling equipment powered by gas or diesel should be parked in a separate building when the warehouse is closed to reduce the risk of fires damaging the

medical storage facility. In order to reduce the fire hazard, fuel stores for diesel or bottled gas should be located outside medical storage facilities in separate buildings.

17.9.2 Offices

An office or at least a dedicated office area is necessary for the medical warehouse manager as well as storekeepers in any medical storage facility for maintaining records, issuing documents and other administrative work. With the exception of very small stores such as holding only contingency stocks, a computer and printer will usually be necessary. An area should also be dedicated for maintaining records and archives. Ideally offices should allow overseeing the warehouse.

Figure 17.33 Warehouse office

The office (area) should be furnished with desks and office chairs, a filing cabinet as well as a cupboard for stationery and books (see table).

- Filing cabinet.
- Office chairs.
- Chairs (staff and visitors).
- Cupboard (administration, books, stationery).
- Desk.
- Desk lamp.

Table 17.39 Office equipment for medical storage facilities

17.9.3 Amenities

Good staff facilities motivate workers and encourage cleanliness. In cold climates they must be heated to room temperature, especially if the temperature inside the medical storage facility is maintained at a lower temperature (although above around 10° C in any case).

A changing room with lockers should be available for allowing staff to change their clothing before and after work.

A lounge or resting area should be available for taking (tea) breaks and resting as well as for holding meetings.

Cooking facilities, a kitchen, canteen or cafeteria should also be available but must be separated from the medical storage facility as they pose a fire hazard and may attract vermin and pests which could damage stored health care goods.

17.9.4 Sanitary facilities

Access to running water and sanitary facilities such as bathrooms and washrooms are necessary for personal hygiene, for cleaning purposes as well as maintaining cleanliness in general.

Facilities for temporary storage of waste before final disposal outside the medical storage facility or an incinerator on the warehouse premises or necessary for appropriate waste disposal. Damaged packaging material and superfluous fillers can cause considerable waste volumes.

17.10 Utilities

Medical storage facilities require basic utilities such as telecommunication equipment, electricity, lighting, water and waste water disposal, cooling, heating and ventilation (see table 17.40).

- Telecommunications.
- Electricity.
- Lighting.
- Water.
- Waste water disposal.
- Cooling.
- Heating.
- Ventilation.

Table 17.40 Utilities for medical storage facilities

17.10.1 Telecommunications

In order to be able to alert warehouse staff in case of a deterioration of the security situation, every medical storage facility must be fitted with some kind of telecommunication equipment. In order to ensure independence from public telephone networks which may be interrupted, a radio base station should be installed or staff should at least receive a hand-held radio transceiver.

Moreover telecommunications means are needed to facilitate the flow of information such as customer orders. Telephone, fax and data transmission lines are useful for larger medical distribution centres.

17.10.2 Electricity

Electricity is useful although not indispensable provided that storerooms do not require air-conditioning or electricity for refrigerators and ice-pack freezers.

Electricity may be needed for telecommunication equipment, security lighting, lighting inside the storage facility, water supply, cooling, heating, ventilation, telecommunication equipment, computers as well operating various appliances. Electricity may be provided from the mains electricity supply or from a generator set. Refrigerators, ice-pack freezer and some specialized appliance can be operated by solar power.

Connections to the mains electricity supply or generator set, cabling as well as installation of electricity switch boards must be carried out by professional technicians in order to ensure electrical safety and avoid creating fire hazards.

17.10.3 Lighting

Even if stores and warehouses have sufficient natural lighting, artificial lighting should be installed to allow working during evenings and nights in emergencies.

All offices and aisles as well as receipt and dispatch areas should be well lit. Areas where order picking takes place must be lit particularly well.

17.10.4 Water and waste water disposal

Water is needed for cooking, cleaning of the store, personal hygiene as well as toilets. If a sprinkler system or wall hydrants are installed a water tank is needed unless the public water supply has a sufficient capacity and is reliable.

A sewage system is needed to drain waste water from sanitary facilities as well as for draining rain water from the roof and impermeable surfaces such as concrete parking lots.

Water and drainage pipes should be in good condition as well as free of leaks any blockage. If no public sewage system is available, latrines can be built. Sewage can be disposed of in septic tanks.

17.10.5 Cooling

Most drug products require storage at room temperature (+ 15° to + 25° C) and health care goods such as single use gloves and catheters which contain latex should also not be exposed to high temperatures.

Careful selection of storage facilities and storerooms can decrease the internal temperature without the need for consuming energy.

As far as possible the walls of medical storage facilities should not be exposed directly to the sun. The roof should be well ventilated and reflect as much sunlight as possible and trees can shade buildings from direct sunlight.

The amount of radiation which enters the storage facilities and increases the internal temperature can be reduced by selecting buildings without or with small windows as well as covering windows with shades or curtains.

In multi-storey buildings the basement and rooms on the ground level will be cooler than rooms directly under the roof. Buildings with thick stone or concrete walls will warm up slower than buildings with thin walls.

If internal temperatures of storage facilities exceed the storage temperatures recommended by the manufacturer, first of all passive cooling measures can be selected.

When passive means of cooling are used, rooms should be at least 3 metres high. Hot air will rise to the ceiling and will disperse through ventilation openings in the wall below the ceiling. Vegetation around the building can help to cool the vicinity of buildings.

In climates with high day-night fluctuations of temperature, windows should be opened during the night to vent hot air which has accumulated during the day, and kept closed as far as possible during the day.

Active means of cooling storerooms include active ventilation and air-conditioning. Although ceiling fans can cool staff working in storerooms through increasing evaporation of water on their skin, ceiling fans do not cool storerooms and actually increase the temperature by circulating hot air which accumulates below the roof. Instead extractor fans should be installed in walls below the ceiling in order to increase cross ventilation by blowing hot air out of storerooms and drawing in cooler air from the outside, especially during the night.

Since air-conditioning is expensive in hot climate, a section of the warehouse should be dedicated to storage of health goods which require storage at controlled temperatures. The reduction of temperature through air-conditioning also decreases absolute humidity. The capacity of required air-conditioning equipment will depend on many factors such as the outside temperatures, exposure of storerooms to the sun, building materials as well as the number and size of openings in the building. However, as a rule of thumb, approximately 100 BtU cooling capacity should be calculated for every cubic metre of storeroom. Split units with separate indoor and outdoor units are easier to install, more reliable, more efficient and should be preferred to window units.

Figure 17.34 Split air-conditioning unit

Some health care goods such as dressing material, will not be damaged by high temperatures. Since dressing material for example is bulky the cost for air-conditioning can be reduced considerably by not cooling the entire medical storage facility.

In order to maximize flexibility and allow later changing the layout of the medical warehouse, ideally all store rooms should be heated and/or cooled. However, in case this is not possible for technical reasons, part of the warehouse or a store room can be partitioned with insulated wall and ceiling panels for creating a cool room for storage of health care goods at room temperatures.

Figure 17.35 Partitioning of store room for cool room

17.10.6 Heating

In cold climates all drug products must also be protected from low temperatures and at least prevented from freezing by heating storerooms.

If the installation and operation of heating systems is necessary, buildings should be well insulated in order to reduce energy consumption.

The heating system should not pose any fire hazard, ideally by installation of a central heating system. Some air-conditioning equipment can also be used for heating.

17.11 Stores layout

Planning of the stores layout must consider all the areas and facilities discussed above (see table 17.41).

Throughout the process of planning the layout of medical storage facilities, avoiding and minimizing safety hazards for warehouse staff must be a priority. For example by reducing the risk of accidents by clearly separating areas for pedestrians and areas where heavy materials handling equipment is used

Every pallet, shelf, cupboard, refrigerator or adjustable pallet rack should be accessible individually without having to move any goods out of the way and all stock should be easily accessible.

All the warehouse areas and facilities described above must be laid out and connected in a way which allows maximizing the effectiveness and efficiency of the flow of health care goods through the medical storage facility from receipt to dispatch.

The overall distance staff have to travel during activities, especially for put-away and order picking, should be minimized and staff should not get in each others way. Cross-flows of staff and goods as well as congestion of warehouse areas should be avoided.

A) Office and amenities

- Office area.
- Resting area.
- Facilities for preparing and eating meals.
- Change room and lockers.
- Sanitary facilities (toilets and showers).

B) Stores operations

- Parking area.
- Docks.
- Receipt area.
- Inspection and quality control area.
- Quarantine area.
- Storage area / equipment (floor pallets, shelving, adjustable pallet racking).
- Aisles and cross-aisles.
- Storage area of dangerous goods.
- Storage area for medical gases.
- Storage of internationally controlled drug products (room and/or cupboard).
- Cold storage (cold room or ice-lined refrigerators).
- Area for ice-pack freezers.
- Storage of empty pallets.
- Storage of packaging material.
- Storage of cold chain equipment (cold boxes, vaccine carriers, spare packs etc.).
- Parking and maintenance of materials handling equipment.
- Storage for goods awaiting disposal.
- Packing area.
- Staging and dispatch area.

C) Utilities and services

- Water pump (and if necessary water tank / water tower).
- Mains electricity supply (switch board or room).
- Telephone switch board .
- Server room.
- Central fire alarm switch board and fire fighting equipment.
- Store for cleaning material.
- Storage of waste before final disposal.
- Waste incinerator.

Table 17.41 Areas and facilities which the layout must consider

The overall movement of materials handling equipment as well as health care goods from the time they are received at the medical storage facility until they are dispatched should be minimized.

The main consideration for planning the layout of medical storage facilities is the ***effective and efficient flow of health care goods*** *from receipt to dispatch.*

The best possible use of available space should be made and the overall utilization of the medical storage facility should be optimized.

- Minimizing any hazards for staff arising from poor layout.
- Individual access to each piece of storage equipment.
- Good access to stock.
- Effective and efficient flow of health care goods.
- Minimal travelling distances for staff.
- Minimal cross-flows.
- Avoiding congestion.
- Minimal travelling distances of materials handling equipment.
- Minimal travelling distances of health care goods from the time of receipt until dispatch.
- Optimizing utilization of medical storage facility.

Table 17.42 Objectives for planning the layout of medical storage facilities

Generally medical storage facilities with a square or rectilinear layout are more efficient to operate than long and narrow facilities (Quick, J.D. (ed.) 1997, 386).

17.11.1 Layout of stores areas

There are two basic designs for the general layout of a medical storage facility (Rushton, A., Ph. Croucher, and P. Baker 2008, 325):

- Through-flow: receipt area and dispatch area are located at opposite sides of the medical storage facility, each near an entrance.
- U-flow: receipt and dispatch area are located at the same side of the medical storage facility. Ideally the building has two entrances on the same side but in some cases only a single entrance will be available.

The through-flow layout has the advantage that incoming and outgoing goods are clearly separated and are not confused and mixed up. Cross-flows and congestion are also unlikely. Therefore the through-flow layout should be preferred to the U-flow layout.

One disadvantage is that any item has to travel at least the entire distance from one entrance to the other from the time of receipt until dispatch which may increase the overall travelling distance.

The need for two entrances and doors, one at each of the opposite sides of the medical storage facility, makes ensuring that only authorized staff enter the building, more difficult. However, the entrance used for loading and dispatch of consignments can be kept closed (and locked) unless loading is taking place. A through-flow layout is not possible if the building has only a single entrance.

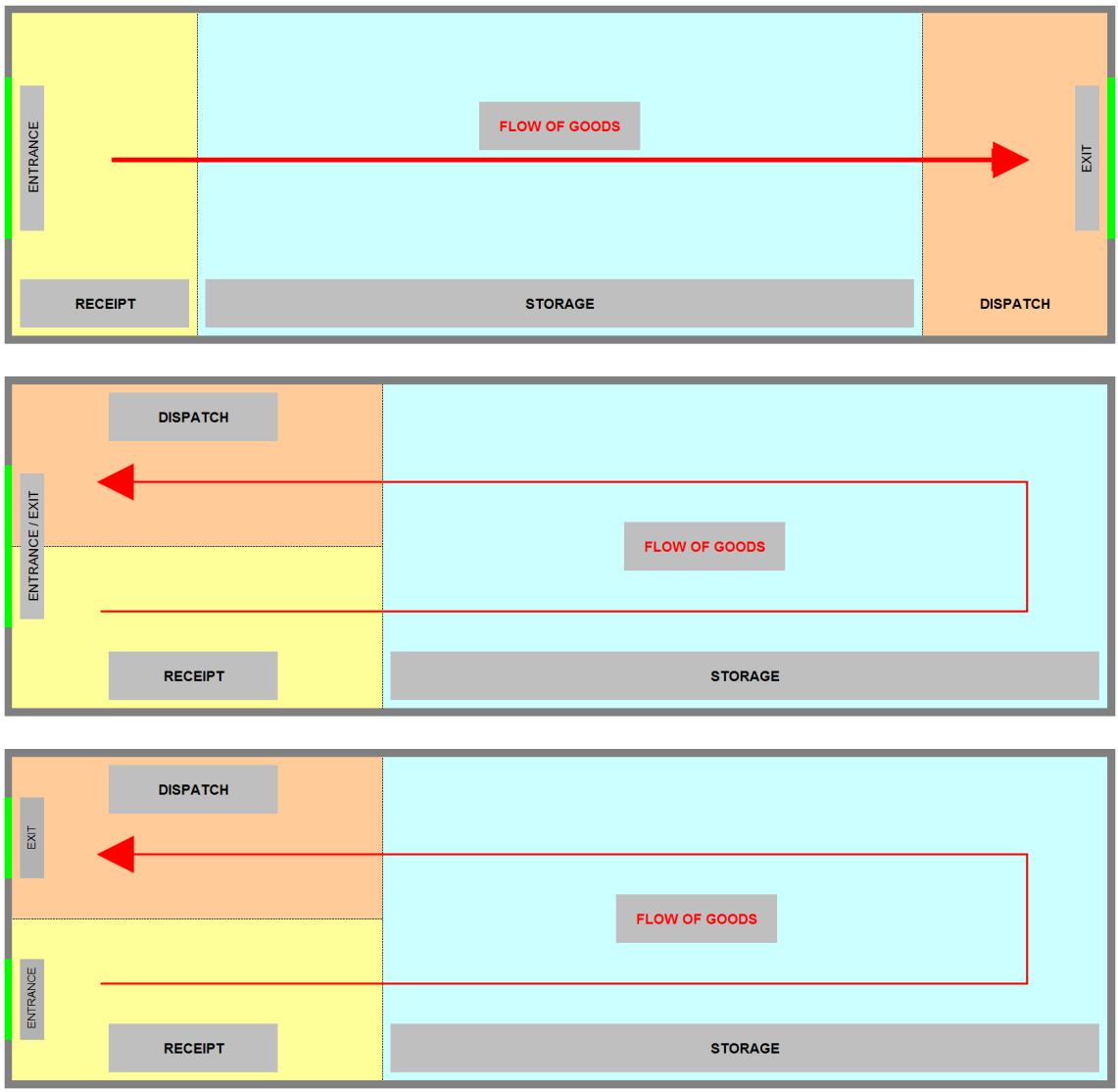

Figure 17.36 Through-flow and U-flow layout of medical storage facilities

Warehouse layout	Advantages	Disadvantages
Through-flow	• Clear flow of goods. • Reduced risk of mixing incoming and outgoing goods. • Reduced cross-flows. • Reduced likely of congestion.	• Overall longer travel distances. • Requires two entrances at opposite sides of the building. • Not possible if warehouse has only one entrance.
U-flow	• All entrances on one side of the building. • Better overview of receipt and dispatch of goods.	• Incoming and outgoing goods may be confused. • More difficult to clearly separate receipt and dispatch area.

Table 17.43 Advantages and disadvantages of through-flow and U flow layout

The U-flow warehouse allows the warehouse manager to oversee handling of incoming and outgoing goods simultaneously. Overall travel distances may be reduced because goods with a high turnover can be stored near the receipt area and goods with low turnover further away. A single entrance reduces the area required on the site.

The main disadvantage of the U-flow layout is that the receipt and dispatch area are not as clearly separated and incoming and outgoing goods can easily be confused, especially when the warehouse has only one entrance. However the receipt and dispatch area must be separated as much as possible for example by locating them at opposite sides of the entrance.

Whether a through-flow or a U-flow layout is selected, the different warehouse areas should be laid out adjacent to each other according to the flow of health care goods from receipt until dispatch.

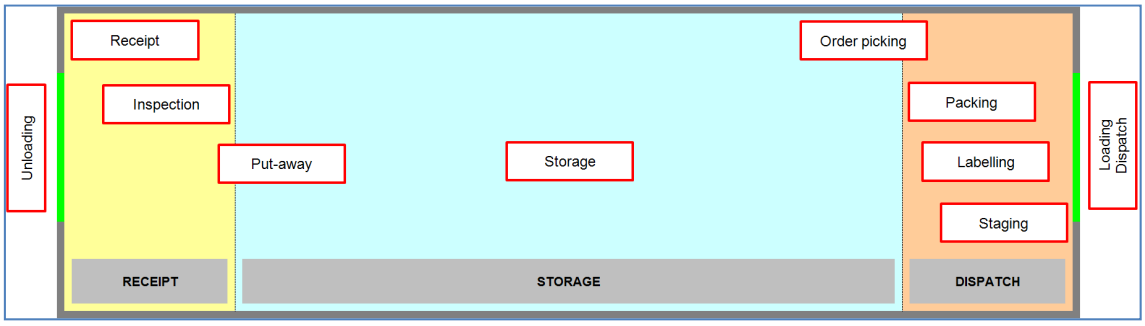

Figure 17.37 Flow of health care goods through medical storage facility

Other warehouse areas such as equipment parking, maintenance and service area, offices, amenities, sanitary facilities as well as service areas should be placed on the periphery in order not to interfere with the effective and efficient flow of goods through the medical storage facility.

The layout of the medical storage facilities should allow simultaneous receipt, put-away, order picking and packing of different warehouse staff without leading to cross-flows or congestion. Staff and materials handling equipment should not be getting in each other's way and as far as possible their paths should not cross each other.

The more staff are working in the warehouse and the more materials handling equipment is employed, the more consideration should be given to the flow of goods and the possibility of congestion.

The area for receipt, inspection, quarantine and repacking of goods must be located next to the entrance. This will avoid confusion of goods and reduce travel distances. Moreover all staff can be sure that any goods inside the storage facility have been inspected. In a medical storage facility with a U-flow layout and provided the entrance is located more or less in the middle of the building, the receipt area should located on the left side of the entrance.

While the size of the storage area is mainly determined by the volume of stored goods and the storage equipment, the size of the areas for receipt, quality control, packing, staging as well as the dispatch area is only determined by expected maximum throughput. For example a large contingency stock which is not regularly supplying health programmes does not need a large receipt and dispatch area. On the other hand, even a small store with a large throughput will require a large receipt and dispatch area.

If the throughput of a warehouse is high, the required size for the receipt and dispatch area also depends on delivery schedules. If large volumes are delivered and shipped infrequently, these areas must be larger than for regular delivery and shipment of small volumes.

Another consideration is the time for inspection, quality control and put-away. If these processes are slow, the receipt area must be large enough to hold the maximum volume of health care goods awaiting processing.

One major determinant for the size of the receipt and dispatch area is the availability of staff and materials handling equipment. The lower the capacity of staff and materials handling equipment the longer consignments will remain in the receipt area and therefore the larger the receipt area must be planned.

The packing, staging and dispatch areas must also be located near the entrance. In through-flow warehouses near the opposite entrance where the receipt area is located. In a medical storage facility with a U-flow layout, the dispatch area must be located on the opposite side of the receipt area.

The office area should be located near the entrance in order to all oversight of receipts and dispatches of consignments and as well as allow controlling access to the medical storage facility.

Amenities can be located on the periphery of the medical storage facility as staff will spend comparatively little time in these areas.

Sanitary facilities should be located on the perimeter of the building to allow natural ventilation and keep plumbing outside the building as far as possible.

17.11.2 Warehouse zones

All health care goods which are received must be stored in a systematic order to facilitate warehouse operations.

All health care goods must be stored in a zone that provides the required environmental conditions in terms of temperature and humidity as well as the required level of safety and security.

A warehouse zone is defined as an area which provides distinct environmental conditions, a certain level of safety or the required level of security. A zone can for example be a separate building, a storeroom within a warehouse, a walk-in cold room or a refrigerator. Some health care goods, such as internationally controlled drug products, may require storage in a cool room as well as at a high level of security.

Some warehouse zones may imply or require the use of specific storage equipment such as refrigerators or lockable cupboards.

The required environmental conditions are specified by the manufacturer and indicated on the packaging of health care goods. Health care goods such as some health care equipment may not be susceptible to high temperatures while others require storage at room temperature (+ 15° to + 25° C) or only protection from freezing.

Product information and labelling provided by the manufacturer indicates hazards health care goods may pose. The required level of security for internationally controlled drug products is determined by national legislation and regulations. Moreover the level of security will also depend on the risk of theft which may be high for internationally controlled drug products as well as antibiotics for example.

The number of items requiring specific storage conditions as well as their average stock levels will determine the required size each zone should have. For example a medical storage facility may require only a small steel safe or a reinforced vault for storage of internationally

controlled drug products. Cold chain loads may require only a single refrigerator or require a walk-in cold room.

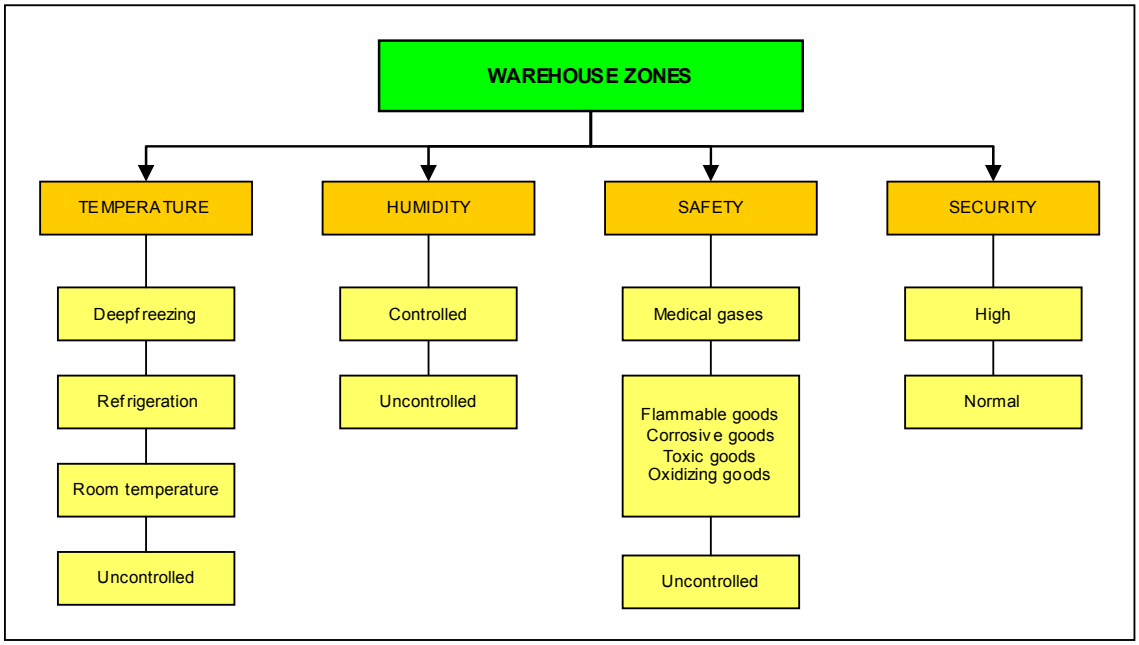

Figure 17.38 Classification of warehouse zones

Possible changes in the need for different zones as well as the capacity of individual zones should be taken into account from the very beginning. The zoning plan should be as flexible as possible to allow future changes such as extension of the cold room with a minimum of structural changes to the building.

17.11.3 Layout of storage equipment

The majority of space in medical storage facilities will be dedicated to the storage area. However only two thirds of the total surface should be reserved for storage while the remaining third must be planned for the receipt and dispatch area and the other required warehouse facilities.

*Reserve **2/3 of the area for storage** and 1/3 for other warehouse areas.*

The layout of storage equipment depends on the type and specifications of the storage equipment as well as the materials handling equipment which mainly determines the width of the aisles.

In general, storage equipment should be laid out in parallel rows and never along all four walls of a storeroom.

All storage equipment must be placed at least 10 centimetres away from (outside) walls. In hot climates outside walls heat up and will radiate heat at the inside of storerooms which can cause a substantial increase of the temperature of internal surfaces and may damage health care goods (Battersby and Garnett 1993, 42). Walls may be moist from water which moves from the foundations upward or from moisture condensing on walls.

Moreover in case of leaks in the plumbing system, water which leaks from walls or runs down walls is more likely to damage health care goods if shelving or pallets are placed directly against walls.

Never place any storage equipment or health care goods directly against walls.

Adjustable steel shelving should be set up in parallel rows with a distance of at least 10 cm from walls.

Shelving must never be placed in a square along all four walls of a storeroom as this wastes valuable storage space in the centre of the room (AHRTAG 1994, 10).

Never place shelving in a square along all four walls.

Always set up shelves in parallel rows.

Aisles between rows of adjustable steel shelving should have a width of at least 100 cm to allow easy access of staff, allow movement of staff carrying parcels as well as operating of materials handling equipment such as hand trucks or platform trucks.

Therefore a double row of standard adjustable steel shelving of 50 centimetres depth and with a 100 centimetre aisle requires 1 square metre of aisles for every square metre of storage equipment.

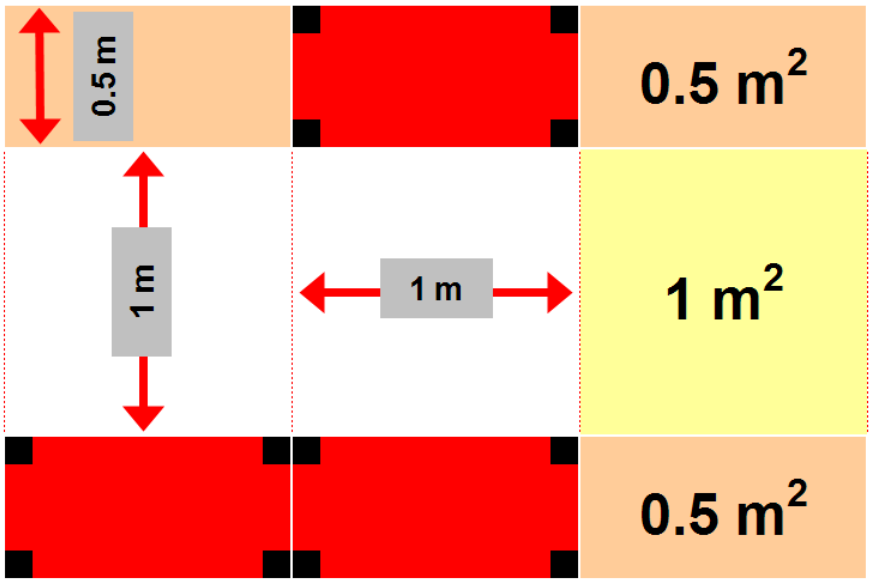

Figure 17.39 Calculation of surface area required for setting up shelves

In stores with large flows of health care goods and several store keepers two-way aisles with a width of 150 centimetres may be necessary.

In large storerooms cross-aisles should be foreseen every 5 to 10 metres in order to reduce the distance of movement when having to travel from one aisle to another.

Unfortunately pallets are sometimes laid out adjacent to each other entirely covering a certain surface. While this layout keeps goods off the floor, it is highly inefficient as it makes the use of materials handling equipment impossible and requires handling all goods manually.

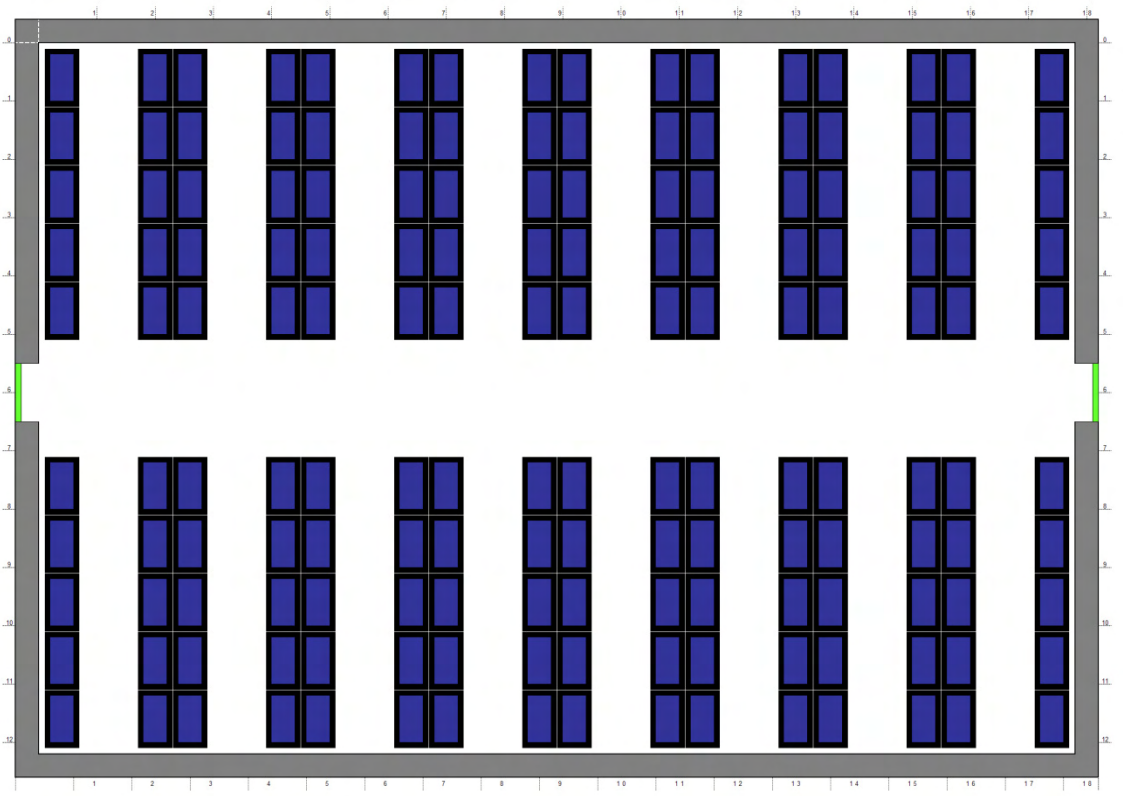

Figure 17.40 Layout of adjustable steel shelving with aisles and cross-aisles

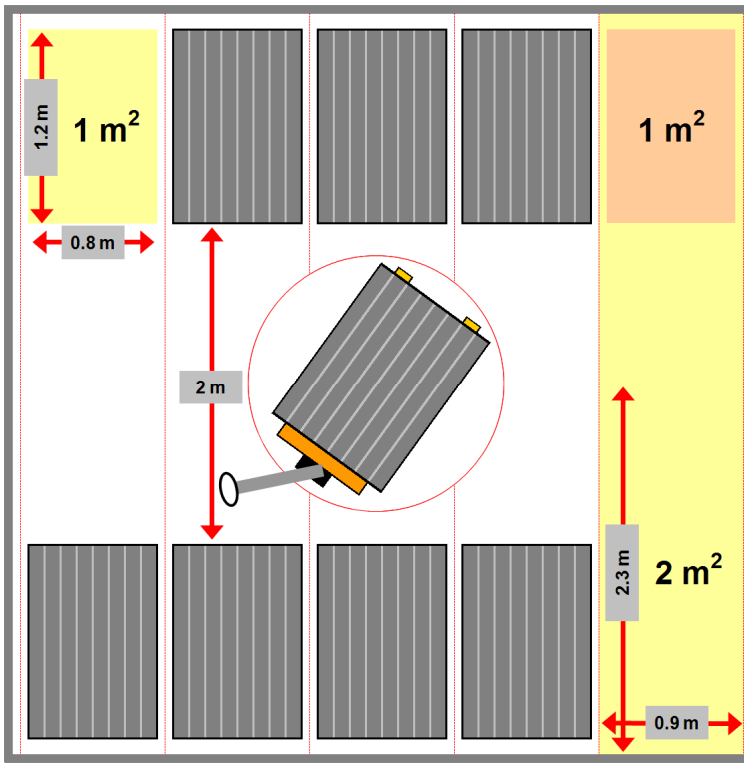

Figure 17.41 Calculation of surface area required for floor pallets

Floor pallets must be set up in parallel rows and spaced 20 centimetres apart from each other in order to facilitate removal and placement of individual floor pallets between two others. Any floor pallet must be placed at least 10 centimetres away from walls in order to prevent direct contact of health care goods or their packaging with the wall.

Ideally every pallet should be accessible individually from the aisle. However the required surface area can be reduced by placing two pallets behind each other. It may then be necessary to remove the front pallet for gaining access to the pallet behind but the space savings can be considerable.

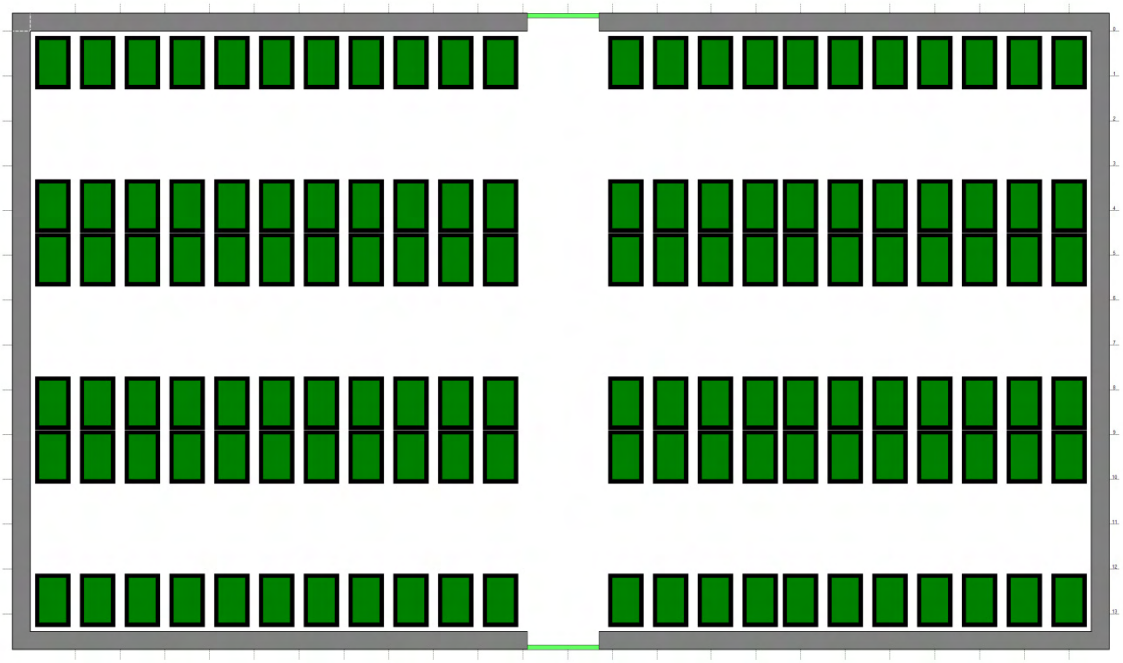

Figure 17.42 Layout of floor pallets

Whether single, double or even triple rows of pallets are used mainly depends on the turnover of goods. For example in contingency stocks which are rarely used, several pallets can be placed behind each other.

The width of the aisle between the parallel rows of floor pallets depends on the materials handling equipment which is used. However aisles must be at least 200 centimetres wide in order to allow access of hand pallet trucks. Therefore each floor pallet of approximately 1 square metre surface area requires 1 square metre surface area for aisles.

The pallet positions should be marked on the floor with painted white or yellow lines. These will avoid that floor pallets are placed randomly and block access to other floor pallets.

Block stacking requires less space than floor pallets. The space requirement depends on the number of pallets stacked in depth, width and height. The aisle width depends on the turning circle of the counterbalanced forklift truck.

Adjustable pallet racking should be set up in parallel rows with sufficiently wide aisles for operating materials handling equipment.

The required aisle width depends on the materials handling equipment which is used. Aisles must not only be wide enough for moving materials handling equipment along the aisles but also for turning perpendicular to the adjustable pallet racks for placing and retrieving individual pallets.

If several stacker trucks, reach trucks or counterbalanced forklift trucks are used which might have to travel in opposite direction in the same aisle, the aisles must be wide enough for two trucks carrying loads to pass each other.

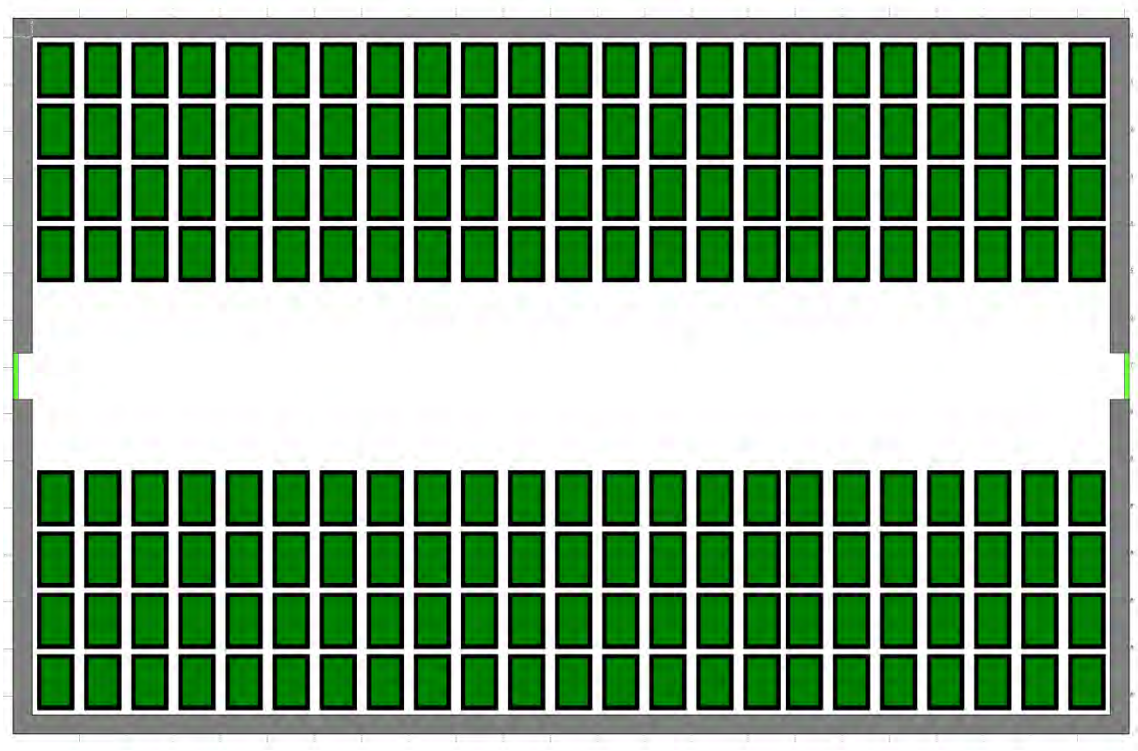

Figure 17.43 Layout of block stacked pallets

Materials handling equipment	Movement (m)	Put-away / retrieval (m)
Pedestrians	0.9	1.0 - 1.2
Trolley / platform truck	1.0 - 1.2	1.3 - 1.5
Roll cage pallet	1.0 - 1.2	1.3 - 1.5
Hand truck	1.0 - 1.2	1.3 - 1.5
Cylinder truck	1.0 - 1.2	1.2 - 1.4
Hand pallet truck	1.2 - 1.5	1.8 -2.1
Hand stacker truck	1.2 - 1.5	1.8 -2.1
Pedestrian electric pallet truck	1.7 - 2.0	2.0 - 2.3
Order picking truck (rider truck)	1.8 - 2.1	- - -
Powered pedestrian stacker truck (straddle truck)	1.7 - 2.0	2.3 - 2.5
Reach truck	2.0 - 2.5	2.5 - 3.0
Counterbalanced forklift truck	2.0 - 2.5	3.6 - 5.0

Table 17.44 Minimum aisle width for different materials handling equipment

Regardless of the storage equipment used, minimum aisles width depends on the materials handling equipment in use and whether several pieces of materials handling equipment have to be able to move in the same aisles in opposite directions.

In medical storage facilities where powered materials handling equipment is used, separate aisles and access doors should be planned for pedestrians to reduce the risk of accidents.

Cross-aisles are openings in rows of storage equipment which provide "shortcuts" between parallel (adjacent) aisles.

Cross-aisles must be wide enough to allow materials handling equipment to turn from and into aisles with the loads they are carrying.

17.12 Expanding the storage capacity

The possible need for future expansion of the storage capacity of medical storage facilities should be considered during selection of storage facilities as well as before setting them up (Battersby, A., and A. Garnett 1993, 23). Medical storage facilities which are too small cannot be managed effectively or efficiently and moving medical storage facilities can be expensive and time consuming.

Increases in the number and size of health programmes are often unpredictable and stock levels difficult to forecast.

An increase of stock levels will require increasing the storage capacity while an increase of throughput without an increase in stock levels only requires increasing the size of the receipt and dispatch area, possibly the width of the aisles as well as the number of docks apart from providing additional materials handling equipment and hiring additional staff.

Before simply extending existing buildings the possibility of organizational as well internal expansion should first be considered (table 17.45).

Before the storage capacity is increased, possibilities to eliminate the need for this additional capacity should be considered.

Stock levels can be reduced by asking suppliers to hold dedicated stocks, especially of bulky goods, and thereby effectively outsourcing part of the warehousing.

Likewise safety stocks can be decreased at the respective medical storage facility by increased safety stocks at upstream medical distribution centres with sufficient storage capacity.

The required storage capacity can be decreased by increasing space utilization for example by changing from a fixed to a semi-fluid or fluid stock location system.

Stock levels can be reduced by carefully reviewing stocks and removing any unusable health care goods such as broken equipment as well as distributing any goods for which there is no demand (dead stock).

Stock levels should be reviewed in order to identify items with higher than necessary stock levels and decrease their stock levels by distribution or return to upstream medical distribution centres.

Decreasing the length of the review period reduces cycle stocks and therefore average stock levels.

Decreasing lead times from suppliers or upstream medical distribution centres and increasing reliability of deliveries allows decreasing safety stock levels.

Internal expansion of existing medical storage facilities can be achieved by setting up storage equipment in areas which were previous not utilized for storage. However, increasing the storage capacity must not impede stores operations. Storage equipment must not be set up in corridors and goods must not be stored on the floor in front of existing storage equipment. Doors, aisles and especially emergency exits must be kept clear at all times.

Replacing floor pallets by adjustable pallet racking may increase overall storage capacity despite the need for increasing aisle width to allow operation of powered materials handling equipment.

Installation of mezzanines in storerooms with an internal height of at least 5 metres allows to double the available surface and therefore storage capacity.

In order to allow effective and efficient warehouse operations, the size of receipt and dispatch areas must not be reduced and they must not be used for keeping stock.

Extensions should also be planned in a way that require as little changes to existing buildings as possible especially when buildings are rented or leased. Existing doors and aisles should be used rather than moving walls and entrances. Any physical changes will require permission of the proprietor and must comply with building legislation. Moreover any physical changes may have to be reversed at the expense of the humanitarian organization when buildings are (eventually) returned to the proprietor.

Only after opportunities for organizational and internal expansion have been explored the possibility of external expansion should be considered.

The storage capacity may be extendable by extending the medical storage facilities to previously not used storerooms in the same building, preferably at the ground level.

Organizational expansion

- Asking suppliers to hold dedicated stocks.
- Decreasing safety stocks and increase stock levels at upstream medical distribution centres.
- Increasing space utilization.
- Removing unusable health care goods.
- Distributing goods for which there is no demand.
- Decreasing stock levels of items with excess stock.
- Decreasing the review period.
- Decreasing supplier lead time and increase reliability.

Internal (horizontal or vertical) expansion

- Setting up additional storage equipment in areas which were previously not utilized.
- Replacing floor pallets by adjustable pallet racking.
- Installation of mezzanines with additional shelving.

External (horizontal or vertical) expansion

- Use of additional rooms in the existing building, preferably at the ground level.
- Use of adjacent buildings.
- Building extensions to the existing building.
- Renting or leasing buildings at another location.
- Relocating the entire stock to a larger store or warehouse.
- Building a larger medical storage facility.

Table 17.45 Methods of expanding the storage capacity

A further possibility is the use of storerooms in adjacent buildings, again preferably at the ground level. However scattering of stocks in several different storerooms, buildings or locations should be avoided as far as possible.

The capacity of existing buildings can be expanded by building an extension to the building.

Another storage facility at a different location may be rented or leased or a larger medical storage facility may be constructed at another site.

17.13 Site layout

Once the layout of the medical storage facility and especially the location of its entrances and the flow of goods has been determined, the layout of the site can be planned.

The layout of the site must make economic use of space, facilitate the flow of vehicle traffic and consider security and safety.

Access to any building on the site should only be possible through the main gate to allow effective access control. Visitors as well as staff should park vehicles outside the main entrance to facilitate control of goods leaving the site. Visitors should not have access through side entrances, loading bays or docks and should use separate sanitary facilities.

In order to avoid accidents, pedestrians and vehicles should access the site through separate and dedicated doors or gates.

Buildings and other facilities as well as car parks must be laid out in a way that allows access of emergency vehicles, especially fire engines, to all sides of buildings.

In order to reduce fire hazards, stores for dangerous goods as well as fuel should be located as far from any building as possible.

If a site has two entrances, a through-flow layout where vehicles enter through one entrance and leave through the other can be chosen. However access control is easier if the site has only one entrance. Then the site must be laid out as a U-flow flow where vehicles enter and leave the site through the same entrance.

Several vehicles should be able to enter and leave the site at the same time without blocking each other. Ideally vehicles should be able to access and depart from docks or loading bays without having to turn around.

17.14 Medical store kit

Especially in acute emergencies, medical storage facilities often need to be set up quickly. Storage equipment may not be readily available domestically or not be available in the requested quantities. This can lead to unsystematic use of various and sometimes inappropriate storage equipment which reduces the efficiency of stores management.

Alternatively a medical stores kit may be used for furnishing medical storage facilities as well as pharmacies in clinics and hospitals with the required equipment.

Because equipment is standardized the store can be quickly planned and set up in a systematic way.

For example a kit can be designed for furnishing a storage facility of 100 square metres with 20 shelves and small containers. If health care goods are shipped in standard corrugated cardboard containers, goods can be placed on the shelves without the need for repacking

immediately after inspection. Ideally all goods will be delivered with pre-printed bin cards as well as stock cards.

Light weight fibreboard pallets (for example 20 pieces) are not long-lasting but will be sufficient for storage until high quality timber pallets can be purchased domestically. Moreover in emergencies distribution centres should take care to ship goods on standard EURO pallets which can be permanently used as storage equipment in the receiving distribution centres.

The kit contains 25 ready to assemble adjustable steel shelves (50 x 100 x 200 cm) which do not require any tools for setting up.

This storage equipment occupies 30 square metres and therefore requires 60 square metres of surface area with the remaining 40 square metres being available for receipt, dispatch as well as other required facilities. The small containers must fit the shelves and either be nested or folded (carton) for reducing the transport volume.

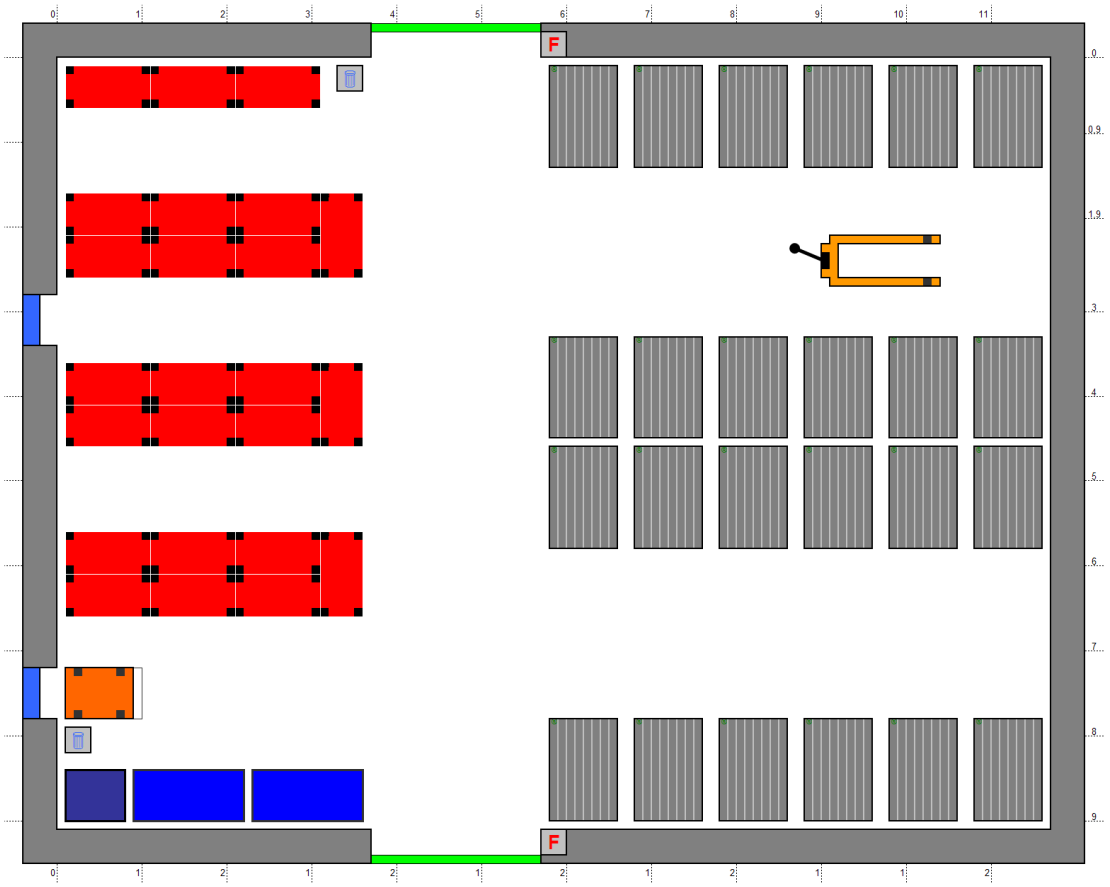

Figure 17.44 Layout of medical stores kit

Furthermore the kit should include some safety equipment, stationery, packaging equipment, a scale, materials handling equipment, cold chain equipment, reference books and basic tools (see table 17.46).

Other equipment such as fire extinguishers, ice-pack freezers, air-conditioning units, office furniture as well as cleaning material can be purchased domestically.

All equipment can be packed on floor pallets and made ready for shipment at the international distribution centre.

Assembly of the shelves requires 10 wo/man hours and all equipment can be set up within a few hours in an existing building.

Setting up the medical store in a systematic way from the very beginning should ensure orderly management from the very beginning. As many kits as necessary can be combined and stores can later be easily extended by adding the more standardized storage equipment without having to change the existing set-up.

This kit can be used in emergencies as well as for a permanent set-up of medical stores. The equipment can easily be dismantled and returned to a distribution centre or transferred to another location if it is no longer needed where it has initially been set up.

- Gloves.
- Smoke detectors.
- Bin cards.
- Stock cards.
- Tape dispensers.
- Adhesive tape.
- Stretch wrap foil and dispenser.
- Box cutters with spare blades.
- Electronic industrial floor scale.
- Small containers (cardboard or plastic).
- Ready to assemble adjustable steel shelving units.
- Hand trucks.
- Hand pallet trucks.
- Voltage regulators.
- Digital minimum/maximum thermometers.
- Cold boxes.
- Ice-lined refrigerators.
- Standard item catalogues.
- Logistics manuals.
- Medical reference books.
- Pocket calculators.
- Stationery.
- Safety container.
- Level.
- Measuring tape.
- Tool kit.

Table 17.46 Contents of a medical store kit

18 COLLABORATIVE PLANNING AND FORECASTING

Collaborative planning is a strategy to anticipate future customer demand by close planning between Health programme managers and logistics services of the humanitarian organization and their suppliers.

Forecasting, in general, is a scientific process, sometimes also seen as an art, of trying to predict or estimate future events, values or variables by analysing historic data.

Collaborative planning can be seen as sharing of qualitative forecasts between Health programmes and logistics services on a range of issues such as programmes and their locations or budgets while in the following forecasting refers mainly to quantitative methods for forecasting customer demand.

It is very important to understand that the fundamental assumption of most forecasting techniques is that, in respect to certain events, the future will be similar to the past.

Collaborative planning is far more important and effective than applying sophisticated customer demand forecasting systems and techniques.

Involvement of Logisticians in any planning of any new health programmes as well as any changes as early on as possible is the key to collaborative planning.

The parallelization of planning processes allows Logisticians to plan, or improve their planning, concurrently to planning processes by Health programme managers.

Wherever the planning period is longer than the supplier lead time, unpredictable demand is converted into predictable demand, eliminating any need for stock holding and avoiding shortages as well as stockouts. For example, if the supplier lead time for an autoclave is 2 months, and the project is planned 3 months (or longer) in advance, the equipment can be ordered from the supplier and delivered to the health care facility without the need to hold any stock.

While demand forecasting is purely reactive, demand shaping aims at proactively influencing demand generated by health programme managers by offering substitutes in order to reduce the number of required stock items and improve stock availability.

While the demand variability generated by end-users cannot be prevented, any distortion of end-user demand variability in the upstream supply network must be prevented or at least minimized.

- Involvement of Logisticians in the planning of any health programme (changes) as early as possible.
- Parallelization of planning processes of programmes and logistics services.
- Conversion of unpredictable into predictable demand.
- Demand shaping.
- Measures for preventing demand distortion.

Table 18.1 Measures for collaborative planning and forecasting

18.1 Levels of collaborative planning and forecasting

Collaborative plans and forecasts can be made at several different levels, representing a hierarchy with different degrees of demand aggregation at each level and for different purposes (figure 18.1). Unlike commercial companies, overall demand for humanitarian assistance always by far exceeds supply. Consequently humanitarian organizations are always able to utilize funds they receive and do not have to be concerned about developing excess capacities.

At the macro level the overall worldwide need for humanitarian assistance depends, among others, on the world's population, poverty levels as well as the number, extent and intensity of conflicts.

Regardless of the overall need for humanitarian assistance, worldwide expenditure for humanitarian assistance is limited and every humanitarian organization is limited by its own budget. Like commercial organizations, humanitarian organizations must establish annual budgets which can serve as an orientation for the overall number and size of humanitarian assistance programmes which can be expected. Although donor funding will often increase during acute crises, many humanitarian organizations are competing for the same funds and the extent to which a humanitarian organization can quickly expand its capacity is limited.

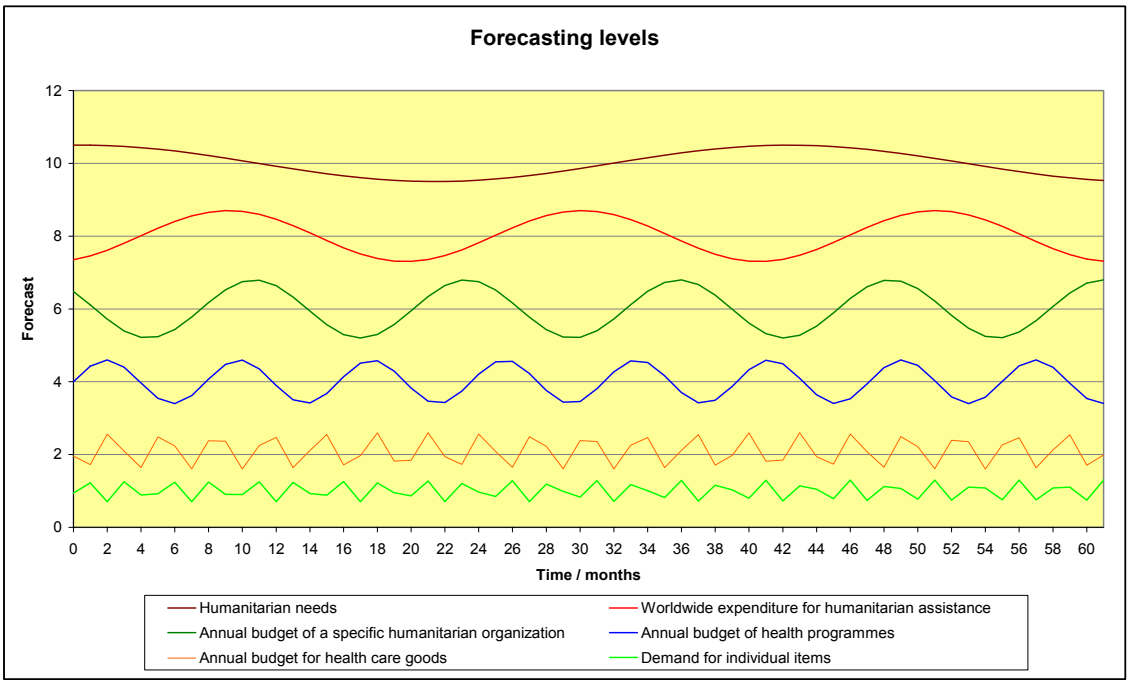

Figure 18.1 Forecasting levels

Depending on their field of expertise, humanitarian organizations will devote a certain proportion of their overall budget to health care programmes and from this, reserve a certain amount for purchasing health care goods. Although the annual value of purchased health care goods will vary to some degree, expenditures of the past years allow forecasting an upper limit for future expenditures.

At the next lower level, total expenditure for health care goods can be forecasted by country and by project, at least for humanitarian assistance programmes which are ongoing at the time of forecasting. Forecasts at this level are particularly important for planning needs and capacities for logistics resources such as staff, medical distribution centres or means of transportation.

At the micro level demand for health care goods can be forecasted by group of goods such as drug products or health care equipment and finally at the item level for a whole country, whole health care programmes as well as individual assisted health care facilities.

In order to plan and allocate resources, logistics managers must also forecast geographical markets for humanitarian assistance. Health programme managers need to consider likely developments and possible expansions of acute as well as chronic crises, the size of affected populations as well as likely health care needs in geographical regions as well as individual countries.

Provided that no large scale displacement of populations occur and that people throughout a country or region are affected equally, needs for humanitarian assistance will be proportional to population densities.

The size of a population a humanitarian organization has decided to serve allows estimating the number of required health care facilities which in turn allows estimating needs for health care goods. For example a health care centre can serve a population of 5,000 - 10,000 and a district hospital 100,000 - 200,000 people in peace times (Perrin, P. 1996, 219). Experience allows estimating that approximately one percent of a refugee population will consult a health care centre every day, approximately one percent of these will require hospitalization and one hospital bed should be calculated for every 1,000 persons (Perrin, P. 1996, 222).

Health care needs will be increased by the effects of acute and chronic crises but demand on health care facilities may also decrease because of reduced accessibility for patients (Perrin, P. 1996, 319).

Customer demand should be forecasted only for essential and regularly used health care goods while non-essential goods which are not used regularly can be ordered when needs arise and can be delivered directly from the supplier. This distinction allows providing high customer service level for the majority of required health care goods, limiting the stock value and avoiding accumulation of health care goods with low turnover.

In order to ensure that all essential health care goods are available and no unnecessary goods are stocked, customer demand should be forecasted for all items which are included in the respective national standard lists. Stock items are regularly replenished according to customer demand forecasts while all other items are ordered as and when requested from customers.

Generally customer demand for health care goods must be considered as unpredictable and stochastic. Forecasts for future demand will rely on statistical analysis of historic demand data (Steinbuch, P.A. 2001, 57). Wherever possible unpredictable demand should be converted into dependent demand as the later no longer requires forecasting. Rationing systems distribute a fixed amount of health care goods at fixed intervals to a defined number of health care facilities. The total amount of kits can easily be calculated and forecasts are unnecessary. However either assisted health care facilities have other additional supply sources to cover increased demand or the number of provided rationing kits allows covering for possible increases in demand.

18.2 Parallelization of planning processes

Collaborative planning seeks to minimize end-user demand distortion (Gattorna, J. 1998, 200) by capturing real demand as near to the end-users and as soon as possible after end-user demand arises.

"In the absence of planning, managers must spend a disproportionate amount of their time in the role of "fire fighter". . ." (Lambert, R.S., and J.R. Stock 1993, 718).

"In the absence of planning, managers must spend a disproportionate amount of their time in the role of "fire fighter" - reacting to crises rather than anticipating change and developing strategies to deal with it" (Lambert, R.S., and J.R. Stock 1993, 718). According to Thomas, A. logisticians are rarely included in the planning stages of humanitarian assistance programmes (Thomas, A. 2005, 5).

Effective and efficient implementation of humanitarian assistance programmes requires close cooperation between health programme managers and logistics services (PAHO 2001a, 146). Valuable time is lost if programme and logistics managers plan and carry out their activities after each other (figure 18.2).

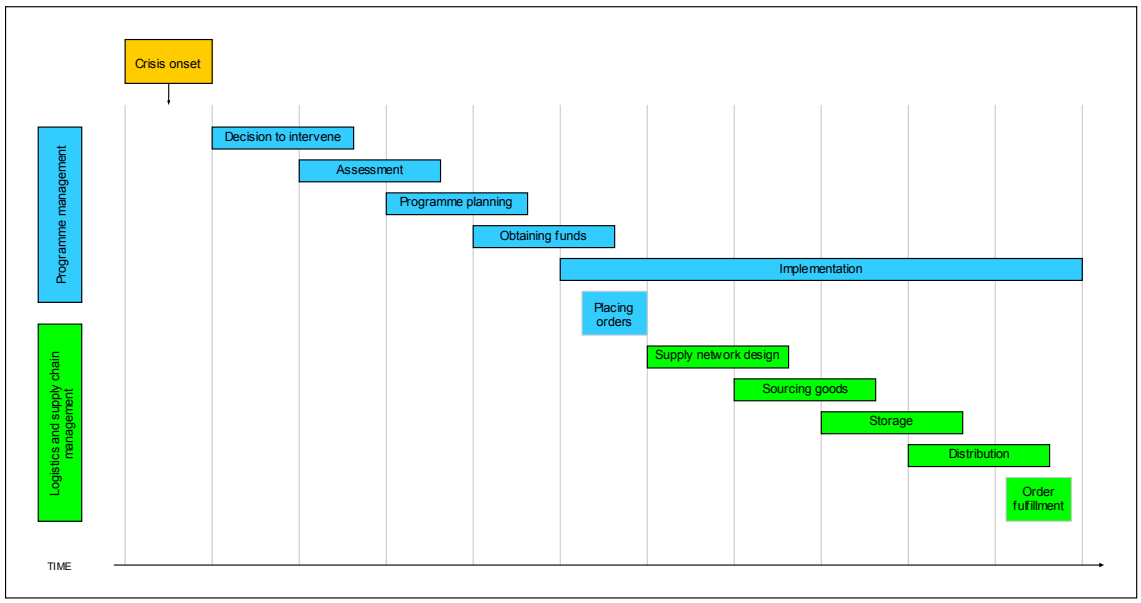

Figure 18.2 Subsequent planning process

Exact determination of specifications of health care goods and establishing standard item catalogues allows narrowing down the number of items for which logistics managers have to anticipate demand considerably without compromising the quality of provided health care services.

Close collaboration is needed for offering immediately available substitutes rather than spending resources on sourcing health care goods which do not offer significant advantages over substitutes.

The need for health care goods arises as soon as a patient is injured or falls ill. In countries with a chronic lack of adequate health services, needs may even persist for years before a specific humanitarian organizations decides to intervene, for example because health services have even declined further.

However, a demand signal only arises once humanitarian organizations decide to provide assistance and orders for health care goods are approved. Before developing assistance programmes, health professionals need to carry out assessments and obtain approval for assistance programmes as well as funds from donors. Consequently a considerable amount of time, weeks or even months, may pass between the decision of humanitarian organizations to

intervene and placing of firm orders by programme managers. Collaborative planning allows to carry out activities in parallel (figure 18.3) and save valuable time.

Demand can be anticipated by early warning systems and by health programme managers informing logistics services as soon as humanitarian organizations consider intervening. Likewise a continuous exchange of information allows logistics managers to quickly adapt their strategy and operations to any planned or actual changes in needs humanitarian assistance programmes or treatment protocols.

Even before receiving firm orders, logistics managers can check (worldwide) stock levels of the most likely requested goods, inform suppliers of expected orders and draw up plans for expanding an existing or establishing a new supply network. Even if health care goods are not purchased and distributed, lead times for these activities can be considerably reduced with advanced planning. Contingency stocks can be moved nearer or into the expected crisis area in anticipation of imminent demand from health programme managers. Logistics services must be considered as an enabler of humanitarian assistance programmes and become part of planning humanitarian assistance programmes rather than being limited to order fulfilment.

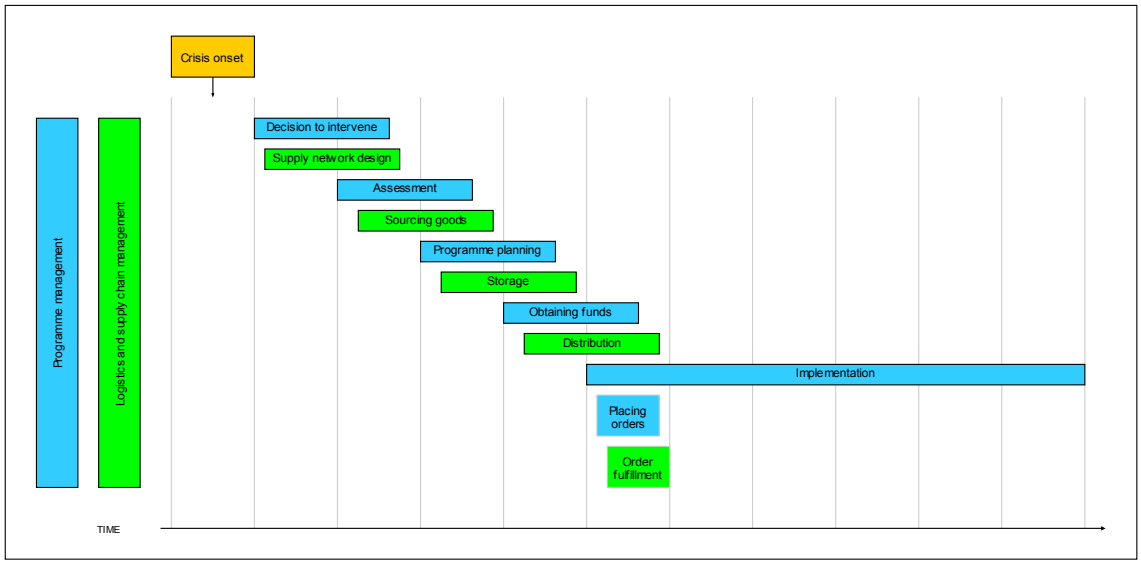

Figure 18.3 Parallel planning process

18.3 Converting unpredictable into predictable demand

Whenever demand is unpredictable, logistics services have to either set up a supply network which allows supplying health care goods within very short lead times or must establish safety stocks to hedge against uncertainty of customer demand. In both cases, significant resources are required and possibly wasted. Moreover sometimes the potential for reducing lead times is limited, for example when time for clearing customs cannot be reduced and establishing safety stocks in acute crises also takes time.

Instead, wherever possible unpredictable demand should be converted into predictable demand by anticipating customer demand (see figure 18.4).

The greatest potential lies in the difference between the time when needs arise and when health programme managers raise orders. Needs are often chronic and may exacerbate during acute crises. It is therefore not so much the needs of affected people and health care systems which are unpredictable but rather the interventions planned and undertaken by humanitarian organizations and health programme managers which are expressed in orders for health care

goods (demand). Implementation of humanitarian assistance programmes require humanitarian organizations to take a decision for intervening in a particular acute or chronic crisis, assessing needs, planning interventions, negotiating access, obtaining approval from the authorities, obtaining funds and mobilizing resources. Even though the needs are often obvious at the beginning of this, sometimes lengthy, process, orders are often placed only after completing this process.

For example, during a refugee crisis the need for measles vaccination is very likely, unless the populations is already sufficiently immunized. The need for immunization services arises at the time of displaced not when humanitarian organizations decide to intervene. The main uncertainty in this case is whether national authorities have sufficient capacities, assistance by humanitarian organizations is needed and which humanitarian organization will be in charge. Measles is highly contagious, can rapidly spread in crowded conditions and is a major cause of death in nearly all refugee situations. In order to prevent an epidemic, vaccinating children against measles is a priority in emergencies affecting large, displaced and malnourished populations. The size of the population together with demographic data allows estimating the number of children and determining the number of doses of measles vaccine which are required for a mass vaccination campaign. The need for measles vaccines also implies the need for establishing an effective and reliable cold chain. At the same time, the demand for vitamin A tablets, which must be administered to every vaccinated child, can be forecasted.

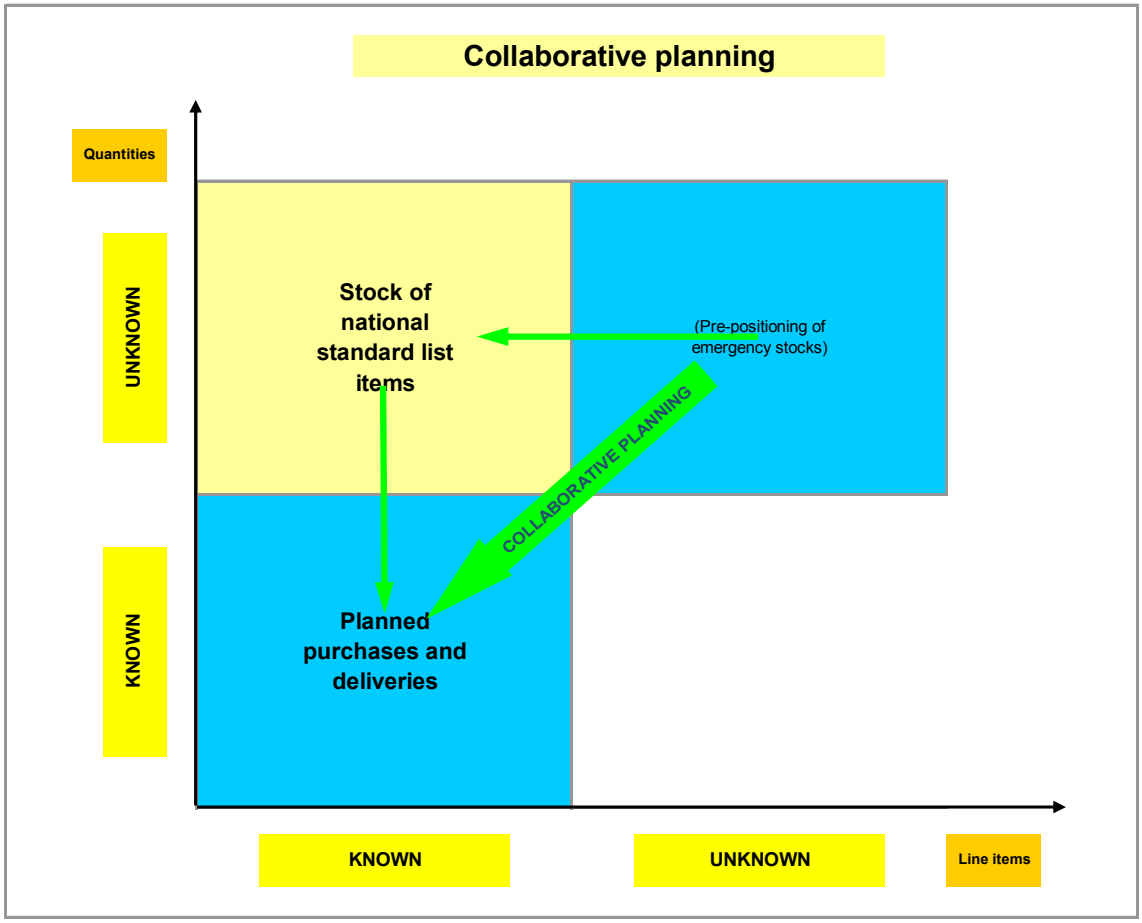

Figure 18.4 Converting unpredictable into predictable customer demand

The primary causes of morbidity in less developed countries and displaced populations are measles, diarrhoeal diseases, acute respiratory infections, malnutrition and, where endemic, malaria (Hanquet, G. (ed.) 1997, 145). These can also be expected in less developed countries

affected by acute or chronic crises. Displacement and general lack of food not only cause malnutrition but make children more susceptible to infections (Perrin, P. 1996, 126) and also aggravate other medical conditions. Two out of three people killed in relation to armed conflict during the past 15 years were children (Denny, Ch. 2005, 155).

The need for treating wounded can be expected in the immediate aftermath of conflicts while communicable diseases or malnutrition will develop and increase after fighting has ceased especially where populations are displaced and live in increasingly crowded conditions.

The worst case for logisticians is the upper right square (figure 18.4) where neither quantities nor items of future customer demand are known. In this case, logistics services can only hedge against uncertainty by pre-positioning contingency stocks.

In chronic crisis as well as during the early stages of acute crises, uncertainty of future customer demand can be significantly decreased by establishing national standard lists which include all items regularly used in health programmes. Although the future customer demand for the items included in the national standard list can only be estimated, uncertainty concerning the items is very significantly reduced. Even though a national standard list will not cover all needs of all future health programmes, national standard lists will contain all essential health care goods and allow filling the great majority of future customer orders.

In the best case, uncertainty is further reduced and eventually removed by planning items as well as quantities in advance. Provided that the time period of planning ahead is at least as long as the total order lead time, all requested health care goods can be ordered directly from suppliers and be delivered to customers on time without the need for holding any safety stocks. This may be possible when humanitarian organizations rehabilitate health care facilities and donate health care equipment or when planning vaccination campaigns.

A special material assistance strategy which removes all uncertainty of customer demand is a rationing system. Assisted health care programmes regularly receive predetermined quantities of specific health care goods. This system allows planning purchasing for example a whole year in advance and ship consignments to assisted health care facilities according to predetermined schedules without the need for holding any safety stocks. A special variation is the provision of ration kits for example providing one complete kit to every health care centre once a month.

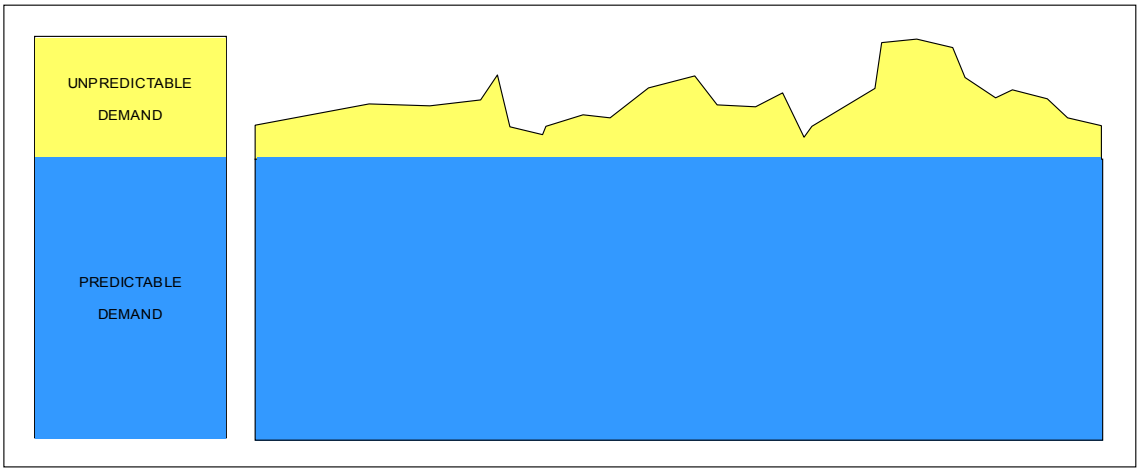

Figure 18.5 Predictable and unpredictable customer demand

For replacement parts, unpredictable demand can be converted into nearly predictable demand by applying preventive maintenance (Lonergan, E. 2003, 65). Certain parts of health

care equipment such as fuses, filters or tubing are replaced at regular intervals even if they are not damaged or worn (yet) rather than waiting until parts become defective and have to be replaced.

The use of kits itself does not eliminate uncertainty from customer demand. However since a large number of health care goods are combined in kits, the variability of demand for kits is greatly reduced through demand aggregation of individual health care goods.

In practice only part of future customer demand is predictable. However, every effort should be made to convert as much unpredictable demand as possible into predictable demand by collaborative planning. This will allow focusing on efficiency of supply chain management for the predictable demand while focusing on effectiveness and reduction of lead for the remaining real acute crises (see figure 18.5).

18.4 End-user demand variability

The variability of end-user demand is caused by patients receiving care as well as health professionals and can hardly be influenced as it originates outside the supply network of humanitarian organizations. Demand variability can also occur at any other upstream stage of supply networks. While demand variability can occur in a single-stage supply network, the emergence of demand distortion requires at least two stages.

The perfectly normal end-user demand variability, even if it may be very large and very irregular, must not be confused with demand distortion, an increase in demand variability (see table 18.2) at upstream stages of the supply network. The causes of demand variability and demand distortion differ and can be influenced by different measures (see table 18.2). Even if end-user demand is level (standard deviation and therefore Cove are zero) over very long periods of time, demand distortion can still occur in the supply network. End-user demand variability can, by definition, not be the "cause" of demand distortion and multi-stage supply networks without any distortion of end-user demand are conceivable even if rarely realized.

However, (end-user) demand variability and demand distortion are of course related. Any increase of (end-user) demand variability is likely to increase demand distortion in a non-linear fashion. Demand (already) distorted at one level of the supply network can be further distorted in the upstream supply network.

Demand variability	External demand variability	Internal demand distortion
Origin	• Patients receiving care. • End-users (health professionals).	• Any actor (except end-users) throughout the supply network.
Causes and aggravating factors	• Fluctuation in the numbers of patient. • Changes in epidemiology. • Epidemics. • Lack of standard treatment protocols. • Changes of treatment protocols. • Use of substitutes. • Lack of national standard list. • Changes of national standard list. • Expiry and damage of stock.	• Shortage gaming. • Forecasting. • Inventory control systems. • Infrequent orders. • Changing of inventory control parameters. • Lead time. • Order batching. • Minimum order quantities.

Consequences	• Fluctuations in demand. • Step changes. • Positive or negative trends. • Seasonality. • Cyclical demand.	• Creation of internal demand variability. • Amplification of external demand variability.
Mitigation	• Adherence to treatment protocols. • Adherence to national standard list. • Demand shaping. • Preventing expiry of stock.	• Use of end-user demand. • Minimizing stages in supply networks. • Use of imprest systems by end-users. • Gradual changes of inventory control parameters. • Regular stock replenishment ordering. • Reduce lead times. (see table 18.8 for details)

Table 18.2 Comparison of demand variability and demand distortion

Demand variability is measured by the coefficient of variation (CoV) which is calculated by dividing the standard deviation of demand by average demand (Cachon, G., and Ch. Terwiesch 2006, 106). Demand distortion is present whenever the coefficient of variation of demand at any stage of the supply network is smaller than the coefficient of variation of any upstream stage in the supply network.

18.4.1 Reasons for end-user demand variability

Variability of demand at any stage upstream from end-users is either propagated end-user demand (with or without end-user demand distortion) or entirely created by actors in the supply network.

End-user demand originates from and is caused by patients receiving treatment or health care professionals providing care to or diagnosing patients. For all intents and purposes the aggregated end-user demand (aggregate confirmed orders) of an entire health care facility will be considered as "end-user demand".

Although theoretically possible, level end-user time over a long period of time is very unlikely (see table 18.2). In practice level (secondary) demand occurs only if health programme managers implement a rationing system.

Many patients which require health care may not be treated and an increase in the number of health professionals and the capacity of health care facilities will lead to an overall increase in the number of treated patients. The number of patients in general as well as those seeking treatment at any health care facility will generally fluctuate, for example as a result of changes in the security situation.

Despite predominant epidemiologies in a population, in a camp or at any health care facility, the type and number of medical conditions will fluctuate. Some endemic diseases such as malaria or diarrhoeal diseases typically show seasonal patterns and, unlike ongoing immunization programmes mass vaccination programmes cause short but large increases in demand.

The epidemiology of the population or part of it can also change quickly, for example during an epidemic of infectious diseases or as a consequence of armed conflict or increased conflict intensity.

Even if all factors mentioned above remain constant, health professionals may treat medical conditions differently especially when standard treatment protocols are not available or not implemented. Even where standard treatment protocols are adhered to, preference of different substitutes by different health professionals can cause variability. While standard treatment protocols apply to the use of drug products, the use of medical devices and different sizes leaves more room for personal preferences. Likewise the absence or frequent changes of the national standard list causes variability of secondary demand.

Changes in standard treatment protocols, for example because resistance of a micro-organism to a drug product emerges, are possible at any time but should be infrequent.

Even if needs at the health care facility are constant, end-user demand (orders placed to a specific humanitarian organization) may vary because of changes of budgets or because the respective health care facility (irregularly) receives donations from other sources.

18.4.2 Demand shaping

Demand forecasting assumes demand and its variability as a given input without considering the possibility of influencing customer demand (Stadtler, H., and Ch. Kilger (ed.) 2002, 124). Forecasting is therefore purely reactive in passively responding to (changes in) demand while demand shaping is a proactive process.

In commerce demand shaping seeks to reduce the variability of demand, for example by adjusting prices. However, humanitarian organizations do not seek to increase "sales" (demand) and providing assisted health care facilities with more or less of the required quantities of items could lead to misuse or inappropriate treatments.

An extreme form of demand shaping would be a rationing system with a predetermined number of items and quantities which are distributed to certain health care facilities at regular intervals. However, this kind of rationing system is rarely used as it does not allow any adjustment to actual needs at assisted health care facilities.

The national standard list is established at the beginning of any health programme after carefully assessing and determining the needs (demand) of assisted health care facilities.

The use of different but similar items by different health care facility leads to a large number of line items on the national standard with low demand and high variability of some line items which are not used by all assisted health care facilities.

For example one health care facility may be using sizes 8, 12 and 16 of a specific catheter or tube while another facility commonly uses sizes 10, 14 and 18. Demand shaping is a way of harmonizing the stock lists from different health care facilities and establishing a national standard list with the smallest number of line items which nevertheless covers all essential needs of all assisted health care facilities.

Therefore, at the tactical level demand shaping can be considered as the systematic substitution of some stock list items of assisted health care facilities in order to minimize the overall number of national standard list items without reducing the quality of provided care at any of the assisted health care facilities. Effectively demand shaping seeks to align differences of the stock lists of all assisted health care facilities in order to reduce variety and reduce demand variability through product pooling with the ultimate objective of increasing stock availability (see table 18.3). This alignment can either lead to assisted health care facilities

adjusting their stock lists accordingly or lead to (regular) substitution when assisted health care facilities submit their orders.

- Avoiding waste of resources.
- Reducing the number of line items in the national standard list/standard item catalogue.
- Avoiding any reduction of quality of services health care facilities provide.
- Reducing the complexity of supply chain management.
- Reducing demand variability of (remaining) line items (product pooling).
- Increasing forecasting accuracy.
- Increasing stock availability.
- Improve customer service.

Table 18.3 Objectives of demand shaping

A second consideration is the alignment of the national standard list (demand) with the standard item catalogue (supply) as these items will be more readily available from upstream medical distribution centres and effectively results in a harmonization of all national standard lists from different countries. Therefore demand shaping which takes place primarily at the tactical and national level has important strategic and global implications.

Demand shaping is part of a circular process where national standard lists are aligned to the standard item catalogue but likewise feedback on discrepancies in the long-term lead to changes and adjustments of the standard item catalogue.

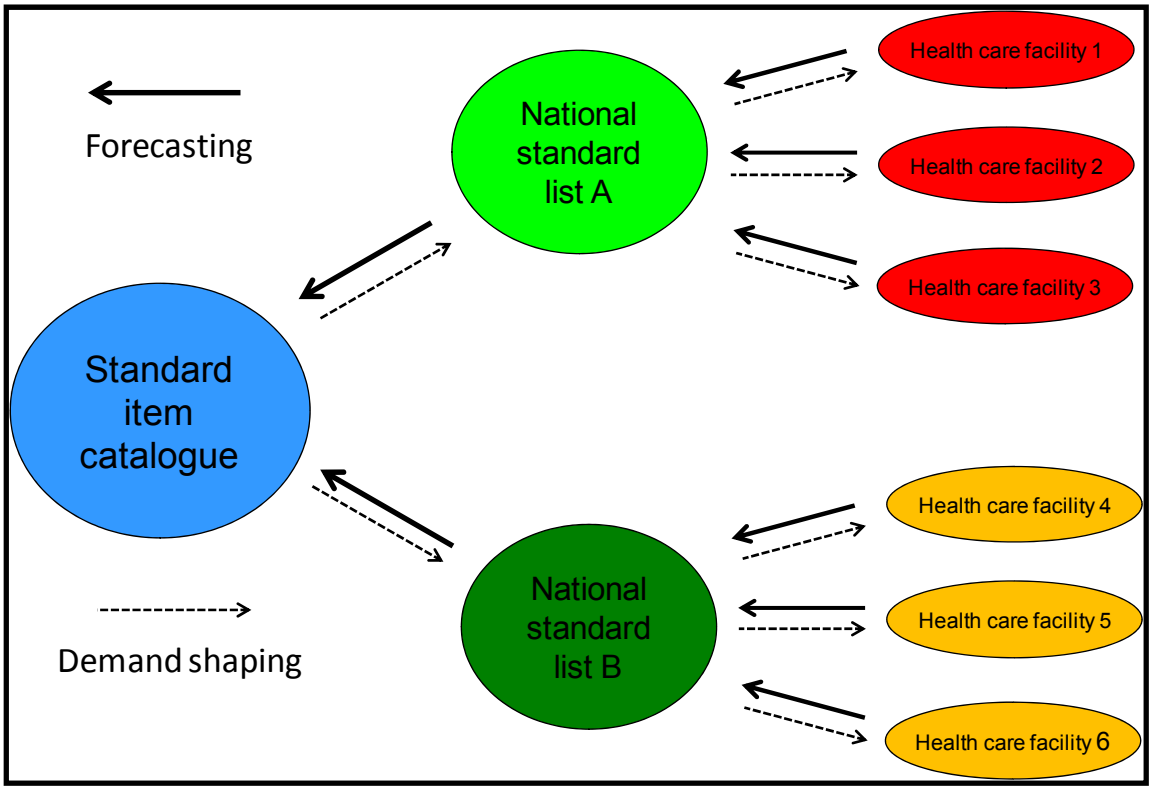

Figure 18.6 Demand shaping

Substitutes may differ only in quantity or size. For example tablets with half the strength can be used in the same way but require administering twice the quantity. Several injectable drug

products are manufactured with different strengths requiring only the change of administered volume. 10 by 20 cm compresses can be folded and used as 10 by 10 cm compresses.

Other items may be interchangeable. For example different widths of adhesive tape can be substituted for each other. Provided that the syringe is not used to administered only part of the contents of an ampoule or vial, a larger syringe can be used. Often similar sizes of various catheters, tubes and drains can be used.

Different substances are effective as disinfectants provided they are applied according to the instructions. The WHO Model List (WHO 2007n) specifically indicates drug products with similar clinical performance within a pharmacological class with a symbol (□) which possibly allows their substitution. However, the possibility of substitution of drug products is limited for example most antibiotics have specific indications and cannot be substituted for each other.

In practice substitution leads to increasing demand of substitutes and decreasing demand of substituted items without changing overall demand.

18.5 Risk pooling

Aggregation of demand across products, space and time allows reducing variability of aggregated customer demand which in turn allows decreasing uncertainty, increasing forecasting accuracy and reducing safety stocks (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 197).

While measures for reducing end-user demand variability concern individual customers, the objective of risk pooling strategies is reducing the variability of aggregate customer demand from all immediate downstream customers.

- Goods: Product pooling.
- Space: Location pooling.
- Time: Lead time pooling.

Table 18.4 Risk pooling strategies

Product pooling refers to the aggregation of demand across products. The aggregate demand variability of two pooled items cannot exceed the sum of variability of each individual but can be smaller and, in the best case, even be zero. For example the aggregate demand variability of different sizes of catheters is in most cases smaller than the sum of the variability of each catheter alone. The higher (or increasing) demand for one item can be compensated by the lower (or decreasing) demand for another item. Intuitively anyone would prefer to forecast demand for all beverages sold by a retailer than forecasting demand for any particular beverage.

Consequently product pooling is achieved by reducing the variety of items which are available in different sizes, weights, packaging quantities etc. For example variability of 10 x 20 gauze compresses will be lower than the sum of the demand variability of 10 x 10 compresses and 10 x 20 compresses.

The strategy of pooling demand across (many) customers is called location pooling (Cachon, G., and Ch. Terwiesch 2006, 281). A small number of customers implies high variability of aggregate demand while the variability of aggregate demand decreases with the number of customers. Again purely intuitively, anyone would prefer to forecast aggregate demand of a specific drug product used by a large number of health care facilities than forecasting demand at a single health care facility.

Location pooling is achieved by reducing the number of medical distribution centres at each stage of the supply network as well as eliminating entire stages in the supply network. Location pooling allows providing the same level of service with lower safety stocks or increasing service levels without having to increase safety stocks (Cachon, G., and Ch. Terwiesch 2006, 284). The maximum benefit of location pooling could be achieved by direct deliveries to all worldwide customers from a single medical distribution centre.

As demand is aggregated across customers (locations) the likelihood that an increase in demand at one customer is offset by a corresponding decrease in demand at another customer increases and the variability of aggregate customer demand is decreased (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 48).

The decrease in aggregate variability of demand is proportional to the correlation of the individual demand patterns. Although highly unlikely, location pooling would not yield any benefits if demand from all customers were perfectly correlated (Cachon, G., and Ch. Terwiesch 2006, 292). On the other hand variability of demand could be eliminated if the correlation of an even number of equally large customer demands were perfectly negatively correlated (Minner, St. 2000, 124).

The concept of lead time pooling considers the uncertainty of demand as well as the uncertainty of location, that is which customer will order a product (Cachon, G., and Ch. Terwiesch 2006, 298).

The reduction of the number of medical distribution centres in order to benefit from location pooling has the undesirable side effect of increasing the distance to customers and therefore increasing lead time (Cachon, G., and Ch. Terwiesch 2006, 294). While the central medical distribution centre still allows benefiting from location pooling, as lead times increase all customers must increase their safety stocks.

Lead time pooling allows to benefit from location pooling while keeping lead times short. By establishing an additional stocking point near to all customers lead time can be decreased and stock can be distributed to any customer which eliminates the uncertainty of location (Cachon, G., and Ch. Terwiesch 2006, 298). Effectively customers are sharing safety stocks and lead time pooling can be seen as a kind of "delayed final delivery" where the final destination is decided "at the last moment" and therefore can benefit any customer in need.

Although an additional stocking point is introduced, the overall echelon stocks of the central medical distribution centre, which include the additional stocking point as well as all stocks held at customers, can be decreased.

The consolidated-distribution model (with the additional stocking point) outperforms the direct-delivery model if the lead time between the medical distribution centre exceeds three to four weeks and particularly if the lead time between the medical distribution centre and the stocking point is larger than the lead time between the stocking point and the customer (Cachon, G., and Ch. Terwiesch 2006, 298).

18.6 Demand distortion (Forrester effect)

The phenomenon of supply chain dynamics and demand distortion was first discovered, analysed and described by Jay Forrester in his famous article "Industrial Dynamics: A major breakthrough for decision makers" (Forrester, J.W. 1958, 37). As a result of modelling a simple four-stage supply chain of a factory, factory warehouse, distributor and retailer he concluding that in an "oscillatory system" changes and random disturbances of demand signals tend to be amplified as they move upstream (backwards) through the supply network (Forrester, J.W. 1958, 45).

All actors influencing demand (information) in supply networks, including end-users and health programme managers, can cause demand distortion ("homemade") and must be aware of this phenomenon in order to reduce its extent and impact.

The Forrester effect is the increase in demand variability (up- and downswings) as demand information moves upstream (backwards) through the supply network.

The Forrester effect which is sometimes also called "bullwhip effect", "whiplash effect", "whipsaw effect" or "fly-wheel effect" is endemic, pervasive, nearly ineradicable and inevitably occurs in any supply network with more than one stage even if it is not recognized.

The Forrester effect can occur when end-user demand is perfectly level or shows any degree of variability and whether the time series shows any trend or not. This demand information is used at the next upstream stocking point for forecasting demand and generating a replenishment order which is in turn sent to the next upstream stocking point for forecasting and calculating a replenishment order and so forth until it reaches the supplier of raw materials for the respective product. The variability of the end-user demand information tends to be, often significantly, amplified and distorted as it propagates (backwards) upstream through the supply network. The demand pattern at the final stage of the supply network is determined by the end-user demand signal as well as the characteristics of the system itself (Forrester, J.W. 1958, 45).

"A consumer demand for a single aerosol becomes translated into a requirement for 10 tonnes of steel plate at the other end" (Waters D. (ed.) 1999 204).

The Forrester effect may occur or be increased at any particular, several or all stage of the supply network and overall the distortion increases with the number of stages the demand information has moved up the supply network. Even if demand over a longer period of time is level without any trend, periodicity or cyclicality, small (random) changes can cause oscillations (Forrester, J.W. 1958, 45).

The Forrester effect can simply increase the amplitude of a (regular) demand pattern but can also lead to strong irregularities or distortions. It is important to note that while end-user demand patterns tend to be amplified, the extent of upswings as well as the downswings are usually increased. Over a long period of demand, the cumulative demand at every stage of the supply network is the same and therefore upswings during one or several periods must eventually be compensated by downswings (Minner, St. 2000, 70). Especially when average end-user demand over a longer period of time is level, an upswing of demand may also be followed by a (long) period without any demand. While the initial increase in demand variability causes shortages and stockouts, the subsequent decrease in demand variability as well as absolute demand, leads to overstocking.

However, regardless of whether demand happens to increase or decrease at any given time by definition the *variability* of demand as measured by the coefficient of variation (see equation 18.1) is always increased (Cachon, G., and Ch. Terwiesch 2006, 336) or decreased.

The coefficient of variation (CoV) is calculated by dividing the standard deviation by average (aggregated) demand (equation 18.1).

$$\mathrm{CoV} = \frac{\sigma}{\bar{d}} \qquad \text{Eq. 18.1}$$

The presence of the Forrester effect is proven whenever the coefficients of variation at any stage in the supply network is larger than at any other stage further downstream (Lee, H.L., V. Padmanabhan, and S. Whang 1997, 95).

$$1 < \frac{\mathrm{Var}_{\text{stage k+n}}}{\mathrm{Var}_{\text{stage k}}} \qquad \text{Eq. 18.2}$$

Therefore variable and even periodic or cyclical demand at any stage of a supply network in itself do not prove the Forrester effect as in the same demand pattern could appear unchanged at all upstream stages of the supply network.

Even in a simple supply network the Forrester effect can be very significant. Figure 18.7 shows a five-stage supply network consisting of a central hospital pharmacy, a national medical distribution centre, a regional distribution centre, an international distribution centre and a commercial supplier over a period of three months. All stages use demand from the next downstream stage for forecasting their demand using six months moving averages. All stages use a (R, S) inventory control policy with a review period of one month and the lead time between all stages is one month. Demand at the first stage is level with the exception of doubling of demand in month four to 100 units which leads to a demand of nearly 600 units five months later at the supplier. An important observation is also that systems require very long to stabilize even though demand is perfectly level.

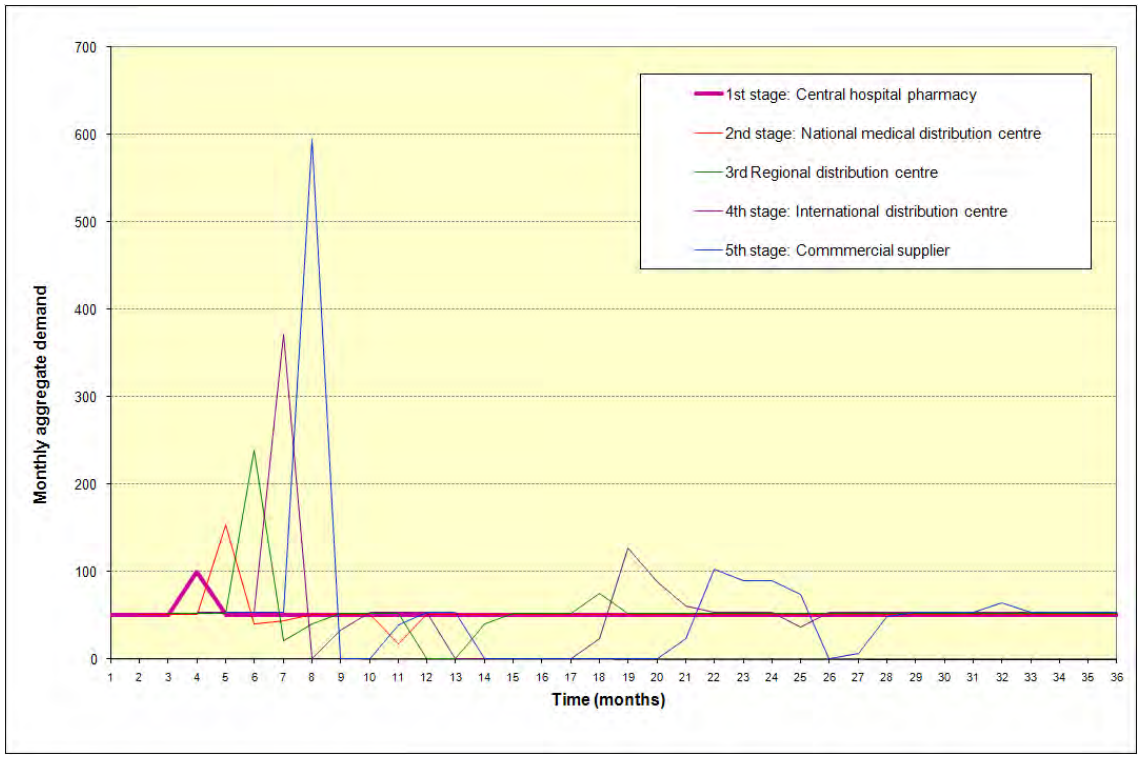

Figure 18.7 Example of demand distortion in a five-stage supply network

18.6.1 Causes of demand distortion

A large number of individual factors or factors compounding each other can cause or increase demand distortion (see table 18.5). While demand distortion often cannot be

prevented entirely, it is often self-induced by organizations (Gregory, I.C., and S.B. Rawling 1997, 57).

The use of demand data from the next downstream medical distribution centre is one of the most common causes of demand distortion. However, demand distortion can also occur even if end-user demand (from the most downstream stage in the supply network) is used for forecasting customer demand at all upstream stages of the supply network (see table 18.5).

Demand distortion can occur even if inventory control is systematic and all decisions are rational. While irrational behaviour can cause demand distortion perfectly rational behaviour can also be a cause (Lee, H.L., V. Padmanabhan, and S. Whang 1997, 95).

Changes in end-user demand which are usually the basis for forecasting demand, will lead to changes in demand forecasts which in turn will lead to changes of order-up-to-levels and consequently replenishment order quantities (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2004, 23) even if neither the inventory control system nor any of its parameters are changed. The extent of the demand distortion will depend on the variability of end-user demand but demand occurs even if end-user demand is fairly stable (Stadtler, H., and Ch. Kilger (ed.) 2002, 21). Moreover changing the length of the time period from which demand data is used for forecasting can also change the demand forecast.

In general any increase in end-user demand will not only require increasing replenishment orders for replenishing stocks but the increased demand will also increase the demand forecast and therefore, in general, require increasing safety stocks as well as order-up-to-levels (Thonemann, U. et al. 2003, 112). Likewise a decrease in end-user demand will not only require less stock for filling orders but stock replenishment orders will decrease or even be suspended until stock issues have depleted the excess stock and stock levels have dropped according to the lowered safety stock and order-up-to-levels.

On the other hand, even if end-user demand is used for forecasting changes in forecasting methods or any parameters can likewise cause demand distortion. For example using the same set of end-user demand data, changing from moving averages to exponentially weighted averages, changing the order of simple moving averages or the smoothing constant of exponentially weighted averages will change the demand forecast.

The use of qualitative forecasting methods for correcting or adjusting qualitative forecasting methods based on end-user demand will also lead to demand distortion.

The variability of aggregated end-user demand decreases with the increase of the order of moving averages. Therefore the use of moving averages of different order at different stages of the supply network will cause demand distortion.

For example if end-user demand from the past three months is used at on stage of the supply network and the same set of end-user demand but from the past six months is used at the upstream stage in the supply network, demand will be distorted.

Despite the use of end-user demand and maintaining the use of a specific inventory control system, any change of one or several inventory control parameters (length of the review period, the reorder level or the order-up-to-level) will change order quantities and therefore cause demand distortion. Likewise changes of the type of demand distribution as well as safety factors will change the safety stock levels.

The use of periodic review systems or the receipt of replenishment orders from different customers at different times (for example some customers ordering at the beginning of the month other at the end) in themselves do not cause demand distortion.

However, if the review periods at different stages of the supply network differ or the unit time period of aggregating end-user demand data are greater than the review period at the respective stage of the supply network, then demand will be distorted.

For example if end-user demand is aggregated in weekly unit time periods, the upstream medical distribution centre aggregates end-user demand in monthly unit time periods then an upstream medical distribution centre using weekly aggregated end-user demand will see a demand spike every four weeks while no demand will be recorded during the other three weeks. Likewise, if two customers place their monthly orders in different weeks of the month, the medical distribution centre serving them will see two spikes during different weeks of the same month.

Any change of the inventory control system for example from a continuous review to a period review system, will change the order-up-to-level and therefore the order quantities for stock replenishment.

Safety stocks levels as well as order-up-to-levels and therefore order quantities will increase and decrease with any increase or decrease in estimated replenishment lead time. Replenishment lead times alone do not cause demand distortion and demand distortion can occur in supply networks even if replenishment lead times are zero.

However, replenishment lead times do increase ("magnify") the extent of demand distortion (Lee, H.L., V. Padmanabhan, and S. Whang 1997, 95).

Moreover even short (expected) replenishment lead times inevitably cause demand distortion. However an increase in expected replenishment lead time is also an incentive for inflating orders.

Customers may want to place orders only in integer multiple quantities of a specified quantity of an item (order batching or batch ordering) in order to reduce the number and costs of replenishment orders or to benefit from transportation economies (Cachon, G., and Ch. Terwiesch 2006, 340). Consequently customers will not place any replenishment order as long as the order quantity is smaller than the specified quantity.

Therefore, even if end-user demand is level customers will order large quantities during one review period and not place any orders for the following review period(s) (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 156).

However order batching will only have a (significant) effect if the demand during the review period is not a multiple of the specified quantity. For example if the specified quantity corresponds to weekly demand, customers will place four weekly orders. If these weekly orders are aggregated over monthly unit time periods at the upstream medical distribution centre and end-user demand is also aggregated over months, no demand distortion will occur. On the other hand if the specified quantity corresponds to three weeks of demand, customers will alternatingly place one and two orders during the following months.

Minimum order quantities (MOQ) imposed on customers cause demand distortion for the same reasons as batch ordering. However, as primary or secondary manufacturer packaging must never be opened, quantities of secondary supplier packaging will inevitably have to be minimum order quantities.

For some products such as laboratory reagents, rarely used drug products or sutures, average monthly demand at any health care facility can be significantly smaller than the minimum packaging size available or provided. This makes intermittent demand patterns inevitable.

Even if end-user demand is level, demand can be distorted by customers placing their orders to another medical distribution centre at the same level of the supply network (lateral transhipment) or bypassing ("shunting back") one or several upstream stages in the supply network (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 123). For example a customer may bypass upstream stages by placing an order directly with the manufacturer and therefore decreasing demand (in comparison to end-user demand) to the upstream stage.

The lack of a rational and systematic inventory control system will lead to frequent changes of demand analysis, demand forecasting, inventory control systems as well as inventory control parameters with all the detrimental consequences described earlier.

For the same reasons irregular order intervals and erratic ordering will cause demand distortion.

The consideration of quantities of expired, damaged, lost or stolen health care goods in (aggregate) demand data used for forecasting at any stage of the supply network will cause an increase of demand compared to end-user demand and therefore cause demand distortion.

Basing demand forecasts at all stages of the supply network on actual end-user demand data requires correct collection, recording and aggregation of this data. Any mistakes in the used set of end-user demand data will cause discrepancies with the actual end-user demand data and therefore lead to incorrect forecasts.

In order for all stages in the supply network to use the same set of actual end-user demand data, this data must be transmitted without any errors.

Even if end-user demand is level, any errors in calculating stock replenishment orders will cause differences and therefore demand distortion.

Likewise the reordering of backordered quantities by customers as well as reordering of stock on order by any stage in the supply network will lead to too high order quantities and therefore cause demand distortion.

Irrational behaviour of actors in the supply network can also cause demand distortion.

Logistician may be tempted to overreact to actual, perceived, suspected or expected shortages of health care goods in the upstream supply network and increase the order quantities calculated by the applied inventory control system (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 473).

Such over-reactive ordering (inflated ordering, reactive ordering) can lead to very significant "spikes" which inevitably cause demand distortion.

While overreactive ordering may not be justified, the order quantities correspond to an increase in perceived future demand.

A Systematic inventory control

- Changes of end-user demand and demand forecasts.
- Changes of forecasting methods or parameters.
- Use of moving averages of different order at different stages of the supply network.
- Changes of any inventory control parameter.
- Use of different review periods at different stages of the supply network.
- Change of inventory control system.
- Changes of estimated replenishment lead times.
- Order batching.
- Minimum order quantities.

- Low demand in relation to smallest packaging quantities.
- Changing the flow of orders within the supply network.

B Unsystematic and incorrect inventory control

- Lack of rational and systematic inventory control system.
- Irregular order intervals (erratic ordering).
- Consideration of quantities of expired, damaged, lost or stolen goods in the demand data.
- Errors in the collection, recording, aggregation and transmission of end-user demand data.
- Errors in calculating quantities for stock replenishment.
- Reordering backordered quantities.

C Irrational behaviour

- Overreaction to (expected) shortages and stockouts.
- "Shortage gaming" at any stage of the supply network.
- Phantom orders.

Table 18.5 Causes of demand distortion even if end-user demand is used at all stages

Shortage gaming (gaming, rationing gaming, rationing) is a special kind of overreactive ordering in that customers deliberately order more than they need according to their calculations in anticipation that suppliers will "ration" deliveries in proportion to ordered quantities (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 156). For example customers requiring 1,000 litres of Ringer lactate may order 2,000 litres in the hope that half of the ordered quantity will be filled.

Demand distortion is encouraged by allowing customers to cancel any orders at any time without any penalties. This may encourage customers to place (excessive) orders "just in case" which they cancel if the expected increase in their demand does not occur (Cachon, G., and Ch. Terwiesch 2006, 346) or to return (excess) stock at any time.

Not using end-user demand for forecasting and inventory control is in itself a major cause of demand distortion (see table 18.6) which can also compound any other causes of demand distortion discussed earlier.

Whenever end-user demand is not used for forecasting and inventory control at all stages of the supply network, the extent of demand distortion increases possibly disproportionately, with the number of stages in the supply network (Gattorna, J. 1998, 149). By definition, demand distortion for finished goods cannot occur in a two-stage supply network where a manufacturer is delivering directly to all customers, even though demand for components and raw materials may be distorted.

Demand distortion will occur in any supply network unless actual end-user demand is used for forecasting and inventory control at all stages of the supply network. As discussed earlier, even if rational and systematic inventory control systems are used at all stages, demand distortion due to changes of demand forecasts safety stocks and order-up-to-levels are inevitable.

The use of demand data from two stages down the supply network rather than from the next downstream stage will cause less demand distortion but not eliminate it.

The use of demand data from the next downstream stage in the supply network ("local information") is often quoted (Lee, H.L., V. Padmanabhan, and S. Whang 1997, 95) but in fact a special case of not using end-user demand.

In this case each stage in the supply network uses (aggregate) customer orders for forecasting demand and calculating replenishment orders (Chopra, S., and P. Meindl 2007, 507). However, customer orders almost certainly do not correspond to the end-user demand as the demand data used by customers for forecasting and inventory control themselves were almost certainly already distorted.

The use of customer demand data at each stage of the supply network is nearly the worst case scenario as the extent of demand distortion inevitably increases as demand moves upstream through the supply network. Even a small (random) fluctuation in end-user demand will be interpreted as a positive or negative trend at all stages of the supply network and lead to increases or decreases of safety stocks and order-up-to-levels.

The use of (aggregate) stock issues at the same stage of the supply network for forecasting demand and stock replenishment is the worst case scenario which maximizes demand distortion.

The quality of data on stock issues is even inferior to customer demand from the next downstream stage in the supply network as there is usually a delay between receiving and filling orders. Therefore the demand forecast will always lag behind and customer demand which arose during a unit time period might be considered in the forecast only of the next unit time period.

This worst case scenario can be even more compounded in case of shortages and stockouts as, even if there is no delay in treating customer orders the ordered quantities will only be filled once replenishment orders have been received and backorders are filled. For example in case of a stockout during two months, the "demand data" for forecasting will show two unit time periods with zero demand, despite customers having placed orders and probably urgently waiting for deliveries.

- Large number of stages in the supply network.
- Use of other than end-user demand data for forecasting demand.
- Use of demand data from the next downstream stage of the supply network.
- Use of aggregate stock issues at the same stage for forecasting demand data.
- Shortages and stockouts (when using stock issues for forecasting demand).

Table 18.6 Causes of demand distortion if end-user demand is not used at all stages

18.6.2 Consequences of demand distortion

Demand distortion in supply networks occurs regardless of whether end-user demand is used at all stages of the supply network or not. However, If end-user demand is used at all stages of the supply network variance of demand increases additively with the total lead time between the respective stages in the supply network (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 159). But if demand from the next downstream medical distribution rather than end-user demand is used for forecasting the variance of demand increases multiplicatively at each stage of the supply network (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 159).

If demand from the next downstream stage of the supply network is used for forecasting each stage will further amplify the extent of demand distortion. Demand distortion also occurs between stages if end-user demand is used at all stages. However, while any stage has to fill the increased (distorted) customer demand, the use of end-user demand at the same stage of

the supply network will not amplify customer demand. The respective stage has to fill larger (or smaller) customer orders but, as the forecast is not based on customer demand, this larger (or smaller) customer orders only causes (temporary) decreases (or increases) in stock levels. While every stage in the supply network can still distort demand between stages of the supply network, the increased fluctuations are partially "buffered" by the next upstream stage.

For example if end-user demand is level, an increase of customer demand (for example because of minimum order quantities or overreactive ordering) will not pass through the next upstream stage as the forecast (based on level end-user demand) remains unchanged. If end-user demand is not level and used at all stages of the supply network, demand distortion will still occur. However demand distortion at every stage will be proportional to the variability of end-user demand and therefore not be amplified from one stage to another.

Considering all its detrimental consequences (see table 18.7), demand distortion can only be seen as an ubiquitous plague.

The increase of variability of customer demand which demand distortion causes decreases forecasting accuracy (Boone, T., and R. Ganeshan 2002, 31).

As end-user demand propagates upstream through the supply network demand tends to progressively increase and become less frequent (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 487) which could lead logisticians to the false conclusion that end-user demand was seasonal or cyclical (Forrester, J.W. 1958, 45).

Forecasting and inventory control

- Decrease in forecasting accuracy.
- Seemingly seasonal or cyclical demand patterns.

Stock levels and service level

- Oscillations of stock on hand.
- Non-value adding increase of network stocks.
- Increased probability of stockouts and decreased service levels at all stages of the supply network.
- Decreased service levels of commercial suppliers (unforeseeable large order quantities).
- Increased replenishment lead times.

Resources

- Mismatch between available and required resources and inefficient resource utilization.
- Inefficient use of working capital.
- Increased manufacturing costs.
- Increased costs for receipt and shipping.
- Increased transportation costs.
- Increased need for expediting transport of consignments.
- Increased overall costs for supply chain management.

Relations

- Impairment of relationship between stages of supply network (because of poor services).
- Decreased trust between logisticians at different stages of the supply network.

Table 18.7 Possible consequences of demand distortion

While overstocking as one consequence of demand distortion is often mentioned the oscillation of stock levels also leads to shortages and stockouts (Cachon G., and Ch. Terwiesch 2006, 336). If end-user demand is level average stock levels over a long period of time will remain constant despite demand distortion. Demand distortion does not cause stock levels to

continuously and permanently increase. Eventually increases of stock levels must be compensated by decreases and are therefore reversible (Forrester, J.W. 1958, 45).

The increase of demand variability requires maintaining larger safety stocks at all stages of the supply network for maintaining the same level of customer service as without demand distortion (Lee, H.L., V. Padmanabhan, and S. Whang 1997, 94). The increase in network stocks does not provide any added value to customers when compared with networks stocks which would be sufficient if no demand distortion occurred. Nevertheless higher storage costs are incurred and the remaining shelf life of products is reduced. Even temporarily higher stock levels incur higher storage costs as storage capacity requirements are mainly determined by maximum stock levels not by their averages.

Since excess stock in a medical distribution centre is of no added value to customers, the temporary overstocking in no way compensates for the shortages and stockouts in terms of customer service. Low stock levels caused by the oscillations described earlier increase the probability of shortages and stockouts and therefore decrease service levels at all stages of the supply network (Lee, H.L., V. Padmanabhan, and S. Whang 1997, 93).

Demand distortion in the internal supply network also affects commercial suppliers which inevitably will decrease the services they can provide to humanitarian organizations.

The shortages and stockouts lead to larger replenishment lead times (Chopra, S., and P. Meindl 2007, 500) which in turn require increasing safety stock levels.

The mismatch between available and required resources leads to poor utilization of resource capacities in general (Simchi-Levi, D. Ph. Kaminsky, and E. Simchi-Levi 2004, 42) and to the inefficient use of warehouse resources in particular (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 472).

The increased variability of customer demand filled by manufacturers leads to an increase in the variability of the size of production batches (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2004, 42) and therefore increases production costs. In his simulation, Forrester showed that a mere 10% of increase in orders from retailers caused an increase in production of 31% with a subsequent decrease of 40% during the following year (Forrester, J.W. 1958, 46).

The higher variability of customer demand causes a higher variability of required transportation capacities as well as flows through medical distribution centres and therefore increases overall costs for receiving and shipping (Chopra, S., and P. Meindl 2007, 500). Costs for transportation are further increased by the need for expediting shipments (Lee, H.L., V. Padmanabhan, and S. Whang 1997, 93).

Consequently, the overall costs for managing flows of health care goods through the supply network increase.

As demand distortion impairs customer service throughout the supply network and the different stages blame each other the relationship between these stages is negatively affected (Chopra, S., and P. Meindl 2007, 500).

As the negative consequences of demand distortion caused at any stage of the supply network are not noted by the respective stage, it cannot learn from its mistakes and will instead blame other stages of the supply network for the poor (and possibly deteriorating) services (Chopra, S., and P. Meindl 2007, 505). The decrease in services received by all stages in the supply network causes distrust and ". . . stages in the supply network becoming enemies rather than partners" (Chopra, S., and P. Meindl 2007, 506).

18.6.3 Measures for preventing and reducing the extent of demand distortion

The problem of demand distortion must be a constant concern and an important consideration at strategic, tactical and operational levels for everyone, individually as well as together, for all those involved in or affecting logistics and supply chain management. Staff at assisted health care facilities as well as health programme managers play an absolute critical role in minimizing variability as well as distortion of end-user demand.

> ***"Instead of spending time and energy finding inventory and production policies that respond well to that variability, it is better to find ways to lower it" (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 123).***

While demand distortion cannot be totally prevented, many factors which individually contribute to demand distortion can be eliminated or at least controlled in order to reduce their impact and adverse effects. Eliminating and reducing factors must take preference over taking measures for coping with avoidable consequences of demand distortion.

A Supply network design

- Minimize the number of stages in the supply network.
- Serving as many customers as possible from a single medical distribution centre.

B Demand data

- Use of end-user demand data for forecasting at all stages of the supply network.
- Ensuring accurate and timely transmission of end-user demand data.
- Prevent expiry and damage of stock at all stages of the supply network.

C Demand forecasting

- Reducing variability of demand forecasts.
- Avoiding sudden changes in forecasting methods and parameters.

D Inventory control

- Use of imprest systems at all assisted health care facilities
- Systematic use of rational inventory control systems at all stages of the supply network.
- Coordination of unit time periods used at all stages of the supply network.
- Changes of inventory control system and parameters only for good reasons.
- Only gradual change of inventory control parameters.
- Minimizing variability of (maximum) replenishment lead times.
- Ensuring regular and correct update of backorders.

E Order fulfilment

- Ensure that all customers order at least once during every review period used at upstream stages.
- Reduce end-user demand variability.
- Provide health care goods in smaller packaging sizes.
- Share information on available stocks.
- Fair share allocation.

Table 18.8 Measures for preventing and reducing the extent of demand distortion

Although demand distortion which has already been created and possibly increased at downstream stages cannot be undone at any particular stage of the supply network, all

possible measures must be taken to contain demand distortion and decrease its extent. The downswings caused by demand distortion require the same attention as upswings as they are only two different aspects of the same problem.

The careful identification of causes of and the extent to which they contribute to demand distortion allows identifying the correct measures for preventing any further increase (Lee, H.L., V. Padmanabhan, and S. Whang 1997, 98). All irrational as well as rational factors at the strategic, tactical and operational level which contribute to demand distortion must be addressed at the same time, which may involve reconfiguring the supply network.

Eliminating, reducing and as far as possible minimizing stages in the supply network without compromising customer service is certainly one of the key measures for reducing demand distortion. Apart from the internal supply network of humanitarian organizations, the internal distribution system within health care facilities, especially hospitals, also requires particular attention.

"May not a good deal of instability be caused by the existence of so many levels [stages]?" (Forrester, J.W. 1958, 47).

As discussed earlier, serving as many customers as possible from a single medical distribution centre decreases variability of aggregate customer demand and therefore reduces demand distortion in the upstream supply network.

The use of (aggregate) end-user demand for forecasting, inventory control and stock replenishment at all stages of the supply network (Forrester, J.W. 1958, 47) is another indispensable key measure for preventing and reducing demand distortion. The end-user demand should be captured from as close to the point of use as possible (Christopher, M. 2005, 122).

It is important to point out that the this measure will not eliminate demand distortion but will still significantly reduce the extent of demand distortion (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 161). Even if the same forecasting methods and inventory control systems are used at all stages and all parameters remain unchanged, the variability of averages and standard deviations of end-user demand still require changes of safety stocks and order-up-to-levels. However the use of end-user demand avoids the propagation of demand distortion and prevents the increase of the extent of demand distortion from one level to the next.

Moreover any stage in the supply network can determine and analyse actual customer demand patterns in end-user demand which are distorted if not disguised by demand distortion (Cachon, G., and Ch. Terwiesch 2006, 347). Information on the reasons for step changes, outliers or erratic customer demand patterns should be explained to allow inclusion in the forecasts at all stages of the supply network.

The corrected and aggregated end-user demand from each assisted health care facility must be collected and transmitted upstream throughout the supply network. Every medical distribution centre will further aggregate the end-user demand from all the health care facilities in its own echelon as a basis for forecasting, inventory control and stock replenishment.

In case demand distortion leads to a stockout at any stage of the supply network, the routine inclusion of backorders in the order quantities for stock replenishment will ensure that eventually all customer orders from the immediate downstream stores are filled. Therefore

while end-user demand is used for calculating safety stocks and order-up-to-levels, all customer orders must of course be filled in full.

A complete set of end-user demand from all assisted health care facilities must be transmitted upstream to all the stages in the supply network accurately and timely (Corsten, H., and R. Gössinger 2001, 91). However, even if for technical reasons a delay of some days or even a few weeks cannot be avoided, forecasts, even based on the delayed end-user demand data, will be far more accurate than forecasts based on timely but distorted demand data from the next downstream stage in the supply network.

The expiry and damage of stock should be prevented at all stages in the supply network. While the order quantities required for their replacement will not change end-user demand, these additional orders will cause demand distortion between stages in the supply network.

Differences and changes of forecasting methods and parameters at different stages of the supply network can cause demand distortion even if all stages base their forecasts on the same set of end-user demand (Lee, H.L., V. Padmanabhan, and S. Whang 1997, 99).

Even if end-user demand is used as a basis for all forecasts, the variability of demand forecasts will depend on the forecasting method as well as forecasting parameters. Reducing the variability of demand forecasts will reduce the variability of replenishment orders which are filled by the next upstream stage in the supply network.

For example increasing the order of moving averages (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 158) or the use of smoothing methods will decrease variability of forecasts, decrease variability of replenishment orders and therefore reduce demand distortion between stages of the supply network.

The variability of demand forecasts at all stages of the supply network can also be reduced by decreasing their frequency. For example if end-user demand is aggregated over unit time periods of weeks, monthly forecasts will display a lower variability than weekly forecasts.

The forecasting methods and parameters at all stages of the supply network should only be changed if there are compelling reasons and, wherever possible, gradual changes should be preferred to sudden changes.

The use of imprest systems at central storage facilities as well as throughout internal distribution systems at all assisted health care facilities reduce variability of end-user demand. Moreover, if the imprest levels at the central storage facility such as a central pharmacy are not changed, regular (weekly, monthly) replenishment orders are identical with the demand on the central pharmacy. Therefore the transmission of aggregate demand data from the hospital pharmacy is no longer necessary as it is included in the replenishment order.

Imprest systems should be used for inventory control at central storage facilities as well as throughout internal distribution systems at assisted health care facilities.

If all stages in a supply network strictly apply an imprest system and do not change the imprest level demand distortion can be entirely prevented (Cachon, G., and Ch. Terwiesch 2006,337). However such distortion free supply networks are practical only in exceptional cases for example for contingency stocks.

Using end-user demand alone is not sufficient for preventing or reducing demand distortion. In order to minimize fluctuations of order quantities and therefore demand placed on the next upstream stage of the supply network, all stages must systematically apply rational inventory

control systems. Replenishment orders must be calculated regularly and according to a clearly defined algorithm.

The same unit time periods, for example months, should be used at all stages of the supply network or unit time periods should increase in multiples from one stage to another upstream stage. This will, for example, avoid significant demand distortion by one stage placing monthly replenishment orders while the next upstream stage places weekly orders and therefore has to react to the large order received every fourth period with no demand during the remaining periods.

Any changes of inventory control systems or parameters, which inevitably will cause demand distortion, should only be made for compelling reasons and logisticians must refrain from any arbitrary changes.

"The behavior of a simple production-distribution system . . . is probably more affected by the practices followed in adjusting inventories and in-process orders than by any other single characteristic" (Forrester, J.W. 1958, 48).

Any inevitable changes of inventory control parameters must be gradual in order to limit any demand distortion (Forrester, J.W. 1958, 49).

Reduction of the variability of (maximum) replenishment lead times can significantly reduce demand distortion throughout the supply network (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2004, 26) and is particularly beneficial for seasonal end-user demand (Chopra, S., and P. Meindl 2007, 508).

Regularly providing customers with accurate and updated stock on order records will prevent accidental reordering of backorders.

All assisted health care facilities must place at least one order during every review period with upstream stages in the supply network in order to avoid intermittent demand.

End-user demand variability is not a cause of demand distortion. Nevertheless, given any set of factors causing demand distortion, demand variability at upstream stages in the supply network will be proportional to end-user demand variability. Therefore lower end-user demand variability will contribute to lower absolute variability at upstream stages in the supply network.

Where applicable, providing health care goods in smaller packaging sizes will prevent intermittent demand patterns, therefore reduce end-user demand variability and can decrease demand distortion at all stages of the supply network.

Sharing information on stocks available at medical distribution centres assures customers and reduces their temptation to engage in shortage gaming (Lee, H.L., V. Padmanabhan, and S. Whang 1997, 101).

Allocation of stock according to the fair share method will discourage shortage gaming of customers and inflating orders will have no effect on actual allocation of stock.

18.7 Forecasting customer demand

Forecasting requires a process of several steps. First, the problem for which a forecast is required needs to be identified and defined and it must be clear how the result of the forecast will influence management decisions. Information and data must be collected, recorded, if

necessary corrected, and aggregated. A preliminary analysis of data, such as determining time series patterns, will help in determining suitable forecasting methods. Depending on various aspects such as forecasting situation and availability of data, a suitable forecasting method will be selected. After every forecast, the respective forecasting error is calculated in order to assess and monitor the quality of forecasts. If the forecasting accuracy is satisfactory, the forecast can be used to make management decisions. If the forecasting accuracy is considered unsatisfactory, a more suitable forecasting method must be found before repeating the forecast.

Generally, one can assume that forecasts do not have an influence on the future. However in some cases the opposite might be true. For example, forecasting low customer demand for an item may lead to shortages and stockouts and decrease actual customer demand while increasing customer demand for a substitute.

"Most people are surprised to learn that most of the decisions they make involve forecasting" (Makridakis, S., and S.C. Wheelwright 1989, 3)

Assuming that a value in the following month will be equal to the value of the current month is a simple forecasting technique, even if managers are not aware. Often judgemental forecasts are made without distinguishing between forecasting and decision making (Makridakis, S., and S.C. Wheelwright 1989, 3). In organizations forecasts are often based on wishful thinking, guessing and biases rather than on scientific analysis.

Forecasting is used at all levels of an organization to prepare for the future and plan resources, to help make good decisions and to improve operational, tactical and strategic planning. It is needed for planning purchasing, stores and warehouse requirements and capacities, transport requirements and capacities as well as staff requirements and financial forecasts are required for establishing budgets. Forecasts on customer demand at all stages of the supply network are indispensable wherever supplier lead time is longer than order lead time acceptable to customers and a prerequisite for inventory control management.

- Items which will be ordered.
- Quantities of each item.
- Geographical location where customer demand will arise.
- Time when customer demand will arise.
- Duration of customer demand.

Table 18.9 Aspects of customer demand requiring forecasting

Collaborative planning can be seen as exchange of information and health programme managers sharing their global qualitative (informal) forecasts with logisticians, especially before new health programmes are implemented. Although invaluable, logisticians must eventually forecast customer demand at the line item level.

Depending on the situation, logisticians will have to forecast one or several different aspects of demand. In principles the issues of items and their quantities (matter), the place where they will be required (spatial demand) as well as when (temporal demand) and how long they will be required (duration of time) are of interest. Especially in emergencies, the location(s) and time when customer demand is likely to arise need to be forecast. In some cases the onset of an emergency may have already occurred while especially in prolonged conflicts, the time where the situation deteriorates to a point where humanitarian assistance is necessary, may

be difficult to predict. Tension between conflict parties may last for a long time before a conflict actually breaks out. The responsibility of forecasting the need for humanitarian assistance as such lies with programme managers and the decision when and where humanitarian assistance will be provided is taken by the management. Logisticians need to carefully follow and analyse all available information in order to prepare themselves for various contingencies. Unless large scale displacement occurs, the majority of humanitarian assistance is likely to be needed in the most populated places of a country. Programme managers also need to forecast how long demand is likely to last.

19 DEMAND ANALYSIS

Analysing customer demand is only the first step in forecasting customer demand. Moreover, analysing customer demand allows programme managers to gain insight into the use of various health care goods such as compliance with essential drug policies, standard treatment protocols and good prescription practices. It also allows monitoring the consistent use of inventory control policies at assisted health care facilities.

Needs for health care goods arise whenever health professional require health care goods for providing medical care to patients. However customer demand only arises once health care facilities place orders with humanitarian organizations. This distinction is important because needs for health care goods are often overwhelming even before acute and chronic crises. However logistics services of humanitarian organizations are requested only once orders have been defined and placed.

Customer demand arises whenever a customer places an order for health care goods and corresponds to health care goods and quantities which are requested. Therefore customer demand data is a list of all orders from customers with order date, items and quantities for each item.

Customer demand for health care goods arises at all stages of the supply network: patients request drug products from care givers in wards or from dispensaries, hospital pharmacies replenish their stocks from medical warehouses and humanitarian organizations order from commercial suppliers.

In principle, the end-user is the patient who swallows a capsule, the health professional applying a dressing or an anaesthetic drug product or a laboratory technician who is carrying out a test. However throughout this text end-user demand corresponds to the customer demand from the most downstream stocking points in the supply network such as dispensaries at clinics or central pharmacy at hospitals, which place written and documented replenishment orders. This corresponds to considering EPOS (electronic point of sales) data as end-user data in commercial supply chain management, even though goods may not be consumed for long periods of time after purchasing and the person purchasing them is in many cases not the end-user.

A second important issue is that for all practical purposes end-user demand data must be aggregated over some unit time period. Strictly speaking end-user demand would be a huge set of data of exact times at which individual units of items were demanded (for immediate use). This data is unavailable and would, unnecessarily, require enormous resources for recording, storing and analysing without adding any value. Instead end-user demand must, for all practical purposes, be aggregated over unit time periods of days, weeks or months.

For the reminder of this text, end-user demand refers to the periodic (weekly or monthly) replenishment orders which central storage facilities at assisted health care facilities place on the next upstream medical distribution centre. Assuming that assisted health care facilities apply periodic review inventory control systems, the calculated replenishment orders correspond to aggregated (daily, weekly, monthly) demand from or issues to patients or hospital services.

End-user demand refers to the demand which is (periodically) placed by central storage facilities at assisted health care facilities on the next upstream medical distribution centre.

Customer demand is frequently confused with consumption. Health care goods are consumed when they are applied or used. For example when a patient swallows a tablet, is given an injection, a dressing is applied or a suture is made. If stocks are available consumption of health care goods will not trigger customer demand to the upstream stage in the supply network. On the other hand, customer demand for health care goods might arise even if there has been no consumption. For example if goods expire or are stolen, health care goods need to be replaced in a store or sets are pre-positioned in anticipation of an emergency.

The crucial issue for logisticians is that very unfortunately, consumption is almost never known. Care givers do not record ever bandage or suture which is used and although prescriptions of drug products are documented in manual patient records, this data is not (easily) available to logisticians for analysis. It is also important to realize that customer demand at one stage of the supply network may not cause any customer demand at the (next) upstream stage. Although a hospital pharmacy might face severe shortages and stockouts, the respective humanitarian organization may not (yet) be providing humanitarian assistance or may not have access. Therefore needs may arise long before customer demand is placed on logistics services of a humanitarian organization. Another example is a medical distribution centre which is overstocked and can fill customer demand from downstream stores without having to replenish its own stocks.

The distinction between consumption and customer demand is so important because they can differ significantly. Although over a long period of time, consumption will correspond to customer demand, differences over the short-term can differ significantly.

Another important distinction is between customer demand and stock issues. Ideally any customer demand is filled in full and instantly from stock. In practice, delays will occur through processing of orders and because of shortages and stockouts. Therefore stock issues do not correspond to customer demand and should not be used instead of customer demand data.

19.1 Types of demand

The distinction between predictable and unpredictable demand is crucial for forecasting. Predictable demand, also called deterministic demand, is known in advance and requires planning but no forecasting. For example if a humanitarian organization decides to vaccinate a certain number of people, the requirements for vaccines and single use medical devices can easily be calculated in advance and are therefore known. Predictable demand corresponds to the term dependent demand which is commonly used in production management.

Unpredictable demand, which is also called stochastic or probabilistic demand, is not known and inventory control requires forecasting future demand. In production management unpredictable demand corresponds to the term independent demand.

Demand is continuous if goods can be ordered and delivered in any quantity, such as liquids (water for example), gases or electricity. Health professionals can apply any quantity of liquids, for example injectable drug products, or ointments. However in practice demand for health care goods is always discrete as they are packaged, ordered and delivered in units, such as bottles of 1 litre or tins of 250 grams.

Demand, usually of components of a larger product, is called dependent if there is a defined relationship with the demand of another product. Dependent demand is mainly found in production management where demand for parts and components is directly derived from a bill of materials and calculated with MRP (material requirements planning) systems. While the dependent demand for parts or components is always known with certainty, demand for the final product is usually independent and requires a forecast. For example demand for a certain

type of medical kit is usually independent while demand for the components of the same kit is dependent as each kit contains defined products in defined quantities.

19.2 Demand data

The first step in analysing customer demand is collecting customer demand data item by item. In order to minimize demand distortion, customer demand data must be collected as far downstream in the supply network and as near to the end-user as possible.

As pointed out earlier, it is essential to collect data on actual customer orders rather than on actually issued health care goods.

Assuming that unlimited historical data is available, deciding how far to go back in the past for selecting customer demand data presents a dilemma. Provided that patterns in the time series do not change, generally, models will be more accurate, the more historic data is included. This is particularly the case for periodic patterns in time series. However, the further data lies in the past the less relevant it tends to be for predicting the future. Some forecasting methods, for example "smoothing" methods will consider this decrease in relevance while this is not the case for classical decomposition for example.

Ideally demand data would be recorded whenever health professionals or patients use or consume health care goods. However collecting demand data directly from end-users would require unreasonably large resources and ensuring reasonable accuracy of data would be difficult.

The next upstream source of demand data are the stores maintained in health care facilities, for example in the sterilization department, patient wards or the laboratory or the pharmacy of a health care centre. These will either record stock issues individually or regularly prepare reports on aggregate stock issues during the past week or month. Even if records are primarily maintained for monitoring and controlling appropriate use, demand data can also be used for inventory control.

In many less developed countries hospital wards do not keep stocks of health care goods but are supplied from the hospital pharmacy daily according to actual patient needs and prescriptions. In this case demand data can be collected directly from the hospital pharmacy records.

In acute crises customer demand data may not be available because records have not been maintained or were destroyed. When humanitarian organizations set up new health services, historic customer demand data is also not available. In these cases it is important to establish an accurate system of record keeping immediately in order to have reliable customer demand data after one or two weeks.

Forecasts can never be more accurate than the data on which they are based.

With the exception of occasional direct deliveries from suppliers to health care facilities, humanitarian organizations are faced with multistage systems (see figure 19.15). An echelon refers to the distribution centre itself as well as all the downstream distribution centres and customers it supplies (Minner, St. 2000, 70). If forecasts at different stages of the supply network are based on demand data from immediate downstream stores, due to demand distortion, forecasting accuracy will decrease with every upstream stage (Lee, H.L., V. Padmanabhan, and S. Whang 1997, 98). However if end-user demand is used for forecasting at all stages forecasting accuracy will increase with every upstream stage as demand is

aggregated over a larger geographic area (Gudehus, T. 1999, 217) and the number of customers served by each medical distribution centre increases upstream.

In supply networks demand will need to be collected and analysed for forecasts at several stages. The best forecasts are invariably achieved by using end-user demand (Webster, B. 1996, 17) and in order to minimize demand distortion, end-user demand should be used at all stages of the supply network. Every distribution centre should aggregate end-user demand from all health care facilities of the echelon they supply rather than analysing stock issues or replenishment orders from downstream medical distribution centres. Correct aggregation of demand data requires using the same unit time period at all health care facilities. For example, if health care facilities would calculate aggregate weekly demand and medical distribution centres would use aggregate monthly demand, inconsistencies would occur.

Use end-user demand for demand analysis at all stages of a supply network.

The use of end-user demand data for forecasting throughout the entire supply network requires an effective and reliable communication network which allows upstream transmission and distribution of end-user demand data. Ideally end-user demand data would also be shared with commercial suppliers of humanitarian organizations for improving their own forecasts.

If end-user demand is not available or cannot be transmitted to the medical distribution centre regularly, the next best set of data are customer orders from the assisted health care facility or from the downstream medical distribution centre which is being supplied.

In any case data should not be collected from the stock issues or shipments of the medical distribution centre which is analysing demand. Data on stock issues can be severely distorted and misleading whenever stockouts occur and requires complicated calculations for correction. Whenever stockouts occur records on stock issues will imply that no customer demand has occurred although customers orders are received and added to the backorder record. Conversely once the medical distribution centre has replenished the stocked out item and fills all accumulated backorders, data on stock issues will suggest a sudden large increase in customer demand which is in fact just an artefact (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 123).

Moreover, even without stockouts stock issues always lag behind customer orders and therefore any forecast will lag behind changes in customer demand data.

Never use data on stock issues for demand analysis and forecasting.

19.3 Demand aggregation

The analysis of order quantities and order frequencies of each item from individual health care facilities is possible but requires rather complex calculations. It is easier to use customer demand aggregated over time as well as over customers for demand analysis as well as for forecasting. Also note that customer demand aggregation leads to a risk pooling effect which increases forecasting accuracy.

Customer demand can first be aggregated over unit time periods of days, weeks, months or years ("time buckets") simply by adding up all order quantities from the respective customer which occurred during the respective time period. The longer the period over which demand is aggregated, the less data needs to be processed during further demand analysis and

forecasting. In practice monthly aggregation is a practical compromise for weighing the resources required for collecting customer demand data and ensuring sufficient responsiveness of the inventory control system. The length of the unit time period should be selected to ensure that one customer order can be expected at least every two unit time periods (Lewis, C.D. 1975, 89). For example if one customer is served who places a monthly order, a weekly time period should not be selected since otherwise the time series will certainly be intermittent and difficult to forecast.

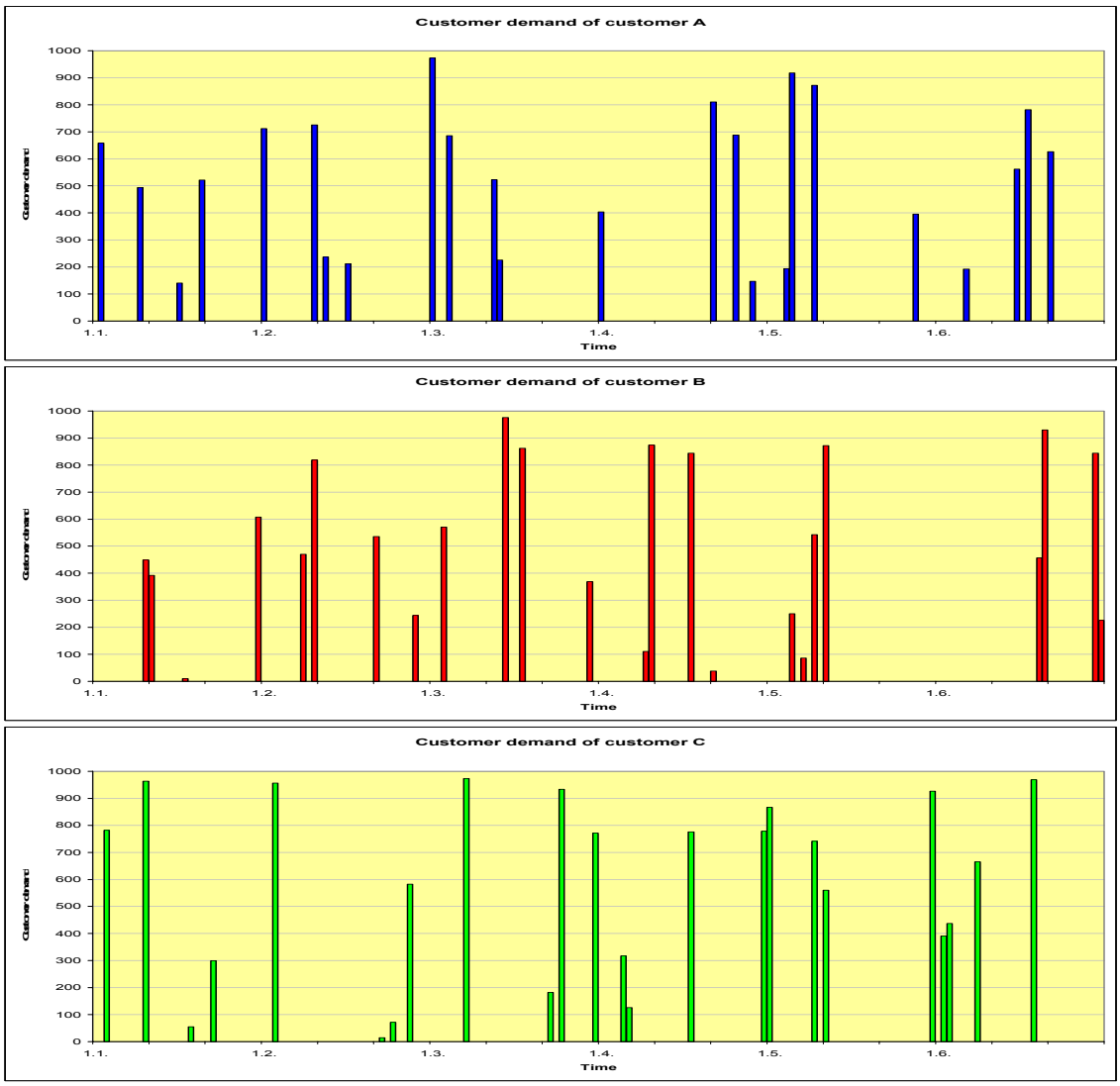

Figure 19.1 Example of three sets of customer demand

Once a unit time period has been selected, it is usually maintained throughout the further process of demand analysis and forecasting. For example it is not practical to aggregate customer demand over a unit time period of 3 weeks and make forecasts for monthly unit time periods.

For example, collecting one set of customer demand data from each health care facility once a month limits the overall amount of data which needs to be collected and allows using fairly simple information management systems. However, increasing the length of the unit time period also decreases the responsiveness of the forecast and inventory control system to changes.

One should also be aware that monthly aggregation of customer demand can cause some artefacts. Even if daily demand were to be equal throughout the year, monthly aggregated demand would show fluctuations of up to 10% since the number of days in a month varies between 28 and 31 and create an artificial cyclical customer demand pattern. The number of working days also differs from month to month. Since end-user demand for many items will be higher during weekdays than during weekends where services are often limited to emergencies. This problem can be avoided by weekly aggregation.

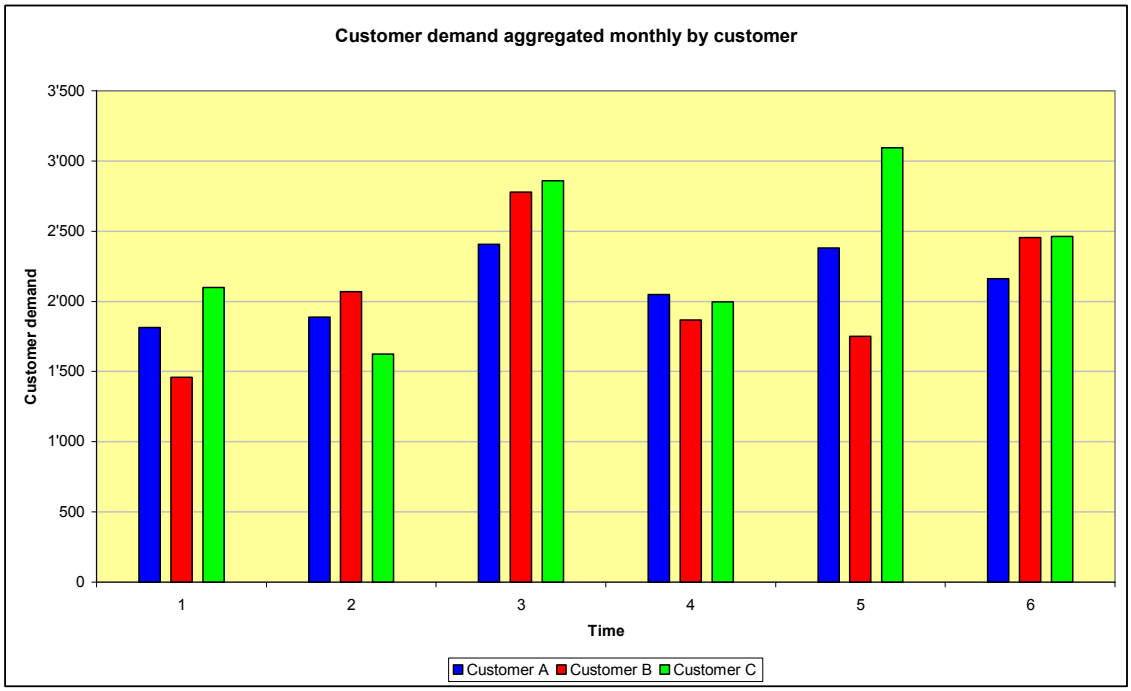

Figure 19.2 Monthly customer demand aggregation

However, the impact of these fluctuations on the inventory control system is quite limited if historic demand over several months is used for forecasting as these artefacts will even out over longer periods of time.

Customer demand can also be aggregated over several customers. For any medical distribution centre it is far more important to forecast customer demand for all customers its serves than trying to forecast customer demand for each assisted health care facility individually. Incidentally, aggregating all orders from all served customers has a "risk pooling" effect which increases forecasting accuracy.

Risk pooling is a vital concept which is intuitively easy to understand and that everyone who is dealing with demand analysis forecasting and inventory control must be familiar with. For any item, demand from different customers will vary over time and fluctuate along a constant mean. Since it is unlikely that demand from all customers will increase or decrease at the same time, there is a high probability that increased demand from one customer will be (partially) evened out by decreased demand from another customer during the same unit time period. As a result, aggregate customer demands shows less and smaller fluctuations than individual customer demand. During an acute crisis it is of course possible that all hospitals receive a large influx of patients at the same time. However, especially in chronic crisis conflict intensity often increases in one town or area while it decreases in another. Moreover orders to medical distribution centres will also depend on available stocks, which are very likely to differ from one assisted health care facility to another.

Figure 19.3 Monthly aggregated customer demand aggregated over all customers

In any case, even in the unlikely case that demand from all customers were completely "synchronized", variability of aggregated customer demand cannot exceed variability of individual customer demand. In all other cases, the variability of aggregated customer demand will be less than the variability of demand from each customer. The example in figures 19.1 throughout 19.3 clearly demonstrates the decrease in variability of demand.

Finally customer demand can also be aggregated over groups of items such as infusions, sutures or dressing material. Again the variability of demand aggregated over a group of items will be less than for the individual items and forecasts will therefore be more accurate. Such aggregate forecasts may be useful for planning required storage space for infusions or vaccines. However, for inventory control forecasting customer demand for a groups of items is only relevant if the respective items can be substituted for each other.

19.4 Time series

The final result of correcting and aggregating customer demand over customers and times is a discrete time series of data for each item with the total monthly demand from all customers during the respective month. A time series is simply a sequence of observations taken over a period of time, in our case at equal intervals. Time series allow to visualize data and detect patterns without the need for mathematical analysis.

For each item customer demand aggregated over a fixed unit time period (for example every month) corresponds to one observation at a fixed time interval (once a month). The contrary would be a continuous time series where a parameter, such as room temperature, can be measured at any time and is continuously recorded over a time period. As demand for health care goods is always discrete, continuous time series will not be considered in this text and time series will always mean discrete time series.

Discrete time series are traditionally presented as continuous graphs falsely implying an underlying continuous process and continuous demand. Since line charts are more intuitive

than bar charts, time series will be represented as bar charts with connecting dotted lines. The dotted lines indicate, that they do not represent values of the variable but are only added to underline certain features of time series such as trends or cycles. Graphic representations of aggregated customer demand are often used because their are intuitive and sometimes allow detecting outliers and patterns.

The abscissa (x-axis) will indicate the month and the ordinate (y-axis) will indicate monthly aggregate demand of that month.

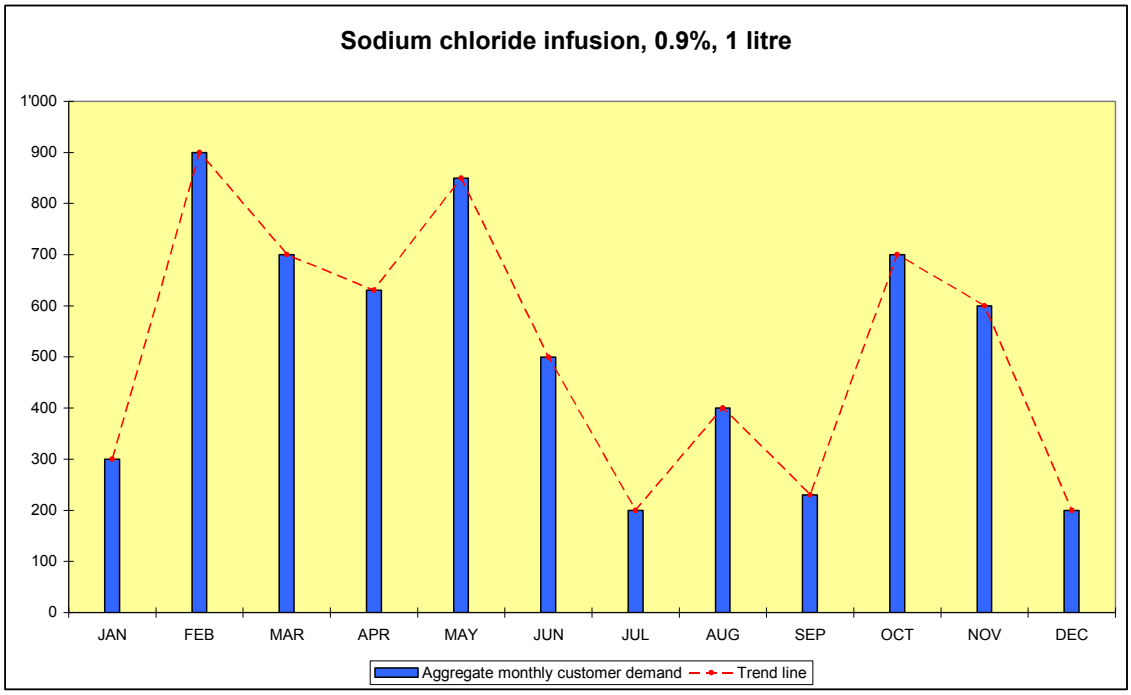

Figure 19.4 Example of a discrete time series

An example of a time series is given in figure 19.4 The example represents the time series over 12 months but of course time series can be shorter or much longer. Note that the aggregate monthly customer demand was 300 units in January. This means that the customer placed one or more orders between the first and the last day of January for a total of 300 units but no information on when how many units were ordered is given. The customer could have made one order for 300 units on January 2nd or ordered 75 units each Monday.

19.5 Time series analysis

After establishing the time series for each item, the next step is to analyse the time series in order to draw some conclusions which will be useful for forecasting future demand.

Any time series can be seen as the sum of the five components level, trend, periodicity, cycles and random fluctuations. The superposition of these five components creates the actual demand pattern of an item.

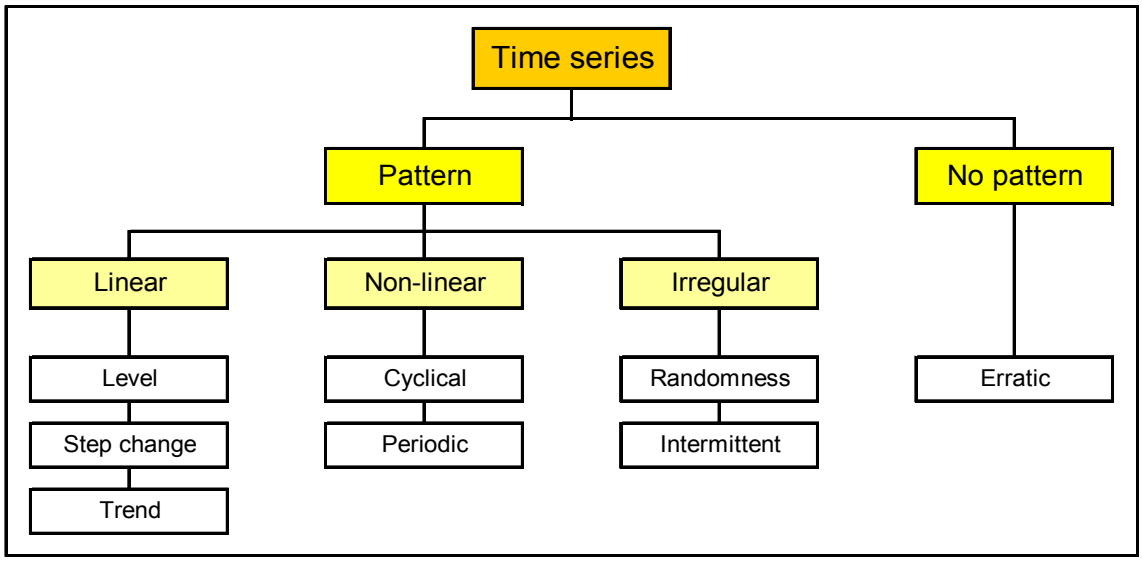

Figure 19.5 Classification of customer demand patterns

19.5.1 Customer demand patterns

In the simplest, and best case in terms of forecasting, demand is level, also called horizontal, steady or constant. Demand is level, if aggregate monthly customer demand is the same every month.

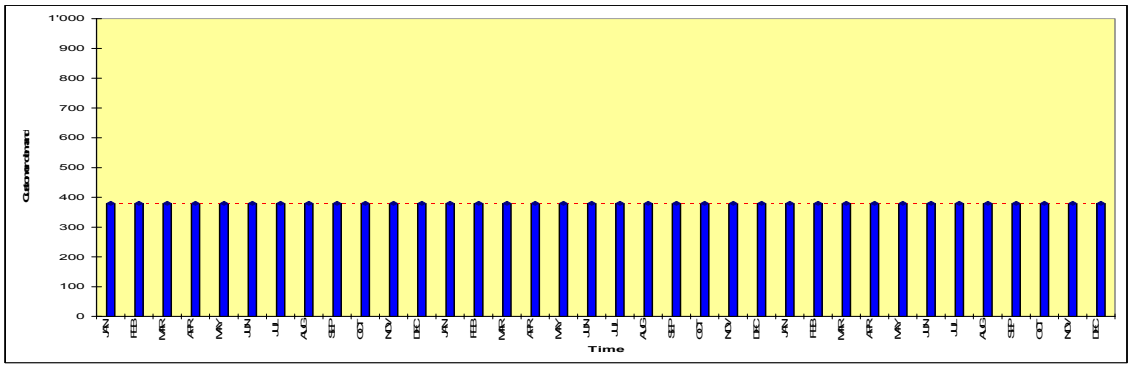

Figure 19.6 Example of a level time series

For level demand the demand rate can be low (slow-moving item) or high (fast-moving item).

A level shift, also called step change, in a time series occurs when demand is level at different demand rates during different periods of time. A level shift change may be caused by a sudden influx of patients at a hospital during an outbreak of a conflict.

Note that in this case the change is sudden although the connecting line falsely implies a gradual change.

The opposite of level demand is time varying or variable demand, also called non-stationary demand. These variations can be gradual such as in trends, cyclical or periodic patterns or be intermittent or erratic.

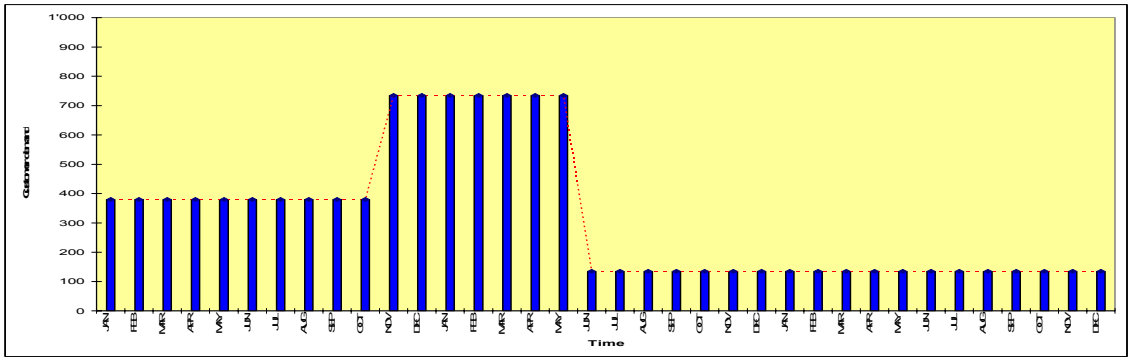

Figure 19.7 Example of a level shift in a time series

Linear trends, also called slopes or ramp changes, are steady increases or decreases of the demand rate in a time series and may be difficult to distinguish from periodic or cyclical changes. As a rule of thumb, seven observations are needed to recognize and establish a positive or negative trend (DeLurgio, St.A. 1998, 756).

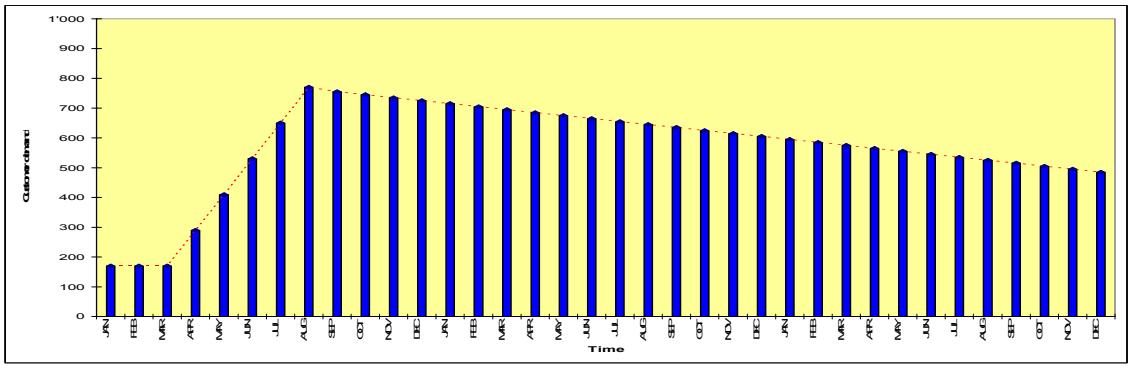

Figure 19.8 Example of a positive and negative linear trend

A linear trend might be caused by a gradual increase of patient consultations at a clinic or admissions at a hospital due to an increase of the resident population from arriving internally displaced people.

Customer demand is called periodic if increases and decreases occur at equal periods of time. This customer demand pattern is also called seasonal. However since it is counterintuitive that a "season" could last only a day or a week, this customer demand pattern will be called periodic instead. A "seasonal" pattern, in the usual sense of meaning, would be a special case of a periodic customer demand pattern with a period of one year. Three to four periods are required to recognize and establish a periodic pattern (DeLurgio, St.A. 1998, 756). Periodic customer demand patterns can have natural causes, such as climatic influences, or be manmade for example shortages of funds of humanitarian organizations towards the end of the fiscal year.

Periodic demand may be caused by a gradual increase and decrease of conflict intensity over many years or by the increase and decrease of availability of funds available to a humanitarian organization over several years. Periodic changes of demand according to the climatic seasons occurs with certain drug products used for treating malaria, acute respiratory infections or diarrhoeal diseases which increase during certain climatic seasons of the year.

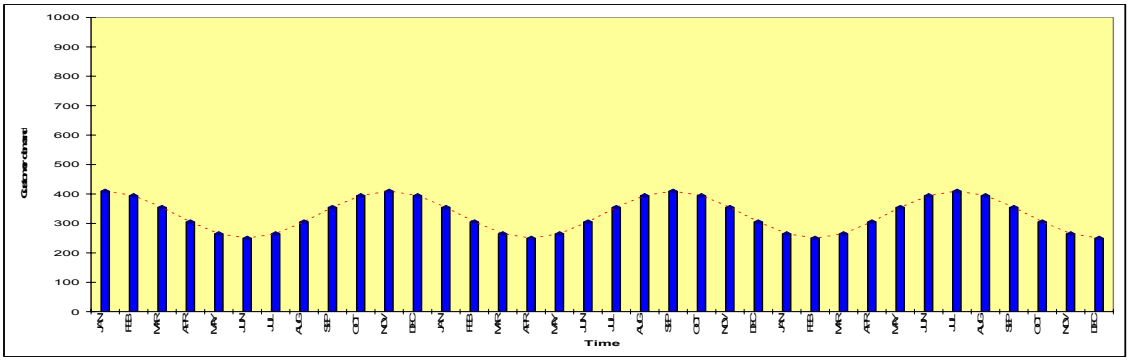

Figure 19.9 Example of a periodic customer demand pattern

Determining the suitable number of unit time periods which are included in the data set for forecasting present a dilemma. Identifying and determining periodic patterns in a time series requires data covering at least several periods. However the more periods are included the less relevant the oldest data becomes and periods might be changing over time. A compromise is the use of data of between four and six periods (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 100). However the relevance of the data will have to reviewed and judgement might be needed to adjust forecasts. Caution is necessary when insufficient demand data is available. For example if customer demand has a strong periodic pattern with a period of one year, then customer demand data from the past six months only will be a poor indicator of customer demand during the next six months.

Customer demand patterns are cyclical if they show periodic increases and decreases but when the length of periods varies from period to period. This means that the time period between peaks and troughs varies. For example funds available to humanitarian organizations may vary according to the economic situation in donor countries and economic growth and decline often show long cyclical patterns lasting years. Therefore periodic demand can be seen as a special case of cyclical demand where all periods are of equal length.

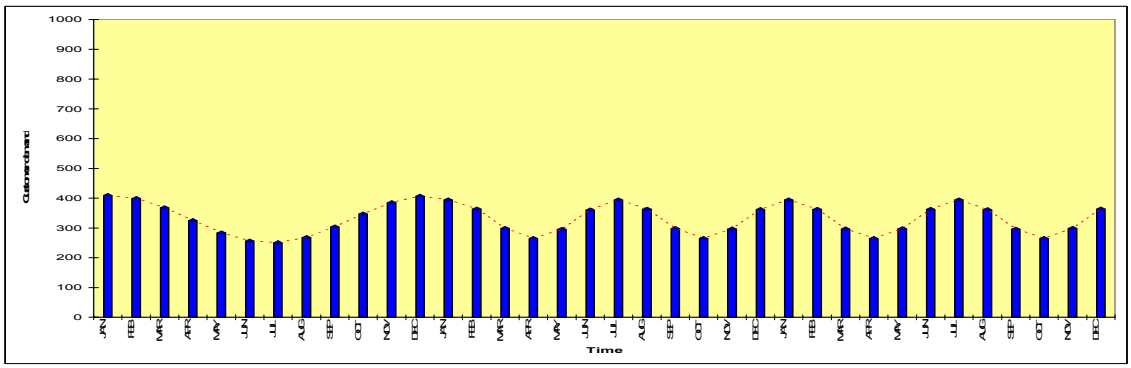

Figure 19.10 Example of a cyclical customer demand pattern

The final component of a time series are random fluctuations around a constant mean called randomness, irregular random fluctuations, noise, random noise or white noise. The mean of random time series is always zero and no trends, periods or cycles are present. Randomness will be present in nearly all time series. If the randomness is significant it may mask any other customer demand patterns in the time series.

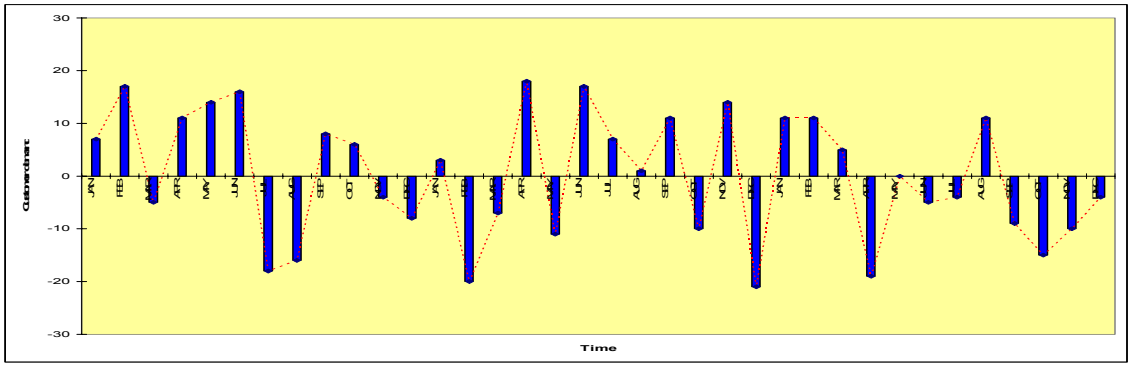

Figure 19.11 Example of a random customer demand pattern

Demand is intermittent if the time series shows observations with no (zero) demand.

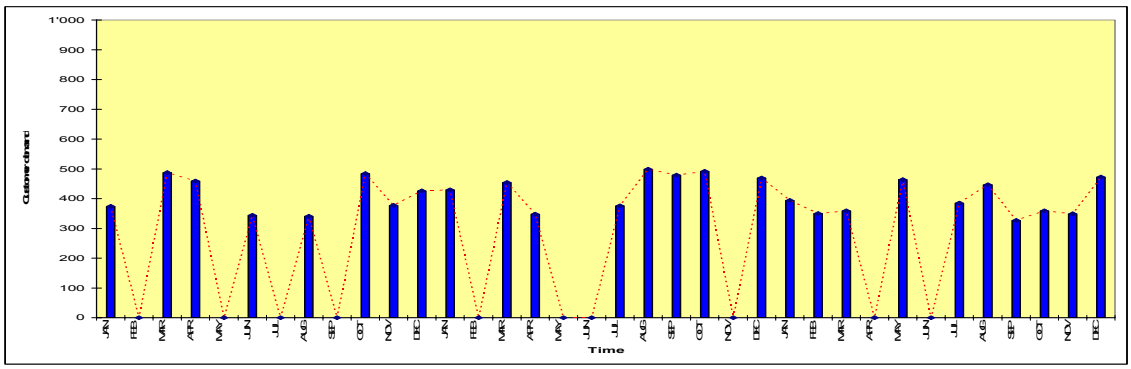

Figure 19.12 Example of an intermittent customer demand pattern

Variable customer demand patterns can vary in the degree of their variability. The variability of demand can be measured by the coefficient of variation which is defined as the ratio between the standard deviation of customer demand and average customer demand. Demand is called erratic, if the standard deviation of customer demand exceeds average demand in which case the coefficient of variation is greater than 1 (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 129). Contrary to randomness, erratic customer demand patterns do not have means of zero and cause the greatest difficulty in forecasting.

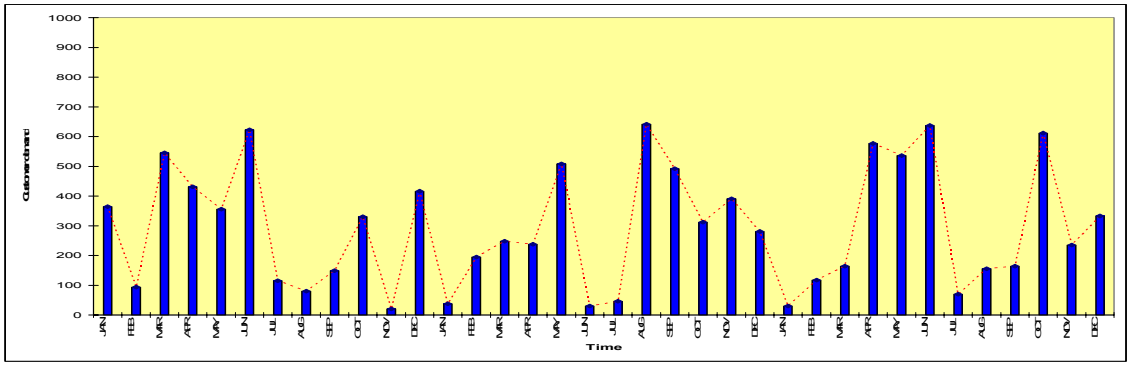

Figure 19.13 Example of an erratic customer demand pattern

In practice time series will be the result of a combination of several or all of the customer demand patterns described above. Unfortunately the individual components may be (completely) obscured, especially when randomness is the prevailing pattern. Over a short

period of time, any slight linear trend may appear as level demand and over a short period of time a trend might be impossible to distinguish from periodic or cyclical demand.

The combination of level demand with randomness is also called a stationary customer demand pattern. Although the customer demand patterns shows variability, demand always fluctuates above or below an unchanging average. This customer demand pattern has an unchanging average and a regular variance. This customer demand pattern can be expected in a stable situation with constant number of treated patients, more or less unchanging epidemiology and adherence to treatment protocols. On the contrary, a time series is called non-stationary if the mean changes, also called a "random walk".

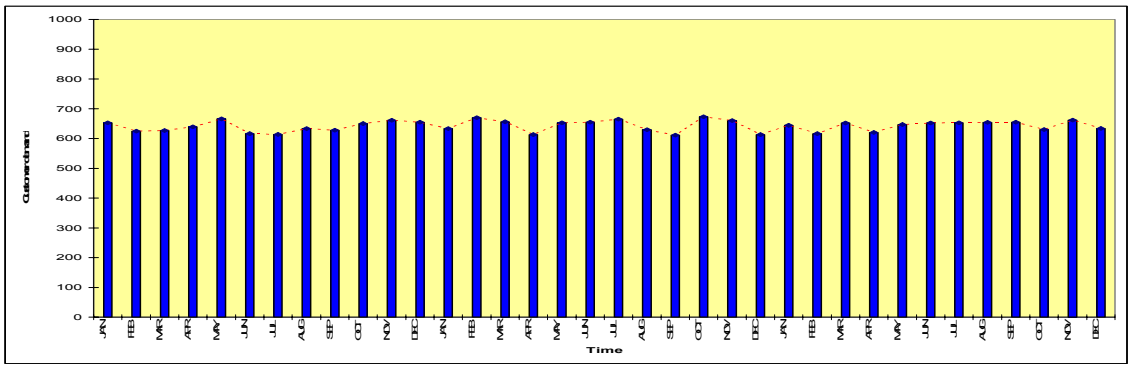

Figure 19.14 Example of a stationary customer demand pattern

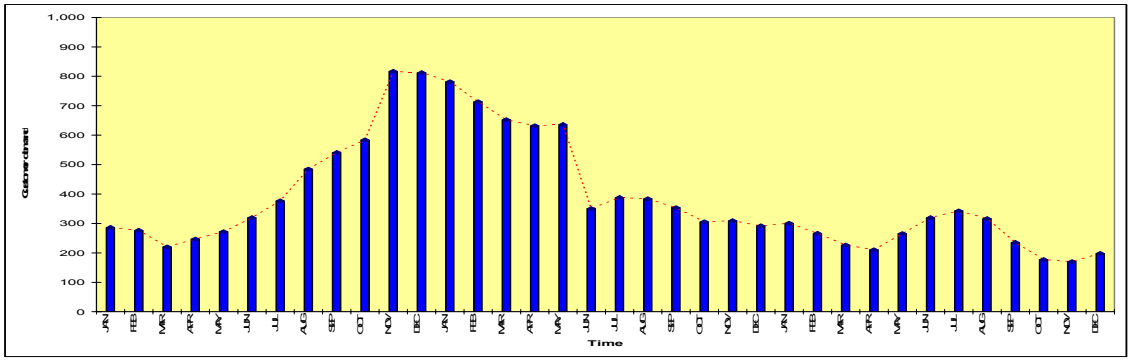

Figure 19.15 Example of a combination of customer demand patterns

It should be kept in mind, that the usefulness of detecting periodic and cyclical demand in humanitarian assistance is of limited value since their detection requires at least three to four periods. In an acute crisis, level shift and erratic demand are likely to be more significant than any periodic or cyclical changes. The detection of periodic and cyclical demand requires a stable environment with more or less steady numbers of treated patients and with little changes to treatment protocols, conditions which are unlikely to found, at least in acute crises.

19.5.2 Intervention analysis

While extrapolating time series with regular customer demand patterns is easy, significant events, also called interventions, can cause sudden and lasting but unpredictable changes. For example a sudden influx of patients at a hospital caused by a sudden increase in the conflict intensity, displacement of people, outbreak of an epidemic or introduction of a new drug product.

Interventions significantly impact on future values of the time series and they must be at least detected in order to avoid large forecasting errors to persist. The intervention itself must be confirmed and the time when the intervention has occurred and its impact on the time series must be determined. An event which caused the sudden change in the time series must be determined in order to determine whether the intervention is significant and to ensure that a simple outlier is not mistaken for an event with a permanent impact.

The pulse intervention lasts only for one unit time period corresponding to a single outlier while the sustained pulse lasts for more than one unit time period but only for a short time. Interventions with a permanent impact lead to a level shift in the time series.

Once the intervention and the extent have been analysed, complex intervention models can be developed to improve forecasts which take the expected impact of the intervention into account.

19.5.3 Classical time series decomposition

Classical decomposition is a method of identifying, isolating, separating and quantifying the separate components, also called subseries, in a time series. These individual components, such as trends, periods, cycles and randomness, can be useful for extrapolation and forecasting future customer demand. Moreover, time series decomposition can help in understanding a time series and its patterns. Apart from classical decomposition a variety of alternative methods have been proposed.

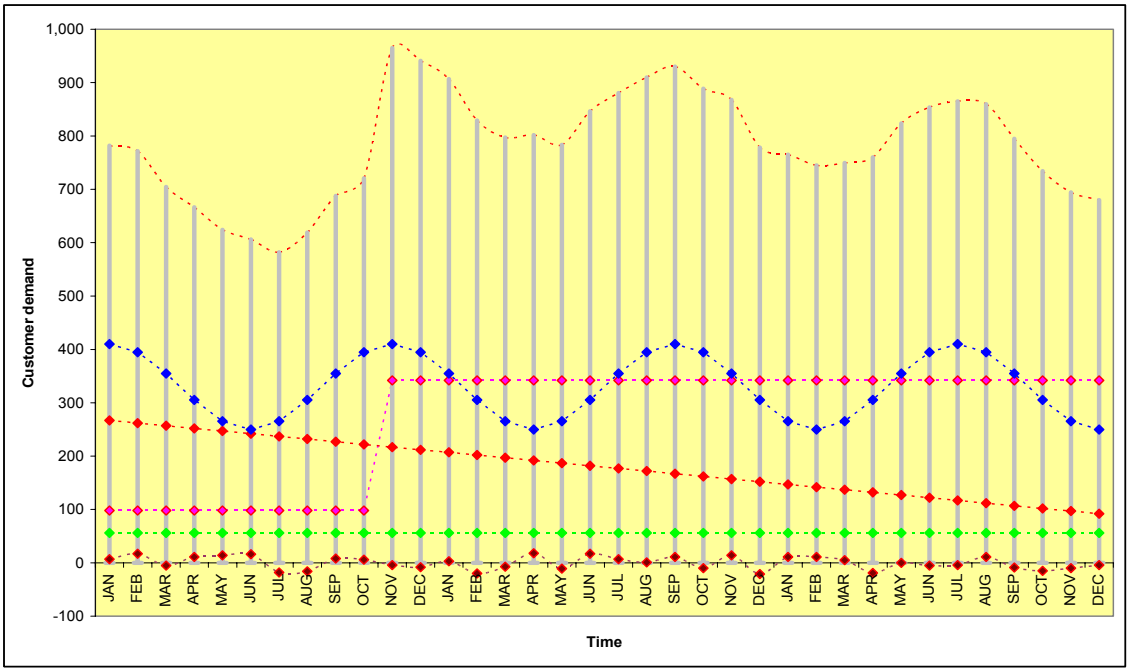

Figure 19.16 Example of classical decomposition

The entire time series is decomposed into the subpatterns level, trend, periodicity, cyclicality and randomness. Adding or multiplying these sub-patterns results in the original time series.

The mathematical analysis required for decomposing time series is rather complex and software can be used if classical time series decomposition is required for forecasting future customer demand.

Using mathematical algorithms, one by one the subseries level, trend, periodicity and cyclicality are removed. The final subseries is randomness, which is also called "residue" as it remains the "unexplained" component of the time series.

The possibility of classical time series decomposition does not imply that the entire demand pattern can always be explained. Rather, apart from the randomness a smaller or larger part of the demand data might remain "unexplained" which can also not be forecasted. For example outliers, intermittent or erratic patterns or "random walks".

19.5.4 Autocorrelation analysis

Autocorrelation analysis is a mathematical method for identifying patterns in a time series and determining suitable forecasting methods.

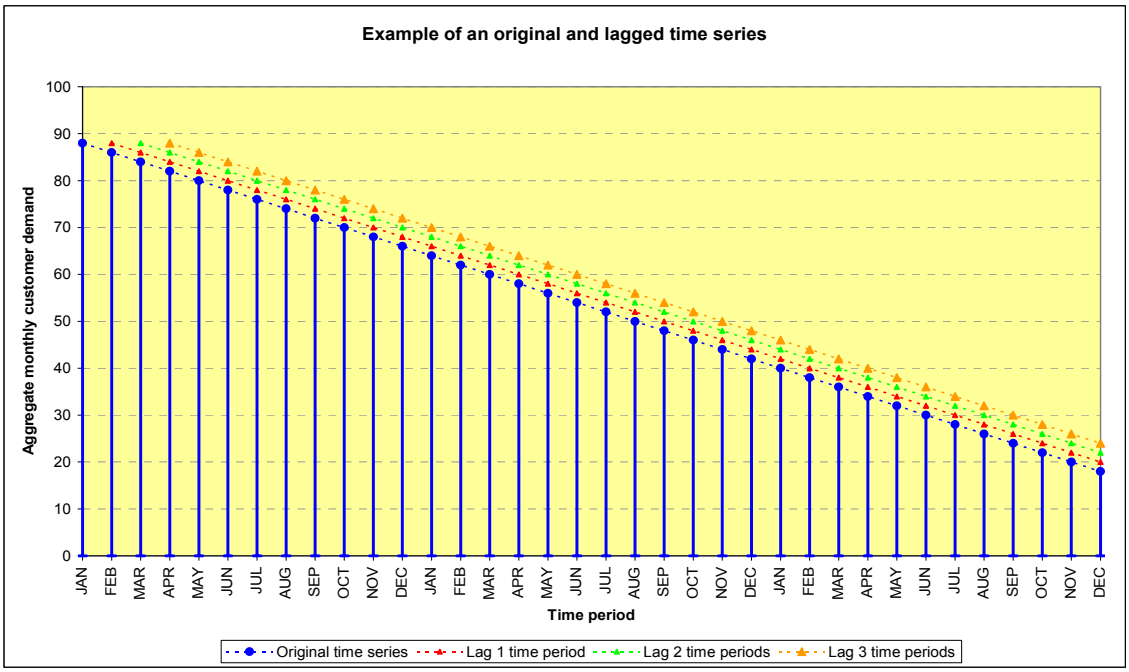

Figure 19.17 Example of an original and the lagged time series

Simple regression analysis allows determining the relationship between an independent variable x and a dependent variable y. Autoregression (AR) is a special case where the values of a time series are the independent variable and the values of the same time series but lagging k unit time periods behind are the dependent variable.

The patterns of the four time series in figure 19.17 are identical but the values of the second, third and forth time series lag exactly 1, 2 and 3 unit time periods "behind" the values of the original time series. These three "doubles" are like shadows which have the same shape and follow any move of the object casting the shadow. Although all three "doubles" were generated from the same set of data, they can be separated and treated as pairs of variables x and y. Now regression analysis can be applied to each pair of time series in order to determine whether a relationship between the two variables exists.

If a relationship between successive values of the time series exists, the value of the time series in unit time period t can be calculated as a function of the value in an earlier unit time period. For example if the time series presents a perfect line, the value in unit time period t + 1 can be calculated by adding a constant to the value in unit time period t. Looked at

in another way, values of the time series B at any time t can be calculated by simply adding a constant to the value of the time series A at the same time t.

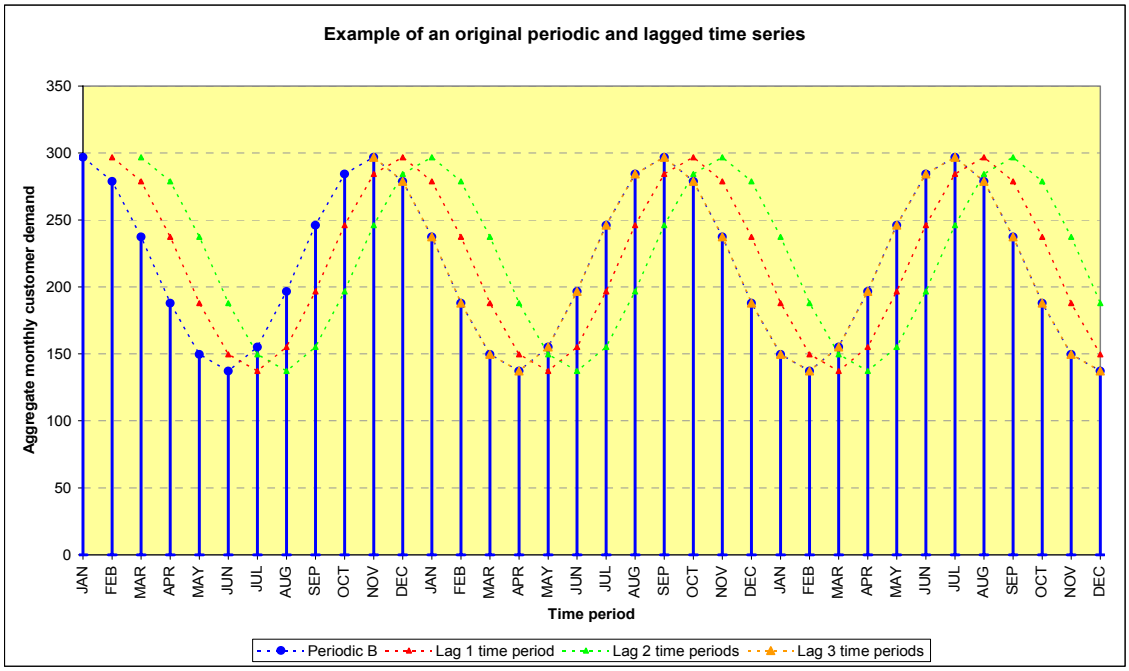

Figure 19.18 Examples of an original periodic and the lagged time series

Instead of only one time lagged time series a whole set of pairs of the original time series and the same time series lagging 1, 2, 3 etc. unit time periods behind can be derived. Autocovariance is a statistics that measures the strength or extent of the relationship between two variables and which can assume any value. The standardization of the autocovariance gives the autocorrelation which can only assume values between -1 and +1 and is therefore much easier to interpret. Autocorrelation coefficients near to 1 indicate a strong positive relationship meaning that whenever values from the independent variable increase, variables from the dependent variable increase. Autocorrelation coefficients near to -1 indicate a strong negative relationship where the dependent variable decreases whenever the independent variable increases. Finally if the autocorrelation coefficient is zero, the independent and dependent variable are completely unrelated.

Autocorrelation analysis determines a whole set of autocorrelation coefficients between the original time series and each of its time lagged "doubles". Although in principle for a time series with values of k unit time periods k-1 autocorrelation coefficients can be derived, in practice only k/4 should be calculated since with the increasing lag less and less pairs of data are available (DeLurgio, St.A. 1998, 68).

The resulting autocorrelation function (ACF) can be presented as a graph which can now be analysed to draw conclusions on patterns in the time series.

The calculation of the autocorrelation function requires a minimum of about 50 values of the time series (DeLurgio, St.A. 1998, 68) and eight to ten periods are required for determining periodicity in time series (DeLurgio, St.A. 1998, 73).

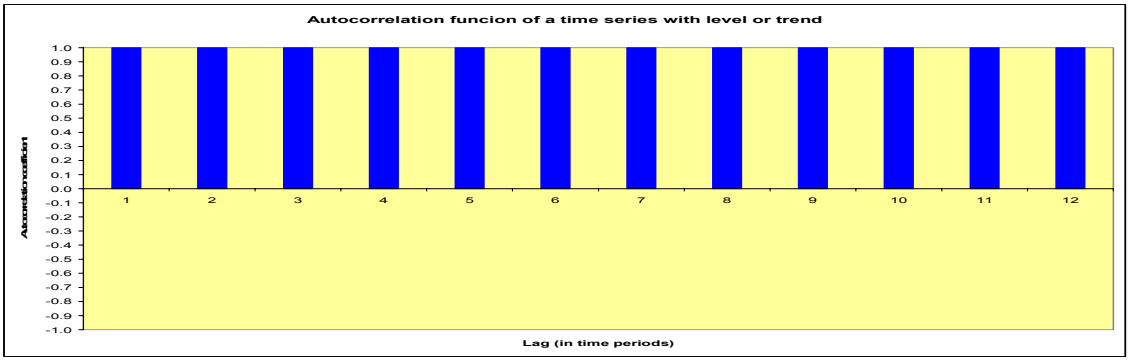

Figure 19.19 Autocorrelation function of a time series with level or trend

In a time series with level or positive or negative trend all pairs of the values of the original and lagged time series are perfectly correlated. Any future value of the time series can be calculated precisely from past values of the time series.

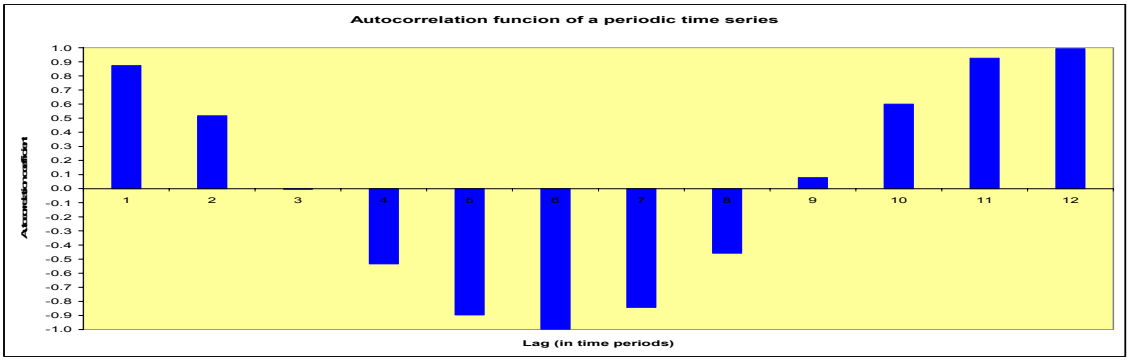

Figure 19.20 Autocorrelation function of a periodic time series

The autocorrelation function of a periodic time series shows declining autocorrelation coefficients which become negative at the unit time period which corresponds to half of the periodicity and increase again to a perfect correlation after a full period, in the example after 12 unit time periods. In a periodic time series (without any trend, cyclicality and randomness) the values of time series B at any time t are equal to the values of the time series A if the time series B lags the time series A by the number of time periods of a full period.

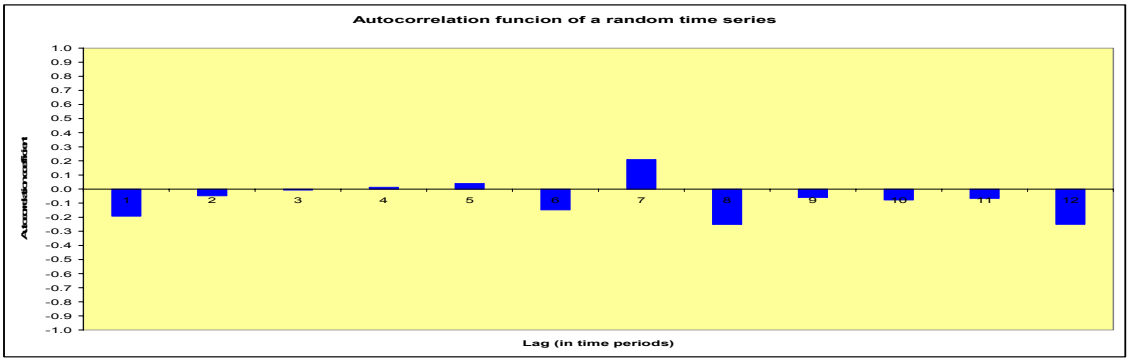

Figure 19.21 Autocorrelation function of a random time series

Final the autocorrelation function of a random time series does not display any distinctive pattern.

19.6 Demand distributions

Analysis of the statistical distributions of customer demand are relevant for understanding the variability as well as for forecasts and their accuracy.

The statistical distributions of individual customer demands as well as aggregate customer demand can be analysed. Following, only the distribution of aggregate customer demand will be considered.

The first step is collecting aggregate customer demand data and establishing a table of raw data. The entire range of values the variable can assume is separated into between 5 to 18 classes of equal width, depending on the number of available observations and the purpose of the analysis. All observations must lie within the selected range and every observation must be assigned to one and only one of the sections. The number of values falling inside each range are counted in order to establish the frequency distribution. Such frequency distributions can be best represented graphically by a histogram. Another useful graphical presentation is to plot the cumulative values of the histogram.

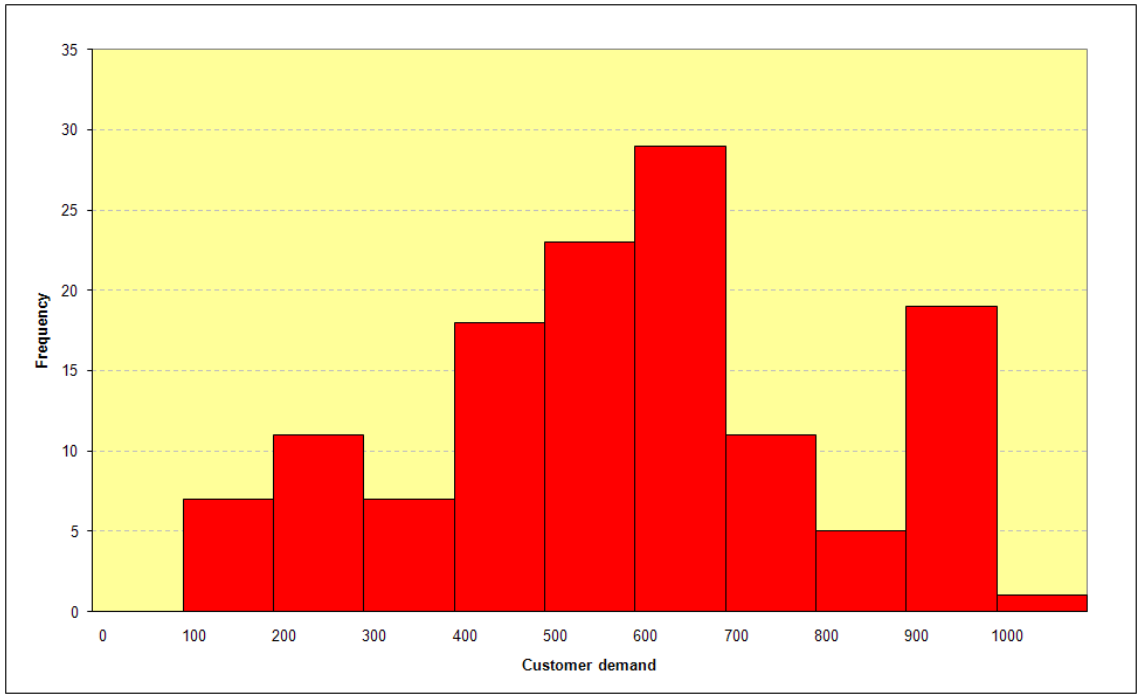

Figure 19.22 Example of a frequency distribution

The probability distribution is derived by dividing the values of the frequency distribution by the total number of observations. The resulting histogram has the same shape but the values now represent the percentage of values which lie within each class rather than the absolute number of values.

A wide range of probability distributions, such as Bernoulli, Binomial, Erlang, Exponential, negative Exponential, Gamma, Geometric, Laplace, Logistic, Lognormal, Normal, Pareto or Poisson distribution are known (Hastings, N.A.J., and J.B. Peacock 1975). Although strictly speaking the actual type of distribution would have to be determined for further analysis, usually a normal distribution, also called Gaussian distribution, is simply assumed.

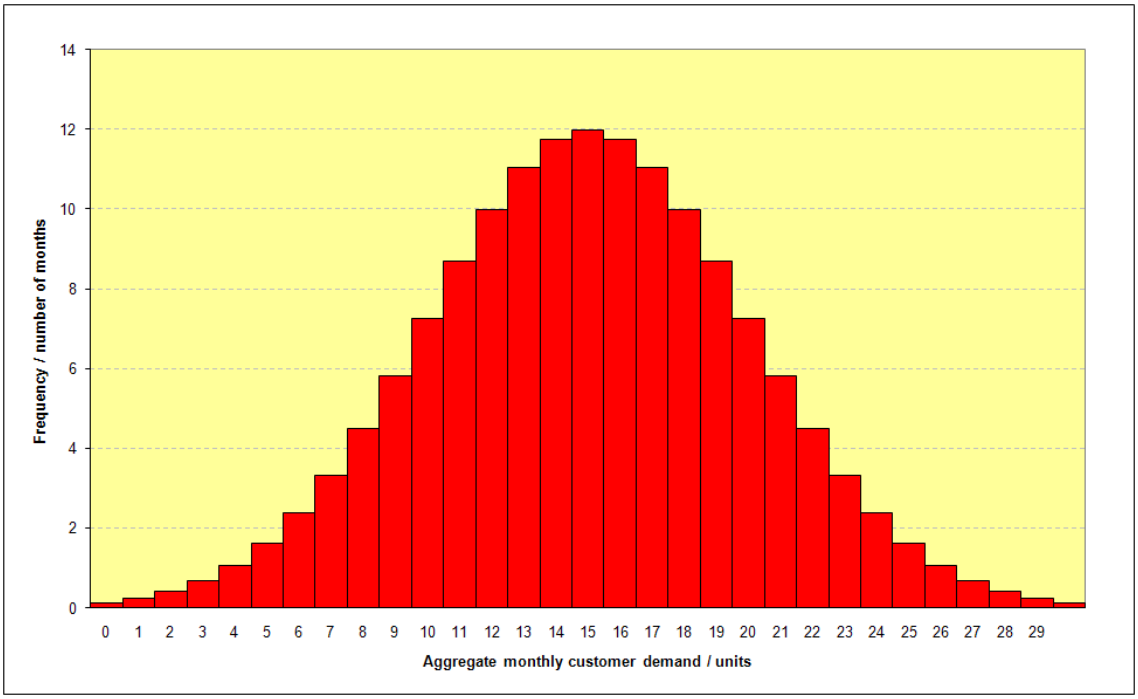

Figure 19.23 Normal distribution

Assuming a normal distribution, even though it does not accurately describe the actual probability distribution, will increase forecasting errors.

However, the normal distributions is often a good representation of data found in inventory control, it is convenient to use and the impact of using other distributions is usually quite small (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 272). The values of large populations tend to show a normal distribution and the number of available observations might not be sufficient to determine the exact type of the actual distribution.

The discrete Poison distribution may be considered where demand is less than 10 units during lead time (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 318) and non-normal demand distributions such as the Gamma distribution should be considered whenever the coefficient of variation is greater than 0.5 (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 273).

The probability distribution allows assessing the dispersion or spread of the deviation which for the normal distribution can be measured accurately with the standard deviation. This measure is very powerful as it allows determining the probability that future values will lie within a certain class or range of classes. The smaller the spread of a probability distribution, the greater the probability is that future values will lie near to the mean.

In a normal distribution about two thirds of all observed values lie within one standard deviation below and above the mean and approximately 95% of the observations lie within two standard deviations.

19.7 Pareto analysis

The Pareto analysis, also called ABC-analysis is a very powerful tool which can be applied to many problems. In many cases a fairly small number of values of an independent variable account for the majority of the cumulative value of the respective dependent variable, sometimes called the 20/80 rule. Approximately 20% of the independent variables accounts

for 80% of the dependent variable and 50% of the independent variable for 95% of the dependent variable.

For example only 20% of the items in a warehouse may account for 80% of the value or 20% of items in a consignment may account for 80% of the weight or volume. Or 20% of customer orders will account for 80% of the ordered health care goods and require 80% of the resources for filling orders.

This type of analysis is very helpful for planning resources. For example when estimating the required storage space in a medical store, calculating the volume of only 20% of items will save time and nevertheless allow a fairly accurate estimation of the total required storage capacity.

However, unlike commercial logistics the Pareto analysis by value is often not relevant for humanitarian assistance since the value of health care goods does not necessarily correspond to their importance.

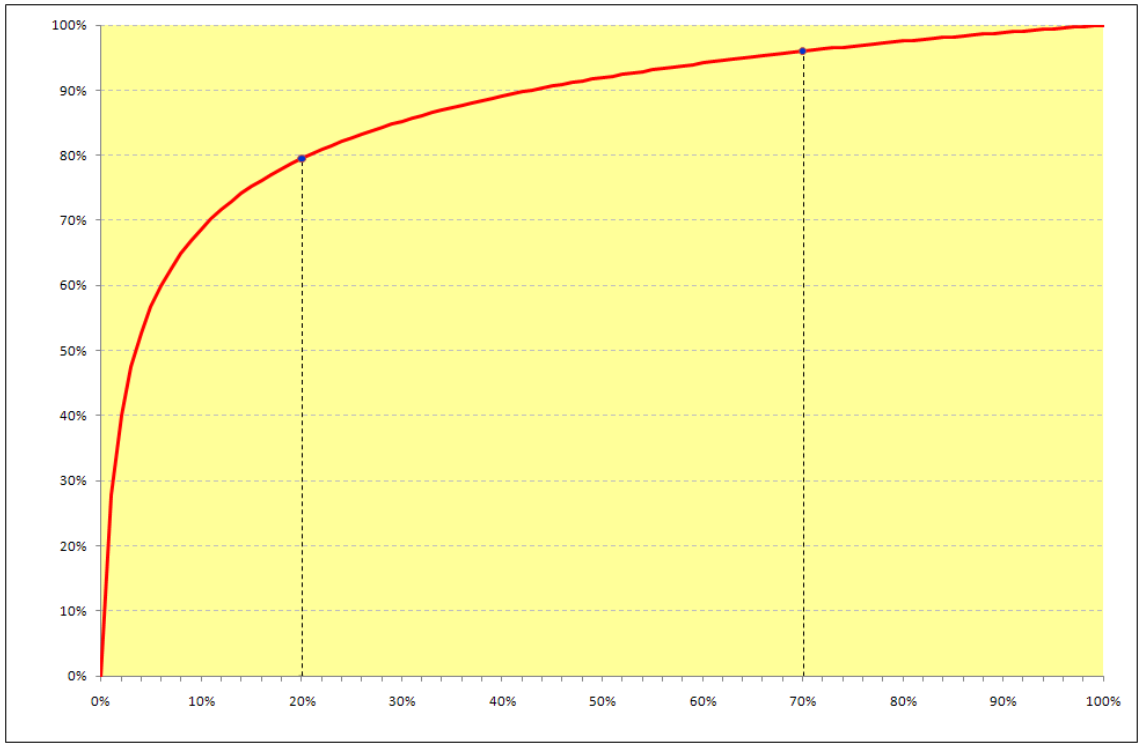

Figure 19.24 Example of a Pareto analysis

20 DEMAND FORECASTING

20.1 Forecasting horizon and forecasting period

The forecasting horizon, also called the time scale, is the length of the future time period over which a forecast or prediction is made and can be expressed in days, weeks, months, years or decades. The forecasting horizon always extends from the present ahead. As current data becomes historic, the forecasting horizon moves ahead and is therefore also called a "rolling" horizon.

Although there are no universally accepted definitions, traditionally forecasts can be categorized according to the length of the forecasting horizon into short-, medium- and long-term forecasts (Waters, D. 2003, 233). Short-term forecasts have a forecasting horizon of less than half a year and are sometimes called "myopic". Medium-term forecasts are made over forecasting horizons of half a year to two years and long-term forecasts for forecasting horizons of more than two years.

Within any particular forecasting horizon customer demand forecasts may be made for only one or several forecasting periods ahead of one or several hours, days, weeks, months, quarters, years or decades. For example eight weekly customer demand forecasts may be made over a forecasting horizon of the next two months where each forecast is made for future aggregate weekly customer demand. However it is also possible to make cumulative forecasts over several unit time periods. For example for a unit time period of one month an aggregate forecast for 12 unit time periods, or one year, could be made instead of separate forecasts for each of the 12 future unit time periods.

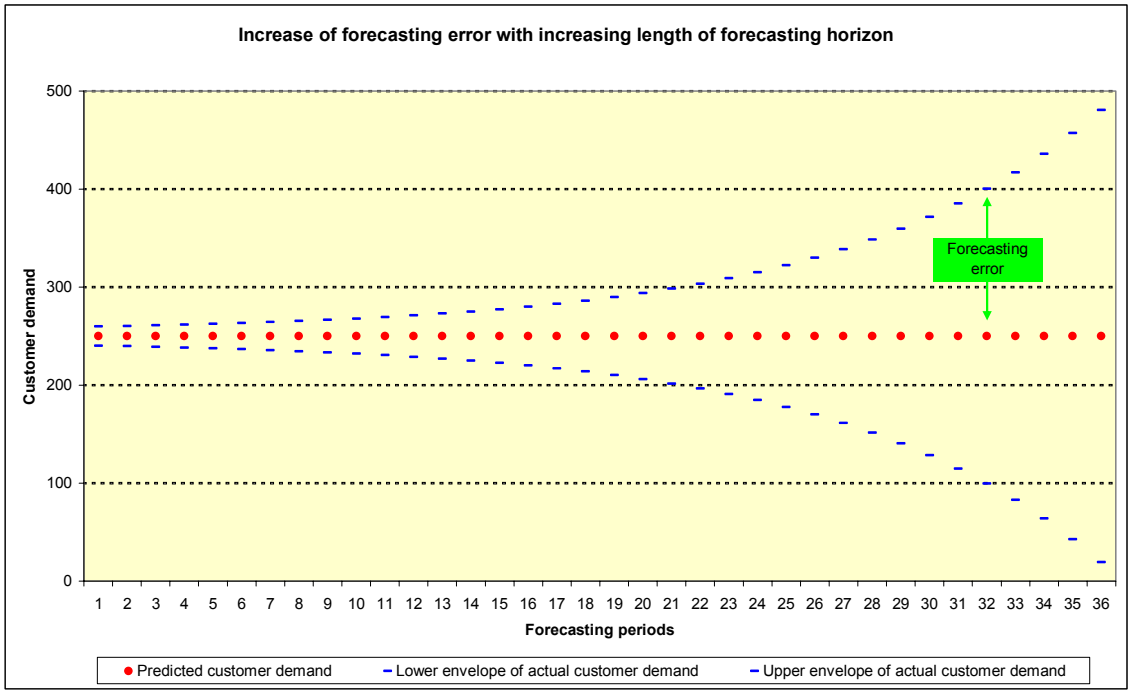

Figure 20.1 Relation between length of forecasting horizon and forecasting error

For any k-period ahead forecast the forecasting horizon will depend on the selected unit time period. For example for a unit time period of one year the time horizon for a one-period ahead forecast will be one year while for a unit time period of one week the forecasting horizon for a 12-period ahead forecast will be 3 months.

Just as for the historic customer demand data used for forecasting, customer demand forecasts are aggregate forecasts for the respective forecasting period. Consequently the forecasting period must be at least as long as the unit time period used for aggregating the respective customer demand data. For example it would not be possible to make weekly forecasts based on customer demand data which was aggregated over a unit time period of one month.

Shorter forecasting periods require more periods within the same forecasting horizon. The forecasting period must be at least long enough to ensure that at least one customer order is received every two forecasting periods (Lewis, C.D. 1975, 4).

Once an appropriate forecasting period has been determined, the forecasting horizon may be determined as a certain number of forecasting periods. For example a forecasting horizon of three forecasting periods ahead.

Generally speaking it is the more difficult to forecast future events the further they lie in the future and unfortunately the forecasting error increases more than proportionally rather than in a linear way (see figure 20.1). Therefore in general short-term forecasts tend to be more accurate than long-term forecasts. Short-term forecasts are also not influenced by cyclical or periodic customer demand patterns.

Long-term forecasts are made for strategic decisions, medium-term forecasts for tactical decisions and short-term forecasts for operational decisions. In inventory control the forecasting horizon must be at least as long as the total order lead time.

20.2 Classification of forecasting methods

Different authors have classified the wide range of forecasting methods in a variety of ways without establishing a universally accepted classification. Figure 20.2 shows on overview of the most commonly used methods which are also relevant for health care logistics. In addition some forecasting methods, such as the morbidity method, which are specific for health care logistics are discussed while other highly specialized forecasting methods which are not relevant in this context, such as Fourier analysis, are not considered.

Forecasting methods are commonly separated into qualitative and quantitative methods. The results of quantitative forecasting methods are independent of the forecaster while qualitative forecasts will differ from forecaster to forecaster.

The prerequisite for applying quantitative forecasting methods, which are also called statistical methods, is the availability of sufficient quantitative or quantifiable historical data. All quantitative forecasting methods are based on predicting the future by extrapolating historical data. Consequently all quantitative forecasting methods are based on the premises that past patterns (univariate methods) or relationships (multivariate methods) observed in the past will, or are at least likely, to continue in the future or at least throughout the time horizon in which forecasts are made. This premises, which holds true for any forecasting method is called the "Assumption of continuity" (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 9). This assumption may be disguised by the use of mathematical methods and models as well as software tools but holds true regardless of the sophistication of applied forecasting methods.

Just because a pattern or relationship was observed in the past by now means ensures that the same pattern or relationship will continue in the future. Rather the forecaster has to make a judgement and have confidence that, in respect to the forecast made, the observed pattern or relationship is likely to continue. Although the use of statistical forecasting methods imply

that the forecasts are scientific, in the end all forecasting methods, implicitly or explicitly, rely on human judgement. Although there is no method of accurately predicting the future, drawing inferences from the past for predicting the (near) future is reasonable in many cases.

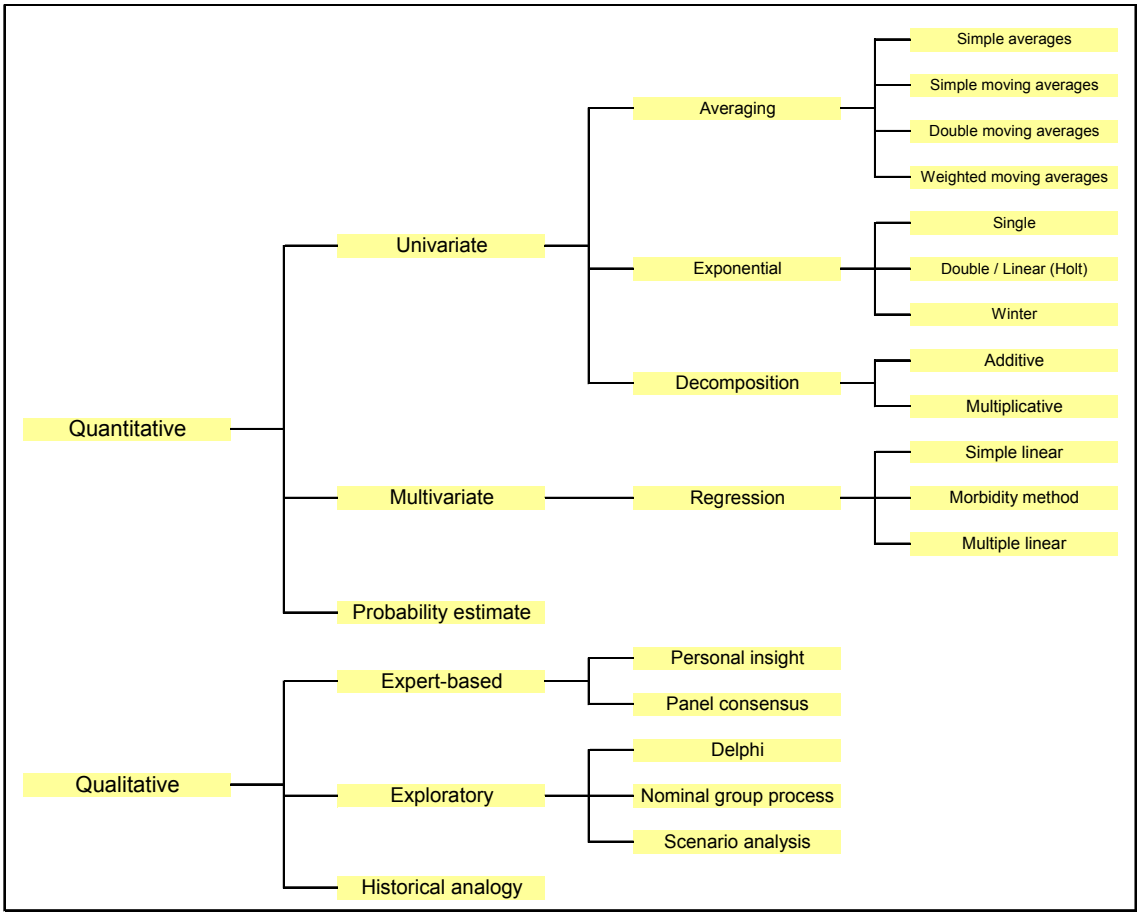

Figure 20.2 Classification of forecasting methods

All quantitative forecasting methods are based on the "assumption of continuity".

The following chapters will discuss the principles of forecasting methods without explaining the sometimes complex mathematical details since in practice calculations will be carried out by software applications.

20.3 Univariate forecasting methods

Univariate forecasting methods extrapolate established and identified historic data patterns, or combinations of patterns, of a single variable into the future. Historic customer demand patterns are projected or cast into the future and future values of variables are a mathematical function of past variables. Since the variables are usually time dependent, these forecasting methods are also called time series methods.

Univariate forecasting methods are "intrinsic" as they rely solely on a set of historical data and do not try to "understand" the "internal" pattern or "behaviour" of the time series or analyse any external factors which affect, influence or shape patterns. Because there is no

attempt to understand the underlying process, the system that generates the time series which is being extrapolated is treated as a "black box". Customer demand is not questioned and assumed to be correct even if the quality of prescription practices is poor.

This approach is justified when the system generating the time series would be too difficult to understand or the relationships between the multitude of parameters are too complex and difficult to formulate mathematically. Moreover in many cases it is not important to know the reasons why a variable assumed a certain value if this understanding does not increase forecasting accuracy and gaining insight into the underlying process my require considerable resources.

In general univariate forecasting methods are fairly simple, easy to apply, yield results quickly, are fairly cheap and can be automated. They are usually highly accurate in the short-term and reasonable accurate in the mid-term. However their main disadvantage lies in the inability to consider changes of patterns and relationships and they are therefore of limited value for long-term forecasting.

Univariate forecasting methods can be divided into smoothing methods, decomposition methods and autoregression methods.

Smoothing methods can be further divided into averaging methods and exponential "smoothing" methods. All smoothing methods attempt to remove randomness from a time series in order to uncover the remaining subpatterns and facilitate their extrapolation for obtaining the forecast.

20.3.1 Averaging methods

Smoothing of time series can be achieved by various averaging methods which can be divided into simple averages and various types of moving averages. As values from several consecutive unit time periods are added up, positive and negative fluctuations (randomness) cancel each other out and the randomness can be (partially) removed from the time series, revealing the underlying pattern which can be extrapolated.

The simple average uses the mean of all N unit time periods for which data is available and is calculated by dividing the sum of the variables of all unit time periods by the number of unit time periods (Eq. 20.1).

$$F_{t+1} = \frac{d_t + d_{t-1} + d_{t-2} + \ldots + d_{t-N+1}}{N} \qquad \text{Eq. 20.1}$$

The parameter N is not a constant but rather increases by one each unit time period.

Simple averages are easy to calculate but forecasts become less and less responsive to changes as the number of unit time periods grows. Moreover simple averages can only be used for forecasting stationary time series.

Figure 20.3 shows an example of simple averages in a time series. For example the forecast for the month of August is the mean of all previous periods from January to July. Note how the forecasts fluctuate in the beginning but over time become less and less responsive, eventually resulting in a nearly straight line.

The responsiveness of forecasts can be increased by excluding values from "old" unit time periods and calculating the mean only of a certain and constant number of most recent unit time periods. Each new forecast "moves ahead" by adding the value from the most recent unit

time period while removing the value from the last (oldest) unit time period, resulting in "moving" averages (MA). According to the number of included unit time periods, moving averages are called k-period moving averages or moving averages of the order k.

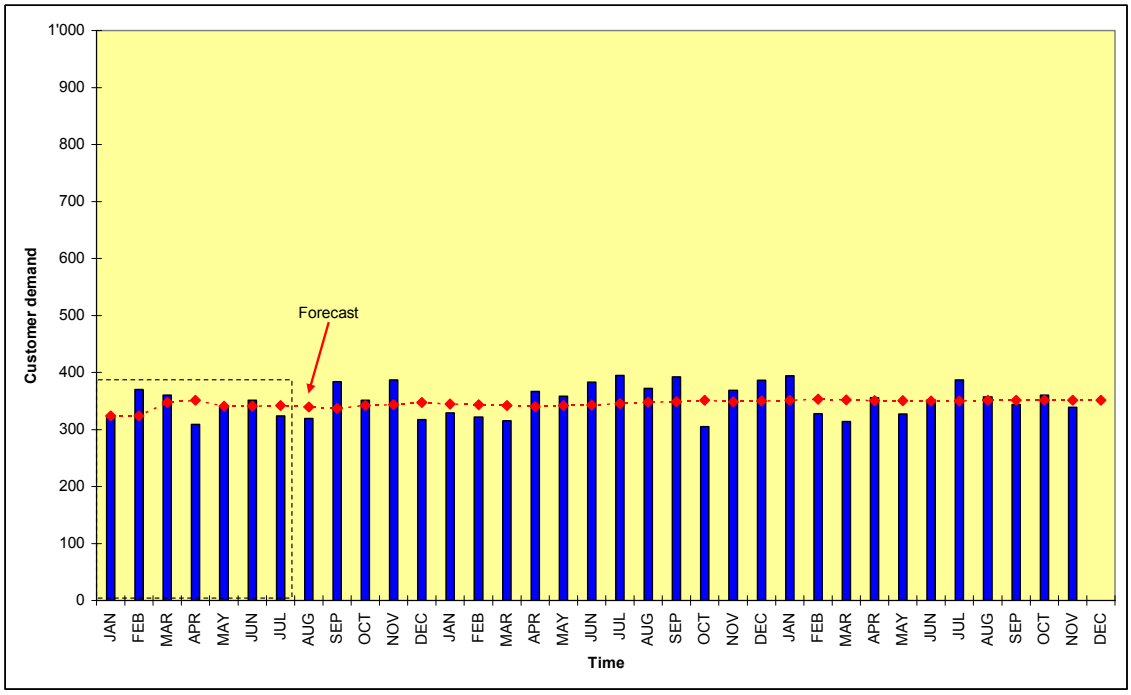

Figure 20.3 Simple averages

The forecast using simple moving averages (SMA) for the future unit time period is equal to the mean of the values of the past k unit time periods (Eq. 20.2).

$$F_{t+1} = \frac{d_t + d_{t-1} + d_{t-2} + \ldots + d_{t-k+1}}{k} \qquad \text{Eq. 20.2}$$

The parameter k is a constant which corresponds to the order of the moving average.

Simple moving averages assign equal weights (1/k) to the values from all unit time periods and therefore the variables from all k unit time periods, regardless of their "age", are counted equally while any unit time periods going back more than k unit time periods are disregarded.

Increasing the number of unit time periods included in the calculation of moving averages (high order moving averages), for example using a nine month moving average, reduces the effect of random variations and therefore increases smoothing while at the same time decreasing responsiveness to recent changes. Moreover the first forecast can only be generated once data is available from at least k unit time periods. For example forecasts using a six month moving average require historic data from at least the past six unit time periods. However, until data is available for a k-order forecast, lower order forecasts can be used.

Figure 20.4 shows forecasts with increasing order of the moving average. The graphs are spaced apart since otherwise the graphs would overlap and could not be distinguished.

Likewise decreasing the number of unit time periods (low order moving averages), for example using a three month moving average increases responsiveness while decreasing the smoothing effect. Typical values for k range from 3 to 12 (Silver, E.A., D.F. Pyke, and R.

Peterson 1998, 88) and a typical compromise is a six period moving average (Waters, C.D.J. 1992, 197).

The special case of a one period simple moving average where the forecast for the next unit time period is equal to the value from the most recent available unit time period is also called naive forecast 1.

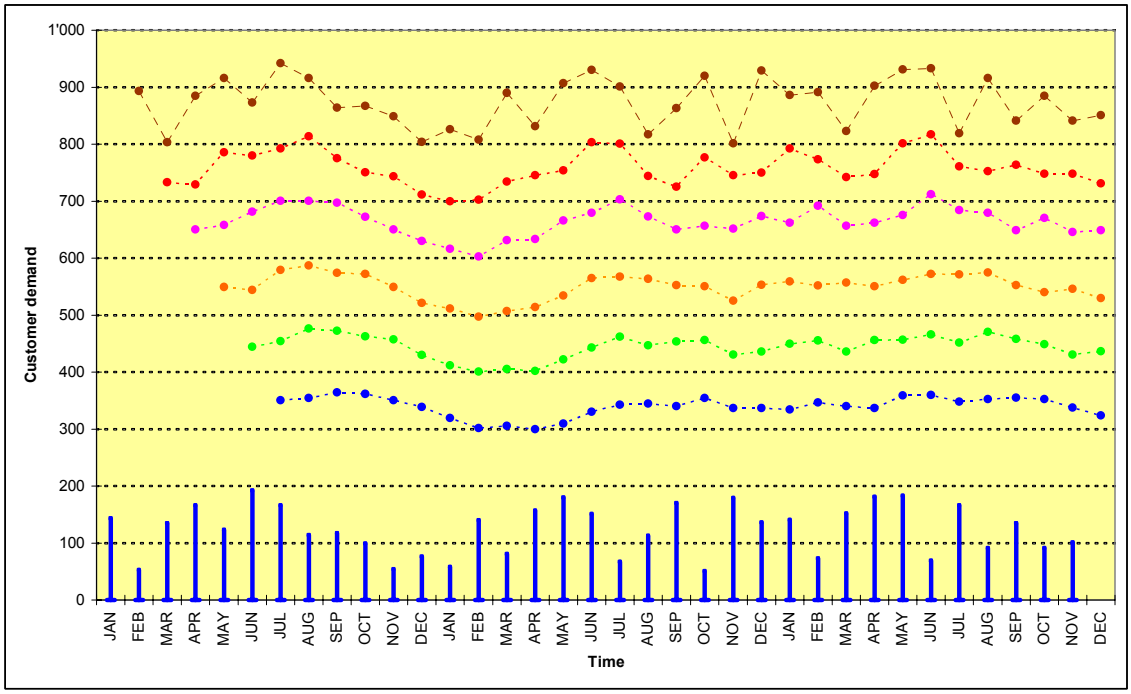

Figure 20.4 Effect of the order of simple moving averages on forecasts

Simple moving averages are suitable for stationary time series and allow reducing (smoothing) randomness. They do not yield accurate forecasts for time series with trend, periodicity or cyclicality as forecasts systematically lag or trail behind future values of the time series. Simple moving averages can be used to "depersonalize" time series if the order of the moving average corresponds to the length of the period in the time series.

Forecasts using simple moving averages have the disadvantage of lagging behind if the time series is not stationary but has a trend.

Double moving averages also called linear moving averages, are calculated by calculating simple moving averages from a time series and then using the resulting values for calculating a further simple moving average.

The forecast for the next unit time period is calculated by adding the simple moving average, the difference between the double moving average and the simple moving average as well as the trend estimate which is calculated as a fraction of the difference between the double moving average and the simple moving average. This method allows to accurately predict time series with trends and does not lag behind actual data.

Weighted moving averages (WMA) assign different weights to the values of each unit time period and are an extension of simple moving averages. The relevance of values of more recent unit time periods on the forecast is increased by assigning greater weights. This forecasting method assumes that the values of more recent unit time periods give a better indication of the forecast than values of past unit time periods.

$$F_{t+1} = a_1 d_t + a_2 d_{t-1} + a_3 d_{t-2} + \ldots + a_k d_{t-k+1} \qquad \text{Eq. 20.3}$$

Any set of decreasing weights can be assigned to the individual values as long as the sum of all weights equals 1 (DeLurgio, St.A. 1998, 151). For example:

$$F_{t+1} = 0.4\, d_t + 0.3\, d_{t-1} + 0.2\, d_{t-2} + 0.1\, d_{t-2} \qquad \text{Eq. 20.4}$$

The figure below shows an example with the above weights and simple moving averages (without weights, grey dotted line) as comparison.

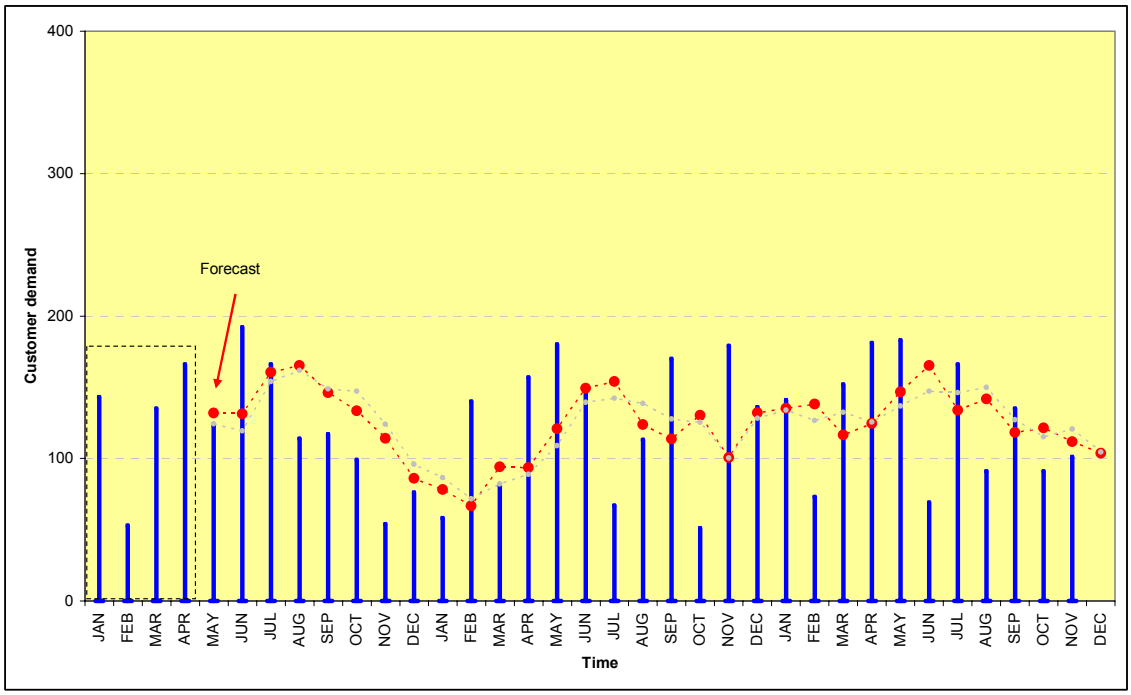

Figure 20.5 Forecasts using weighted moving averages

There is no scientific way of determining the ideal set of weights. Rather different weights can be applied empirically to a set of historic data in order to determine the combination which yields the best forecast, assuming that the same set of weights will best predict future values.

Weighted moving averages have the advantages that values from the last unit time period are not abruptly removed but rather fade out as their weight is decreased with ever new unit time period.

20.3.2 Exponentially weighted averages

One of the disadvantages of simple moving averages is that it considers only the past k values and disregards any other values. The forecasting method commonly called single exponential "smoothing" (SES), considers the values from all available unit time periods although with decreasing weight, and therefore avoids the arbitrary cut-off of the simple moving averages which considers only the values of the last k unit time periods. This

forecasting method is based on the assumption that the values of more recent unit time periods are more relevant for the forecast and should therefore be given greater weight than values from older unit time periods.

Single exponential "smoothing" requires only a single smoothing constant α (alpha) which must be greater than 0 and less than 1. The forecast for the next unit time period is the sum of the value from the current unit time period weighted (or multiplied) by α and the forecast for the current unit time period weighted (or multiplied) by 1-α.

$$F_{t+1} = \alpha\, d_t + (1-\alpha)\, F_t \qquad \text{Eq. 20.5}$$

For example for α = 0.7 the next forecast is calculated by multiplying the value from the current unit time period by 0.7 and adding the forecast of the current unit time period weighted by 0.3:

$$F_{t+1} = 0.7\, d_t + 0.3\, F_t \qquad \text{Eq. 20.6}$$

Equation 20.5 can also be rearranged and interpreted as the current forecast corrected by the weighted forecasting error, which is simply the difference between the forecasted and the actual value:

$$F_{t+1} = F_t + \alpha\,(d_t - F_t) \qquad \text{Eq. 20.7}$$

Each forecast is calculated by considering the previous forecast and therefore, unlike simple moving averages, the values of all previous unit time periods are considered. The calculation is simple as only the current forecast and current value are needed for making the next forecast and in principle there is no need to keep a complete record of values from all previous unit time periods.

However, a forecast can also be made by using the values of all previous unit time periods. Substitution of F_t in equation 20.7 results in:

$$F_{t+1} = \alpha\, d_t + \alpha\,(1-\alpha)\, d_{t-1} + (1-\alpha)^2\, F_{t-1} \qquad \text{Eq. 20.8}$$

Repeating this substitution further results in:

$$F_{t+1} = \alpha\, d_t + \alpha(1-\alpha)\, d_{t-1} + \propto (1-\alpha)^2\, d_{t-2} + \propto (1-\alpha)^3\, d_{t-3} + \ldots + \propto (1-\propto)^k\, d_{t-k} \qquad \text{Eq. 20.9}$$

The sequence of terms (1-α), (1-α)^2, (1-α)^3 etc. represent a geometric progression as each successive term is derived by multiplying the previous term with the constant, in this case 1-α. This constant is also called the common ratio as the quotient of any two successive terms is equal to this constant.

Provided that α lies between 0 and 1, the sum of an infinite number of terms of a geometric progression α , α(1-α), α(1-α)^2 etc. is given by:

$$S = \frac{\alpha}{1-(1-\alpha)} = 1 \qquad \text{Eq. 20.10}$$

Therefore this sequence of weights fulfils the requirement for all sets of weights that their sum has to be 1 or unity (Lewis, C.D. 1975, 13).

Since the values of the terms of a geometric progression lie on the graph of an exponential function and therefore increase (or decrease) exponentially this forecasting method is also called "exponential" smoothing. However, in fact geometric smoothing would be a more appropriate name (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 89).

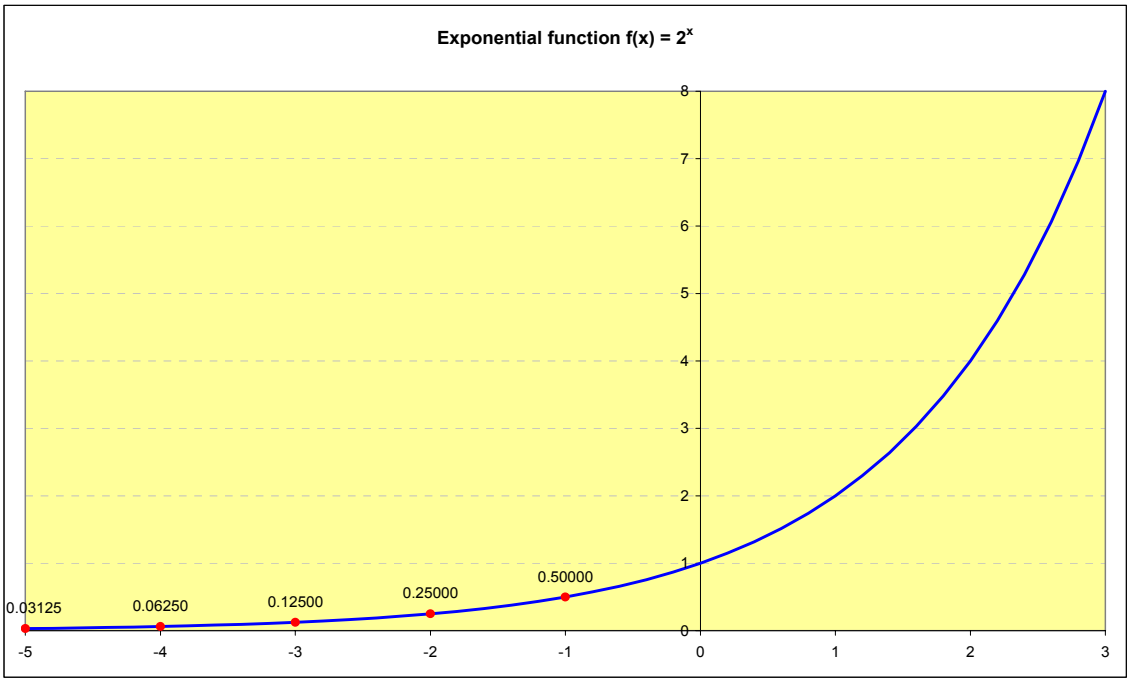

Figure 20.6 Exponential function and weights

The smoothing constant alpha (α) can assume any value greater than 0 and smaller than 1. A large smoothing constant ("low smoothing"), such as $\alpha = 0.9$, gives a large weight to the value from the current unit time period and little value to the previous forecasts. Although in principle the values of all past unit time periods are considered, their weights ($1-\alpha$, $(1-\alpha)^2$ etc.) decrease so strongly (0.1, 0.01, 0.001 etc.) that past values have very little influence.

A small smoothing constant, such as 0.1, gives little weight to the value of the most recent unit time period and great weight to the values of past unit time periods. Since the weights of $1-\alpha$ decrease slowly (0.9, 0.81, 0.73, 0.66 etc.) many more values of past unit time periods influence forecasts.

If a smoothing constant of $\alpha = 1$ were chosen, forecast would be identical with the value of the most recent unit time period and therefore correspond to the naive forecast 1 (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 152).

Conversely, if the smoothing constant is zero, all forecasts are equal to the initial or the first forecast and any values of later unit time periods have no effect on any of the forecasts.

Figure 20.7 shows the effect of different smoothing constants on the forecasts. The smaller the smoothing constant, the less weight is given to values of more recent unit time periods and the greater the smoothing effect is on the time series but also the smaller adaptability to recent changes in time series. Larger smoothing constants allow forecasts to respond quickly to changes in the time series but have a smaller effect on smoothing randomness in time series.

The graphs in figure 20.7 are again spaced apart since otherwise the graphs would overlap and could not be distinguished.

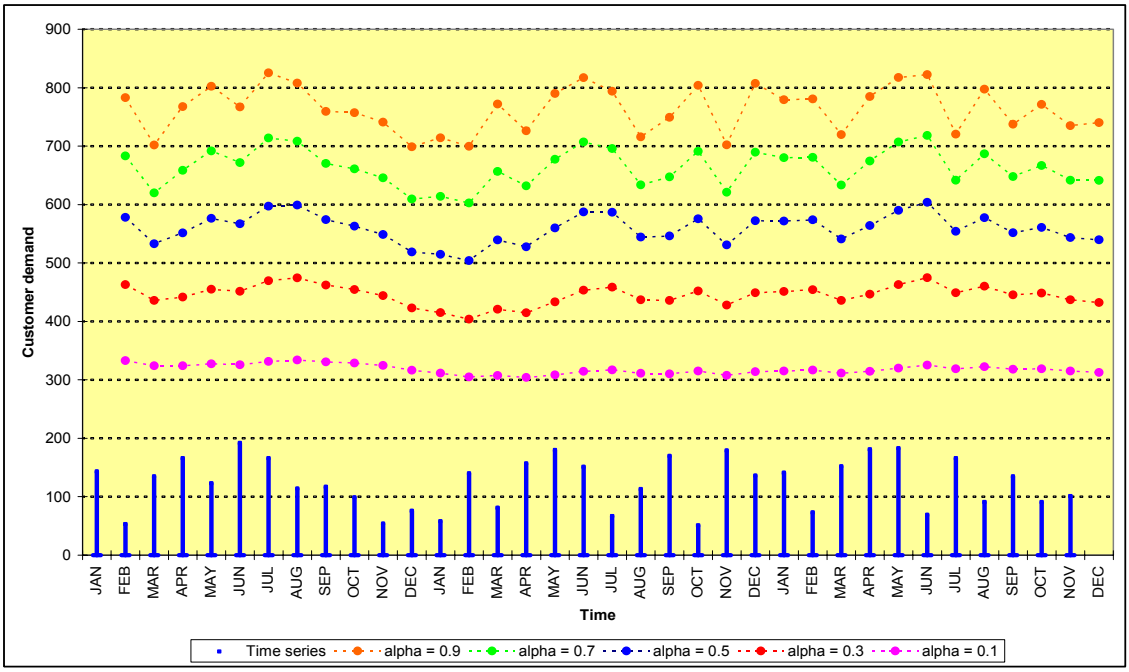

Figure 20.7 Forecasts with different smoothing constants alpha

Another interpretation of the smoothing constant can be seen from equation 20.7. A large smoothing constant will give a large weight to the forecasting error and therefore make a large adjustment while a small smoothing factor will lead to only a small adjustment.

For selecting the smoothing constant α a compromise between responsiveness and smoothing of randomness has to be found. Ultimately smoothing factors are selected based on judgements and in practice smoothing factors between 0.01 and 0.3 are selected with 0.1 often being quite reasonable (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 107). The objective of selecting the smoothing constant is removing randomness and exposing the underlying pattern of the time series.

There is no scientific way to determine the optimal smoothing factor which will ensure the most accurate forecast. Different smoothing factors can be applied to historic data to determine the smoothing factor which produces forecasts with the smallest forecasting error (Waters, D. 2003, 254) which is then applied to all future forecasts. However even if a certain smoothing factor has minimized the forecasting error in past forecasts there is no guarantee that the same smoothing factor will also minimize the forecasting error in future forecasts.

Exponentially weighted averages are easy to apply and can also be automated but only yield accurate forecasts in stationary time series.

Although exponentially weighted averages lead to smaller forecasting errors than moving averages they are not necessarily statistically relevant (Lewis, C.D. 1975, 20).

Holt extended the concept of single exponential "smoothing" which uses a single smoothing constant to double (or linear) exponential "smoothing" using two parameters. As in single exponential "smoothing" the smoothing constant α reduces randomness while a second smoothing constant β estimates the expected trend in the time series.

Brown's double exponential smoothing method is a special case of Holt's method but which requires only a single smoothing constant.

In general the ability to accurately forecast trends is a significant advantage. However the method will project the detected trend indefinitely into the future while trends often eventually end and therefore large forecasting errors will result especially in long-term forecasts. Methods for "trend dampening" have been developed which reduce the trend component in proportion to the length of the time horizon of the forecast.

A further problem with extrapolating trends is the difficulty of distinguishing (long-term) trends from periodicity or cyclicality.

Winter has further extended exponential "smoothing" by including a third parameter which allows to consider periodicity in time series.

The concept of single exponential "smoothing" (see equation 20.7) can be extended to adaptive methods which use past forecasting errors to correct the next forecast. Instead of a fixed smoothing factor α tracking signals adjust smoothing parameters in order to minimize forecasting errors.

20.3.3 Decomposition method

While some smoothing methods allow considering customer demand patterns such as trend or periodicity in their forecasts, they do not attempt to actually identify the underlying subpattern.

The concept of classical time series decomposition described in chapter 19.5.3 can also be used for forecasting. The subpatterns or components of the time series are identified and isolated, their parameters are determined and, except for randomness, each component is projected into the future separately. Finally the forecasts for each of the components (subpatterns) are added for forecasting values of the entire time series.

For the additive decomposition model the value for demand at time t is represented by the periodicity, trend (which includes level shift), cyclicality and randomness, all at time t respectively:

$$d_t = P_t + T_t + C_t + R_t \qquad \text{Eq. 20.11}$$

The mathematical calculations for decomposition require lengthy and laborious calculations and therefore in the following only the principles are briefly outlined.

In a first step periodicity is removed by calculating moving averages of the same order as the length of the observed period. Simple moving averages are applied if the period has an odd number of values while centred moving averages are applied for even number of values.

For the sake of simplicity, below a period of 12 months will be assumed. A 12 months moving averages of the time series is calculated in order to even out any periodic changes as well as randomness. After subtraction of the 12 months moving averages only the trend and cycle are left. In order to determine the periodic subpattern, the trend and cycle are subtracted from the original time series. Then "seasonal" indices are calculated by calculating the sum of the first value of each period, sum of the second value of each period etc. For example adding all values for customer demand in January, all values for customer demand in February etc. The forecast for the next unit time period is calculated by selecting the "seasonal" index of the next

period. For example if the last available value of the time series is customer demand from September, the seasonal index from October is the forecast for the periodic component.

The second step is to apply regression analysis to the trend and cycle in order to determine the linear trend component and calculate its parameters. The forecast is then calculated by extrapolating the regression line which is determined by the parameters intercept and slope.

Finally, the trend is removed from the trend-cycle to reveal the cycle of the time series. Cyclical indices can be calculated in a similar way to seasonal indices. However, since the length of periods of the cycles is not constant, cyclical indices are less accurate than seasonal indices. Cycles with long periods can be difficult to distinguish from trends and therefore some forecasting methods prefer to forecast them together rather than separately.

The forecast for the entire time series is calculated by adding the forecasts for periodicity, trend (which includes level shift) as well as cyclicality. The same principles apply to the multiplicative decomposition except that instead of subtractions, ratios are calculated and values of subpatterns are multiplied rather than added.

The decomposition method requires considerable expertise, computational effort and time. Since predicting cyclicality requires human judgement the method cannot be fully automated. Large random fluctuations or outliers might be mistakenly interpreted as trend or periodic patterns. There is also a danger of "overfitting" time series where the model matches the actual time series but the forecast does not necessarily predict the future well.

20.4 Multivariate forecasting methods

Strictly speaking multivariate forecasting methods are no forecasting methods as such since they only analyse relationships between past values of at least two variables. Rather after forecasting independent variable(s) using any other forecasting method, the established relationship(s) between the independent variable(s) and the dependent variable is (are) applied to estimate the value of the dependent variable which then serves as the actual forecast for the dependent variable. The regression analysis itself is therefore actually only one step in the forecasting process.

Multivariate methods determine and model linear or non-linear relationships between one or more independent variable(s), also called explanatory, exogenous variable(s) or the predictor(s), and the dependent (predicted) variable. The dependent variable can be described as a mathematical function of the independent variable(s).

Simple bivariate regression methods analyse the relationship between one independent and one dependent variable while multiple or multivariate regression methods use several independent variables. Econometric forecasting is based on several regression equations, and therefore several independent as well as several dependent variables, of interdependent variables. Unlike time series analysis, variables other than time are used.

Multivariate forecasting methods are also called extrinsic because they include analysis of variables other than the one being forecasted as well as explanatory because an attempt is made to understand the relationship between the variables. The term causal forecasting must be used with great caution since even a highly significant relationship alone does not prove any cause-and-effect relationship and does not tell which variable is the cause and which variable the effect. However for the purposes of forecasting, determining or confirming causality is of little importance as long as the forecast is accurate and there is no need to explain the relationship for other purposes.

The assumption of continuity also applies to multivariate forecasting methods. Any relationship between variables, which is always based only on past values, is assumed to continue at least throughout the time horizon for which forecasts are made. Therefore even if the forecast for the independent variable is accurate, the forecast for the dependent variable can be inaccurate if for some reason the determined relationship between the independent and dependent variable changes or does not continue. For example a significant relationship between the number of patients admitted to a health care facility with a certain medical condition and the demand for a certain drug product may be found. Even if the forecast for the number of patients with the medical condition is accurate, the forecast for demand of the drug product may be very inaccurate if the treatment protocol changes.

Moreover even if a highly significant correlation is found for values of the independent variable which lie within a certain range this (linear) relationship might not hold true for values of the independent variable outside that same range. Therefore any extrapolations outside the data range which was used to establish the regression equation must be made cautiously.

Multivariate forecasting methods have the advantage of providing forecasts for a whole range of variables. However they require first detecting a significant relationship as well as collecting and processing data of at least two variables.

20.4.1 Simple linear regression method

Simple regression methods analyse the relation between a single independent variable and a single dependent variable.

Regression analysis is usually based only on a sample of all independent and dependent variables. Therefore determination of the regression line and various coefficients depends on the selected sample, different samples will yield different results and the results of the analysis are subject to sampling errors. In order to ensure that the results are statistically significant and to obtain reasonably reliable results a sample of at least 30 pairs of independent and dependent variables is needed.

Linear regression analysis assumes that a linear relationship between the independent and dependent variable exists. Moreover that the values of the dependent variable are normally distributed around the regression line and have the same standard deviation (homoscedasticity). If a non-linear relationship is found, more complex non-linear regression methods can be applied.

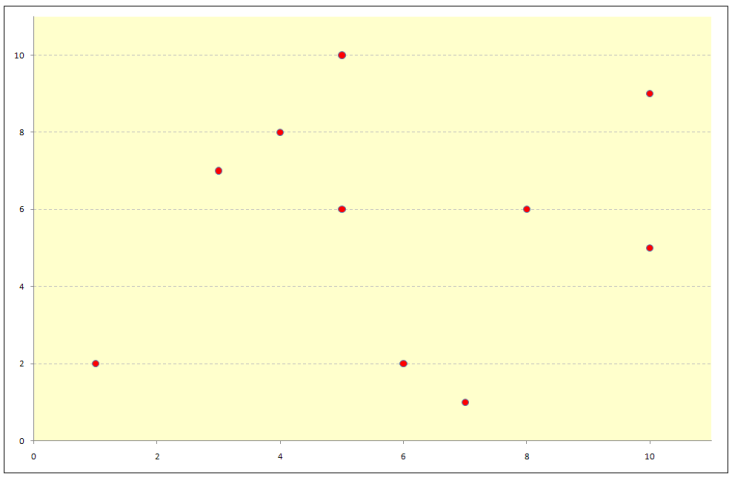

Figure 20.8 Example of scatter diagram

In order to obtain a forecast several steps are necessary. Plotting the values of the independent and dependent variable on a scatter diagram allows getting a first impression of the data set and visually determining a possible relationship.

The calculation of the coefficient of correlation allows to accurately determine the strength of the relationship between the values of the independent and dependent variable. The coefficient of correlation (r) is a relative measure which can assume any value between -1 and +1. A coefficient of correlation of 0 means that no relationship exists, a r of -1 shows a perfect negative correlation and a r of + 1 identifies a perfect positive correlation. Correlation coefficients between - 0.7 and + 0.7 indicate a weak correlation and therefore using simple linear regression will not yield accurate forecasts.

If the correlation is found to be significant the next step is to fit a regression line through the points plotted on the scatter diagram which minimizes the mean squared errors between the dependent variable and the respective point on the regression line. Mathematical calculations yield the two parameters to define the regression line namely the intercept a (the y-value of the regression line for a x-value of zero) and the slope b (regression coefficient). The regression coefficient is a measure for the influence of the value of the independent variable on the value of the dependent variable. Note that different samples of independent and dependent variables will yield (slightly) different parameters. Assuming that the found relationship holds true for any independent variable at any time, any dependent variable can be calculated with the regression equation.

As regression analysis itself does not allow to forecast values of a time series, any other forecasting method is applied to generate a forecast for the value of the independent value. It is important to realize that the final forecast for the dependent value cannot be more accurate than this forecast for the independent variable even if a highly significant correlation exists.

A point estimate of the dependent value on the regression line is predicted from the value of the forecast of the independent value by applying the regression equation. Unless a perfect correlation was found, the value of the dependent variable on the regression line will have a certain error in relation to actual values of the dependent value. The coefficient of determination (r^2) is a measure for the percentage of variation that can be explained by the independent variable. A coefficient of determination of 1 means that there is an exact match between the values of the dependent variable and the regression line and the error of estimate is therefore 0. With decreasing coefficient of variation the error of estimate increases. In order to yield a reliable forecast the coefficient of variation should not be lower than 0.5 since otherwise less than 50% of the variation of the dependent variable can be explained by the independent variable. Therefore even if the forecast for the value of the independent variable is highly accurate, the forecast for the independent variable is not reliable.

The standard error of estimates (s_{yx}) is a standard deviation which measures the scatter of values of the dependent variable around the regression line. Assuming that the errors of estimates are normally distributed and homoscedastic for all values of the independent variable, a prediction interval can be determined for each forecast.

Intuitively this is simple to see. For example if during two different time periods 100 patients (independent variable) were admitted with a specific medical condition and during one period the demand (dependent variable) was 900 tablets while it was 800 for another time period then the value on the regression line for 100 patients is 850. If the number of patients forecasted for the next unit time period is 100 (again) then the forecast for demand for the tablets will be 850. However the actual value could lie inside the range of 800 and 900 tablets or even outside and there is no way of obtaining a more accurate forecast than the estimate.

20.4.2 Morbidity method

The morbidity method (Quick, J.D. (ed.) 1997, 196) can be seen as an application of the simple linear regression method.

First a list of clearly defined common medical conditions which are regularly treated at the assisted health care facilities is established. A standard treatment protocol, if necessary differentiated according to the age of patients and the severity of the medical condition, allows calculating the quantity for each drug product for one treatment episode. Usually different standard treatment protocols must be applied at least for children and adults. In some cases calculations may have to be made for each of several alternative standard treatments.

Alternatively the number of patients treated for a specific medical condition in the past can be compared with the historic demand to calculate actual historic average demand for one patient. Either way a relationship will be found between the number of treatment episodes and the required quantities of drug products which allows calculating the regression equation.

Instead of directly forecasting demand for drug products the number of treatment episodes, which serves as the independent variable, is forecasted. The term "morbidity method" might falsely suggest that future morbidity is known and it must be stressed that future morbidity and the number of treatment episodes is never known with certainty. Then the relationship determined by the regression analysis is applied to estimate the forecast for the dependent value, namely the quantity of drug products. In other words, demand is forecasted by multiplying the expected number of treatment episodes with the quantity of a specific drug product required for one treatment episode. Compared to time series analysis, the morbidity method has the advantage of forecasts not being influenced by shortages and stockouts.

If specific drug products are used for treating different medical conditions, the respective forecasts have to be added.

Although in principle this method is simple, in practice it will only allow to estimate future demand. Some patients will not be diagnosed correctly, standard treatment protocols may not exist or may not be applied correctly, drug products may be additionally used for other medical conditions which are not included in the forecast, patients might not comply with the treatment and some quantities of drug products may be damaged or stolen. If humanitarian organizations use the morbidity method for forecasting they must be willing and able to encourage and enforce standard treatment protocols and rational prescription practices.

The morbidity method depends on the availability of complete as well as accurate morbidity data from a reliable health information system and is time consuming as it requires collecting, analysing and processing a multitude of data and information. In practice it can only be applied to the most common medical conditions for which standard treatment protocols are available and can hardly be applied to surgery.

20.4.3 Multiple linear regression method

The concept of simple linear regression with a single independent variable can be extended to multiple linear regression where a single dependent variable can be expressed as a linear function of two or more independent variables. The mathematical theory and the calculations are more complex, but the basic principles remain the same.

The forecast for the dependent variable will only be accurate if the multiple linear regression established with historic data does not change in the future. If the independent variables

among each other are highly correlated, the multiple regression will yield unreliable results. In this case one of the correlated variables should be removed.

In the case of two independent and one dependent variable, the data sets can be graphically represented in a three dimensional space. If none of the three variables are correlated, they will be randomly distributed and represent a spherical cloud. If a correlation exists, a three-dimensional regression plane can be fitted through the data points which minimizes the distances between the data points and the regression plane. The standard error of estimate is a measure for the dispersion or scatter of the data points around the multiple regression plane.

The strength of the relationship is again determined by the coefficients of correlation which are calculated for each pair of variables, for example a correlation matrix of 9 coefficients of correlation for a multiple linear regression with two independent and one dependent variable. The coefficients of correlation show the influence of each of the variables on each of the other variables and the coefficient of determination shows how much of the variation of the dependent variable can be explained by the combined variation of the independent variables.

If a correlation exists, a regression plane can be defined mathematically by the multiple regression equation. The intercept corresponds to the value of the dependent variable when both of the independent variables assume the value of zero and the two slopes correspond to the slope of the regression lines which result when the other independent variable is zero.

In order to forecast the dependent variable, again all of the independent variables have to be forecast with another forecasting method. A point estimate for the dependent variable is predicted by inserting the forecasts into the multiple linear regression equation. The forecast for the dependent variable will only be accurate if the forecast of the independent variables are accurate and if the multiple regression is significant in the time period which is being forecast.

Multiple linear regression can be further extended to a system of multiple linear regression equations with several interdependent variables which are often used in economics and therefore also called econometric models.

An extension of simple or multiple regression analysis is non-linear regression where data points are scattered around a curve. Dynamic regression models allow considering a delayed effect of the independent variable on the dependent variable which is spread over several future unit time periods.

20.5 Probability estimates

Probability estimates are an alternative to forecasting a point estimate of customer demand.

Instead of extrapolating a time series the same historic values can be grouped into classes of equal intervals for calculating relative frequency distributions which can be used as probability distributions for forecasting under certain conditions.

If only a sample of data is available, it must be representative for the whole population. The assumption must be made that the distribution of historic customer demand data is similar and indicative of future probability distributions (assumption of continuity).

The probability distribution itself can be used to forecast the probability that customer demand will be below or above a certain value. Together with the mean this forecasting method provides the required point estimate range as well as a probability.

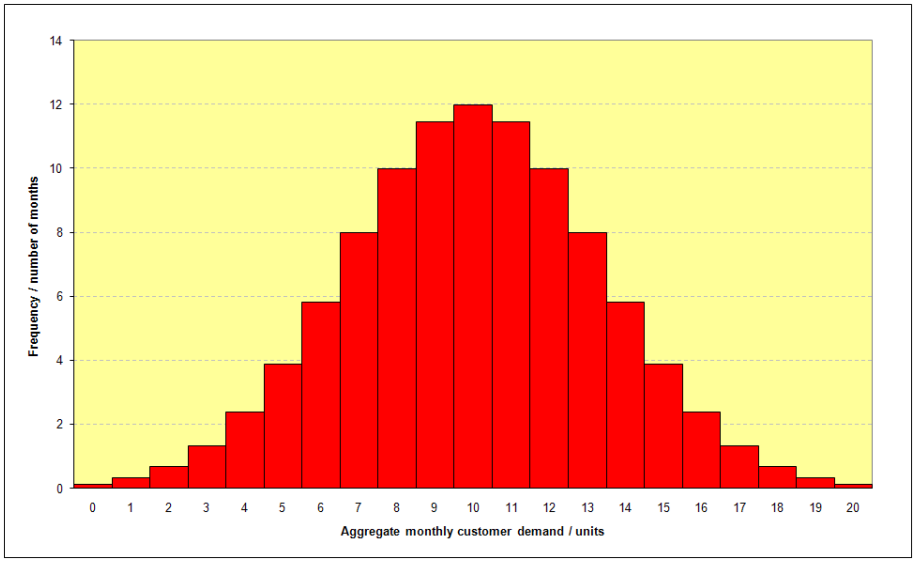

Figure 20.9 Example of a frequency distribution

If the probability distribution is known or assumed to be normal, probability estimates can be very easily calculated for any range with the standard deviation. There is a 50% probability that future customer demand will lie below the mean and a nearly 98% probability that the value will lie between zero and 2 standard deviations above the mean.

20.6 Qualitative forecasting methods

Qualitative forecasting methods are the only alternative if historic data is insufficient, unavailable or inaccessible. Further if quantitative forecasting methods yield large forecasting errors, no significant patterns or relationships can be found or no formal mathematical models can be built. Qualitative forecasting methods can also not be used if the available data is not relevant for the future and if the assumption of continuity therefore does not apply.

Qualitative forecasting methods are used very commonly and widely and rely on subjective judgement of one or more individuals, on their opinions, intuitions, insights as well as knowledge about the world and the future. Because they are often used for predicting long-term changes of technology and the general environment they are sometimes called technological or environmental forecasts.

Although quantitative and qualitative forecasting methods may seem diametrically opposed in principle they both rely on the same information although observed and recorded in different ways. Qualitative forecasting methods also analyse the past and consider trends, historical patterns and relationships but by using knowledge and intuition instead of mathematical analysis.

Quantitative forecasting methods can identify and extrapolate patterns and relationships better than human judgement but only qualitative forecasting methods can predict systematic changes of patterns or relationships, their extent as well as their effects and impact.

Qualitative forecasting methods are easy to use but do not allow to estimate the expected forecasting error and are usually not as accurate as quantitative forecasting methods as human judgement is often influenced by different types of bias (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 492 f.).

Human beings tend to be inconsistent and may change their mind as well as decisions without any apparent reason. They sometimes apply different criteria in the same situation and for making similar decisions. Human beings might erroneously believe that circumstances and conditions have changed even if there is no objective evidence for such changes. Opinions and decisions may be influenced by moods, wishful thinking or people might simply want to try something new, especially when forecasting is repetitive.

Conservatism is the failure to adapt to new situations and information which have an impact on forecasts. On the contrary forecasters may tend to be influenced more strongly by more recent events, even if they are not necessarily more relevant or more indicative for predicting the future, while ignoring the importance of the less recent past. More generally there is a danger of relying on specific events or information which is readily available from memory even if these may not be most pertinent.

Anchoring describes the phenomenon of being strongly influenced by the initial information given to forecasters, again even if it may not be the most relevant.

Human beings tend to believe having found patterns or causal relationships even where they do not exist in reality (illusory correlation). For example short-term increases or decreases in patterns may be pure chance rather than indicating a genuine trend.

Human beings also tend to (selectively) look for facts and evidence which support their hypothesis or conclusions even if they are wrong, and disregarding others. Unfortunately accumulating supporting facts does not prove the conclusions. Paradoxically the active search and inability to find any evidence falsifying the conclusion is the most reliable way for proving them.

Human beings tend to attribute accurate forecasts to their skills and inaccurate forecasts to adverse circumstances and therefore may miss an opportunity to learn and improve their skills.

Generally human beings tend to be overconfident and underestimate uncertainty. Paradoxically increasing the amount of available information does not improve the quality of forecasts but nevertheless increases the confidence of the forecaster.

Decisions, including forecasts, made by groups are prone to bias caused by overconformity among group members (groupthink). Members of cohesive groups tend to support each other as well as each other's opinions and decisions. This conformity is caused by deliberate or non-deliberate pressure on group members and suppression of internal dissent. There is generally a lack of searching for alternatives and they are evaluated only superficially. Self-censorship prevents group members from questioning ideas and opinions of other group members. The group seeks harmony and consensus and tries to avoid conflict and any dissent. Information which may jeopardize this consensus might be prevented from reaching other group members. The group as a whole tends to isolate itself from the outside world and does not make any attempt to seek advice from outside their own group. This situation may be compounded by one or few individuals who dominate the group.

The overall lack of critical thinking leads to poor decisions and, compared to individuals, groups tend to amplify bias. Groups tend to be overly optimistic and take more risky decisions than individuals.

20.6.1 Expert-based forecasting methods

Forecasts relying on the experience and personal insight of a single expert who is familiar with the situation are widely used although they are unreliable and very susceptible to

ignorance, prejudice and bias. In general human judgement yields worse forecasts than formal methods.

Generally forecasts made by a panel of several experts which deliberate freely and reach a consensus are more reliable than those made by a single expert. The panel consensus is a simple forecasting method and allows to consider the expertise, diversity of opinion as well as complementary perspectives of the different panel members.

However predictions by panel consensus, also called jury of executive opinion, are susceptible to various negative effects which social pressures and group dynamics can have and must be considered with caution. Panel members may stand in a hierarchical relationship to other members and therefore exert social pressure and individuals might (try to) dominate the entire group. Moreover no accepted methods for combining diverging or even competing views and opinions are available.

20.6.2 Exploratory forecasting methods

While most forecasting methods try to predict future events as accurately as possible, exploratory forecasting methods seek to identify different developments in the future.

Like the consensus method, the Delphi method involves a panel of expert. However the bias and negative effects of working in a group are reduced by requesting the experts to complete the questionnaires independently without consulting other members of the panel and to return them by mail. Questions or scenarios are presented to the experts who are requested to identify possible future developments and estimate their probability and timing.

The anonymous replies from all experts are summarized by an administrator and distributed among the members of the panel together with a revised questionnaire without disclosing the authors of individual contributions. The experts are then requested to study the results, reconsider their own position and modify their comments. This process allows to express and present different opinions and to develop a range of possible future developments. The process is repeated between three to six times and may result in a consensus.

The nominal group process (NGP) is similar a combination of the Delphi method with the panel consensus. In a first phase experts individually study the question and write down their thoughts and predictions. All views are shared with other panel members and each contribution is then openly discussed by the entire panel.

Scenario analysis or scenario building explicitly tries to envisage a number of ways the future could develop and to predict their implications by combining extrapolation of trends with assumptions about the future. The scenarios may subsequently be discussed by experts who were not involved in their development.

20.6.3 Historical Analogy

If historical customer demand data for a certain health care facility is not available or too unreliable, forecasts can be based on customer demand data from other comparable health care facilities.

When a humanitarian organization establishes a new health care facility or starts assisting a health care facility which cannot provide accurate records on historic customer demand, available customer demand from comparable health care facilities in the vicinity, the country or other countries with similar epidemiology can be used for forecasting. The health care facilities must be comparable in terms of their sophistication and technical equipment, level of

care, essential drug lists, treatment protocols, number of patient consultations, age distribution of patients, climate and epidemiology. A regular supply at least of all essential health care goods must be ensured.

For example customer demand data from a health care centre at a refugee camp will allow good estimates of a health care centre providing similar services at another nearby refugee camp. The quantities of health care goods used for example for 100 consultations can be used as a basis for the forecasts.

Likewise at the onset of certain types of crises, for example military attacks displacement or epidemics, historical customer demand data from similar (recent) crises can be used for predicting customer demand for the current crisis. For example needs during a cholera epidemic are similar in different places and past experience can be used to predict customer demand at the onset of a cholera epidemic at another time in another place.

On a global level crude forecasts for the kind and quantities of required health care goods can be forecasted from the context and using historical analogies and experience.

The type of conflict and type of weapons used in the conflict allows forecasting the type of prevailing injuries which can be expected. Knives and machetes will cause cuts and deep flesh wounds, gunshot wounds can be expected where small arms are used, shelling and bombing will cause crush injuries and fractures, use of incendiary devices will cause burns and use of anti- personnel mines will require amputations (Perrin, P. 1996, 224). However the biggest cause of mortality in complex political emergencies is not trauma from direct effects of the armed conflict but rather the high rates of infectious diseases (Guha-Sapir, D., and W. van Panhuis 2002, 19).

Outbreaks of some communicable diseases can be expected in large populations especially when they live in crowded and poor sanitary conditions (Perrin, P. 1996, 125).

Forecasts for complements (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 27) could be seen as a special form of analogy. Many health care goods are often or always used in combinations. Certain drug products are combined for anaesthesia, syringes are often used with hypodermic needles and infusion solutions require infusion sets for intravenous application. Therefore if a forecast for infusion solutions is available, a prediction for infusion sets can be made by analogy.

20.7 Selection of forecasting methods

The most suitable forecasting method cannot be simply deducted according to rigid rules but some general principles can be outlined and general recommendations can be given. The selection of appropriate forecasting methods depends on a variety of aspects and criteria and the forecasting method has to be matched and adapted individually to each forecasting situation. Under the same circumstances, different forecasting methods may be appropriate at different times.

The forecasting method must consider the situation in which the forecast is made as well as the objectives of the user. For decisions at the operational level, short-term univariate forecasting methods will often be sufficient while tactical and strategic decisions with mid- and long-term effects will usually require multivariate or quantitative forecasting methods.

The expected impact of the forecast and especially the corresponding forecasting error are important decision criteria. Where the forecasting error could have serious negative consequences, the application of more complex forecasting methods which require larger resources is justified. For example forecasting a life saving drug product which does not have

any substitutes. On the other hand simpler forecasting methods will be sufficient if the consequences of a forecasting error can be easily and quickly corrected.

a) Situation and user of forecast

- Objective and use of forecast.
- Importance of forecast.
- Importance of forecasting changes of patterns and relationships.
- Amount of resources the user is willing to commit.
- Confidence of the user in the respective forecasting method(s) and intuitive appeal.
- Ability to interpret forecast.
- Urgency of obtaining forecast.
- Required accuracy.

b) Forecaster/analyst

- Availability of resources.
- Knowledge of forecasting method(s).
- Confidence in forecasting method(s).

c) Forecasting method

- Simplicity and ease of use.
- Possibility of automation.
- Accuracy and reliability.

d) Data and information.

- Availability, reliability and accuracy.
- Historic time period for which data is available.
- Patterns and relationships of data.

e) Forecasting parameters

- Time horizon.
- Number of forecasts.

Table 20.1 Criteria for selecting univariate forecasting methods

Qualitative forecasting methods are necessary whenever forecasting changes of patterns and relationships is important, which is usually the case with mid- and long-term forecasts.

Managers need to consider how much resources in terms of staff, soft- and hardware as well as time they are willing to commit. Simple univariate forecasting methods which can be automated are cost-efficient and will be selected when resources are scarce. Complex forecasting methods require committing considerable resources for developing the method, acquiring and preparing data and carrying out forecasts.

Users will be very reluctant to take decisions based on results of forecasting methods which are not intuitive and which they do not fully understand, even if the forecasts are very accurate. They will only make use of forecasts if they have full confidence in methods with which they were obtained. Otherwise they will tend to put them aside and rely on their own judgement.

The forecasting method must be adapted to the knowledge of the user who must be able to understand and make use of forecasts. Simple forecasting methods are easy to understand and interpret.

The time available for preparing forecasts can be a limiting factor as urgent forecasts will not allow applying complex forecasting methods. Personal insight or fully automated univariate forecasting methods will allow to quickly prepared urgently required forecasts.

Quantitative forecasting methods allow to estimate forecasting errors and are generally more accurate than qualitative forecasting methods. Systematically applied statistical forecasting methods generally outperform qualitative forecasting methods even if carried out by experts.
The resources, especially time, hard- and software, available to the respective forecaster are an important selection criteria.

In order to generate accurate and reliable results, the forecaster must have the necessary knowledge and understanding of the respective forecasting method and be experienced and skilled in its application.

Apart from the requester and user, the analysts or forecasters themselves must have confidence in the forecasting methods they apply.

In general, users of forecasts prefer simple forecasting methods which are easy to apply and they should be used whenever they give reasonable results. According to an extensive comparison of the forecasting accuracy of a large number of time series, for short-term forecasts, relatively simple methods performed much better than statistically sophisticated methods and adaptive methods did not outperform nonadaptive methods (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 131 f.).

Quantitative forecasting methods can be largely automated which allows to generate forecasts quickly, repeatedly and efficiently for a large number of items while qualitative forecasting methods rely on human judgement.

While high accuracy of forecasting methods is usually desirable, increasing the forecasting accuracy may not always have a significant influence on the decisions which are based on the forecast. Moreover a balance between the required resources and the forecasting accuracy which can be achieved with them has to be found.

Qualitative forecasting methods are prone to bias and overall quantitative forecasting methods are more accurate. For repetitive and routine forecasting, systematically and consistently applied forecasting methods can even outperform experts since human beings tend to be inconsistent.

The availability, accuracy as well as reliability of data and information is crucial for selecting forecasting methods. Quantitative forecasting methods require data on one or more variables while qualitative forecasting methods are the only alternative if available data is considered insufficient, unreliable, inaccurate or not representative. Even highly sophisticated forecasting methods will yield poor forecasts if they are based on inaccurate data.

The application of forecasting methods which consider periodicity and cyclicality requires data which cover at least several periods or cycles and long-term trends can only be identified if sufficient historic data is available.

Matching demand patterns with the appropriate forecasting method is essential in order to avoid large forecasting errors. Generally qualitative forecasting methods are inferior to quantitative forecasting methods in predicting continuation of patterns in a time series. However the use of various univariate forecasting methods is limited to certain patterns of the respective time series.

While any averaging methods and single exponential "smoothing" can be used for level demand series, double moving averages or double exponential "smoothing" (Holt) are

appropriate forecasting method for demand patterns displaying a trend. However averaging methods may also be appropriate for short-term forecasts of demand patterns with long-term trends and single exponential "smoothing" can also be applied to demand patterns with weak trends.

Winter's forecasting method or "seasonal" indices can be applied for forecasting periodic time series.

Cyclicality is the most difficult pattern to forecast. Since the lengths of the periods change unpredictably, they cannot be systematically predicted with quantitative forecasting methods. Over a short horizon, long-term cycles are difficult to distinguish from trends and forecasting methods which consider trend will yield reasonable forecasts. Moreover, cycles mainly affect mid- and long-term patterns and are not as important for short-term forecasting and qualitative forecasting methods may be used to explain and predict the cyclicality in a time series.

By definition randomness cannot be forecasted. However small fluctuations around a constant mean have little impact on forecasts and can be reduced by averaging as well as "smoothing" methods. In general the more randomness a time series displays, the more appropriate simpler forecasting methods are.

Intermittent and erratic time series cannot be forecasted (accurately) with quantitative forecasting methods. However if the time series is stationary over the mid-term, higher order moving averages will provide reasonable results. As mentioned earlier, whenever intermittent and erratic customer demand is noticed, its reason should be identified and measures for reducing demand distortion should be taken. If demand is genuinely intermittent or erratic, such as for replacement parts, judgement and expert knowledge must be used for making forecasts (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 317) and an imprest system should be used for inventory control.

No forecasting methods are available for the irregular and random "residue" of a time series. High order moving averages can smooth the random walk but require a lot of historic demand data and may disguise a trend. A compromise lies in using data from a long historic time period to ensure sufficient smoothing while giving more weight to recent values of the time series in order to account for any possible trend. In any case the impact of random walks on short-term forecasts is limited.

By definition (assumption of continuity) discontinuation of established patterns and relationships cannot be predicted with quantitative forecasting methods and requires application of qualitative forecasting methods.

The XYZ-analysis differentiates items according to the regularity and forecasting accuracy of their demand (Gudehus, T. 1999, 225) as runners, repeaters and strangers. Since X-items have a high turnover and demand is regular, they can be forecasted with high accuracy and do not require keeping large safety stocks. Y-items display high variability and require larger safety stocks while demand for Z-items is erratic and highly unpredictable. Since demand distributions of Z-items do not resemble a normal distribution, service levels methods will not yield good results. Consequently forecasts for Z-items must be adjusted by judgement.

For vital items, such as drug products or essential replacement parts, stocks may have to be maintained even if demand is small and very irregular.

For short- and mid-term forecasting, quantitative forecasting methods are most appropriate. For longer time horizons there is a high probability that the assumed patterns and relationships will change, quantitative forecasting methods therefore perform poorly and can lead to large forecasting errors. Therefore qualitative forecasting methods are more suitable

for mid- to long-term forecasting where changes in patterns and relationships can be considered.

The overall number of required forecasts is determined by the number of different items concerned as well as the frequency (weekly, monthly, quarterly etc.) of forecasts. The larger the number of required forecasts the less time is available for each forecast. Consequently simple quantitative forecasting methods which can be automated will be preferred. Moreover in repetitive and routine situations quantitative forecasting methods yield more consistent and accurate forecasts than qualitative forecasts since human beings tend to be inconsistent.

Complex forecasting methods will be reserved for highly critical items where a large forecasting error could have a severe negative impact. Because of the complexity of calculations and the required time, application of the morbidity method is practical only for the most common medical conditions.

Conversely complex forecasting methods can be applied where a small number of items or other issues need to be forecasted infrequently.

Generally the combination or average of forecasts from several quantitative forecasting methods yields more accurate forecasts than the respective forecasting methods separately (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 132 f.).

Forecasting accuracy can often be increased by adjusting forecasts from quantitative forecasting methods with qualitative forecasting methods which predict changes of patterns or relationships. The combination of quantitative and qualitative forecasting methods allows to make use of the consistency and reliability of statistical methods while taking advantage of knowledge and experience for predicting changes in patterns and relationships.

In summary, a simple framework for selecting forecasting methods is presented in figure 20.10.

For short-term forecasting of customer demand univariate forecasting methods and probability estimates are easiest and fastest to apply while yielding consistent and reasonably accurate results. However they need to be adjusted by human judgement whenever changes of patterns and relationships are expected.

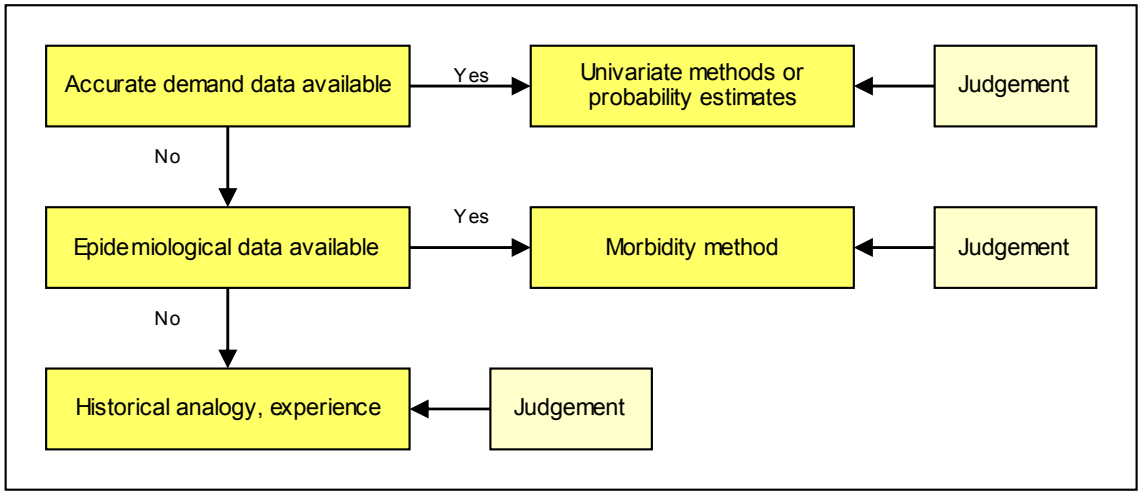

Figure 20.10 Framework for customer demand forecasting

Where no customer demand data is available yet, the morbidity method can be applied to forecasting demand for health care products for the most common medical conditions.

Where accurate data is unavailable the only alternative is using historical analogies either from the same health care facilities or other health care facilities in similar situations and conditions.

20.8 Use of software applications for forecasting

Repetitive quantitative forecasts of a large number of items are very time-consuming and boring for human beings who also tend to be inconsistent. Therefore practically speaking the use of computers and software applications is indispensable for quantitative forecasting.

Software applications must be simple and easy to use in order to quickly train non-specialist staff. As mentioned earlier, complex forecasting methods do not outperform simple ones anyway, especially in short-term forecasting.

Users of the software application as well as users of the forecasts have to be able to understand the applications and methods applied since otherwise they will not trust the forecasts. Moreover users must be able to easily interpret the results generated by the forecasting applications.

Standard spreadsheet applications are readily available, cheap, flexible, easy to use and require little training of users. However they can only be used for quantitative forecasting techniques and the results must be reviewed and where necessary adjusted or corrected by judgement.

The use of commercial forecasting applications is comparatively expensive, requires specialist staff and well be reserved for use at regional and international distribution centres.

20.9 Forecasting accuracy and error

Regardless of the situation and forecasting method, all forecasts are inaccurate to a certain degree and a certain degree of uncertainty about the future is inevitable.

The forecasting error is defined as the difference between the value which is forecasted for a certain unit time period ahead and the actual value which is later observed. Forecasting errors can be measured for the first unit time period in the future (one-period- ahead forecast) or for several unit time periods into the future (multiperiod-ahead forecast).

In inventory control the forecasting error corresponds to the uncertainty of future customer demand.

For quantitative forecasting methods, the forecasting error can be expressed as a certain value or degree of precision. If specific events have been predicted with qualitative forecasting methods, the event might occur later as predicted, not at all or another unpredicted event may occur instead.

While it is impossible to completely eliminate forecasting errors, measures can be taken to minimize the size of these errors. The time and effort to reduce forecasting errors must be balanced against the benefit from increasing the forecasting accuracy.

20.9.1 Factors affecting forecasting errors

Several factors related to the data, the forecasting horizon as well as the used measures influence the accuracy of forecasts and their forecasting errors.

- Availability of historical data.
- Homogeneity of data.
- Detection and removal of outliers.
- Changes in established patterns or relationships.
- Number of observations.
- Forecasting horizon.
- Suitability of the forecasting method for the forecasting horizon.
- Combination of qualitative forecasting methods.
- Measure of forecasting accuracy which is being applied.

Table 20.2 Factors influencing forecasting accuracy

In general the forecasting accuracy increases with the length of the time period for which historical data is available. However older values only contribute to increased forecasting accuracy if they are not outdated and representative of the future time series.

Forecasting accuracy also increases with the homogeneity of data, especially if the different data sets display similar periodicity. For example customer demand data from several health care facilities in the same district or country will tend to more homogenous than customer demand data from different countries.

The detection and adjustment of outliers in a time series is critical for forecasting accuracy. Outliers in itself lead to large forecasting errors and the distortion of the time series makes the detection of underlying patterns or relationships difficult which in turns makes it more difficult to select an appropriate forecasting method.

Any changes of established patterns or relationships (unless they cancel themselves out) will lead to proportional large forecasting errors of univariate and multivariate forecasting methods unless they are detected or predicted by qualitative forecasting methods.

The forecasting accuracy increases with the number of observations (law of large numbers) as well as the level of aggregation. Forecasts of customer demand aggregated over many customers are more accurate since their is a high probability that increased demand from one customer will be compensated by decreased demand from another customer during the same unit time period. For the same reason the forecasting accuracy for groups of items, for example different infusion solutions will be higher than for the individual items of the same group.

In general the size of forecasting errors increases with the forecasting horizon (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 35), since the probability that situations, patterns and relationships will change increases with time. Moreover the effects of changed patterns or relationships are smaller for short-term than for long-term forecasts and long-term forecasts are particularly prone to large forecasting errors. Likewise multiperiod-ahead forecasts will be much less accurate than one-period-ahead forecasts.

Large forecasting errors can also be expected if the forecasting method is not adapted to the forecasting horizon, for example using a univariate forecasting method for a long-term forecast. Generally quantitative forecasting methods are more accurate than qualitative forecasting methods.

For quantitative as well as qualitative forecasting methods, in general combinations of forecasting methods are not only more accurate than the individual forecasting methods used but also decrease the variance of forecasting errors.

Finally forecasting accuracy simply depends on the measure of forecasting accuracy which is being used.

"The phonograph . . . is not of any commercial value" (1880).
"Heavier than air flying machines are impossible" (1895).
“Everything that can be invented has been invented” (1899).
"There is no likelihood man can ever tap the power of the atom" (1923).
"Who the hell wants to hear actors talk?" (1927).
"I think there is a world market for about five computers" (1943).
“There is no reason for any individual to have a computer in their home” (1977).

Table 20.3 Examples of inaccurate long-term forecasts (DeLurgio, St.A. 1998, 627)

20.9.2 Objectives of measuring and monitoring forecasting accuracy

The measurement and monitoring of forecasting accuracy allows to estimate the forecasting accuracy of future forecasts. No forecast should be limited to a point estimate but should include an interval estimate (prediction interval) as well as a probability that the actual future observation will lie within the predicted interval. Such prediction intervals should be part of any forecast and should be clearly communicated to users. For example a point estimate for aggregate monthly customer demand of a drug product of 1,000 units with a 95% probability that the future value will lie between 900 and 1,100 units.

In general it is more important to provide a user with such an estimate of the certainty of forecasts than to (only) increase forecasting accuracy. Knowledge of the estimated interval estimate allows users to assess the uncertainty of the point estimate and adjust their decisions to the probability that the value of the predicted observation will assume a certain value.

In inventory control the estimated forecasting error corresponds to the uncertainty of future demand and allows adjusting safety stocks accordingly.

Deviations of forecasting errors are usually assumed to be normally distributed about the mean forecasting error and the standard deviation of the forecasting error is a measure for its spread.

Another important objective of measuring and monitoring forecasting accuracy is to continuously assess the appropriateness of the forecasting procedure in general as well as the forecasting method and its parameters.

Significant and systematic changes of forecasting errors can indicate changes of established patterns or relationships and the need to review the suitability of the selected forecasting method.

Tracking signals monitor forecasting errors and allow detecting any bias of forecasting methods, such as systematically under- or overestimating future values which requires adjusting parameters or even replacing the forecasting method altogether.

Forecasting errors of different forecasting methods over a longer time period can be compared in order to select the forecasting method with the (on average) smallest forecasting errors. However small forecasting errors of any forecasting in the past does not guarantee small forecasting errors in the future.

20.9.3 Measures of forecasting accuracy

Several different measures of forecasting accuracy are available and the most suitable measure depends on the forecasting situation. While it is of course generally desirable to determine forecasting methods and their parameters which minimize forecasting errors, small forecasting errors in the past to not guarantee that the same forecasting method will yield forecasts with the smallest error in the future.

The forecasting error, also called deviation, is calculated by subtracting the actually observed value from the previously made forecast for that observation. The absolute forecasting errors correspond to the deviation of the actual value from the forecasted value while percentage errors describe the relative difference which facilitates comparison of forecasts.

Usually forecasting errors are calculated for single-period ahead forecasts but calculations can also be applied to forecasts made for several unit time periods into the future.

For monitoring the forecasting accuracy and its changes over time various averages of different forecasting errors can be calculated (see table 20.3).

The simplest measure is the mean error (ME) which is simply calculated by adding up the respective forecasting errors and dividing the sum by the number of considered forecasting errors. The main disadvantage is that positive and negative forecasting errors offset each other and therefore very poor forecasts can have small mean errors. However the mean error is useful as a tracking signal and allows to quickly detect any bias in the forecast.

The mean absolute error (MAE), also called mean absolute deviation (MAD), avoids the offsets by adding the absolute values of the forecasting errors. If any forecasting errors are negative their absolute (positive) value is added for calculating the mean. The mean absolute error has the advantage that it is intuitive and easy to interpret.

The problem of offsetting of negative and positive forecasting errors can also be eliminated by adding the squares of the forecasting errors for calculating the mean squared error (MSE) which is also called mean squared deviation (MSD). This measure corresponds to the variance of the forecasting error and has the disadvantage of being less intuitive. However the squaring gives greater weight to large forecasting errors which is often desirable as they can cause disproportionate negative consequences. The use of this measure therefore implies that forecasting methods with several small errors is preferable to a large forecasting error. The method of determining forecasting methods and parameters which minimizes the mean squared error is also called "least square" method.

The mean squared error measurement has the disadvantage that not only the errors but the units of measurement are also squared which are difficult to interpret. This problem is avoided by calculating the square root of the mean squared error which corresponds to the standard deviation of the forecasting error. Assuming that the forecasting errors are normally distributed, the standard deviation allows estimating the probability that future forecasting errors will lie within a given range.

Absolute measures of percentage error require comparison with observed values since a forecasting error of, for example 5, is in itself is meaningless. Relative or percentage errors are calculated by dividing the forecast by the actually observed value and subtracting the observed value. The use of percentage errors has the advantage that forecasting methods can be compared against benchmarks such as a 15% standard.

However percentage errors can only be used if the scale has a meaningful origin. For example the zero points of different temperature scales are arbitrary and the same absolute error will lead to different percentage errors. Moreover percentage errors have to be

considered with caution if the observed values are small. For example a forecasting error of one hundred percent will usually not cause a problem for an item with an aggregate monthly demand of one or two, unless the item is very valuable. Another problem is the impossibility of calculating percentage errors if the observed value of a time series is zero.

The mean percentage error is calculated by averaging the percentage errors of the individual forecasts. Since percentage errors can assume positive or negative values, the problem of offsetting each other arises.

This problem is again avoided by considering the absolute value of percentage errors and calculating their mean. Intuitively a mean absolute percentage error (MAPE) of, for example 10%, is more meaningful than an absolute number such as the mean absolute error.

The above measures of forecasting accuracy can be used for determining the most suitable, or best available, forecasting method and its respective parameters in two different ways; explaining the past or predicting the future.

- Mean error.
- Mean absolute error.
- Mean squared error (MSE).
- Square root of MSE.
- Percentage error.
- Mean percentage error.
- Mean absolute percentage error.

Table 20.4 Measures of forecasting accuracy

The post-sample method fits a mathematical model as closely as possible to historic data of a time series. For example it is always possible to find a polynomial function which exactly fits the time series. This method actually just attempts to reproduce known historical data of a time series as accurately as possible and is therefore also called "curve-fitting". Although the complexity of the forecasting method is (unnecessarily) increased, empirical studies have shown that the extrapolation of a mathematical function which perfectly fits a time series does not necessarily yield accurate forecasts. On the contrary, this kind of "overfitting" considers randomness in the model which cannot be explained and should be excluded from the model just as outliers. Moreover "explaining the past" by fitting a model is of little relevance for generating accurate forecasts.

Instead of curve fitting the true out-of-sample forecasting accuracy should be measured. The time series is divided into an initialization set and a holdout or test set of withheld values. The values of the initialization set only are used for generating the forecast. Then this forecast is compared to the holdout set, the values which were actually observed, in order to retrospectively calculate the forecasting error. This procedure can be repeated in order to determine the forecasting method or parameters which yield on average the smallest forecasting errors. This approach therefore corresponds to a simulation and calculates the forecasting accuracy that would have been achieved had the respective forecasting method been used in the past.

Forecasting errors can also be systematically calculated with each new forecast in order to monitor and track changes of the forecasting error and thereby monitoring the quality of the forecasting method.

The cumulative sum (cusum) of all past forecasting errors allows determining any bias in the forecasts. Ideally the cumulative sum tracking signal should be zero. However if the forecast is consistently higher (over-prediction) than the actual values which are later observed, then the cumulative sum will consistently increase with every forecast. Any such positive (or negative) bias indicates that the forecasting method needs to be changed or adjusted, for example by considering a trend.

In addition statistical quality control measures can be applied. For example by determining upper and lower control limits within which tracking signals must lie while forecast are considered "out of control" if any tracking signal lies outside these control limits. A sudden significant change of the tracking signal can indicate a sudden change in patterns and point to the need for repeating the analysis of patterns in a time series.

The Trigg tracking signal assigns larger ("smoothed") weights to recent forecasting errors and avoids a too large influence of past forecasting errors on the tracking signal. Rather complex adaptive forecasting method are based on adjusting their parameters according to changes of tracking signals.

21 INVENTORY CONTROL

Inventory control is the science of balancing customer service levels with the resources required for replenishing and maintaining stocks.

The importance of inventory control is often not fully appreciated although it cannot be overestimated. Ultimately customer service depends on the ability to fill orders from stocks and is therefore immediately impaired by shortages and stockouts. Such poor services to customers can only be avoided by carefully calculating replenishment orders and ensuring that sufficient stock levels are maintained at all times. On the other poor inventory control can result in overstocking, expiry and losses of valuable health care goods.

Inventory control is one of the most important tasks of health care logisticians.

Neglect of or mistakes in inventory control often take long to correct because of long lead times which humanitarian organizations often face.

Inventory control can be seen as the "theoretical" side of stocks in a supply network which is intricately linked to warehouse and stores management which deals with the "practical" side of stock management.

Contrary to the widespread belief, inventory control is by no means an easy task and it is far less intuitive than it appears. Rather inventory control is intricate and requires a sound understanding of some basic concepts and principles as well as the systematic application of algorithms rather than naive expectation or calculations on the back of an envelope.

Unfortunately there is no consensus on the definitions of key terms important to inventory control (see table 21.1) and some terms are used by different authors with different meanings. The terms stock and inventory as well as stock control and inventory control are often used as synonyms. Throughout this text physical goods will always be denoted by the term "stock" while "inventory (list)" will denote a list of items which are in stock. Stock management will also only be used in the context of physical storage and managing physical goods in a warehouse.

However, the term inventory control will be used because it is more widespread and because, apart from physical entities such as stock on hand, it also deals with intangible quantities such as backorders or inventory positions.

The following chapter is based on some assumptions which allow reducing the complexity of the topic and limit the vast number of different inventory control systems but are nevertheless reasonable in the context of providing health care goods in humanitarian assistance.

Future customer demand is unpredictable, normally distributed and the uncertainty of customer demand corresponds to the forecasting error.

Wherever future customer demand is predictable, health care goods, for example health care equipment for rehabilitation of health care facilities, can be ordered in advance and delivered directly from suppliers without the need for any stock holding.

Although end-user demand may be used for forecasting at all levels, the inventory control systems will only consider stocks at one medical distribution centre rather than stocks at different stages of the supply network.

Calculations are carried for each item and in general replenishment of one item is not linked to replenishment of other items. All health care goods are available in discrete quantities, including liquids which are available in discrete units of vials, ampoules, bottles, tubes etc.

Item		Distinct type of health care goods (regardless of quantity).
Stock list		List of items which are held in stock and (regularly) replenished.
Stock on hand	SoH	Physically available quantity of items in a store.
Stock on order	SoO	Quantity of item which has been ordered but not delivered yet.
Backorder	BO	Quantity of item ordered by a customer which has not been filled yet.
Net stock		Stock on hand - backorders.
Inventory position	IP	Stock on hand + stock on order - backorders.
Replenishment lead time	LT_{RP}	Delay between ordering and receiving items from suppliers.
Stockholding costs		Annual cost for storage of goods.
Ordering costs		Costs for calculating, issuing and following up (replenishment) orders.
Shortage costs		Costs incurred by shortages (for premium transportation etc.).
Review period	R	Period after which inventory positions are compared to reorder levels.
Reorder level	s	Level below which a replenishment order is triggered.
Order-up-to-level	S	Quantity up to which the inventory position is raised with an order.
Order quantity	Q	Quantity of an item which is ordered for stock replenishment.

Table 21.1 Important inventory control terms

Unlike the provision of food and household goods which are usually quite predictable, in general demand for health care goods is unpredictable and demand distribution is assumed to be normal. In general, stocking health care goods is not necessary in the rare case where demand for health care goods is predictable.

Except for secondary supplier packaging, suppliers are not imposing minimum order quantities. Any medical distribution centre can in principle place a replenishment order to an upstream medical distribution centre at any time. The replenishment lead time is not zero, unpredictable and lead time distribution is considered as normal.

21.1 Elements of an inventory control system

Regardless of the inventory control system which is selected, calculations require knowledge of certain information as "inputs" for the calculations. The values of these elements are considered as given and cannot be freely chosen by logisticians. Although logisticians will influence the stock on hand and stock on order by their decisions, their values are considered as given at any time. For example the stock on hand in a medical distribution centre is determined by counting and cannot be changed to any other level at the same moment.

In contrast the inventory control parameters can be freely determined at the time replenishment orders are calculated and they can be selected independently of any of the elements described below. For example the review period can be set to one week or five weeks and calculations can be carried out regardless of any values of the respective elements of the inventory control system.

The information which is required for forecasting demand is not included in the elements below as the final forecast for customer demand, rather than any information used for forecasting will be used as in input into the inventory control system. Inventory control is primarily concerned with short-term forecasts (Waters, D. 2003, 233).

21.1.1 Stock list

The clear definition of a national standard list by Health programme managers is a critical and indispensable first step in inventory control which is sometimes overlooked. Establishing a clearly defined stock list together with programme managers and health programme staff before humanitarian assistance programmes commence is possibly the most important step to ensure rational and efficient stock management as well supply chain management in general.

Before any further considerations or calculations are made, the items which require regular review and replenishment must be known to logisticians. By definition, the national standard list discussed earlier identifies and defines all items which logistics services are required to keep in stock at all times.

Ever changing stock lists lead to stock shortages and overages. Without a clearly defined stock list the number of items requested will inevitable increase often creating large stocks of health care goods which are not used and eventually are in danger of expiring and being wasted. The stock list should never be determined by the items which happen to be in stock for whatever reason.

Only items which are regularly used as well as contingency stocks should be regularly replenished. Therefore stock lists mostly consist of drug products and single use medical devices. Only simple health care equipment which is prone to damage or loss (thermometers, sphygmomanometers etc.) should be included.

Any other health care goods should only be ordered when their need is confirmed by a health programme and delivered directly to the customer when received from the upstream medical distribution centre.

An item fully defines a type of health care goods by generic specifications without identifying a certain product or manufacturer. For example a single use 10 ml syringe is an item. The term items is also used regardless of the quantity which is ordered, on hand in the medical distribution centre etc.

Unlike commercial logistics, logisticians in humanitarian organizations are not concerned about maintaining separate stocks of health care goods with identical or very similar specifications but from different manufacturers as long as they are interchangeable. Consequently the term stock keeping unit (SKU) which refers to a specific product from a specific manufacturer will not be used. For example a single use 10 ml syringe from two different manufacturers would constitute two different SKUs while there is no benefit in treating them separately in terms of inventory control if they serve the same purpose.

Any item which is permanently maintained in stock and regularly replenished will be called a stock item. A stock list is then simply a list of all stock items.

The term unit is sometimes used as a synonym for item. However for the following the term unit will not be used as it also has the meaning of a "piece" or "thing" and is therefore ambiguous.

A unit of an item refers to the smallest quantity which can be used in a meaningful way such as one tablet, one bottle of intravenous solution, one bottle of syrup, one syringe, one roll of gauze or one pair of sterile surgical gloves.

All measures of an inventory control system must consistently use the same unit of measurement for every item. For example it would be useless to calculate stock on hand in units while calculating stock on order in boxes of 12 units.

All inventory calculations must be carried out in units of the respective item and not in quantities of supplier packaging or their multiples. The number of available boxes or master cartons is irrelevant since in the end only the number of available tablets, syringes or rolls of gauze is meaningful for the patient. Moreover packaging and packing quantities can vary significantly from manufacturer to manufacturer and are therefore often not comparable.

The term product which is more specific than the term item, refers to the respective specifications of a specific manufacturer. For the same item, products from different manufacturers will differ as the composition of materials, packaging, labelling etc. are never identical.

As above, the term health care goods is a generic term for any drug product, single use medical device or piece of health care equipment regardless of detailed specifications or manufacturers.

21.1.2 Stock on hand

Stock on hand corresponds to the current physical stocks in the medical warehouse and the respective stock level is determined by a physical stock count. The stock on hand increases with the receipt of any quantity of the respective item and decreases with every stock issue as well as any damage, destruction or theft.

The stock on hand corresponds to the quantity of the respective item which is physically available in the medical warehouse for filling customer orders at any time and can therefore never assume negative values.

While it is tempting to calculate the stock on hand from stock records or automatically in information systems, the current and actual stock on hand must always be confirmed by a physical stock count before using any stock on hand figures in any inventory control system. Stock records might be incorrect and stock might have been damaged or stolen without anyone noticing (yet). Any error in stock records or information systems tend to be perpetuated and may lead to repeated miscalculations unless theoretical stock levels are compared with actual stock levels.

The minimum, maximum and averages stock levels can be determined from stock records and are useful for planning required storage capacities.

High stock levels have the advantage of increasing stock availability, providing higher customer service levels, decreasing the probability of shortages and stockouts as well as avoiding costs for expediting shipments and placing emergency orders. However higher stock levels require larger storage capacities, incur higher stock holding costs and the on average longer stocking times decrease the remaining shelf-life at the time of order picking which in turn increases the risk of expiry in stock. However items with small volumes and low average customer demand may not incur significantly higher stock holding costs even if stock levels are

doubled or tripled. For example drug products which are only used in life-threatening medical emergencies or (very) small sizes of single use medical devices such as tubes and catheters. This is significant since items with low turnover often have highly unpredictable demand and require large safety stocks.

A stockout occurs when the entire quantity of a stock list item is depleted and the stock level drops to zero. A stockout implies that the respective item should actually be in stock and the term therefore does not apply to items which are not stock items even if they are ordered from customers and are not in stock.

The stock on hand can be expressed in absolute terms as the quantity of the respective item. Alternatively the current stock on hand can be divided by the average monthly (or weekly, daily etc.) demand to calculate the coverage time. This coverage time, which is also called runout time, indicates the time period during which customer demand can be filled provided that average demand does not change. For example a coverage time of two months means that the current stock on hand will allow to fill customer orders for the next two months provided that average demand does not changed and assuming that during this time period no further stock is received at the medical warehouse (since this would of course increase coverage time). Calculation of the coverage time has the great advantage of being able to assess the stock situation without having to know the average demand for each item. The coverage time is a good indicator for shortages as well as overstocking of items.

The annual stock turnover, also called number of stock turns, can be calculated for an individual item as well as an aggregate for the entire stock. The stock turnover of an individual line is calculated by dividing the total annual stock issues by the current or average stock on hand. The calculation of total annual stock issues can be based on records from the past 12 months or be extrapolated from a shorter period of time.

For example if 20,000 rolls of gauze are issued from stock per year and 5,000 rolls are on hand then the annual turnover is 4. This means that a stock of 5,000 rolls could be "turned over" (issued and replenished) four times a year. Calculation of the annual turnover is based on the current values of stock on hand and annual stock issues and therefore can change in future. For example if the average stock level for an item remains unchanged but the total annual stock issues increases, the stock turnover will also increase.

$$\text{Annual stock turnover} = \frac{\text{Annual stock issues}}{\text{Average stock on hand}} \qquad \text{Eq. 21.1}$$

The reciprocal stock turnover is also called the stocking time. Therefore the stocking time of an item with an annual stock turnover of 4 is a quarter year or three months. That means that on average any unit of the item remains in stock for three months between put-away and order picking.

The aggregate average stock turnover for the entire stock of many different items held in a warehouse is calculated by dividing the total annual value of stock issues by the total current stock value. This measure does not allow to make any inference on the stock turnover of individual items but is a good general indicator whether overall stock levels are appropriate.

$$\text{Annual stock turnover} = \frac{\text{Annual value of stock issues}}{\text{Average stock value}} \qquad \text{Eq. 21.2}$$

21.1.3 Stock on order

The stock on order of each item is an aggregate measure which corresponds to the sum of the quantities ordered from upstream medical distribution centres which were not delivered yet. A specific item may have been ordered several times and several orders may not have been filled yet or may have been filled only partially. The stock on order is simply calculated by adding up the quantity of the respective item from all past orders which have not been filled yet.

Stock on order increases with every additional order and decreases with any receipt of stock or with any cancellation of orders. Any quantity of an ordered item received at a medical distribution centre which is entered into stock must be immediately deducted from the stock on order.

21.1.4 Backorders

Backorders are items, or quantities of items, which were ordered from customers but have not been filled yet. These items or quantities of items are "owed" to customers and can be seen as "debts" which have to be paid to customers as soon as the required quantities of the item are available.

For inventory control and calculating replenishment orders the aggregate quantity of backorders for each item, irrespective of the number of unfilled orders or the number of customers, is relevant.

Backorders arise when customers order health care goods which are currently not in stock and are filled by eventually delivering the required quantities.

Backorders can arise for stock items when stock on hand is insufficient to fill the entire quantity as well as for non-stock items which nevertheless have to be eventually filled. Maintaining an accurate backorder record is essential for ensuring that all items or quantities of items are eventually filled.

Backorders and stock on order are two sides of the same coin and depend on from which perspective an order is looked at, from the customer or the service provider. For a health care facility any unfilled replenishment order placed with a medical distribution centre is stock on order while the same order is treated as a backorder by the medical distribution centre. Likewise a medical distribution centre is recording a replenishment order sent to another medical distribution centre as stock on order while the receiving medical distribution centre is recording and treating the same order as stock on order.

Clearly distinguishing between stock on order and backorders is essential for correct calculations in inventory control. Therefore the term "pending" should never be used as it is ambiguous and does not indicate whether it means stock on order or backorder.

In some industries, backorders are not permitted for example if only a limited quantity of a product is being manufactured and demand exceeds supply or if customers are likely to purchase goods from another supplier rather than waiting for a backorder. Certain inventory control policies are based on the assumption that any quantities of a line which are not in stock cannot be sold later but rather will result in "lost sales".

However in humanitarian assistance backorders must be meticulously recorded and filled unless the item or respective quantity of the item is cancelled by the customer. However occasionally an assisted health care facility might obtain health care goods from an alternative source such as another humanitarian organization or by asking patients to purchase health goods in the private market.

21.1.5 Net stock and inventory position

The net stock is calculated by subtracting the backorders for a specific item from its stock on hand.

$$\text{Net stock} = \text{stock on hand} - \text{backorders} \quad \text{Eq. 21.3}$$

The inventory position is further calculated by adding the stock on order to the net stock.

$$\text{Inventory position} = \text{stock on hand} + \text{stock on order} - \text{backorders} \quad \text{Eq. 21.4}$$

The inventory position is a critical measure for any inventory control system. It can be seen as the stock level the physical stock would reach (in the future) if all backorders were filled and all stock on order were received from the upstream medical distribution centre.

It is very important to realize that the stock level will only reach the inventory position in exceptional cases. If good services are provided to customers, backorders should be small or ideally zero during most times. However, unless lead time from upstream distribution centres are very short, medical distribution centres will usually have stock on order, often from several past replenishment orders. The inventory position is therefore a theoretical (or fictitious) measure that is indispensable for calculations but does not have a corresponding physical measure like the stock on hand.

Confusing the inventory position with the stock on hand is a frequent mistake which can lead to very severe shortages of many stock items very quickly.

21.1.6 Expected replenishment lead time

The time from placing a replenishment order with the upstream medical distribution centre until physically receiving the ordered health care goods is called the replenishment lead time. It can be measured for each item individually or for the entire replenishment order of several items and can be measured in days, weeks or months. If an item is received in several partial shipments, the replenishment lead time of the last consignment must be considered as the replenishment lead time for the entire item. Likewise the replenishment lead time for an entire order is the delay from placing the order until receiving the last outstanding quantity of the last item.

Replenishment lead times cannot be chosen although they can be influenced to some degree. In case of shortages, stockouts or an emergency, expediting of shipments can be requested or health care goods might be purchased domestically instead of being ordered from a regional or international distribution centre. Purchase contracts may indicate mandatory maximum supplier lead times and, if available, suppliers are changed if they do not comply with these requirements.

Any distribution centre filling a replenishment order, or part of it, will be called a supplier regardless of whether this may be a commercial manufacturer or an upstream distribution centre of the respective humanitarian organization.

Nevertheless the replenishment lead time is always uncertain to some degree. Since at the time of placing a replenishment order the lead time is not known with certainty, calculations can be carried out only with the expected replenishment lead time. The actual replenishment lead time is known only for past deliveries or after the order under consideration has been filled in the future.

The variability of the expected replenishment lead time has an important impact on inventory control systems. The use of average replenishment lead times in calculations will inevitably lead to shortages of all items which are delivered with an actual lead time longer than the expected replenishment lead time. This can be avoided by estimating the expected replenishment lead time of the item with the longest lead time. However this could lead to accumulation of large stocks of all items which are actually delivered from the supplier earlier than the last item.

The estimation of lead time within which the delivery of, for example, 98% of the ordered items is expected can be estimated from the past performance of suppliers. Assuming a normal distribution of supplier lead times, for example two standard deviations of supplier lead time are added to the average. As in forecasting, this estimate assumes that future average lead times and standard deviations will be the same, or at least similar, to past measures.

If not data on supplier lead times is available, the supplier lead time will have to be estimated or guessed. However, again it is important not to estimate the average but the longest expected supplier lead time.

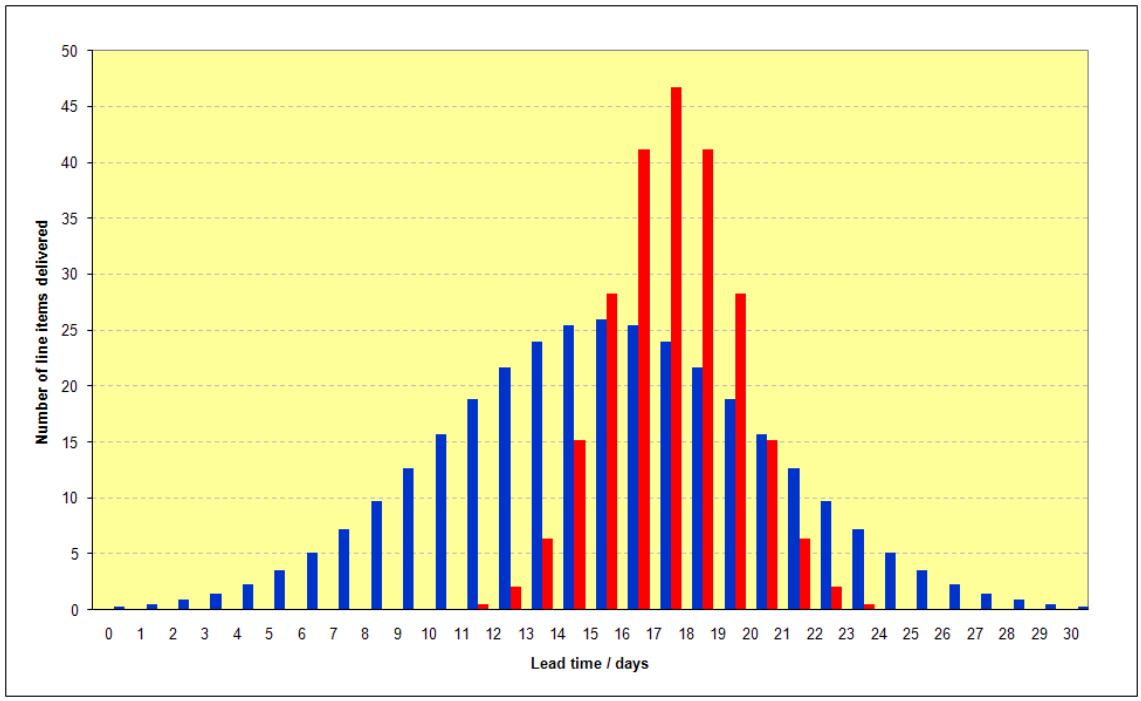

Figure 21.1 Replenishment lead time distribution

The example in of the graph in figure 21.1 indicates that longer but more reliable replenishment lead times (smaller standard deviation) are more important than on average shorter replenishment lead times with larger variability and therefore greater uncertainty.

Wherever possible, the variability of replenishment lead times should be reduced and where possible average replenishment lead times should also shortened in order to reduce uncertainty in the supply network. However, the advantages of shorter and more reliable replenishment lead times have to be balanced with the resources required to achieve this, for example by using faster but more expensive modes of transportation.

Any inventory control system requires forecasting customer demand for the period of the expected replenishment lead time. As pointed out earlier, forecasting errors increase with the

forecasting horizon. Therefore any reduction of expected replenishment lead times will decrease the forecasting error.

Moreover decreasing maximum replenishment lead times allows reducing safety stocks.

In any case unnecessary delays for transmitting replenishment orders to suppliers must be avoided. This includes avoiding incomplete or ambiguous orders as well as errors which will require the supplier to seek clarification concerning the order and losing valuable time which cannot be recuperated. It is also important to avoid any delays of issuing or processing replenishment orders which can be caused by lack of funding or obtaining permission to spend funds.

21.1.7 Remaining shelf-life

All drug products as well as sterile single use medical devices have a limited shelf-life and must be used or applied before the expiry date indicated on the supplier packaging. The total shelf is the time span between the manufacturing date and the indicated expiry date while the remaining shelf-life is the duration between the present day and the expiry date. The total shelf-life is fixed by the manufacturer and does not change while the remaining shelf-life starts decreasing as soon as manufacturing has been completed. Since the term shelf-life alone is ambiguous, only the terms total or remaining shelf-life will be used.

Once health care goods have been purchased the remaining shelf-life of products cannot be changed. Only in very exceptional cases will a commercial supplier be willing to exchange one product with another with a long remaining shelf-life.

However the remaining shelf-life can be influenced to some degree during the purchasing process by demanding a certain remaining shelf-life of products either in percentage of the total shelf-life upon manufacturing or as an absolute duration, for example 18 months at the time of shipment.

Therefore the remaining shelf-life of all health care goods held in stock by a humanitarian organization must be considered as unchangeable and in any case as inevitably decreasing day by day.

The stocking time of any health care product must be shorter than the remaining shelf-life. If a health care product is subsequently stored at several different stages before distribution, the remaining shelf-life must be longer than the sum of the stocking times for that health care product at all stages and the sum of intermediate transportation times. For example the remaining shelf-life of a package of tablets stored for two months at three different stages will have decreased by six months by the time it is distributed to a customer.

Consequently the remaining shelf-life limits the stock levels which can be maintained at medical distribution centres without incurring the risk of expiry and therefore loss of stocks.

21.1.8 Costs

The various cost factors have less importance in humanitarian assistance since humanitarian organizations are not concerned with making or maximizing profits. Moreover, accurately calculating for example purchasing or stock holding costs is more difficult for humanitarian organizations in the field as their analysis requires complex accounting information systems.

On the other hand humanitarian organizations can of course not afford to waste any resources and therefore cost is always an important, although not the primary, concern.

Acquisition costs are incurred by purchasing from a commercial supplier as well as by ordering from an upstream medical distribution centre. The immediate purchase costs include the price of the product, packing, transport by the supplier, insurance, customs clearance charges, taxes and duties.

The total acquisition costs further include costs for staff, offices and premises, information systems, communication (telephone, postage, electronic mail), documentation, record keeping and filing, tendering or obtaining quotations, negotiations, receipt of goods, inspection and quality control, accounting and payment of suppliers as well as bank transaction costs. The same costs are incurred when ordering from upstream medical distribution centres.

Additional costs are incurred for tenders and the costs for visiting, auditing and registering potential suppliers must be considered for any new supplier while repeated purchases from the same supplier will incur lower costs.

The average cost of effecting one purchase can be calculated by dividing the total annual costs of the purchasing department by the number of purchase contracts. Likewise the average cost of purchasing an item can be calculated. Usually repeated purchases of health care goods from the same supplier will incur less costs than the first purchase.

Less frequent purchases or orders will reduce variable costs while not necessarily changing the fixed costs which are associated with the department in charge.

Stocking health care goods in a medical distribution centre incurs costs for staff, safety and security, information and communication costs, energy costs and other utilities, purchase or renting of buildings and premises, storage and materials handling equipment, taxes and charges, insurance, maintenance and repair, heating, cooling and refrigeration, operating and maintaining materials handling equipment as well as packing material. The expiry, damage or loss of a small percentage of stocked health care goods is nearly inevitable and also incurs costs.

The opportunity costs which are incurred by commercial companies by tying funds in stocks and not using the funds for other purposes does not apply to humanitarian organizations. Like obsolescence costs for stored goods which can no longer be sold because they are out of fashion or technologically outdated do not apply to essential health care goods.

Stock holding costs are usually expressed as the percentage of the average annual value of stocked health care goods.

The shortage and stockout costs for commercial companies are notoriously difficult to calculate and such figures should only be used with caution. Unlike commercial logistics, in humanitarian assistance shortage and stockouts do not cause customers to purchase goods and services elsewhere and therefore the classical notion of shortage costs caused by lost sales does not apply to humanitarian assistance. Moreover commercial companies might not attempt to provide high customer service levels to customers because their costs would exceed expected profits.

In humanitarian assistance shortages and stockouts can never be accepted as they lead to insufficient medical care of patients, may prolong hospitalization of patients and can increase or cause suffering and even lead to preventable deaths (Quick, J.D. (ed.) 1997, 328).

Financial costs are incurred by additional costs for expediting shipments of stock on order or by placing emergency orders as well as by using faster and more expensive modes of transportation.

Shortages and stockouts can also lead to the reduction or loss of confidence of customers in the provided logistics services and reduce their goodwill. This loss of confidence can lead to an

increase of safety stock levels at health care facilities without any increase of demand having occurred and therefore contribute to upstream demand distortion.

One of the objectives of inventory control systems is to consider the trade-offs between purchasing, stock holding and shortage costs and balance them. The reduction of purchasing or ordering frequency will reduce acquisition costs while increasing average stock levels and therefore increasing stock holding costs. Reducing stock levels will reduce stock holding costs while at the same increasing the risk of shortages and stockouts and therefore the risk of incurring shortage costs.

However the non-financial consequences of shortages and stockouts outweigh any other cost considerations. Therefore any optimization and reduction of costs must in no way jeopardize providing the highest possible customer service levels to assisted health care facilities and patients.

21.2 Inventory control parameters

While the elements of an inventory control system discussed above are either measurements which cannot be influenced at all (for example stock on hand) or can only be influenced to some degree (for example expected replenishment lead time), the inventory control parameters can in principle be selected freely irrespective of the values of the elements of the inventory control system. However the values selected for each parameter are subject to constraints and certain situations suggest setting the parameters to certain values.

"1. How often the inventory status should be determined

2. When a replenishment order should be placed

3. How large the replenishment order should be"

(Silver, E.A., D.F. Pyke, and R. Peterson 1998, 28).

Despite the vast number of inventory control systems there are basically only three parameters which answer three basic questions and can in principle be combined freely. The first, and very important question which items should be considered for replenishment in the first place is answered by the stock list but only included in brackets in table 21.2 as the stock list is not really a parameter and the answer to this first question is assumed to be known when starting calculations.

Parameter	Notation	Question answered
(Stock list)	-	(What items should be considered?)
Review period	R	When should the next review take place?
Reorder level	s	Should an order be placed?
Order-up-to-level	S	What quantity should be ordered?

Table 21.2 Inventory control parameters

The first two parameters are the review period and the reorder level. The third parameter is either the order-up-to-level or the order quantity as one determines the other. If an order-up-to-level is defined then the inventory control system allows to calculate a reorder quantity and

if an order quantity is set as one of the parameters then no order-up-to-level is needed. As will be shown later the reorder level can be expressed mathematically in terms of an order quantity and vice versa.

These three parameters are conditional upon each other. The first step is to carry out a review and determine whether the criteria for "triggering" an order is fulfilled. The fulfilment of the trigger criteria between two reviews may but not be noticed and therefore not lead to any replenishment order. Likewise the order quantity only needs to be calculated if the trigger criteria is fulfilled.

21.2.1 Review period (R)

The review period (R) determines how often calculations are carried out in order to determine whether a replenishment order is necessary. In practice the review period can assume only discrete values and multiple of days, weeks or months.

The review period is not necessarily identical with the order period. While the order period can change for any item it can only be a multiple of the review period. The review period therefore does not answer the question when an order should be placed but rather only when calculating a replenishment order should be considered at all. Only if an order happens to be necessary at every review, the review period will coincide with the order period. The review may lead to an order but without a review definitely no order will be placed.

Determining an order frequency or order period as such is not reasonable because whether an order will actually be necessary is not known in advance. The order period and order frequency is therefore a result of the inventory control system rather than an input.

A review is the process of determining stock on hand, stock on order, backorders and therefore the inventory position as well as possibly revising the expected replenishment lead time. It is very important that such reviews are by no means limited to the stock level alone. Even if stock levels do not change a replenishment order may be necessary, for example if the backordered quantity has increased.

This review can either be carried out continuously or periodically at regular intervals. In a continuous review system all relevant data are continuously updated and monitored by an information system. In practice the data will not change unless stock transactions have taken place or (additional) orders have been received. Therefore if a review takes place only when relevant data changes, the replenishment decisions will be same as if a continuous review system is used. This is important as it means that for a limited number of items with a limited number of orders (for example contingency stocks) this system of transaction reporting, which amounts to a continuous review system, can be applied without having to use an automated information system.

In a continuous review system reviews are based on physical stock records or on an information system. Since physical stock levels are based on calculations of stock transactions, rather than daily physical stock counts, discrepancies between calculated and physical stock levels can occur through pilferage, damage or expiry of stock without being reconciled with stock records.

In a period review system this review is carried out only at regular intervals such as once a day, once a week or once a month. The shorter the review period the shorter the forecasting horizon and therefore the more accurate the customer demand forecast will be. Moreover shorter review periods allow reacting to changes in customer demand faster. Shorter review periods incur higher reordering and transportation costs but result in on average lower stock

levels. Frequent changes of the review period should be avoided and any change should be well considered and must be justified as it will inevitably increase demand distortion.

The continuous review system can be seen as a special case of the periodic review system with a review period of 0. Even if a continuous review system is applied, in practice replenishment orders will be placed only during working hours unless replenishment orders are automatically placed by an information system.

Instead of fixed review periods the economic review period can be calculated which attempts to balance acquisition and stock holding costs. As this system is similar to concept of economic order quantities it will be discussed later.

Review	Review period	Review system
Constantly	0	Continuous review
At every transaction	variable	Transaction reporting
After economic review period	variable	
At fixed intervals	R	Periodic review

Table 21.3 Review systems

Both review systems have various advantages and disadvantages (see table 21.4).

Continuous review systems result in lower average stock levels for providing the same level of service and allow reacting to shortages and stockouts immediately by placing replenishment orders. Forecasts for customer demand will be more accurate as the forecasting horizon is limited to the expected replenishment lead time.

On the other hand continuous reviews require more (purchase) orders and the workload cannot be planned well as a replenishment order may be necessary at any time. More frequent orders require more frequent transportation of smaller consignments and therefore increases overall transportation costs.

Periodic review systems can be operated manually and allow carrying out reviews regularly at planned times as well as coordinate replenishment orders of all stock list items at the same time which reduces computations needs and working time. The smaller number of required (purchase) orders reduces the workload of the medical distribution centre as well as the workload of suppliers. The joint replenishment allows ordering several items from the same supplier, consolidate shipments and benefit from economies of scope for processing orders as well as for transportation. The poor security situation often demands reduction of transportation frequencies in order to reduce security risks for drivers and pilots.

A further significant advantage is that a complete physical stock count can be carried out before every review and therefore all figures used for calculation are updated and correct.

However periodic review systems do not distinguish between items with high stock turnover which could benefit from continuous reviews and items with low stock turnover which would barely profit from continuous reviews. The probability of shortages and stockouts is higher and they are not noticed until the next review takes place. In the worst case a stockout may occur the day after the review and the necessary urgent replenishment order would be delayed by a whole month for example. As a consequence, more expediting and emergency transportation is needed when the stockouts are detected during order picking. The accuracy of demand forecasts decreases as the forecasting horizon has to cover expected replenishment lead time

as well as the review period. Periodic review systems lead to on average higher stock levels which increases storage costs but on the other hand has the advantage of increasing safety stocks.

The receipt of a small number of larger consignments once during every review period can be considered as an advantage or disadvantage. Receipt and put-away of larger quantities of a larger number of items will be more efficient but may significantly reduce the capacity of the medical distribution centre to treat customer orders (at the same time).

Continuous review systems allow ordering the same quantity while (purchase) order quantities change with every review, which is not really a disadvantage.

Instead of applying either a continuous review, transaction reporting or a periodic review to all stock items, different systems can be used for different items. For example a continuous review or transaction reporting system will be more appropriate for contingency stocks as demand is usually highly unpredictable while a periodic review system is applied to all items with more regular demand.

Review system	Advantages	Disadvantages
Continuous review	On average lower stock levels. Immediate reaction to shortages and stockouts. Shorter forecasting horizon and more accurate forecast.	Larger number or orders. More frequent transportation. Higher transportation costs.
Periodic review	Can be operated manually. Allows planning of reviews. Reduced workload. Consolidation of orders. Smaller number of orders. Economies of scope. Less frequent transportation. Lower transportation costs. Updated stock on hand.	No differentiation according to stock turnover. On average higher stock levels. Higher stock holding costs. Higher probability of stockouts. Delay in reacting to shortages and stockouts. Longer forecasting horizon and larger forecasting errors.

Table 21.4 Advantages and disadvantages of continuous and periodic reviews

21.2.2 Reorder level (s)

While periodic review systems do not require a reorder level (s), it serves as a decision criteria in continuous review systems. A replenishment order is only calculated and placed if the inventory position (not the stock on hand!) drops below the reorder level. The reorder level is sometimes also called the order point or reorder point. However the term reorder level seems more intuitive as it is a threshold which applies to any time.

Ideally replenishment orders are placed whenever the inventory position drops just one unit below the reorder level. This could only be assured if all customers would always order only one unit. In practice however the inventory position is likely to drop (far) below the reorder level and the replenishment order is therefore only placed at this time. The difference between the reorder level and the inventory position after filling the order which caused the inventory position to drop below the reorder level is called the undershoot.

In inventory control systems using an order-up-to-level, introduction of a reorder level avoids placing orders for (very) small quantities which may not be economical or not worthwhile and inventory control systems using fixed order quantities require a reorder level.

The reorder level is calculated in the same way as the order-up-to-level except the calculations of the reorder level only need to consider demand and uncertainty during the expected replenishment lead time while the order-up-to-level must in addition consider demand and uncertainty during the review period.

21.2.3 Order-up-to-level (S)

The order-up-level is the quantity up to which the inventory position is raised by placing a replenishment order. Therefore, assuming that no movement of stock has taken place since the replenishment order was calculated, the inventory position will be equal to the order-up-to-level immediately after the replenishment order has been placed.

The order-up-to-level has to consider demand during the expected replenishment lead time as well as the review period. The order-up-to-level is sometimes called "target stock level". However this term is misleading as calculations are made to raise the inventory position and not the stock level to the order-up-to-level. As mentioned earlier, in most cases the stock level will never reach the order-up-to-level.

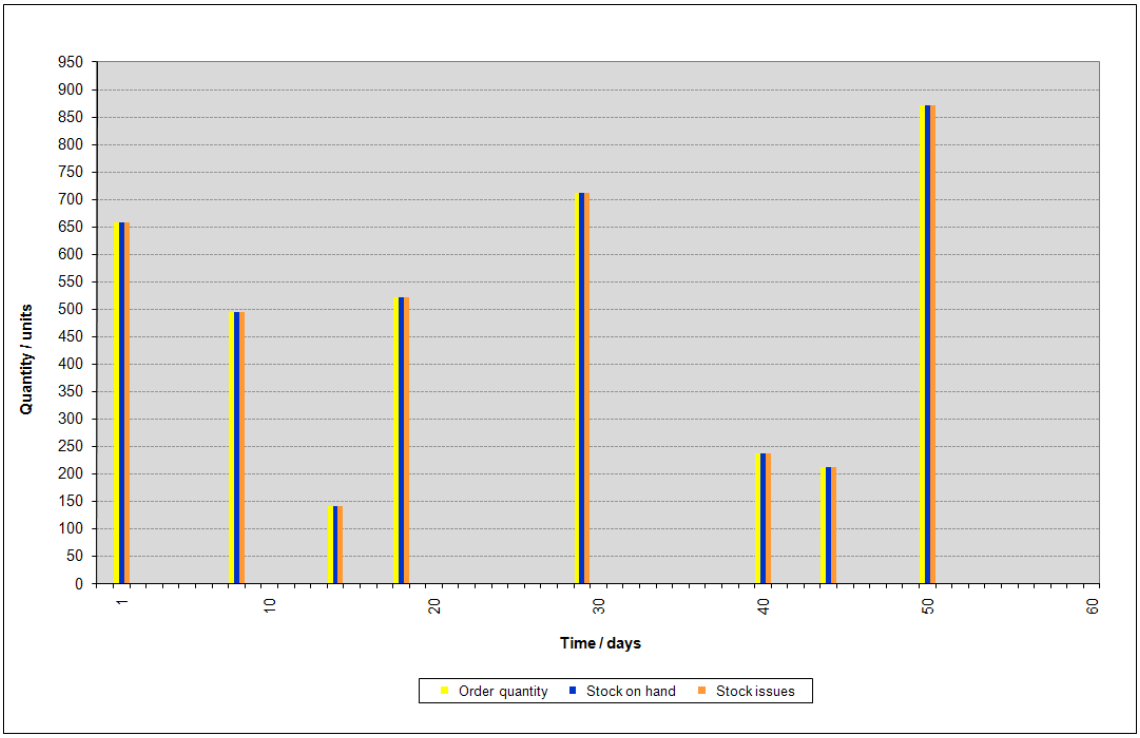

Figure 21.2 Order-up-to-level in a continuous review system with zero lead time

The explanations below will start from the simplest possible situation and add complexity. For the sake of explanation, a situation without uncertainty will be discussed meaning that demand can be forecasted without any forecasting error. The stock which has to be held for covering expected demand during the review period as well as the expected replenishment lead time is called cycle stock (sometimes also called working stock or active stock).

In an ideal situation where expected replenishment lead time is zero and with the use of a continuous review system no stocks would be necessary at all. Whenever a customer places an

order, the respective quantities of all items are backordered to the supplier, delivered immediately to the medical distribution centre which in turn can immediately fill the entire order (see figure 21.2). In this case, no order-up-to-level needs to be calculated as it always corresponds to the most recent customer order quantity.

In periodic review systems sufficient stock must be held to cover expected demand during the review period even if the replenishment lead time is known to be zero. Although the supplier will deliver the same day, the medical distribution centre is placing replenishment orders only once a month (for example).

Assuming that future aggregate monthly demand is known (for example when using a rationing system), and there is no uncertainty in replenishment lead time, the order-up-to-level is calculated by multiplying average monthly demand with the known replenishment lead time in months. For example (see figure 21.3), one month stock must be ordered every month if a monthly review period is used. In this case there is no stock on order.

For the sake of displaying the inventory control parameters, the order-up-to-level is set at a fixed level (imprest level) rather than being based on a forecast and the aggregate monthly orders are variable. At the end of every month, the aggregate monthly stock issues are ordered from the supplier and received the same day (see figure 21.3).

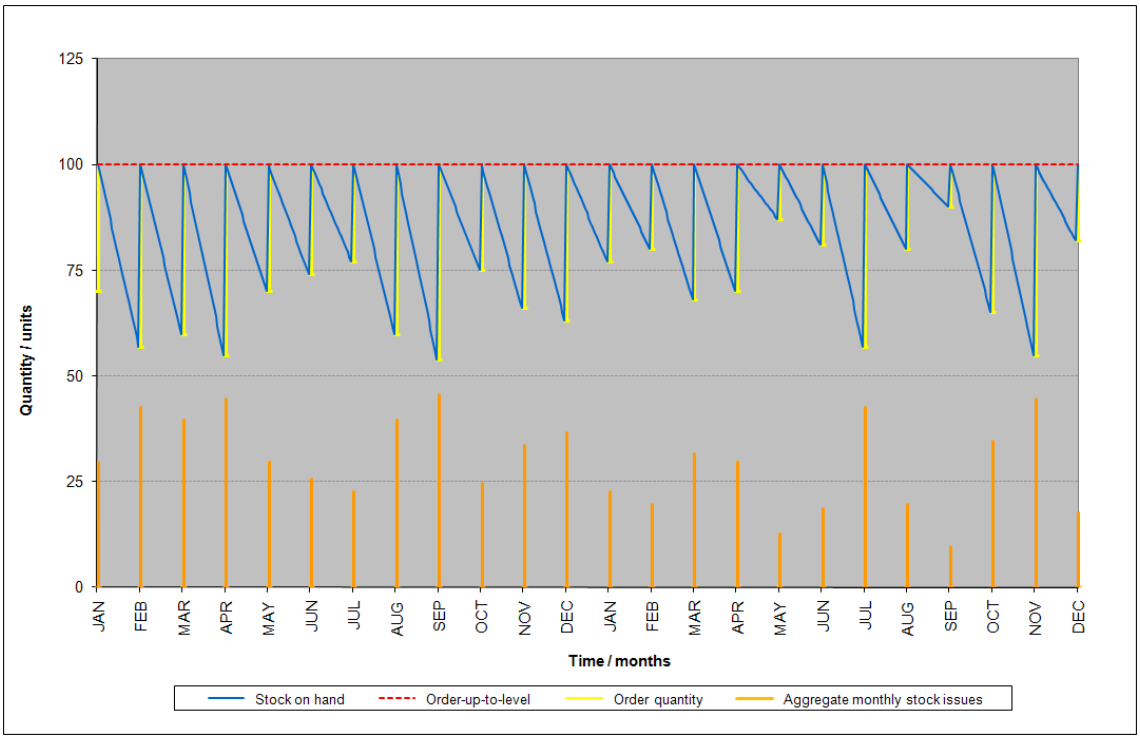

Figure 21.3 Order-up-to-level in a periodic review system with zero lead time

Calculation of reorder levels are based on forecasts of customer demand.

Likewise if a continuous review system is used and the expected replenishment lead time is not zero, sufficient stock must be held to cover expected customer demand during the expected replenishment lead time.

The graph in figure 21.4 assumes a known and constant replenishment lead time (supplier delivery time) as well as known aggregate demand during the replenishment lead time. Any

filled customer order is immediately backordered to the supplier who delivers the required quantity 5 days later. In order to display the various inventory control parameters an imprest level (rather than a forecast) is set for the order-up-to-level. Note that the stock on order is only relevant for calculating the order quantity, if the previous order was made within the past five days and has not been delivered yet.

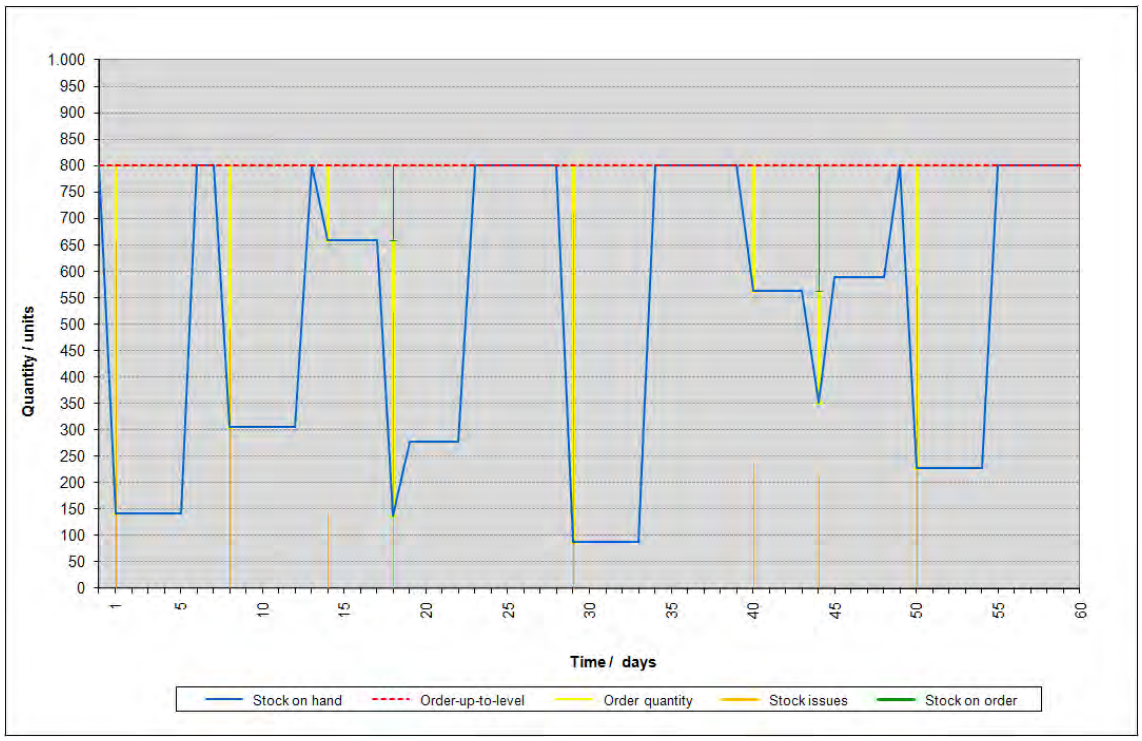

Figure 21.4 Order-up-to-level in a continuous review system with lead time

Consequently in a situation of a periodic review system and expected replenishment lead time greater than zero the order-up-to-level has to cover demand during the review period as well as during the expected replenishment lead time. This may at first seem counterintuitive. Assuming level demand, it would appear that setting the order-up-to-level to average demand during the review period would be sufficient as during every review period the quantity corresponding to the average demand during the review period ordered earlier is received. However this is only true in a steady state where demand is level and the order quantity happens to be the same at every review. If demand is zero during several review periods and therefore no stock is on order, then a sudden resumption of level demand would lead to a stockout at the end of the next review period and last for the duration of the expected replenishment lead time.

The graph in figure 21.5 shows the inventory control parameters for a periodic, monthly, review system with a fixed lead time of two months and a fixed order-up-to-level.

Table 21.5 shows the required order-up-to-levels for continuous and periodic review systems with zero and non-zero lead times. Moreover, demand is assumed to be predictable (known) and replenishment lead times assumed to be constant so that no safety stocks are necessary.

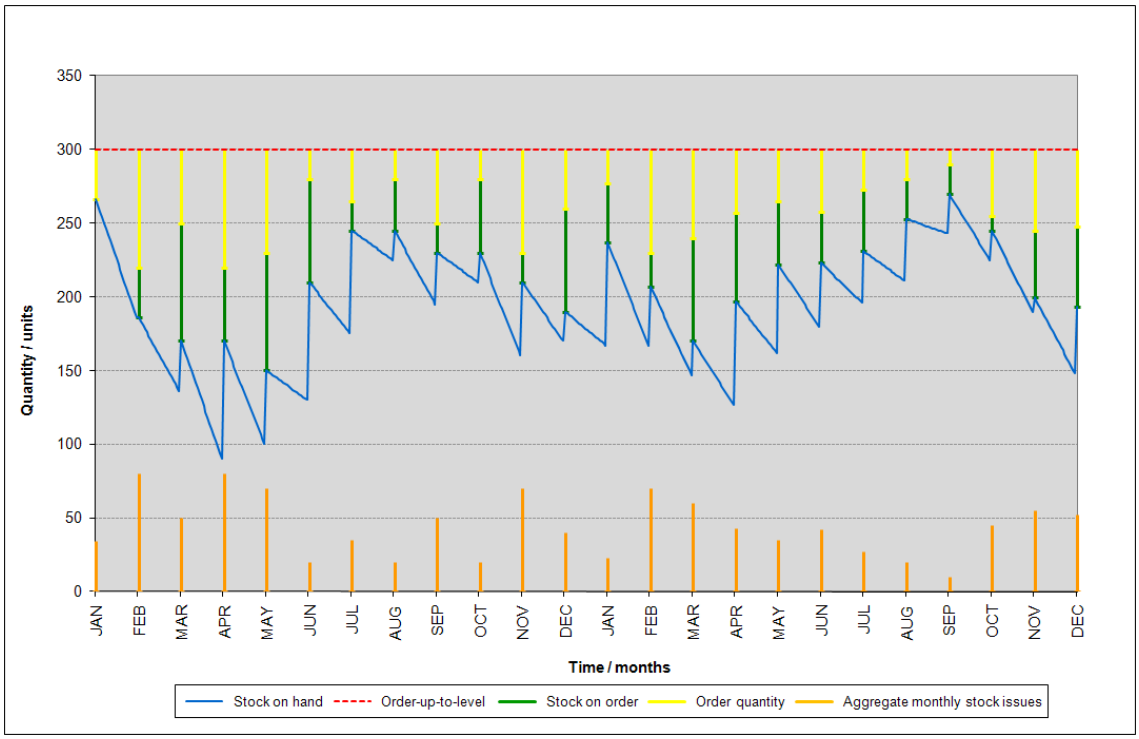

Figure 21.5 Order-up-to-level in a periodic review system with lead time

	Expected replenishment lead time	
Review system	**0**	**> 0**
Continuous review	0	d x LT
Periodic review	d x R	d x (R + LT)

Table 21.5 Overview of order-up-to-levels under predictable demand and lead time

The maximum as well as average cycle stocks increase with longer review periods as well as longer expected replenishment lead times.

Note that the cycle stocks are needed in every periodic review system and are indispensable even if expected replenishment lead times are known with certainty.

If customer demand or expected replenishment lead times are not known with certainty, safety stocks must be maintained in addition to the cycle stocks in order to avoid stockouts or at least reduce their probability.

Future customer demand is almost never known with certainty and the forecast of customer demand is inevitably associated with a forecasting error which corresponds to this uncertainty. Moreover stock levels might decrease because stock expires, is damaged or lost. Therefore additional safety stocks must be maintained to hedge against uncertainty of customer demand and avoid shortages and stockouts in case aggregated customer demand exceeds the forecast.

Nevertheless the discussion below will show that increased variability of customer demand necessitates an increase of safety stocks and therefore every possible measure to decrease demand variability and demand distortion should be taken.

For the time being, expected replenishment lead time will be assumed to be known with certainty. This is an inherent contradiction but this assumption will nevertheless be made for the sake of simplification and explanation and will later be removed.

In theory stockouts can only be prevented with certainty if unlimited safety stocks are maintained. However large safety stocks may be, there is always a small probability that exceptionally high customer demand will deplete the entire stock. The calculation of safety stocks is therefore not a matter of defining stock levels which will prevent a stockout but rather balancing the probability of risks and consequences of stockouts with the costs for holding large safety stocks. However, an alternative would be to stock the maximum demand during the replenishment lead time (Minner, St. 2000, 33).

Service level methods consider the trade-off between service levels (probability of filling all customer orders from stock) and stock levels with the corresponding storage costs. Although humanitarian organizations cannot deliberately risk shortages or stockouts of essential health care goods, realistically stock levels must be limited which inevitably entails the risk of stockouts (Battersby, A., and A. Garnett 1993, A2.4). This dilemma can be alleviated by maximizing stock availability for essential and life saving health care goods while limiting customer service levels for other health care goods for example to 98%. Another strategy for avoiding stockouts is to continuously monitor stock levels and expedite or place emergency orders whenever stock levels drop below a defined hastening level.

Selection of the safety factor has to consider the trade-off between customer service level and storage costs (Christopher, M. 2005, 67). Since humanitarian organizations provide only essential health care goods, stockouts cannot be calculated in terms of lost sales and must be avoided. However, ensuring 100% stock availability would require maintaining large safety stocks. Alternatively a customer service level of around 97% can be maintained and shipments expedited in case the hastening level is reached. Although transportation costs for expediting are high, a reliable system for express deliveries allows reducing the costs for maintaining safety stocks (Tagaras, G., and D. Vlachos 2001, 417).

Assuming that customer demand is normally distributed, the probability that aggregate customer demand will exceed a certain value can be accurately calculated. Conversely the safety stocks which are needed to ensure for example a 98% or 99% customer service level.

The customer service level is the probability that the aggregate customer demand can be met throughout the expected replenishment lead time or the expected replenishment lead time and review period from stock. The customer service level is inversely related to the probability of stockouts.

Note that the absolute number of stockouts depends on the unit time period as well as the length of the sum of the review period and expected replenishment lead time. For example if safety stocks are calculated to ensure a customer service level of 98% over a period of two months, the absolute number of stockouts will be higher than if the same customer service level is calculated for a period of six months.

In a continuous review system, safety stocks must be maintained to hedge against uncertainty of demand during the expected replenishment lead time (see equation 21.5).

$$SS = z \times \sigma_d \times \sqrt{LT} \qquad \text{Eq. 21.5}$$

This safety stock must be added to the forecasted customer demand during the expected replenishment lead time which must be kept in any case. This means that the safety stock can be zero but of course not less. If only cycle stocks corresponding to average forecasted

customer demand during the expected replenishment lead time are kept, the probability of filling the entire aggregate customer demand until the next replenishment order arrives is 50%. Adding any safety stock will increase the probability and therefore the customer service level further. Therefore the probability that aggregate customer demand can be met from stock in full is represented by the surface area under the normal distribution graph up to the mean plus the number of standard deviations corresponding to the safety factor (see figure 21.6).

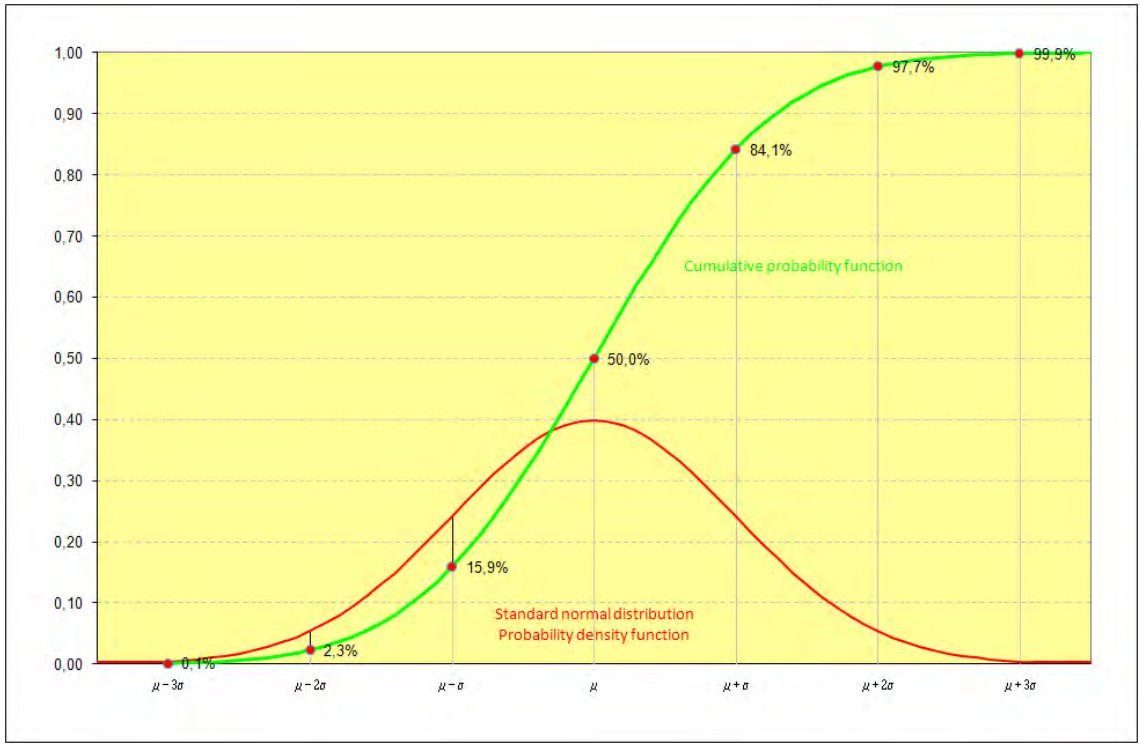

Figure 21.6 Normal distribution and customer service levels

Customer service level	Probability of stockout	Safety factor (z)
50%	50%	0
80%	20%	0.84
84.1%	15.9%	1.00
85%	15%	1.04
90%	10%	1.28
95%	5%	1.64
97%	3%	1.88
97.7%	2.3%	2.00
99%	1%	2.33
99.5%	0.5%	2.58
99.9%	0.1%	3
100%	0%	∞

Table 21.6 Customer service levels and corresponding safety factors

The safety factor k can be found from tables with values of the normal distribution or with a calculator. The table below indicates some customer service levels with the corresponding safety factors.

Unfortunately the required safety stock does not increase in a linear way but rather disproportionately with increasing customer service level. This relation can be graphically presented in single item exchange curves (see figure 21.7). The higher the variability of demand (and therefore the higher the coefficient of variation), the steeper the increase in required stock levels.

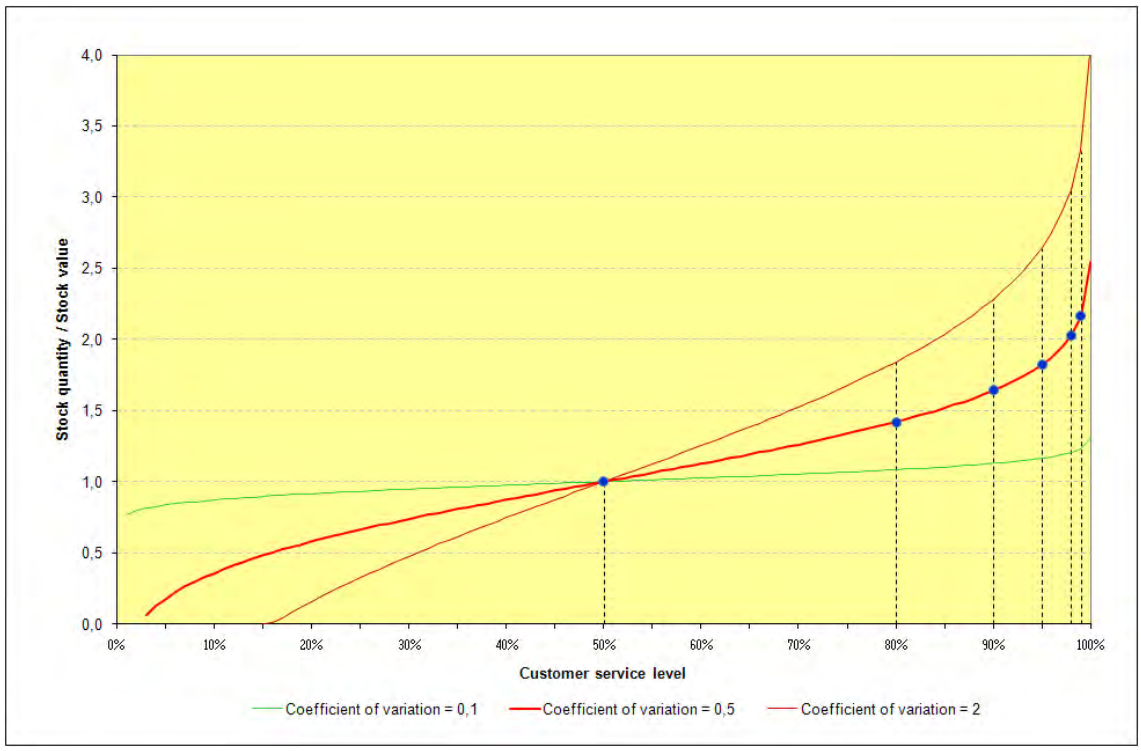

Figure 21.7 Single item exchange curve

The safety factor is selected by balancing the costs for holding stock and the risk and consequences of a stockout. If the financial costs of a stockout can be exactly quantified, an optimal safety and reorder level can be determined scientifically. However, since in humanitarian assistance the shortage costs cannot be determined in financial terms, the choice of safety factors is based on judgement and it is therefore arbitrary. The use of more or less complicated formulas may be misleading and suggest that all inventory control parameters can be determined scientifically which is unfortunately not the case.

Note that these probabilities are only for filling a single item. If, for example, two items are held in stock with a customer service level of 97% of each of the items, the probability of being able to supply both items in full is only 94% (0.97% x 0.97%). If a customer service level of 99% is provided for 10 items the probability of being able to provide all 10 items in full is only 90%, and for 100 items only 36.6%!

The order-up-to-level in a continuous review system with uncertain customer demand but without variability in replenishment lead time is calculated by adding the cycle and safety stocks:

$$S = d \times LT + z \times \sigma_d \times \sqrt{LT} \quad \text{Eq. 21.6}$$

In a periodic review system safety stocks must hedge against uncertainty during the expected replenishment lead time as well as the review period. The same formulas as above apply except that the period is not the lead time but the lead time plus the review period.

$$SS = z \times \sigma_d \times \sqrt{R + LT} \quad \text{Eq. 21.7}$$

The order-up-to-level in a periodic review system with uncertainty of customer demand but without variability in replenishment lead time is again calculated by adding the cycle and safety stock:

$$S = d \times (R + LT) + z \times \sigma_d \times \sqrt{R + LT} \quad \text{Eq. 21.8}$$

As mentioned above, the expected replenishment lead time is almost never known with certainty and an increase of the expected replenishment lead time can lead to shortages or stockouts. While the standard deviation of customer demand can be reliably calculated when many customer orders are received, this is more difficult for expected replenishment lead times. In most cases a single purchase contract will be placed for each item to a single supplier at every review at the most, but often only every two or three review periods. It can therefore be difficult to accurately calculate the standard deviation of expected replenishment lead times, especially when suppliers change.

The following discussion will assume that replenishment lead times are normally distributed. Multiplying the required safety factor with the standard deviation of expected replenishment lead time gives the time period within which the required percentage of expected replenishment lead times will fall. For example if the replenishment lead time is 2 months then there is a 95% probability (corresponding to a safety factor of 1.64) that the actual replenishment lead time will be 3.28 months or less. If customer demand is predictable than a multiple of average monthly demand must be stocked to prevent stockouts with a probability of 95%.

$$SS = z \times d \times \sigma_{LT} \quad \text{Eq. 21.9}$$

The order-up-to-level in a continuous review system with uncertainty of expected replenishment lead time but without variability in customer demand is calculated by adding the cycle and safety stock:

$$S = d \times LT + z \times d \times \sigma_{LT} \quad \text{Eq. 21.10}$$

In a periodic review system with known demand but uncertainty of expected replenishment lead time the following safety stocks are needed:

$$SS = z \times d \times \sigma_{LT} \quad \text{Eq. 21.11}$$

And the order-up-to-level is calculated by adding cycle and safety stocks:

$$S = d \times (R + LT) + z \times d \times \sigma_{LT} \qquad \text{Eq. 21.12}$$

Finally in a continuous review system with uncertainty of customer demand as well as uncertainty of expected replenishment lead times the safety stocks are calculated by adding the variances of the respective safety stocks for hedging against uncertainty of customer demand as well as uncertainty of expected replenishment lead time.

$$SS = z \times \sqrt{LT \times \sigma_d^2 + d^2 \times \sigma_{LT}^2} \qquad \text{Eq. 21.13}$$

The order-up-to-level is calculated by adding the cycle stock to the safety stock.

$$SS = d \times LT + z \times \sqrt{LT \times \sigma_d^2 + d^2 \times \sigma_{LT}^2} \qquad \text{Eq. 21.14}$$

Finally the safety stocks in a periodic review system with uncertainty of demand as well as lead time are calculated by:

$$SS = z \times \sqrt{(R + LT) \times \sigma_d^2 + d^2 \times \sigma_{LT}^2} \qquad \text{Eq. 21.15}$$

The order-up-to-level can serve as the universal formula from which all other formulas are derived by setting various parameters to zero.

$$SS = d \times (R + LT) + z \times \sqrt{(R + LT) \times \sigma_d^2 + d^2 \times \sigma_{LT}^2} \qquad \text{Eq. 21.16}$$

The table below summarizes order-up-to-levels for continuous review systems:

Uncertainty	Expected replenishment lead time	
Demand	**No**	**Yes**
No	$S = d \times LT$	$S = d \times LT + z \times d \times \sigma_{LT}$
Yes	$S = d \times LT + z \times \sigma_d \times \sqrt{LT}$	$SS = d \times LT + z \times \sqrt{LT \times \sigma_d^2 + d^2 \times \sigma_{LT}^2}$

Table 21.7 Summary of order-up-to-levels for continuous review systems

Uncertainty	Expected replenishment lead time	
Demand	**No**	**Yes**
No	$S = d \times (R + LT)$	$S = d \times (R + LT) + z \times d \times \sigma_{LT}$
Yes	$S = d \times (R + LT) + z \times \sigma_d \times \sqrt{R + LT}$	$SS = d \times (R + LT) + z \times \sqrt{(R + LT) \times \sigma_d^2 + d^2 \times \sigma_{LT}^2}$

Table 21.8 Summary of order-up-to-levels for periodic review systems

An alternative method for calculating order-up-to-levels is the use of equal time supplies. In this system the order-up-to-level is arbitrarily calculated as a multiple of average customer

demand. Although equal time supplies have the advantage of being easy to calculate, they lack a rational for determining the factor with which average customer demand is multiplied.

Equal Time Supplies as "Simple-Minded Approach"

"This approach is seriously in error because it fails to take account of the difference in the uncertainty of forecasts from item to item"

(Silver, E.A., D.F. Pyke, and R. Peterson 1998, 244).

Moreover equal time supplies consider only average customer demand and flatly disregard the standard deviation of customer demand and therefore any demand variability (Minner, St. 2000, 33). Consequently order-up-to-levels for items with low demand variability will result in higher customer service levels while items with high demand variability will have lower customer service levels without having any justification. Therefore although equal time supplies are simple to calculate and easy to understand they lack any rational and should not be used.

21.2.4 Fixed order quantity

In continuous inventory control systems a fixed order quantity can be ordered whenever the inventory position drops below the reorder level instead of using an order-up-to-level. In this case the fixed order quantity is a parameter (input) rather than the result (output) of the inventory control system.

The economic order quantity (EOQ) is one of the most frequently discussed fixed order quantities although the assumptions and constraints are not always given enough attention. Although it is not well adapted to the context of humanitarian assistance it will be discussed briefly in order to caution its use.

The concept of the economic order quantity seeks to balance the cost of purchasing or ordering with the cost of stock holding and minimize total costs. Higher stock holding costs and lower purchasing or ordering costs will favour more frequent (purchase) orders and lowering average stock levels. Conversely, high purchasing or ordering costs and low stock holding costs favour less frequent (purchase) orders and keeping larger stocks. The classical formula for the economic order quantity developed by Wilson in 1929 is:

$$Q_0 = \sqrt{\frac{2 \times \text{Order cost} \times \text{Demand}}{\text{Stock holding costs}}} \qquad \text{Eq. 21.17}$$

Equation 21.17 Economic order quantity

The formula is valid only under the following assumptions (see table 21.9) "Some of these may appear to be far removed from reality . . ." (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 150).

It is evident that most of the assumptions cannot be met realistically and the assumption of deterministic demand and zero lead time invalidates the EOQ concept for further consideration in any realistic setting in the context of humanitarian assistance. Moreover the EOQ concept considers only minimization of costs and disregards customer service levels.

- Customer demand is constant (without any variability).
- Customer demand is entirely predictable (deterministic, known with certainty in advance).
- The order quantity can assume any value (including non integer units).
- No restrictions on minimum or maximum order quantities.
- The purchase price is fixed and independent of purchased quantities (no discount).
- Transportation costs per unit are independent of the order quantity (no economies of scale).
- All costs are constant (including low levels of inflation).
- All costs are known exactly.
- All items are treated independently and there are no benefits from joint replenishment.
- The replenishment lead time is zero.
- No stockouts are allowed.
- The entire ordered quantity is delivered at the same time (no partial deliveries allowed).
- All parameters are assumed to maintain their values for a long time.

Table 21.9 Assumptions underlying the EOQ concept

The basic economic order quantity model has been extended in many ways, such as by considering uncertainty, considering quantity discounts or allowing only discrete order quantities.

Based on the same principles of minimizing acquisition and stock holding costs, the concept of economic review period (ERP), also called economic order interval has been developed.

21.3 Inventory control systems

Of the multitude of inventory control systems the following chapter will discuss the most common ones and focus and the inventory control systems most appropriate for humanitarian assistance.

Periodic review systems will be discussed first since they are generally more suitable for humanitarian assistance and because continuous review systems can be seen as a special case of periodic review systems with review periods approaching zero. Simpler inventory control systems will be developed into more complex ones. Finally inventory control systems with reorder levels rather than fixed order quantities will be discussed first as the former are more suitable for humanitarian assistance.

Maximizing customer service levels and preventing stockouts of all stock items at the lowest possible cost is the overall objective of any inventory control system in humanitarian assistance.

Albert Einstein: "Everything should be made as simple as they are, but not simpler"

(Shapiro, R. (ed.). 2006, 231)

21.3.1 Classification

The multitude of inventory control systems can be classified according to the settings of the three inventory control parameters review period (R), reorder level (s) as well as the order-up-to-level (S) or a fixed order quantity.

The settings of the parameters are usually presented in brackets and the three parameters are separated by commas. The most common inventory control systems can be derived from the prototype:

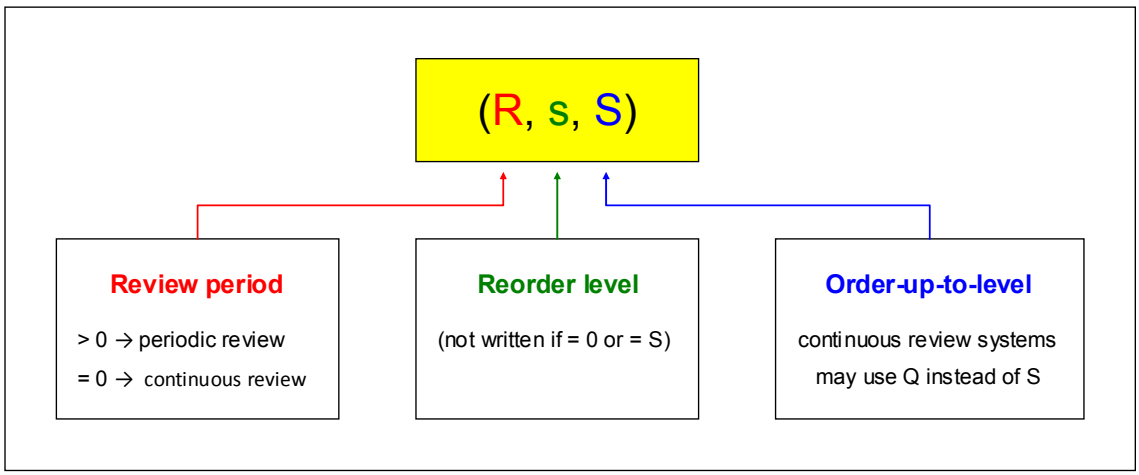

Figure 21.8 Representation of inventory control systems

The review period is indicated as R for all periodic review systems. The review period in continuous review systems can be thought of as zero and is omitted from the notation. Therefore for example a (s, S) inventory control system is identified as a continuous review system where the first position is omitted instead of writing (0, s, S).

The second position indicates the reorder level. Again if no reorder level is required the position is omitted. Therefore, for example, instead of writing (R, -, S) the second position is omitted and conventionally written as (R, S) inventory control policy.

The third position either indicates the order-up-to-level in periodic review inventory control systems or a (fixed) order quantity in continuous review systems. In some inventory control systems the order-up-to-level can be expressed mathematically by the reorder level and the order quantity and vice versa.

Inventory control parameter	Periodic review	Continuous review
Review period	R (≥ 0)	0
Reorder level	s (≥ 0)	s (≥ 0)
Order-up-to-level	S (> 0)	S or Q (both > 0)
Order quantity	variable	fixed (Q) (if demand is unit sized)

Table 21.10 Inventory control parameters in periodic and continuous review systems

In the theoretical case of perfectly predictable and level customer demand without any variability, a fixed order quantity can be ordered at every review. However as soon as customer demand is variable either variable quantities are ordered at fixed review periods (periodic review systems) or fixed quantities are ordered at variable intervals (continuous review systems).

By combining the inventory control parameters from figure 21.8 the most common inventory control systems can be derived as presented in table 21.11.

	Without reorder level	With reorder level
Periodic review	(R, S)	(R, s, S)
Continuous review	(S)	(s, S) or (s, Q)

Table 21.11 Classification of inventory control systems

The inventory control systems are named simply by stringing together the inventory control parameters which are being used. For example a periodic-review order-up-to-level or a continuous-review, reorder level, order-quantity inventory control system.

In order to fully determine the inventory control system, calculations for the reorder level order-up-to-level or the fixed order quantity must be defined. For example the order-up-to-level in an (R, S) inventory control policy may be fixed (imprest system) or recalculated at every review based on a customer demand forecast.

The term "minimum/maximum" policy should not be used as the term is ambiguous and different people have different understandings of its meaning.

A combination of a periodic review and a continuous review system would be a contradiction in itself as the review period cannot be zero and greater than zero at the same time.

However it can be useful to define a hastening level for periodic review systems. The inventory position is continuously monitored in order to immediately place an order between reviews if the inventory position drops below the hastening level. If this is not the case, a review is carried out after the defined review period and an order is placed according to the foreseen order-up-to-level.

Material requirements planning (MRP) is mainly used in the manufacturing industry were complex products have to be assembled from hundreds or thousands of different parts or components with different manufacturing or supplier lead times. Since MRP systems are based on master production schedules for the final product they are appropriate only when demand is predictable. Consequently the use of MRP in humanitarian assistance is very limited but could be considered when assembling kits with components with different supplier lead times. However the complexity of assembling kits is very limited and therefore does not require an in depth understanding or even application of sophisticated information systems.

Just-in-time (JIT) systems will be discussed only very briefly to explain why they cannot be applied to humanitarian assistance. Just-in-time applies only to large-scale highly automated manufacturing of high volumes of identical products on assembly lines according to fixed schedules, for example the manufacturing of vehicles. Throughout the manufacturing process just-in-time tries to eliminate any kind of waste including elimination or at least minimizing any stocks by exactly synchronizing supply to demand. Parts and components are therefore delivered from suppliers or manufactured just at the time when they are required in the assembly process rather than being drawn from stocks.

However the elimination of safety stocks in this "zero inventory" or "stockless production" system also leads to a high vulnerability of the manufacturing process as even a slight delay of a single manufacturer can stop the entire manufacturing plant within minutes. The just-in-time prerequisites of a stable environment, production at fixed levels, reliable suppliers and elimination of safety stocks precludes application of these systems in humanitarian assistance.

Moreover, just-in-time is not simply a manufacturing technique but rather a whole management philosophy which requires years of planning and controlled implementation. Among others, just-in-time requires total quality control and quality at source (Jidoka) where

defects are prevented rather than corrected and continuous improvement (Kaizen). Production processes are standardized and simplified as well as designed to improve flows.

21.3.2 (R, S) Periodic-review, order-up-to-level inventory control system

The periodic-review, order up-to-level inventory control system is a periodic review system. No reorder level is indicated as an order quantity is calculated in any case but no order is actually placed if the inventory position is higher than or equal to the order-up-to-level. Therefore the reorder level is actually equal to the order-up-to-level minus one unit since a replenishment is required whenever the inventory position is less than the order-up-to-level at the time of the review. The reorder level is omitted from the complete notation (R, S-1, S) as it has no relevance and instead the notation (R, S) is commonly used.

Calculation of the order-up-to-level is based on the forecast of customer demand, length of the review period, expected replenishment lead time, safety factor, as well as the standard deviations of customer demand and expected replenishment lead time (see chapter 21.2.3). Unless customer demand and the expected replenishment lead time are predictable and show no variability, the order-up-to-level will change with the recalculation at every review.

Figure 21.9 shows a (R, S) inventory control system with a review period of 30 days, a reorder level based on moving averages from the past 90 days without safety stocks (for the sake of simplicity of the figure) and a supplier lead time of 40 days.

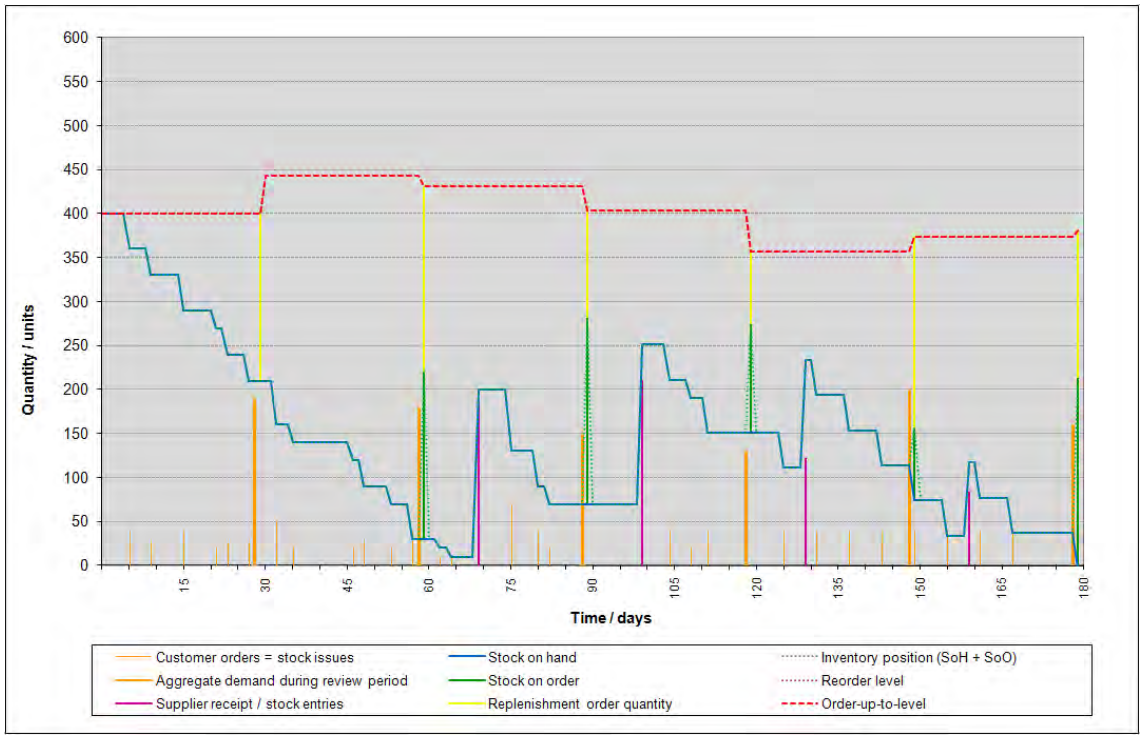

Figure 21.9 (R, S) inventory control system

The (R, S) inventory control system has the advantage of allowing joint replenishment of several items and therefore consolidation of shipment from suppliers. Moreover the periodic review is an opportunity to regularly reassess the appropriateness of the order-up-to-level.

The main disadvantage is the need to hold additional stocks to cover demand during the review period and hold additional safety stocks to hedge against uncertainty of demand during the review period. The timing of replenishment orders is arbitrary to some degree as a large

customer order received just before the review takes place will lead to placement of a replenishment order very soon while a large customer order received just after the review has taken place will not be taken into consideration until almost a whole review period later.

A common misunderstanding is the notion that an order is placed at every review and the review period is identical with the order period. However if a non-positive order quantity is calculated at the review (order-up-to-level is less than or equal to the inventory position), then no order is placed. The shortest order period corresponds to the review period but the order period can assume any multiple of the review period. Therefore an order is only potentially placed at every review and, if at all, a reorder is placed at the review.

Another common misunderstanding is that the order quantity is calculated to raise the stock level to the order-up-to-level. However this is only the case if stock on order as well as backorders are zero. Moreover even when the ordered quantity is entered into stock, the stock on hand (physical stock level) will not necessarily reach the order-up-to-level.

Generally the stock on hand will fluctuate between the order-up-to-level and the safety stock level and drop below the safety stock level if average customer demand or the expected lead time is exceeded. The stock on hand will only reach the order-up-to-level in the rare case that correct replenishment orders have been placed in the past, no customer orders have been received for at least the length of the review period and the actual replenishment lead time. The stock on hand could exceed the inventory position if customer demand and therefore the order-up-to-level also drops while stock on order is still being delivered or if no stock is issued.

21.3.3 Imprest system

A special case of the periodic-review, order-up-to-level inventory control system which is of great practical importance is the so called imprest system. As stock on hand and backorders are not taken into consideration, the inventory position is identical with the stock on hand. Therefore, exceptionally, in principle the stock on hand and not the inventory position is compared to the imprest level. Although the use of the inventory position or the stock on hand will yield the same results, the exceptional possibility of using stock on hand for calculations has the great advantage that the meaning of the inventory position does not have to be explained to users.

The (R, S) and imprest system are very similar in terms of inventory control system as well as calculating replenishment orders but differ in the use of customer demand forecasts. The calculation of the order-up-to-level in an (R, S) inventory control system depends on a customer demand forecast which depends on average customer demand and its variability as well as possibly the expected replenishment lead time and its variability.

On the contrary, the order-up-to-level in an imprest system which is called imprest level, is in principle fixed and changed only under certain conditions. The calculation of the initial setting of the fixed order-up-to-level will depend on a customer demand forecast or judgement. Thereafter the imprest level is only increased if shortages are encountered during the review and only decreased if large overstocks accumulate and are in danger of expiring.

The order quantity is simply calculated by subtracting the stock on hand from the imprest level (Battersby, A. 1985, 103).

$$Q_0 = S_{IL} - SoH \qquad \text{Eq. 21.18}$$

The imprest system also disregards stock on order and backorders. This inventory control system therefore assumes that the replenishment lead time is shorter than the review period and all replenishment orders to an upstream medical distribution centre are filled before the next review. Therefore the expected replenishment lead time must be shorter than the review period. In case the previous replenishment order (or orders) have not been delivered until the next review takes place, the stock on order will be reordered leading to an increase of stock on hand once all stock on order has been eventually delivered. However not considering the stock on order does not lead to a cumulative increase and long-term built-up of stock on hand. Rather the delivered stock on order will eventually increase the stock on hand and reduce the next calculated order quantity.

However disregarding backorders can have a negative effect. In case of stockouts, backorders are not recorded and therefore the order quantity is not increased by the backordered quantity as is the case in the (R, S) inventory control system. When the stocked out item is delivered and backorders to customers are filled, the stock on hand will immediately drop and a shortage, until the next review takes place, is possible.

Figure 21.10 shows an imprest system with a review period of 30 days, the imprest (order-up-to-level) set at 300 units and a replenishment lead time of 10 days. Note that the order quantity is identical with the aggregate monthly demand during the last review period.

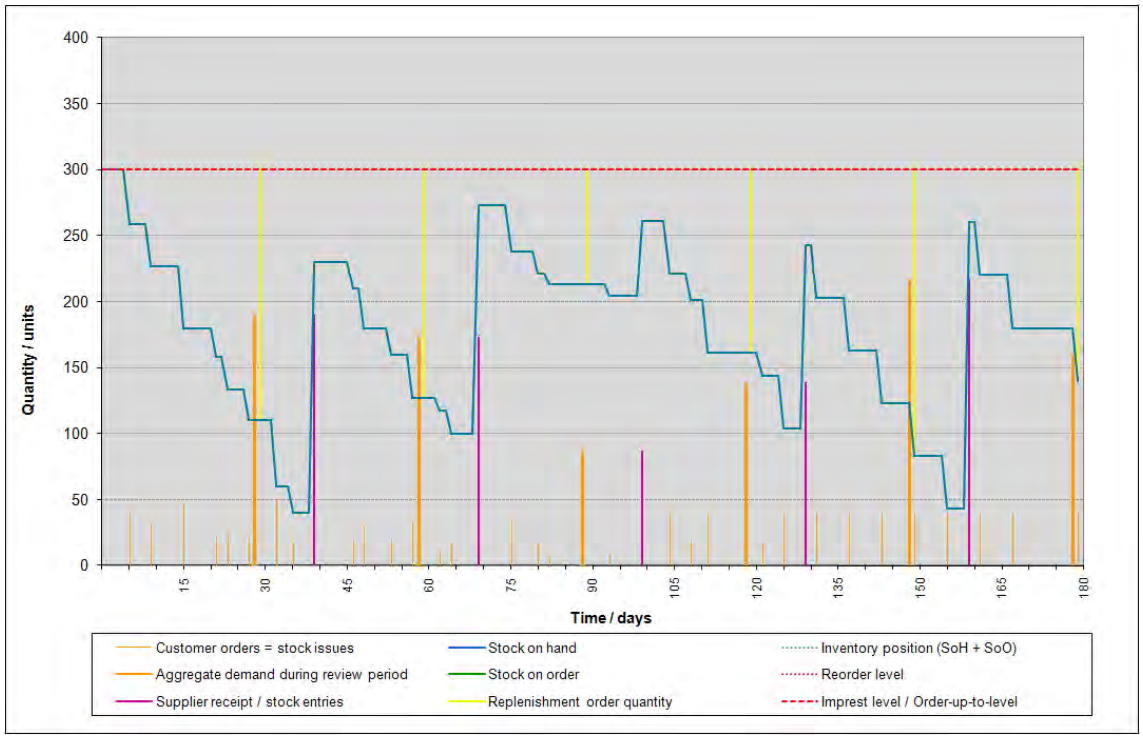

Figure 21.10 Imprest system

This disadvantage has to be balanced against the great simplicity in teaching, implementing and using the imprest system, including in emergencies. Calculation of replenishment orders requires a single subtraction for each item. Moreover, health care facilities will be tempted to inflate any systematically calculated order-up-to-levels but the imprest level can be selected "freely" and any "inflation" will have no adverse effect on the supply network.

Moreover the imprest system does not require maintaining any kind of stock records and does not require recording customer demand for forecasting. Apart from the imprest level only the stock on hand is required which can be obtained from a physical stock count.

The imprest system is most suitable for pharmacies or dispensaries at health care facilities (Quick, J.D. (ed.) 1997, 371) as it does not require any electronic information system and is very easy to use. The imprest system can also be used for any essential items with low, erratic or intermittent demand which must be available at all times despite on average low customer demand. For example life saving drug products which are used mainly for patients in critical conditions but not used (much) otherwise.

While the imprest level of all items can in principle change at every review, in practice the number of items requiring adjustment of their imprest level will be far smaller than in the classical (R, S) inventory control system. This less frequent change of the order-up-to-level greatly reduces demand distortion.

Assuming that the imprest level has not changed since the past review, the imprest system has the great advantage that it is the only inventory control system where the order quantity is identical with aggregate customer demand during the past review period and therefore the only inventory control system which can totally eliminated demand distortion.

"If all retailers use an order-up-to policy (with a constant order-up-to level S), then the standard deviation of the retailer's orders in one period equals the standard deviation of consumer demand in one period: that is, there is no bullwhip effect" (Cachon, G., and Ch. Terwiesch 2006, 337).

21.3.4 (R, s, S) Periodic-review, reorder level, order-up-to-level inventory control system

The (R, s, S) inventory control system is similar to the periodic-review, order-up-to-level inventory system except that an order is only placed at the review if the inventory position drops to or below the reorder level. If the inventory position is greater than the reorder level, no replenishment order is placed.

Therefore if the inventory position drops to or below the reorder level and an order is placed to raise the inventory position up to the order-up-to-level, the order quantity is always equal to or greater than S - s (difference between the order-up-to-level and the reorder level). Compared to the simpler (R, S) inventory control system, the (R, s, S) inventory control system avoids ordering small quantities.

However, the actual calculation of the reorder and order-up-to-level requires complex calculations by inventory control software or the use of approximations. This inventory control system is therefore not well suited for the context of humanitarian assistance which requires simple inventory control systems which can be easily understood by non-specialists.

Figure 21.11 shows a (R, s, S) inventory control system with the reorder level set 100 units below the order-up-to-level, which is based on 90 days moving averages and does not consider safety stocks (for the sake of simplifying the figure). The review period is set at 30 days and the supplier invariably delivers after 40 days. Note that during the reviews on day 90 and day 150 - although the inventory position clearly drops below the order-up-to-level - no order is placed because the inventory position lies above the reorder level.

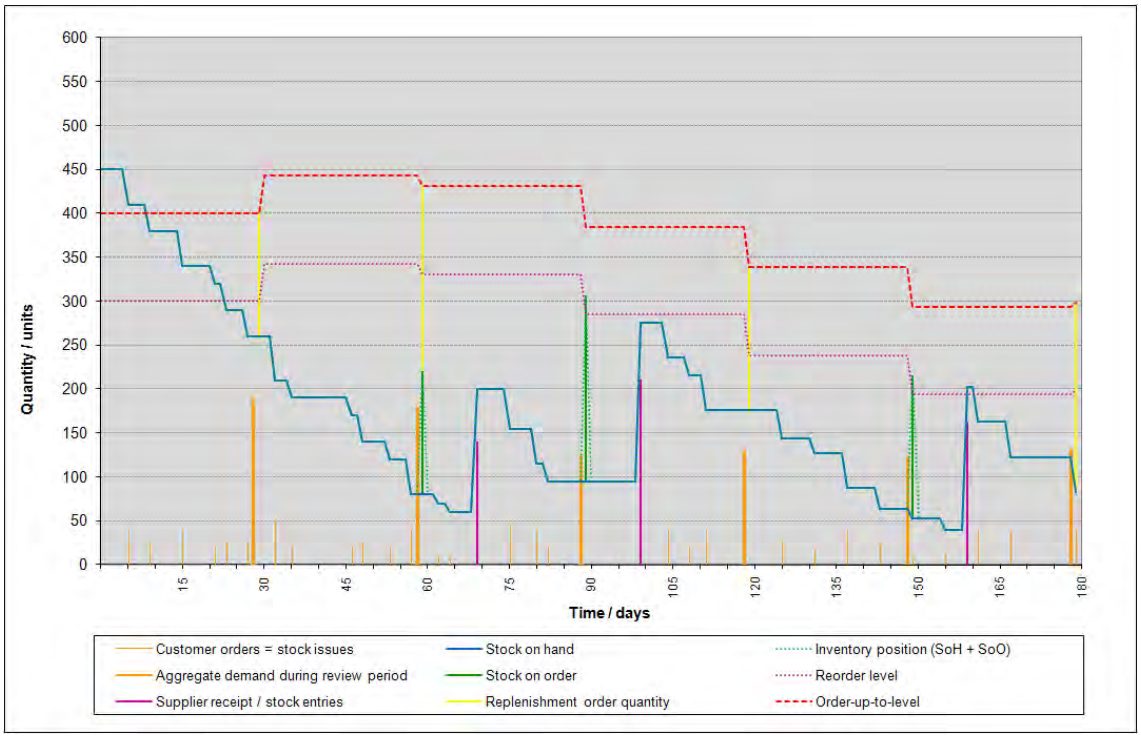

Figure 21.11 (R, s, S) inventory control system

21.3.5 (S) Continuous-review, order-up-to-level inventory control system

The (S) or (S-1, S) inventory control systems corresponds to the periodic-review, order-up-to-level inventory control system (R, S) except for a continuous instead of period review.

The inventory position is continuously monitored and a replenishment order is placed whenever the inventory position drops one or more units below the order-up-to-level.

Actually this inventory control system does not require a reorder level. Instead the inventory position is constantly subtracted from the order-up-to-level and an order is placed whenever this value is greater than zero. In fact this corresponds to a reorder level of S-1 as the order quantity becomes positive only if the inventory position drops to one unit or more below the order-up-to-level. Therefore the two notations (S) and (S-1, S) lead to identical replenishment orders. The notation as (S-1, S) inventory control system can as be seen as a special case of a (s, S) inventory control policy with the reorder level set at S-1.

The order-up-to-level can be calculated as discussed in 21.2.3. or can be fixed according to judgement, for example for contingency stocks where insufficient demand data is available for a customer demand forecast.

Although the calculation of the order quantity is identical with the calculations in a periodic-review, order-up-to-level (R, S) inventory control systems because of the continuous review more frequent but smaller orders are placed.

Figure 21.12 shows a (S) inventory control system with a supplier lead time of 3 days and a safety factor of 3. Note that the reorder level is not visible as it coincides with the order-up-to-level and orders are only placed if the inventory position drops below the order-up-to-level (reorder level).

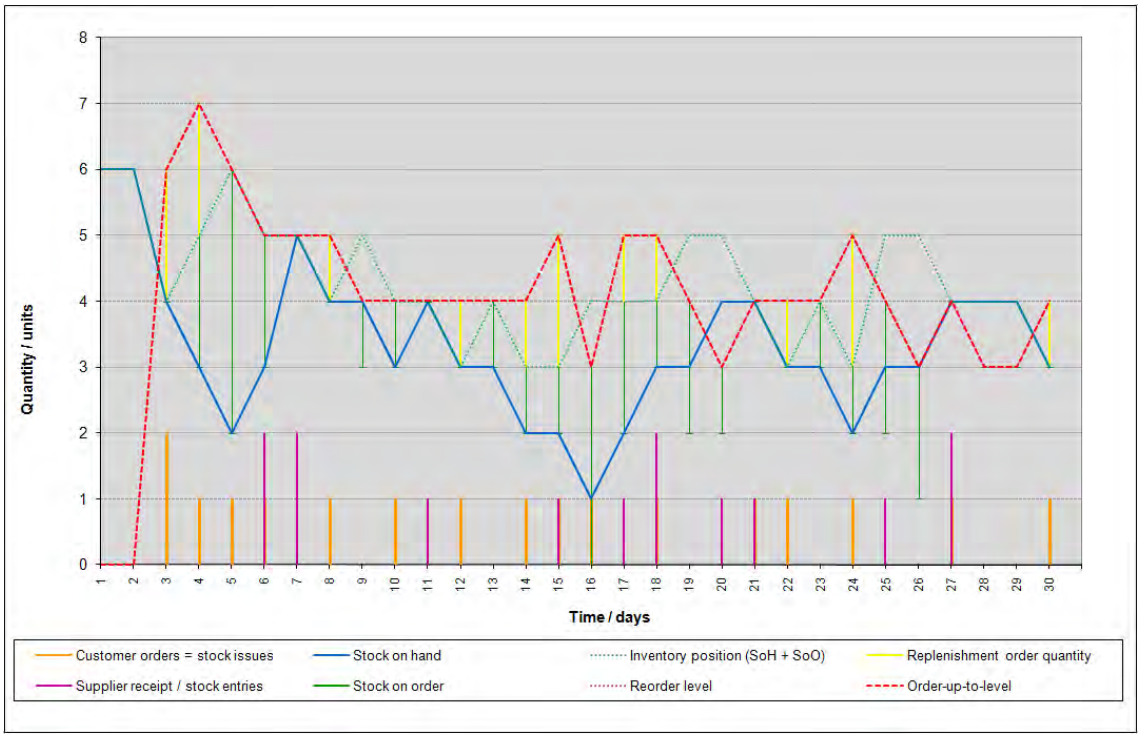

Figure 21.12 (S) or (S-1, S) inventory control system

21.3.6 (s, S) Reorder level, order-up-to-level inventory control system

The reorder level, order-up-to-level inventory control system is a continuous review system. Whenever the inventory position drops to or below the reorder level (s) an order is placed which raises the inventory position up to the order-up-to-level (S).

The reorder level is calculated by considering the expected customer demand and its variability during the replenishment lead time as well the variability of the expected replenishment lead time. Therefore the reorder level in an (s, S) inventory control system corresponds to the order-up-to-level (S) of an (S) inventory control system. Therefore, generally, the order-up-to-level of (s, S) inventory control systems is higher than in (S) systems.

This avoids frequently ordering small quantities, in the worst case where all stock issues are unit size, only one unit is ordered for replenishment every time an order is placed. Despite ordering larger quantities but less frequently, the minimum stock on hand is just as high as in a (S) inventory control system.

The order-up-to-level can be determined arbitrarily, as long as it is larger than the reorder level.

Figure 21.13 shows a continuous review system with all its parameters. The order-up-to-level is calculated with a safety factor of 3 (but rounded to an integer to make the graph easier to read), the reorder level (s) is set 2 units below the order-up-to-level and the supplier lead time at 4 days. Note that a replenishment order is only placed if the inventory position drops below the reorder level.

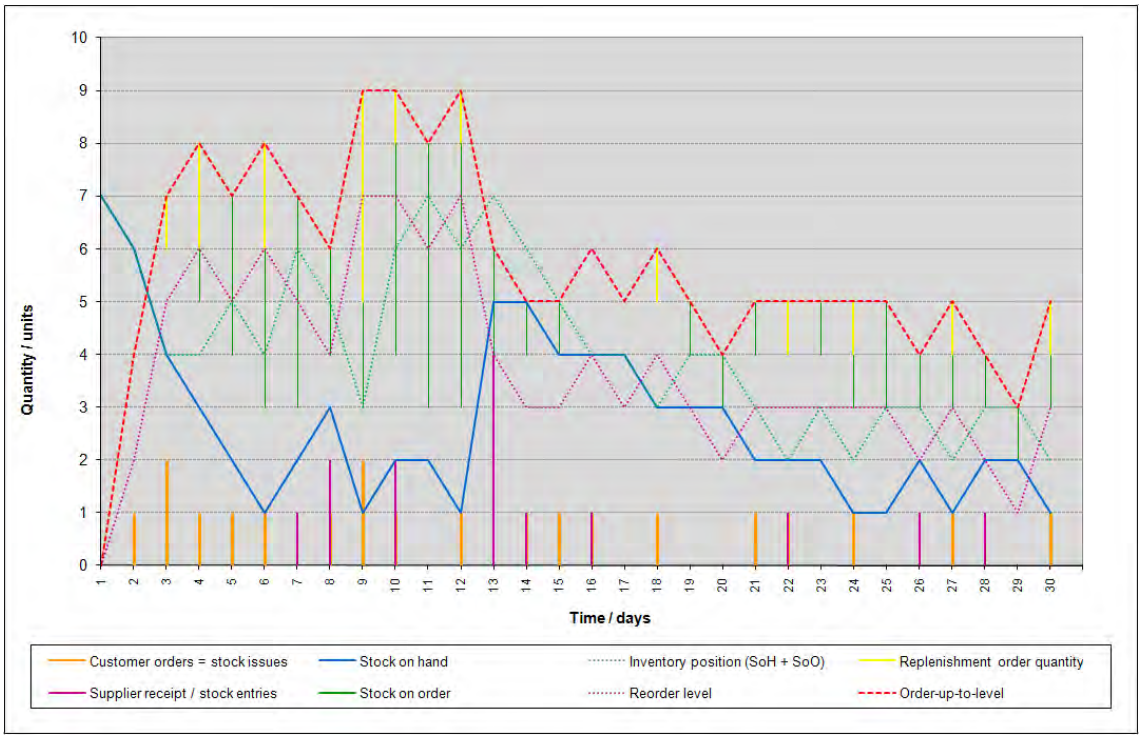

Figure 21.13 (s, S) inventory control system

21.3.7 (s, Q) Reorder level, order-quantity inventory control system

The reorder level order-quantity inventory control system (s, Q) is similar to the reorder level, order-up-to-level inventory control system but has important differences.

Assuming that all transactions in an (s, S) inventory control system are unit sized and the reorder level and order-up-to-level are not changed, the order quantity will be fixed as it is simply calculated as the difference between the two levels. In this case the inventory position will drop only by one unit at each stock issue and the inventory position will certainly equal the reorder level at some time if only sufficient stock is issued.

In this special case the order quantity (Q) will be equal to S - s and the (s, S) inventory control system can also be written as (s, Q).

However if not all transactions are unit sized, then there is only a possibility but not a certainty that the dropping inventory position will equal the reorder level at any time. Instead the inventory position will eventually be above the reorder level before one of the transactions and drop below the reorder level during the following transactions causing an undershoot. Consequently the order quantity in an (s, S) inventory control system will depend on the size of the undershoot and can therefore vary from order to order.

While an (s, S) inventory control system generally leads to variable order quantities the order quantity in an (s, Q) inventory control system is fixed and therefore the actual order-up-to-level varies from order to order.

Whenever the inventory position drops to or below the reorder level, a fixed order quantity (Q) is ordered. As long as the undershoot is less than the fixed order quantity, placing an order for (Q) will raise the inventory position above the reorder level. If the undershoot is greater than the fixed order quantity (Q), the inventory position will remain below the reorder level

after the order. However since the review is carried out continuously a further order of the fixed quantity (Q) will be placed immediately after the previous order. Therefore in practice the (s, Q) inventory control system may resemble a (s, nQ) inventory control system where at times ordering multiples of fixed order quantities may be necessary. The (s, Q) inventory control system can then be seen as a special case of the (s, nQ) inventory control system with n equal to 1.

Another way of looking at (s, Q) inventory control system is to continuously monitor the stock on hand in the medical store during order picking. As the item is picked unit by unit, the inventory position may reach the reorder level while the order picking is still ongoing and a replenishment order is placed immediately. In this case ordering the fixed order quantity (Q) will always raise the inventory position above the reorder level although several orders of the fixed order quantity could be necessary throughout the process of picking a customer order.

The calculation of the reorder level (s) can be based on the forecast for future customer demand as well as safety stocks for hedging against uncertainty of demand and supply as discussed in chapter 21.2.3. Again the reorder level in an (s, Q) inventory control system will correspond to the order-up-to-level system of an (S) or (R, S) inventory control system.

The fixed order quantity is often based on the economic order quantity concept discussed earlier resulting in an (s, Q_{EOQ}) inventory control system.

Alternatively a convenient quantity offered by a supplier such as a master carton of drug products or the quantity which fits on a standard floor pallet could be ordered.

Reorder level, order-quantity inventory control systems have they advantage that they are simple to understand and operate. Ordering fixed quantities may simplify the work of the supplier as convenient packing sizes or pallets can be delivered. Another advantage is the adjustment of the order frequency to demand as items with low demand will be ordered less frequently than items with high demand.

A special case of the (s, Q) inventory control system is the so called two-bin system which can be seen as a (Q, 2Q) inventory control system. A fixed order quantity is defined which is also equal to the reorder level while the order-up-to-level corresponds to twice the fixed order quantity. In practice this inventory control system can be implemented by using two equal bins or other storage equipment such as cage pallets which hold a defined quantity of an item. Another variation is to mark a certain number of positions for example for large equipment or for a certain number of floor pallets.

Initially both bins are filled and customer orders are filled from the first bin. As soon as the first bin is empty an order for the fixed order quantity is placed while customer orders continue to be filled from the second bin. The two-bin system has the advantage that the need for a replenishment order is evident for order pickers without having to consult any stock records.

However the inventory control system only works if there is no stock on order or at least if the lead time for stock on order is very short. Otherwise repeated replenishment orders might be placed when the first bin is emptied as there are no records of the stock on order. Therefore in practice a two-bin system can only be operated for replenishment of stocks inside an organization, for example a dispensing room of a hospital pharmacy.

While the system is simple, it is also inflexible as the size of bins would have to be changed whenever the order quantity is changed. Therefore this inventory control system does not allow adjusting to (frequent) changes in customer demand.

Figure 21.14 shows a (s, Q) inventory control system with an replenishment order quantity (Q) of 3 units, a lead time of 4 days and a reorder level calculated with a safety factor of 2 (again rounded in order to improve reading of the graphs).

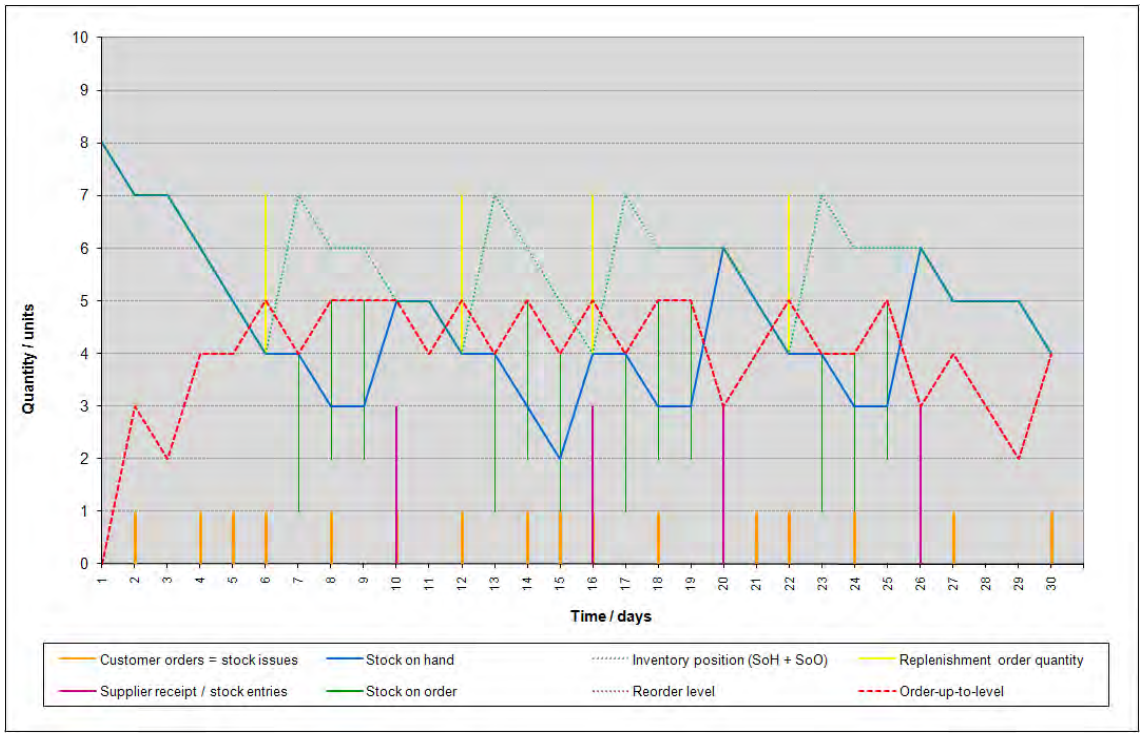

Figure 21.14 (s, Q) inventory control system

21.4 Multistage inventory control system

So far the discussion of inventory control systems was limited to a single stage in the supply network. In practice supply networks in humanitarian assistance are complex and require maintaining and therefore replenishing stocks at several stages.

The stages in a supply network, also called levels or tiers, correspond to the distribution centres or health care facilities which have the same distance from the international distribution centre (stages A, B, C and D in figure 21.15). The echelons comprise the respective distribution centre as well as all downstream distribution centres and customers it supplies.

Echelon stocks are defined as the sum of stocks at any given stocking stocking point and at all the downstream stocking points it supplies (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 479) as well as all stocks moving between these stocking points. Consequently (supply) network stocks can be defined as the sum of stocks throughout the entire supply network, whether in a medical distribution centre or under transport.

Supply networks usually resemble a combination of a convergent network from raw material suppliers, manufacturers and distributors to the international or regional distribution centre and an onward divergent network to national distribution centres and customers (see figure 21.16).

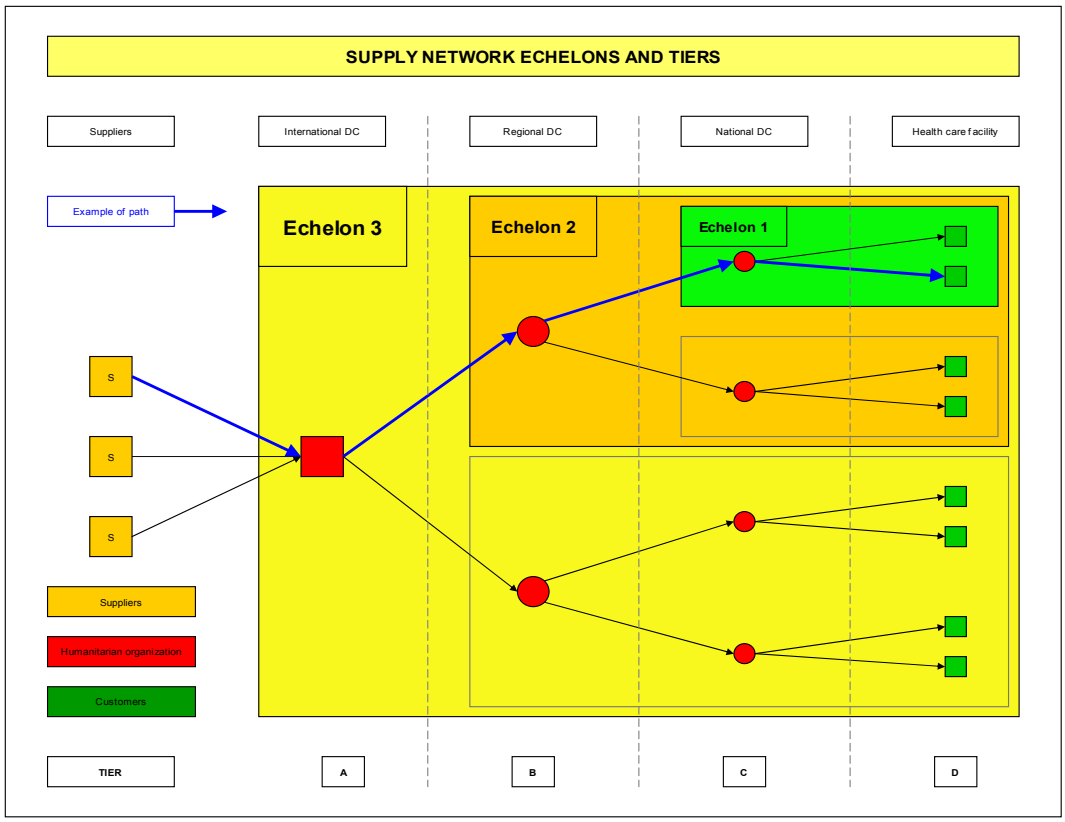

Figure 21.15 Supply network echelons and stages

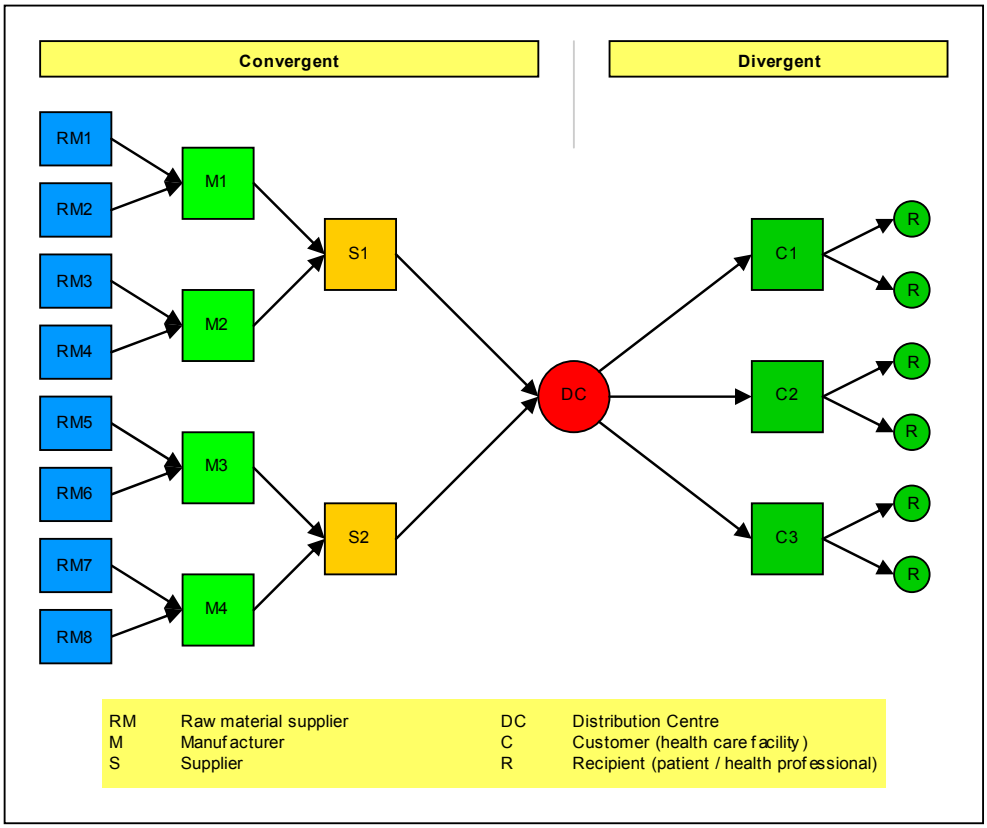

Figure 21.16 Combination of convergent and divergent supply network

Serial networks where one distribution centre supplies only one other downstream distribution centre or one health care facility should be avoided as they usually do not add any value but in any case cause demand distortion and require resources for operation.

Traditional replenishment system use local information (demand from their immediate downstream customers) and local control (see table 21.12). Every distribution centre calculates its own replenishment orders without considering any information from other upstream distribution centres or any downstream stages beyond their immediate downstream stage. Although traditional replenishment systems are very commonly used they lead to significant demand distortion and are therefore not ideal by any means.

	Control	
Information	Centralized	Decentralized
Global	Vendor managed inventory	*Base stock control system*
Local	(does not make sense)	Traditional replenishment systems

Table 21.12 Centralized and decentralized information and control

At the opposite the vendor managed inventory (VMI) system uses global information and centralized control where managers at one distribution centre have full visibility of data from the entire supply network and use the same end-user demand for optimizing stock replenishment for all distribution centres at all stages.

The use of global information and centralized control yields the best solutions (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 11) and minimizes demand distortion but coordination and information throughout the entire supply network is a challenge even in highly developed countries. The inventory control theory even for only a few stages is quite complicated, assumptions to simplify the complexity are often required and sometimes only approximations rather than exact mathematical solutions can be calculated. The execution of such complex systems requires sophisticated software for calculating replenishment orders.

The use of global information throughout the supply network requires reliable and rapid upstream transmission of end-user demand data as well as a range of data from all distribution centres and therefore an advanced information system.

Because of the use of mainly manual stock records at assisted health care facilities as well as lack of reliable telecommunications infrastructure, centralized control in the context of complex political emergencies is often not realistic. Moreover a centralized decision maker would hardly be able to consider the context and constraints of individual distribution centres in dozens of different countries. While use of global information requires only the transmission of end-user demand, centralized control would require full visibility of all relevant information such as stock on hand, customer orders, backorders, losses, returns, lead times and remaining shelf-life at all distribution centres.

If inventory control systems were managed centrally a reliable and fast telecommunications system would be required to transmit instructions for replenishment orders and shipments downstream throughout the entire supply network again. Distribution centres also must not become completely dependent on telecommunications infrastructure which may be damaged or deliberately disabled.

In the context of humanitarian assistance, decentralized control but use of global information is a reasonable and feasible compromise which allows reducing demand distortion significantly while leaving each distribution centre in control of their replenishment orders.

The so called "base stock control system" (Silver, E.A., D.F. Pyke and R. Peterson 1998, 489) regularly collects and transmits end-user demand from health care facilities upstream along the entire supply network where it is aggregated at each distribution centre for the respective echelon. As the number of assisted health care facilities increases upstream with each echelon, the variability of overall demand decreases through aggregation, increases forecasting accuracy and allows reducing safety stock levels (Gudehus, T. 1999, 221).

Base stock control systems are also more responsive to large changes in end-user demand. In a multistage supply network where every stage uses a periodic review system as well as local information and all stages place replenishment orders at the same time, the increased demand would take as many review periods to propagate to the most upstream stage as the supply network has stages.

The use of end-user demand allows to quickly detect level shifts in demand and to immediately adjust stock levels at all stages of the supply network. Correct calculations require collection of data from all assisted health care facilities and excluding demand from health care facilities which is filled from other supply sources such as other humanitarian organizations or the government.

Sharing of demand information is often associated with EDI but demand information can also be communicated by less sophisticated means such as fax (Lee, H.L., K.C. So, and Ch.S. Tang 2000, 262). Unlike large data files, limited amounts of information such as a aggregate end-user demand can also be transmitted through backup telecommunications systems such as radio networks or as hardcopies which are sufficient for local control.

While medical distribution centres at all stages should use the same aggregate end-user demand data, each distribution centre will calculate their replenishment orders independently according to the required safety stocks and the expected replenishment lead time.

In a multistage system with all stages using a continuous review (S-1, S) inventory control policy, any stock issue at a health care facility would immediately lead to replenishment of one unit at all levels of the supply network (Svoronos, A., and P. Zipkin 1991, 68) without any demand distortion. However this would require all stages to use an imprest system and not change their respective imprest levels as well as require transportation between all distribution centres whenever stock is issued to end-users.

Therefore the use of a periodic review inventory control system is more appropriate. In a steady state multistage system with an Equal Time Supplies policy (Silver, E.A., D.F. Pyke and R. Peterson 1998, 244) or fixed reorder levels and (R, S) inventory control policies, constant replenishment lead times, constant review periods, constant safety factor and with level end-user demand at all assisted health care facilities, reorder levels as well as working and safety stock at all stages remain unchanged and aggregate end-user demand is shifted upstream to each stage of the supply network without any demand distortion (see figure 21.17). If end-user demand is not level, it will be distorted by the required increases and decreases of safety stock levels at all upstream stages of the supply network in any case.

To summarize, the most realistic inventory control system in the context of humanitarian assistance is the use of end-user demand throughout the supply network (base stock control system) and apply a periodic-review, order-up-to-level inventory control system at all stages. The order-up-to-level is determined at each stage separately depending on the review period,

expected replenishment lead times and required safety stocks but always based on the same set of end-user demand data.

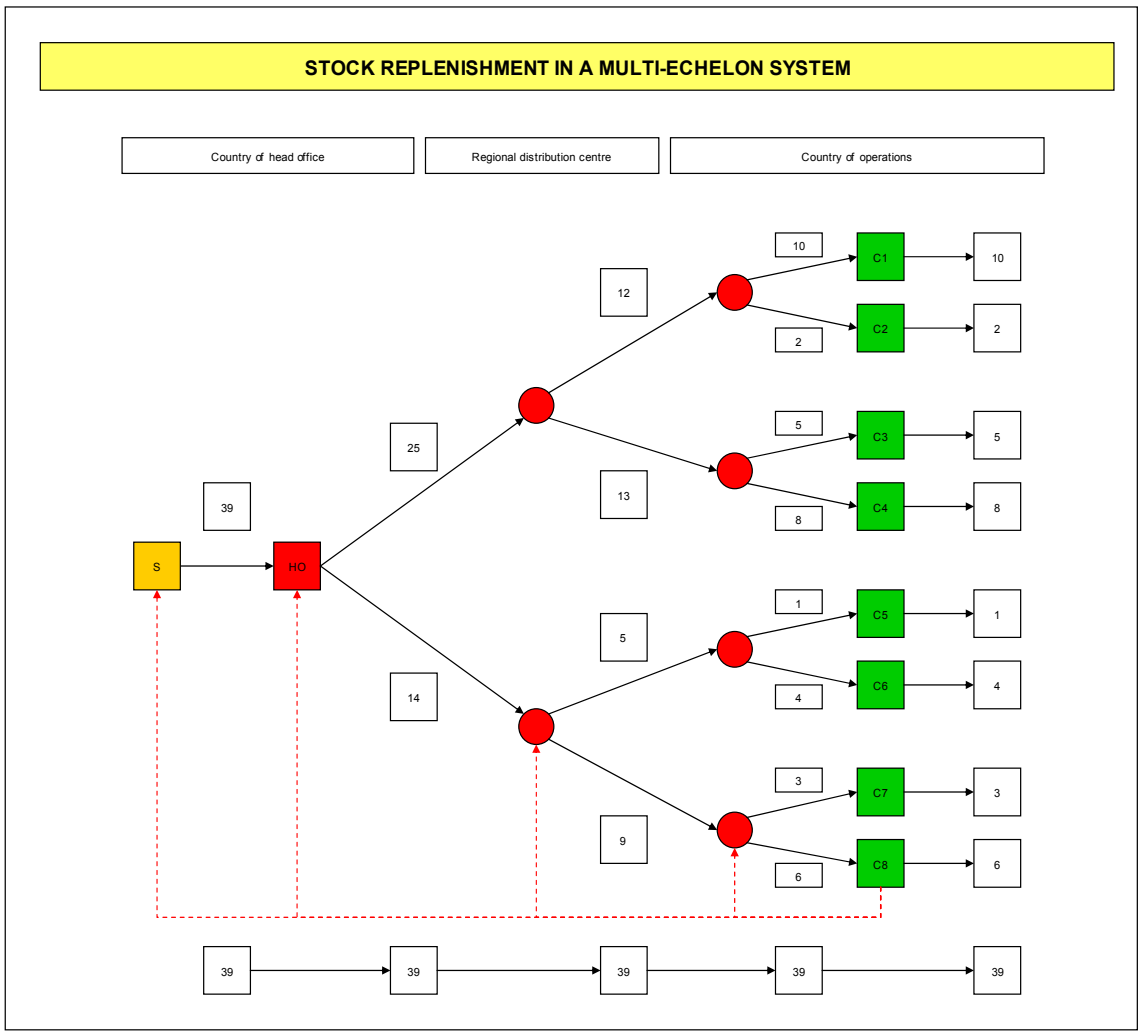

Figure 21.17 Example of stock replenishment in a multistage system

21.5 Selection of inventory control systems

With the vast number of different inventory control systems and the possibility of choosing different values for the parameters the question of selecting appropriate inventory control systems for a specific context and situation arises.

The context of humanitarian assistance poses certain requirements on any inventory control system which need to be considered and imposes certain constraints.

Customer demand must be considered as unpredictable as well as (highly) variable in the great majority of situations. Backordering is of course always allowed, all backorders must be eventually filled and replenishment lead times are always non-zero. The majority of drug products and single use medical devices have limited shelf lives but the expiry date is determined by the manufacturer and therefore known as long as the required storage conditions are maintained. Joint replenishment of stocks is favourable in most situations as it allows economies of scope and facilitates ordering as well as treatment of orders by upstream

distribution centres. Consolidation of transportation reduces costs and is often necessary for reducing security risks.

The primary objective of any inventory control system is maximizing customer service and avoiding stockouts while cost considerations are secondary. Therefore inventory control systems should be based on defined customer service objectives rather than arbitrarily selected parameters such as coverage times.

Selected inventory control systems must be effective and provide required customer service levels to end-users reliably and consistently. While humanitarian organizations have the resources to recruit and train qualified staff as well as establish and maintain information systems, their limitations should be taken into consideration when choosing an inventory control system. As a general rule simple inventory control systems should be preferred which generally yield just as good results as more complex inventory control systems. Certainly simple inventory control systems which are applied accurately and systematically will yield better results than complex inventory control systems which are poorly understood and not applied systematically.

The advantages of joint replenishment and consolidation of transportation favours periodic review systems for health care goods which are regularly provided to customers. Sine determining the reorder level for a (R, s, S) inventory control system is complex, the periodic-review order-up-to-level (R, S) inventory control system will be the choice for medical distribution centres at all stages of the supply network.

The need to replenish contingency stocks as quickly as possible after any issue of stocks clearly demands a continuous review inventory control system. Since the requirements for applying economic order quantities are not met, a continuous-review, order-up-to-level inventory control system with order-up-to-levels defined by health programme managers are most appropriate.

Stocks	Inventory control system
Health care goods regularly supplied to customers	(R, S)
Contingency stocks	(S)

Table 21.13 Recommended inventory control systems

21.6 Managing stockouts

Stockouts occur when the stock on hand of a stock list item drops to zero. If customers have no backorders for items which have stocked out, they will not be affected negatively, at least not immediately. However if future customer orders are received before the stocked out item is restocked, customer orders cannot be filled which may lead to a stockout at the assisted health care facility. Therefore any stockout regardless of backorders, must always be considered as an emergency that requires immediate action.

Any stockout must be considered as an emergency requiring immediate action.

The criticality of a stockout at a medical distribution centre is determined by the number of health care facilities which have stocked out as a consequence of unfilled backorders, the total quantity of backorders as well as the length of the stockout period.

Stockouts can be caused by suppliers, (poor) inventory control management at the medical distribution centre as well as by customers, can have many different reasons and cannot always be prevented.

Suppliers can cause stockouts by exceeding the replenishment lead time for which the inventory control system including its safety stocks is hedging or by delivery of unusable health care products which require re-ordering and therefore increasing the lead time. Stocks of batches recalled by the supplier have to either be kept in quarantine until further notice or have to returned to the supplier but in any case cannot be distributed to customers.

Erroneous records (stock on hand, backorders, stock on order etc.) can lead to too low replenishment orders even if inventory control systems are applied correctly. Available stock on hand may be damaged during handling or inappropriate storage conditions, expire in stock, be lost or stolen.

Customer demand which exceeds the forecast as well as safety stocks will cause stockouts if logistics managers are not informed of (expected) increases in advance. Poor inventory control management at assisted health care facilities can also lead to sudden and expected large customer orders which exceed available stocks.

a) Suppliers

- Longer than expected (or promised) replenishment lead time.
- Delivery of unusable health care products (poor quality, expired, damaged, wrong item).
- Batch recall.

b) Medical distribution centre

- Erroneous records.
- Damage, expiry, loss or theft of stock.
- Poor customer demand forecast.
- Miscalculations.

c) Customers

- Customer demand (unexpectedly) exceeding forecast and safety stock.
- Poor inventory control at assisted health care facilities.
- Unexpected changes (increases) in health programmes.

Table 21.14 Possible reasons for stockouts

Stockouts at medical distribution centres can quickly lead to stockouts at assisted health care facilities. Consequently patients may be treated with less appropriate substitutes, inappropriate means or not be treated at all, prolonging their medical condition and suffering as well as possibly leading to long-term disability or even death. Relatives of patients may have to resort to purchasing, possibly low quality, health care goods in the local market.

Stockouts also reduce confidence of customers and may lead to "hoarding" of stock and "phantom demand" (Gattorna, J. 1998, 191) which in turn causes demand distortion. Partial fulfilment of orders from health care facilities can lead to the "shortage gaming" where customer orders are exaggerated beyond actual needs in the hope that a certain percentage will be delivered and cause demand distortion (Cachon, G., and Ch. Terwiesch 2006, 417).

Patients may seek treatment at other health care facilities or not seek medical attention at all which is especially detrimental to public health and preventive services.

No measure can prevent stockouts to occur with certainty as in theory this would require maintaining unlimited safety stocks. However measures to minimize the probability and frequency of stockouts as well as the length of stockout periods can be taken.

While medical distribution centres can hedge against longer average supplier lead times by maintaining safety stocks, every measure should be taken to reduce the variability and uncertainty of supplier lead times.

Medical distribution centres must meticulously maintain and update stock records to minimize errors and store health care goods appropriately in order to avoid damages and losses. The remaining shelf lives of all stocks must be monitored in order to replenish stock before it expires. Storekeepers must immediately report any stockouts they notice during order picking to allow taking immediate action rather than waiting until the next review. In addition a hastening level can be introduced which will prompt measures at any time rather than waiting until the next review. Staff must be well trained and thoroughly understand inventory control systems as well as calculation of replenishment orders.

The importance of collaborative planning with customers in order to anticipate increases in ongoing programmes as well as expected implementation of new programmes cannot be overestimated.

Any stockout must be treated as an emergency and immediate measures must be taken to replenish stocks. Health care logisticians must maintain stockout records in order to keep customers informed and closely follow up replenishment of stocked out items. Wherever possible, customers must be provided substitutes for their backorders.

Health care logisticians must be aware of all their stockouts at all times.

Any stockout must be lead to immediate measures for replenishing stocks.

An urgent order must be placed immediately if there is no stock on order. Any stock on order with upstream distribution centres or commercial suppliers must be prioritized and expedited immediately. If necessary, a faster mode of transportation or even an express carrier service needs to be used. Other medical distribution centres which usually are not suppliers but could deliver stock quickly should be contacted to inquire about the possibility of exceptionally providing stock. Finally customers can be contacted in order to inquire whether a stockout at one health care facility could be overcome by lateral transhipment between health care facilities.

21.7 Managing excess stock

Excess stocks are either items which are in stock although they are not included in the stock list or items which are overstocked. Items can be considered as overstocked when the coverage time exceeds the order-up-to-level (significantly). Overstocks in principle do not do any harm as long as the coverage time does not exceed the remaining shelf-life and stock is not in danger of expiring with subsequent disposal and waste of funds.

Items without any demand are commonly called "dead stock". As items without regular demand must not be included in the stock list in the first place, dead stock can always be considered as excess stock.

Unfortunately excess stock tends to accumulate in any medical store or distribution centre unless measures are taken.

a) Suppliers

- Delivery of larger than requested quantities.
- Unsolicited donations.

b) Medical distribution centre

- Erroneous records.
- Poor customer demand forecast.
- Miscalculations.
- Replacement of health care products without first distributing "old" stock.

c) Customers

- Cancellation of confirmed customer orders after goods are received in stock.
- Unexpected closing of health programmes.
- Unexpected reduction in customer demand.
- Unexpected changes (increases) in health programmes.
- Inability to deliver because of poor security.
- Poor inventory control at assisted health care facilities.

Table 21.15 Possible reasons for overstocks

Occasionally suppliers may deliver larger than ordered quantities. Unless the overstock is in danger of expiring in stock, the cost of returning stock to the supplier is not justified. Overstocks may also be caused by unsolicited donations which are not announced or could not be stopped.

Overstocking can be caused by errors in records, poor customer demand forecasts as well as miscalculations which lead to too large replenishment orders. Another reason is the failure to distribute "old" stock before starting distribution of "new" stock when items or health care products on the stock list are changed.

Customers may order health care goods and cancel them after they have been received by the medical distribution centre or if cancellation with the supplier is not possible. Health programmes or customer demand may unexpectedly decrease or the stock list at health care facilities may change unexpectedly, for example when treatment protocols are changed or new diagnostic equipment is introduced.

Overstocks may also accumulate because delivery of consignments is made impossible by the lack of security. However these overstocks are usually only temporary as health care facilities will require delivery of all backorders as soon as the security situation improves.

Poor stock management or miscalculations at health care facilities can lead to overstocking and suspension of replenishment orders to the medical distribution centre where the decrease in customer demand will lead to increase in stock levels.

The main problem with overstocking is the danger of expiry in stock with the subsequent waste of funds. Keeping excess stock even if it does not expire, such as unused health care equipment, cannot be justified towards donors who want their funds or donations to benefit health care facilities and patients. The destruction of expired health care goods is not only a waste of funds but can cause an embarrassment towards to the authorities who might have even granted exemption from taxes and duties for importation. Moreover it is difficult to justify the necessary destruction of expired health care goods in a country with chronic shortages of health care goods which can reduce credibility of the humanitarian organization.

Excess stocks should be minimized by establishing strict policies to prevent unsolicited donations, especially during the onset of emergencies. Stock records must be meticulously maintained in order to avoid mistakes which can lead to too large replenishment orders.

When new health care goods or products are introduced, health care logisticians should work together closely with programme managers and customers in order to ensure distribution of "old" stock before "new" stock is distributed.

Close collaboration with health programme managers and assisted health care facilities should avoid unexpected changes of programmes and decreases in demand.

Health care goods should not be maintained in stock simply because they happen to be on hand, health programme managers do not know how to make use of them or nobody wants to take a decision.

Returning stock to suppliers when wrong items or quantities which cannot be used were delivered should be considered. Excess stock can also be offered to other medical distribution centres for their customers provided that transportation costs are reasonable.

Wherever possible, excess stock should be offered to customers as substitutes for other items they order. Health care logisticians must systematically circulate complete lists of all excess stock to health programme managers in order to keep them informed and allow them to distribute excess stock to already assisted or other health care facilities. Donation to other humanitarian organizations or the Ministry of Health can also be considered, provided that they can make use of the donations.

In any case excess stock which cannot be used or expires must be disposed of properly.

21.8 Use of information systems

Maintaining manual records such as stock cards and bin cards is essential in order not to rely entirely on electronic information systems.

While the basic processing of data for inventory control and stock replenishment is fairly simple, it is time consuming and tedious. Moreover performing a large number of manual calculations is prone to error. Information systems can significantly reduce the time needed for performing calculations and increase the accuracy of calculations.

The task can be facilitated by commercial software, database or spreadsheet applications. Simple spreadsheets are very powerful and sufficient for performing basic calculations. Special software can be used but is more expensive and requires installation, maintenance and training of staff.

Software should be as transparent as possible as staff will be suspicious to trust algorithms they do not know or understand.

If software is used there is a danger that it is used without fully understanding its functions. Entering data into a computer and blindly trusting the results of its calculations can lead to inappropriate replenishment, stockouts and overstocking. Any software application must allow users to override and adjust automatic calculations.

Software should be simple to use and the entering of data should be as convenient as possible. Otherwise staff may end up spending more time entering and manipulating data than would be required for performing manual calculations.

Ideally features for inventory control will be integrated into the logistics application used for general logistics management. However separate software applications may be needed to complement existing features.

Software applications must be standardized within the humanitarian organization. This allows compatibility between applications at different sites and simple transfer of data. Moreover staff moving to another programme does not need to familiarize itself with a new application. The frequent change or reinvention of software applications is a huge waste of resources and temporarily reduces efficiency of supply chain management.

The most sophisticated software system will be useless unless well-trained staff and supervision is available. "There is a widely held belief that computerization solves the problem of inventory control. This is not true. A computer is not a substitute for trained staff; it is simply an additional tool for them to use . . ." (Quick, J.D. (ed.) 1997, 342).

Whenever computers are used a complete backup must be made every day to prevent excessive loss of data.

22 STOCK POSITIONING OF ITEMS

For each item a decision must be taken at what stage or stages of the supply network it should be permanently stocked (Toomey, J.W. 2002, 128). At one extreme, items are not stocked anywhere throughout the supply network but made to order by the manufacturer upon an order by a humanitarian organization for a specific health care facility. At the other extreme stocks of health care goods are maintained at all stages of the supply network. In multistage networks storage of the full range of products at all stages is usually not justified (Bowersox, D.J., and D.J. Closs 1996, 486).

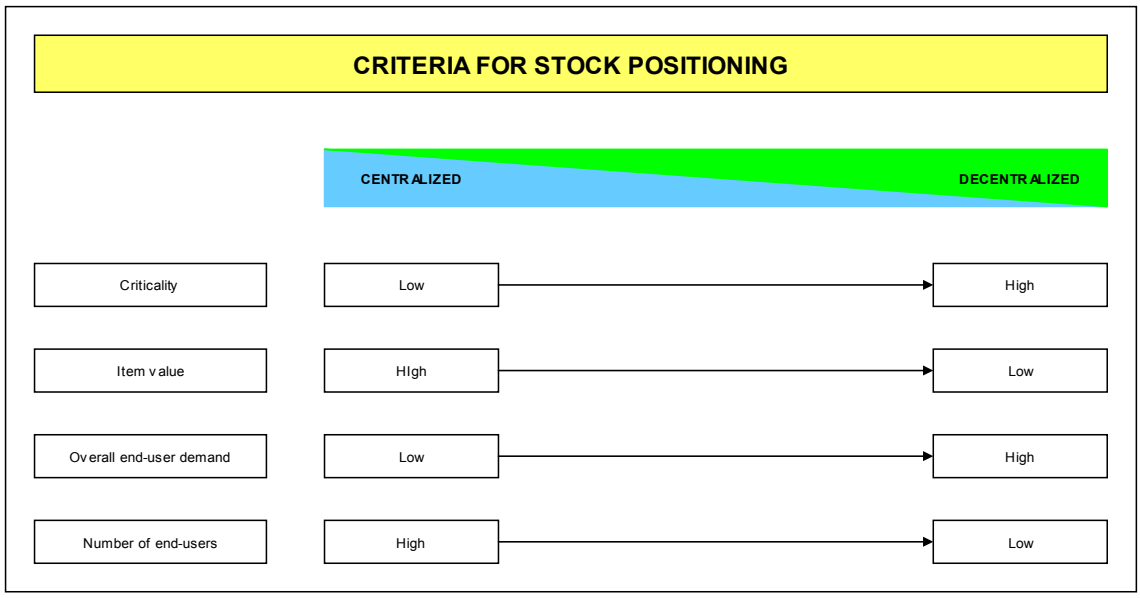

Figure 22.1 Criteria for stock positioning

Logistics managers must consider the trade-off between responsiveness of replenishing downstream stores by stocking items at all stages and the cost of overall network stocks. Centralization of stocks reduces overall stock levels as well as stock holding costs (Christopher, M. 2005, 214).

Moreover at a given level of end-user demand any increase in network stocks decreases overall turnover and therefore reduces remaining shelf-life of health care goods upon delivery to the end-user. Increasing network stocks of slow moving items, such as health care equipment, ties up capital which does not immediately benefit end-users and carries the risk of obsolescence and therefore loss of funds. Donors expect their funds to benefit people in need and will not appreciate funding stocks which remain idle in a store.

Health care goods which are critical and cannot be substituted must be held downstream in the supply network in order to ensure stock availability, high customer service levels as well as short lead times.

Items with high value such as expensive health care equipment should be kept centrally (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2004, 68) in order to reduce the financial resources which are tied up throughout the network as well as to reduce the risk of loss or damage. The low turnover and therefore small number of orders justifies using expensive express delivery services directly to assisted health care facilities.

Items with overall low end-user demand (and therefore more erratic demand) should preferably be held centrally in order to increase stock turnover and avoid expiry caused by holding items at all stages with low turnover (Bowersox, D.J., and D.J. Closs 1996, 464).

A small number of end-users implies overall low turnover and favours decentralized positioning directly at the end-users without keeping any safety stocks upstream.

Essential expendable health care goods with high turnover need to be stocked at all stages of the supply network in order to avoid stockouts, ensure quick replenishment from upstream stores as well as to ensure high customer service levels at end-users (figure 22.2).

All assisted health care facilities must keep a backup for all essential health care equipment which will allow them to continue services until a replacement is delivered directly from the supplier. Equipment can fail any time and delivery of replacement equipment from suppliers may be impossible immediately because of security constraints.

Health care equipment with low demand and high value (for example diagnostic imaging equipment) should be kept centrally, preferably with the manufacturer or supplier, in order to avoid tying up capital as well as risking that equipment becomes obsolescent.

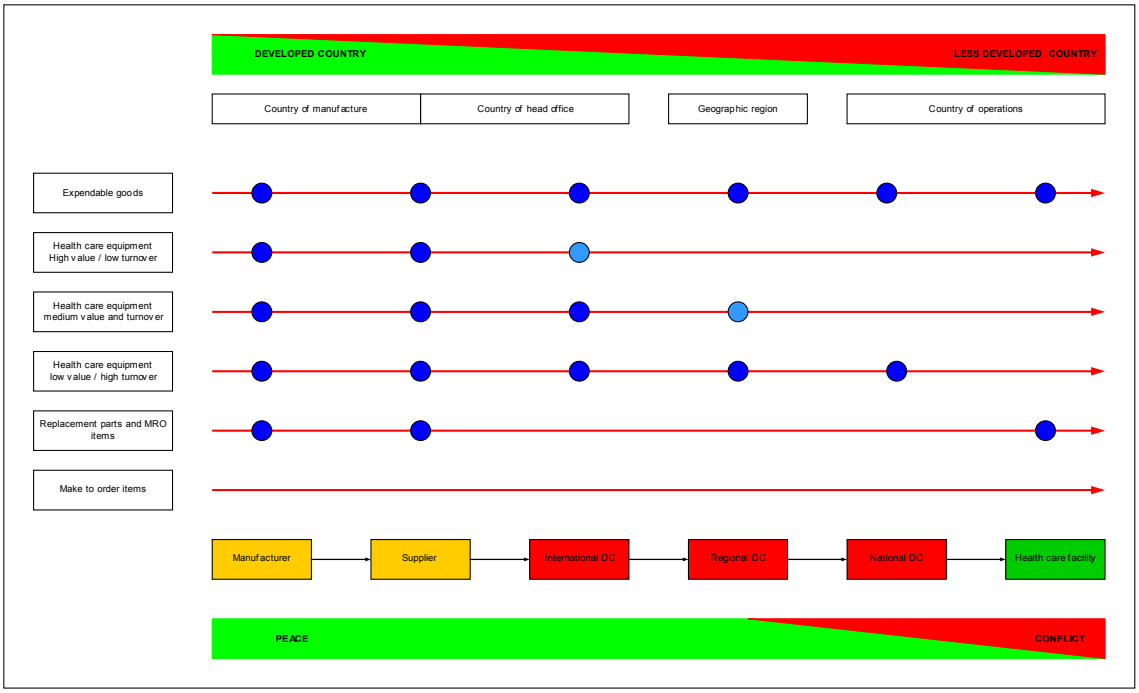

Figure 22.2 Stock positioning of items

In order to avoid the risk that stocks are not available with the supplier immediately when demand occurs, humanitarian organizations can make an agreement with the manufacturer or supplier to reserve a certain quantity which is immediately available at all times. By this humanitarian organizations do not tie up capital but also are guaranteed to always receive the newest models. Availability of health care goods with suppliers at all times should be an important criterion for selecting suppliers in the first place.

Essential health care equipment with medium value and turnover such as oxygen concentrators or suction machines should be kept at international or even regional distribution centres in order to reduce lead times but avoiding large network stocks.

Finally health care equipment of low value and high turnover such as sphygmomanometers or simple diagnostic equipment should be kept at national distribution centres. Critical

replacement parts as well as maintenance, repair and operating (MRO) items must be kept at the assisted health care facility in any case to ensure continuous operation of any critical and essential health care equipment. Because of the great variety of health care equipment at all assisted health care facilities worldwide, demand for individual replacement parts and MRO items for a specific type and model of health care equipment will be low and erratic. Therefore health care facilities should maintain sufficient stocks to cover weeks or months of lead times from suppliers.

In any case health care facilities must keep a backup for any essential health care equipment such as autoclaves, oxygen concentrators or suction machines for immediate replacement in case of any equipment failure. Likewise health care facilities must maintain stocks for any replacement parts as they must be available immediately in case health care equipment fails.

The erraticness of unpredictable demand for replacement parts can be converted into dependent demand by replacing certain parts according to predetermined schedules even if they are not broken.

22.1 Contingency stock positioning

Keeping contingency stocks centrally at the international distribution centre reduces storage costs, increases turnover and decreases the risk of expiry and obsolescence. However lead times for delivery to assisted health care facilities anywhere in the world also increases.

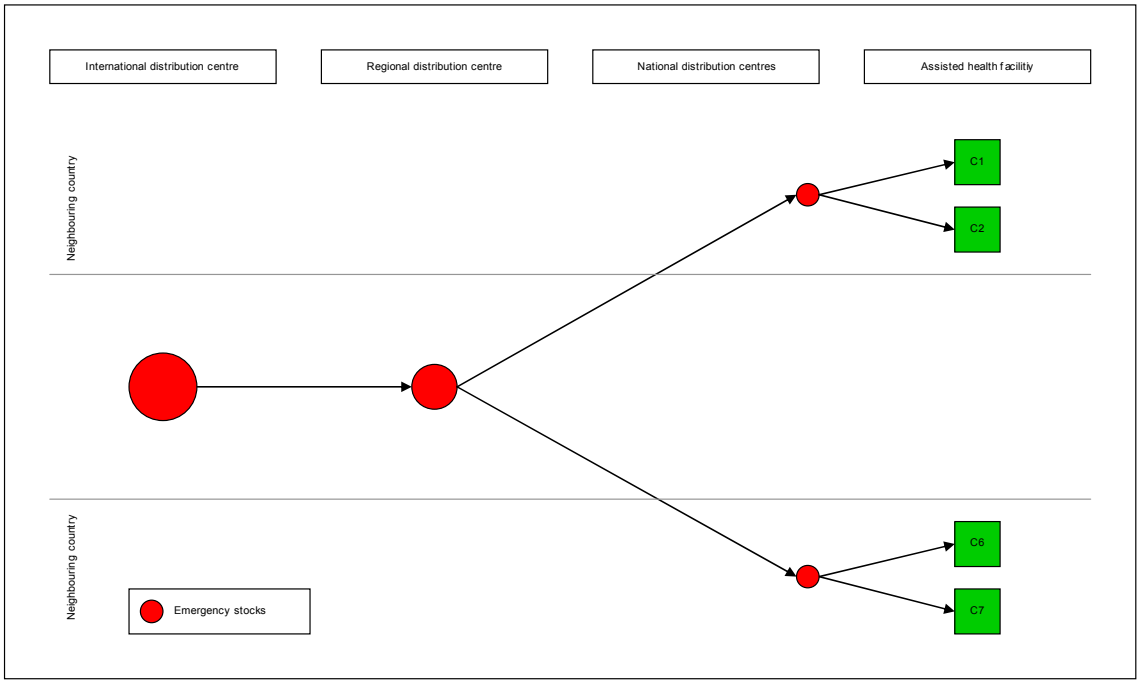

Figure 22.3 Emergency preparedness stocks

The other extreme of keeping large contingency stocks at all international, regional as well as national distribution centres would increase the overall value of network stocks considerably and lead to frequent losses of goods from expiry of unused contingency stocks.

The alternative to the above static systems is a dynamic approach with different phases and repositioning of contingency stocks throughout the network according to an early warning system and anticipation of emergencies.

Worldwide contingency plans should be planned with full visibility of all contingency stocks within the supply network. The stock levels of contingency stocks must be adjusted to the expected lead time for providing contingency stocks from the next upstream store. If the national distribution centre expects a replenishment lead time of 48 hours from the regional distribution centre, it must hold sufficient contingency stocks to supply health care facilities for the same period of time.

During the emergency preparedness phase no immediate emergency is foreseeable and humanitarian organizations have to be prepared to intervene anywhere in the world at short notice (figure 22.3). In order to reduce network stocks, the main contingency stocks are held at the international distribution centre, some stocks are held at regional distribution centres and smaller contingency stocks at national distribution centres. Dedicated contingency stocks for the humanitarian organization can also be held at the supplier according to a clearly defined agreement but must be available at any time and not sold to other customers.

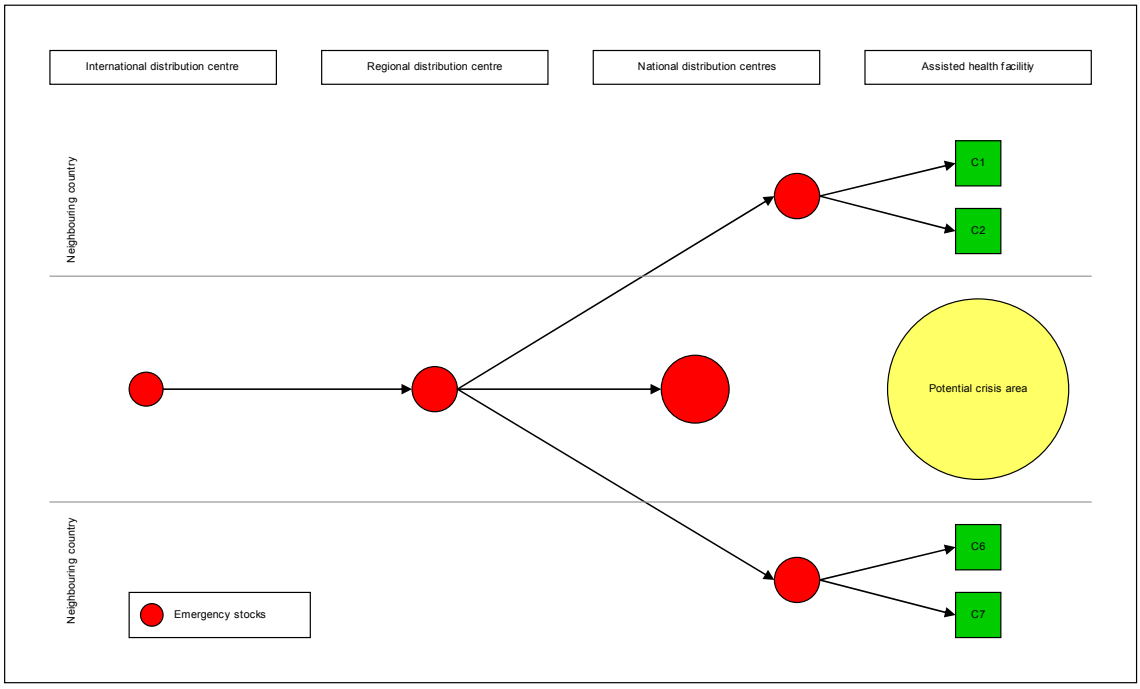

Figure 22.4 Emergency intervention stocks

Humanitarian organizations need to closely monitor political developments globally and identify potential crisis regions. As soon as a crisis is anticipated in a country, contingency stocks are immediately shifted downstream through the network towards the crisis area (figure 22.4). If the humanitarian organization has not been providing humanitarian assistance in the country where an emergency is imminent, then a national distribution centre for holding contingency stocks needs to be established quickly. This will reduce lead times and avoid delays through customs clearance, congested or blocked borders when the contingency stocks are requested.

Establishing contingency stocks in the country where a crisis is anticipated does not only have the advantage of shorter lead times in case of an intervention but establishing national distribution centres allows assessing the context of working in the country, learning about customs procedures and assessing constraints of logistics infrastructure in the country.

Contingency plans need to be regularly updated (WFP 2001, 4) and the size of contingency stocks will depend on the likelihood of the crisis as well as the expected number of people which are likely to require assistance.

If the crisis area can be supplied from neighbouring countries, all national distribution centres must increase their contingency stocks as well. This will allow increasing the overall capacity to respond as well as to resort to alternative network paths in case the main path is blocked by parties to the conflict or due to security constraints. If the humanitarian organization is already providing assistance in the potential crisis area, stock levels at assisted health care facilities can be increased or additional contingency stocks established.

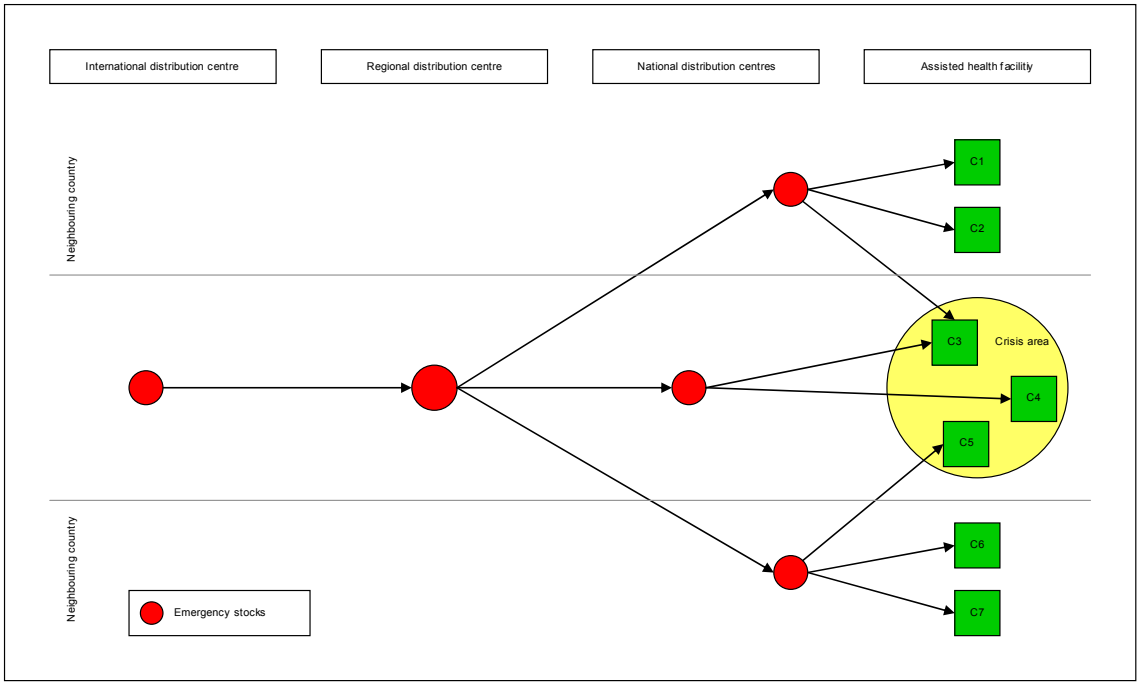

Figure 22.5 Provision of assistance from contingency stocks

At the same time orders must be placed to suppliers to replenish upstream contingency stocks as quickly as possible to be prepared for any other emergency.

As soon as the humanitarian organization decides to intervene, health care facilities which provide assistance to people in need can be supplied (figure 22.5). While emergency assistance is provided, all distribution centres must monitor increased demand and adjust their stock levels in order to continue assistance when the contingency stocks are depleted.

If contingency stocks are not needed, they can be shifted backwards (upstream) through the supply network and be maintained for future emergency preparedness.

This dynamic approach carries the risk that transportation and storage resources are used for moving and storing contingency stocks near to potential crisis areas but stocks are eventually not used. However this disadvantage is balanced by the advantage of reducing network stocks as well as reducing lead times and increasing responsiveness in case of the need to intervene.

Once assistance programmes have been established, humanitarian organizations must maintain emergency response stocks at national distribution centres as well as assisted health care facilities to prepare for sudden increases in demand at assisted health care facilities as

well as new demand from other health care facilities caused by increased severity of the conflict or population movements.

23 PHYSICAL DISTRIBUTION

Within the strategic distribution framework, humanitarian organizations must decide, on a tactical level, on the distribution system within available physical distribution channels and select the modes of transportation which provide the best service to humanitarian assistance programmes. Moreover to what extent transportation capacities should be outsourced and what means of transportation should be selected for in-house transport.

23.1 Distribution systems

Distribution operations can be differentiated by the extent to which consignments are processed and transformed at the distribution centres as they flow (mostly) downstream through the supply network. Consignments shipped directly to end-users bypass distribution centres and are not processed. Transhipped consignments are only temporarily stored at distribution centres but are not transformed and leave the distribution centre as they have arrived. Cross-docked goods are processed in a distribution centre without put-away or order picking. Finally warehousing is the classical distribution strategy where goods are put away, stocked and picked for filling specific customer orders (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 231).

Directly shipped goods flow through the established network but bypass at least one node, avoiding multiple handling, receiving, put-away, order picking, packing and shipment (figure 23.1).

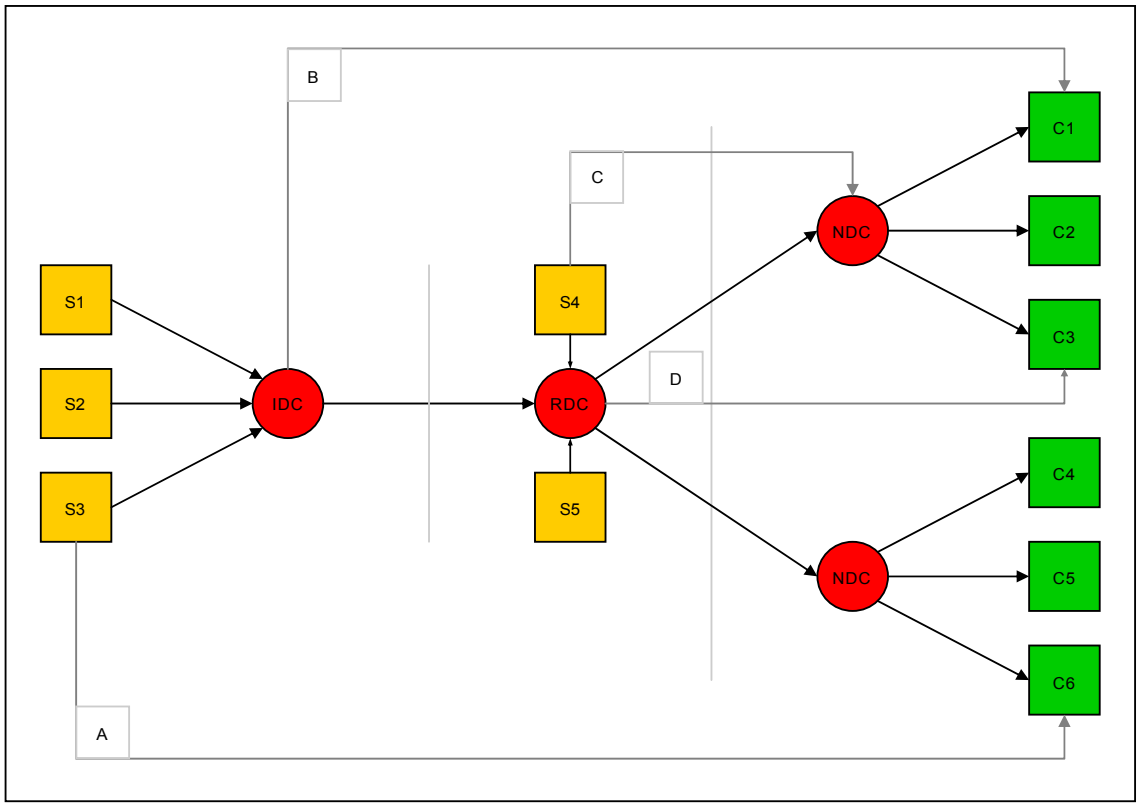

Figure 23.1 Direct shipment

For example drop shipments (Burt, D.N., D.W. Dobler, and St.L. Starling 2003, 345) of equipment which are delivered from a supplier directly to an assisted health care facility (A) or

from a supplier near a regional distribution centre directly to a national distribution centre (C). Likewise humanitarian organizations may bypass facilities within their own supply network for example by delivering consignments from the international distribution centre (B) or a regional distribution centre (D) directly to an assisted health care facility.

For urgent orders and in emergencies lead times can be reduced by shipping health care goods, which are not yet stocked at distribution centres upstream from assisted health care facilities, directly from a manufacturer or an international distribution centre to the end-user. Moreover, management of direct shipments require less resources and shipped health care goods can be tracked more easily than when flowing through a complex supply network. Direct shipments also have the advantage of eliminating demand distortion (Lee, H.L., V. Padmanabhan, and S. Whang 2004, 1883).

Since the delay caused by stock rotation at every stage of the supply network reduces the remaining shelf-life, direct shipments may be necessary for health care goods with short total and remaining shelf-life.

Direct shipments will also be preferred if transportation costs between supplying stores and end-users are low, such as replacement parts or small pieces of equipment, and humanitarian organizations can therefore not gain any significant benefits from transportation consolidation by using the established supply network. For example for countries with regular and cheap commercial international flights, supply directly from an international distribution centre may be more cost-efficient than through a regional distribution centre in the vicinity of the country receiving humanitarian assistance.

Direct shipments can also be used for health care goods which are not stocked at all stages of the supply network and for which overall network stocks should be kept low. For example expensive health care equipment, rarely used replacement parts or health care goods which are provided only once. Sensitive and fragile health care goods can be shipped directly in order to minimize handling and therefore reduce the probability of their damage.

Nevertheless, direct shipments also have a number of disadvantages. Direct shipments reduce the possibility of benefiting from transportation economies between several suppliers and the end-user (Bowersox, D.J., and D.J. Closs 1996, 483) and increase the number of consignments which need to be cleared by customs. Moreover direct shipments also reduce the volume of goods flowing through the established supply network and therefore reduce their efficiency. For example direct shipments from an international distribution centre to a national distribution centre will reduce lead times but also reduce the turnover of health care goods at the regional distribution centre supplying the national distribution centre.

Moreover goods which are stored throughout the supply network but are shipped directly, for example during an emergency, reduce the stock turnover at the stores which are bypassed. This can lead to expiry especially of contingency stocks.

Transhipped consignments are received and temporarily stored at distribution centres without being processed, that is entire consignments leave the distribution centre in the same configuration as they have arrived.

Transhipment may be necessary when the modes of transportation are changed but cannot be fully synchronized. For example consignments arriving with a commercial carrier at an international airport may require temporary storage in a distribution centre until the next road convoy is scheduled for delivery to end-users.

Transhipment is also useful for consolidating shipments of several consignments (Stadtler, H., and Ch. Kilger (ed.) 2002, 195) and reducing transportation costs, especially for international air or sea transportation over long distances. For example consignments for

several different customers which are packed at a regional distribution centre are received at a national distribution centre for separation and onward distribution to their respective final destination.

Transhipment is also necessary when the capacities of modes of transportation for successive shipping legs differ. For example if consignments are transported by truck to a national distribution centre but can be transported to end-users only by small all-terrain vehicles, small boats or small aircraft.

Since humanitarian organizations usually support only a limited number of health care facilities and these do not require large amounts of goods, cross-docking will rarely be a suitable distribution system. However cross-docking may be considered where a fairly large number of health care facilities are supplied by a small number of suppliers such as wholesalers and kind and quantities of provided health care goods are known before purchasing. In this system each supplier delivers one consignment for all health care facilities to a transhipment depot. For each health care facility the consignments from different suppliers are received, combined and consolidated into a single shipment for delivery to their final destination (Bowersox, D.J., and D.J. Closs 1996, 394). This distribution system allows consolidating outbound shipments rather than having each supplier deliver small consignments to each customer (Chopra, S., and P. Meindl 2007, 395). Where humanitarian organizations supply assisted health care facilities according to a rationing system with fixed quantities of defined goods, maintaining stocks is no longer necessary. Another cross-docking strategy would be suppliers delivering the total quantities of certain health care goods required for a defined number of health care facilities as a single consignment to a medical distribution centre. There the quantities of each item are divided up into the quantities ordered by each health care facility. After shipment no stock is left in the medical distribution centre ("picked to zero") and therefore cross-docking can be considered a "stockless inventory strategy".

At distribution centres where stocks are permanently maintained consignments will generally be put away after receiving in order to ensure stock rotation and avoid expiry of goods in stock. Transhipment of goods from an upstream distribution centre to end-users without put-away and order picking would in principle increase efficiency but also reduce turnover of stocks and therefore increase the risk of expiry before use. Therefore all items which are permanently stocked at a distribution centre need to be put-away even if orders for the same item need to be filled at the time of arrival.

Lateral transhipments are transfers of goods between facilities within the same stage of the supply network (Grahovac, J., and A. Chakravartny 2001, 582). They may be considered when the distance or transportation time between two stocks at the same stage is shorter than between the upstream stock and the stock facing a shortage (Lee, H.L. 1987, 1302).

Lateral transhipment (figure 23.2) between two national distribution centres (A) may be warranted in case of shortages or in order to reduce excess stocks (Shawkey, P., and C. Hart 2003, 75). Health care facilities may also share stocks (B) in case the upstream supply network is disrupted and the distribution centre is unable to fill orders.

As mentioned in chapter 11, humanitarian organizations require a "fast track" in case of shortages or impending stockouts. A system for rapid distribution of small consignments should be established in advance and separate from the standard distribution system (Koether, R. (ed.) 2004, 58).

Expediting shipments (Jessop, D., and A. Morrison 1994, 54) requires decisions on whether commercial or humanitarian networks are used, whether to ship consignments directly as well as which combination of modes of transportation can minimize transportation times.

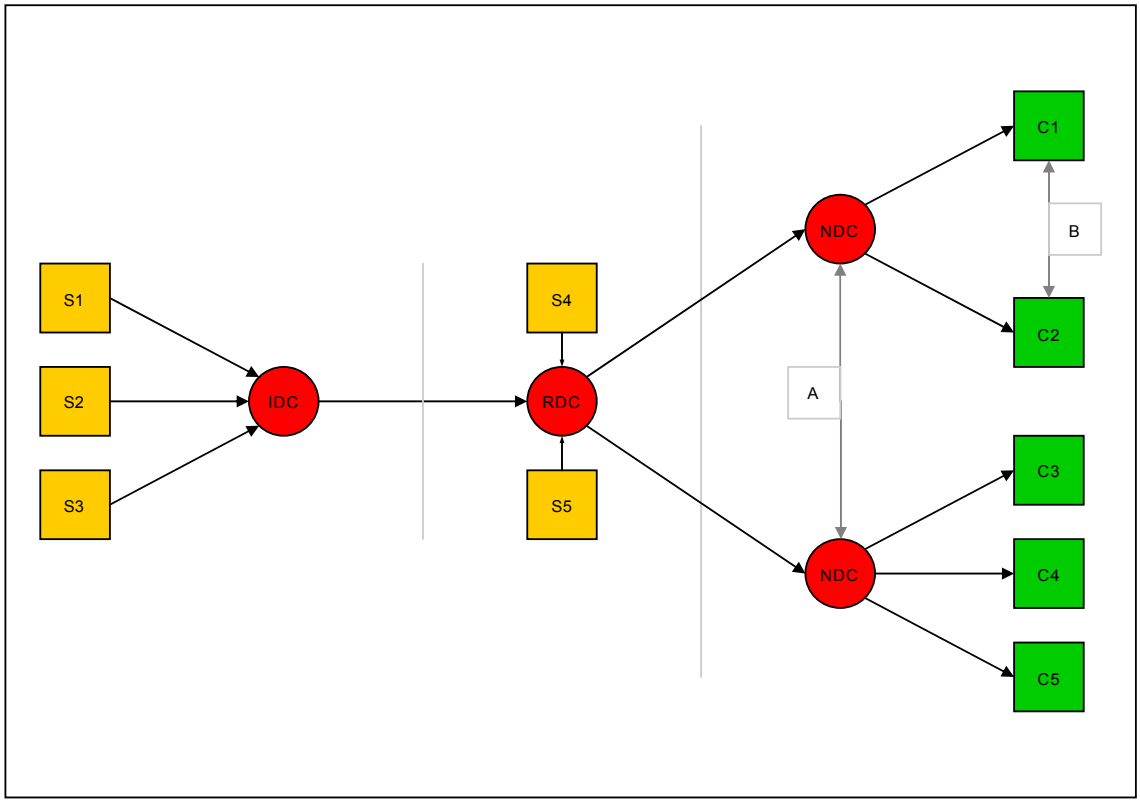

Figure 23.2 Lateral transhipment

Commercial express delivery services offer the advantages of picking up goods, high speed, reliability of transport and final delivery, tracking of consignments and possibly customs clearance in the country of delivery (Steinbuch, P.A. 2001, 288). On the other hand express delivery services are expensive and limit the weight and volume of consignments.

While express delivery services are effective at the international and regional level, services will be unavailable in most countries with ongoing complex political emergencies. Therefore humanitarian organizations must establish a system for final delivery with their own aircraft or vehicles which are available at short notice.

23.2 Importation and exportation

Customs clearance is critical for planning any logistics services. Importation and exportation procedures differ from country to country but can cause delays of weeks or even months and even make humanitarian assistance programmes impossible. Unlike delays caused by suppliers and carriers, customs services cannot be changed. As humanitarian organizations must comply with all national legislation and regulations in the country where they work, all customs regulations must be complied with. However, the World Health Organization recommends that national drug regulatory authorities should use their discretion to waive importation requirements in case of emergencies (WHO 1997a, 123).

During the initial phase of an acute crisis, customs authorities might simplify or even waive regulations and requirements in order to facilitate importation. On the other hand strictly enforced regulations might be used to discourage humanitarian organizations from operating in a country.

Customs clearance requires hiring specialized staff familiar with national legislation and regulation. Alternatively customs clearance can be outsourced by contracting commercial clearing agents for completing all necessary procedures.

23.2.1 International conventions

Several international conventions were established to facilitate customs clearance for humanitarian assistance goods during crises. However, their provisions are legally binding only for states which have acceded to the respective conventions, are signatories and therefore contracting parties.

- **Kyoto convention** International Convention on the simplification and harmonization of Customs procedures (1973)
- **A.T.A. convention** Customs Convention on the A.T.A. carnet for the temporary admission of goods (1961).
- **Istanbul convention** Convention on temporary admission (1990)
- **CCC Recommendation** Recommendation of the Customs Cooperation Council to expedite the forwarding of relief consignments in the event of disasters (1970)

Table 23.1 International customs conventions

The "International Convention on the simplification and harmonization of Customs procedures" (done at Kyoto, 18 May 1973), amended 1999 and entered into force in 2006, covers all aspects of customs legislation. However some of the annexes have implications for humanitarian assistance in natural and manmade disasters.

For certain goods which require priority treatment for customs clearance ("urgent consignments"), such as cold chain consignments, the importer or exporter can provide a request for urgent examination by customs.

Humanitarian assistance goods such as drug products and vaccines as well as rescue and medical equipment which are urgently required in disasters are also covered by the Kyoto convention. The convention also covers importation of vehicles used in humanitarian assistance.

Chapter 5 of the specific annex J on relief consignments outlines provisions customs administrations should establish for facilitating rapid customs clearance to the maximum extent possible. Customs controls should be limited to the absolute minimum required to ensure compliance with the respective national laws and regulations and all efforts should be made to expedite any processes if controls for example by health authorities, are required.

Customs authorities should give absolute priority to "relief consignments" before other goods. Simplified, provisional or incomplete goods declarations and supporting documents can be lodged and registered prior to the arrival of goods allowing them to be released upon arrival. A single goods declaration should be allowed for repeated clearance of the same type of goods by the same person and national legislation may even provide for accepting verbal declarations. Customs authorities can even release goods prior to lodging goods declarations provided that all required formalities will be subsequently completed by the declarant.

The convention also foresees clearance outside designated hours of business or away from customs offices and waiving related charges, provided that sufficient facilities and resources are available. The examination or sampling of goods should be restricted to exceptional circumstances, should be allowed in places other than customs offices and should be carried

out as quickly as possible. Payment of duties and taxes should be deferred without charging interest.

Operators should be allowed to disassemble transhipped consignments in containers or pallets and reassemble them without any need for examination or additional documentation.

The convention specifically recommends that customs authorities should waive any importation or exportation prohibitions or restrictions as well as any duties and taxes for goods which are received as gifts and distributed to recipients by approved organizations free of charge.

Temporary admission should be granted for equipment used for humanitarian assistance such as vehicles or telecommunication equipment provided that an undertaking for re-exportation is provided by the humanitarian organization.

Appendix II contains a model agreement between humanitarian organizations and states.

The "Customs convention on the A.T.A. carnet for the temporary admission of goods" (done at Brussels, 6 December 1961), also called "A.T.A. Convention" for short, facilitates the importation of goods which are granted temporary duty-free admission. The acronym is a combination of the French term "Admission temporaire" and the English term "Temporary Admission).

The convention specifies an A.T.A. carnet which can be used instead of national customs documents. This convention does not have specific provisions for humanitarian assistance. However, in cases where it applies, it allows to use the same document for crossing several borders. The A.T.A. Convention has been incorporated as annex A of the "Istanbul Convention". According to Article 27 of the convention as well as Article 19 of Annex A, the A.T.A. convention is rescinded for contracting parties which accept the provisions of Annex A and replaced by the Istanbul convention.

The "Convention on temporary admission" (done at Istanbul, 26 June 1990), which is also called "Istanbul Convention" for short, makes simplified and harmonized provisions for temporary importation of goods, including means of transportation. It does not concern humanitarian assistance in general but nevertheless contains some provisions relevant for humanitarian organizations.

All goods covered by this convention have to eventually be re-exported from the country of importation. However, the temporary admission may eventually be terminated by clearance for home use if permitted by national legislation.

Annex A contains provisions for the temporary importation of means of transportation.

The "Annex concerning professional equipment" (annex B.2) makes provisions, among others, for temporary admission of communications equipment as well as surgical and medical equipment used by health professionals (appendix III).

The "Annex concerning goods imported for humanitarian purposes" (annex B.9) covers medical, surgical and laboratory equipment as well as "relief consignments".

The "Annex concerning means of transport" (annex C) makes provisions for the temporary admission of means of transportation, spare parts and equipment for their repair.

The "Recommendation of the Customs Cooperation Council to expedite the forwarding of relief consignments in the event of disasters" recommends measures to facilitate crossing of borders for relief consignments during entry, transit and exit in "natural disasters and similar catastrophes".

Any economic exportation prohibitions or restrictions as well as any exportation duties or taxes should be waived and customs authorities should accept the written declarations of exporters at exportation. Where possible random checks should be carried out, consignments should be placed under customs seal if this can facilitate forwarding of consignments at a later stage and the carriage of consignments in customs transit should be facilitated as far as possible.

Admission should be allowed free of importation duties and taxes and free of economic importation prohibitions or restrictions and temporary admission with conditional relief from importation duties and taxes of equipment used for humanitarian assistance should be facilitated.

As far as possible clearance of relief consignments should be authorized outside usual working hours and places without levying any charges.

The respective signatories are requested to issue instructions to their customs authorities which ensure the implementation of the provisions of the recommendation.

In 1995 the Office for the Coordination of Humanitarian Affairs (OCHA) and the World Customs Organization elaborated a model customs facilitations agreement (WCO 1996) which allows expediting importation, exportation and transit of relief consignments in case of disasters and other emergencies. The agreement intends only to simplify and expedite internationally recommended customs facilitation measures rather than granting any privileges.

The model customs facilitation agreement foresees, among others, arrangements for clearance outside official working hours and designated places, waiving of charges, permission for advance lodgement of documents, use of simplified documents and inspection procedures as well as waiving any economic restrictions, duties and taxes.

23.2.2 Importation of health care goods

While any goods exported from or imported into a country must be cleared by customs, often specific laws and regulations apply (additionally) to health care goods.

The importation of sub-standard or counterfeit drug products or other health care goods can pose a danger to the population in general and many states require specific controls and procedures. Like any other organization (WHO 1997a, 211), humanitarian organizations are obliged to abide by any national (pharmaceutical) legislation and regulations in general and should support any effort by national drug regulatory authorities to assure the quality of any health care goods available in the country.

In countries with developed national drug legislation and regulations only certain drug products from certain manufacturers which are manufactured in certain countries are registered by the national drug regulatory authorities and only these can be imported, stored, distributed and sold. For importation of any other health care goods, the importer, such as a humanitarian organization, may obtain a licence from the national drug regulatory authorities which may be prohibitively expensive. Humanitarian organizations may obtain exemptions for certain health care goods only or may be able to obtain a blanket exemption.

In any case the national drug regulatory authorities may request humanitarian organizations to submit various documents such as batch certificates as well as samples for tests in quality control laboratories.

No global certification system where a drug product licensed in one country would automatically be accepted by all other countries is in place and instead every country

establishes its own national legislation and regulations. Exporting countries may apply different controls for health care goods sold in their domestic market as well as health care goods which are exported only.

Ideally any imported drug product should be registered in the country of manufacture, the manufacturing plant should be regularly inspected by the national drug regulatory authorities and every batch should undergo analysis in the manufacturer's laboratory before release. Moreover the drug product should be licensed in the country of importation and samples of every batch should undergo analysis in the country of importation.

Since the required resources are often not available, the World Health Organization has in 1975 adopted and in 1988 revised the "WHO Certification Scheme on the Quality of Pharmaceutical Products Moving in International Commerce" (WHO 1997b) which allows importing countries to obtain at least partial assurance that imported drug products are licensed, have received a marketing authorization in the country of manufacture and are of acceptable quality.

- Regulatory status of the drug product in the exporting country.
- Regulatory status of the manufacturer of the drug product in the exporting country.
- Quality of individual batches of the exported drug product.
- Product information approved by national drug regulatory authorities in the country of export.

Table 23.2 Information for importing countries

Each member state determines its capacity to fulfil the necessary requirements by self-evaluation and no external inspections or assessments are foreseen. This scheme relies on the competency of and the good faith in the national drug regulatory authorities of the exporting country and is therefore no absolute guarantee for the quality of drug products (Broun, D. 1994, 16).

Under this scheme national drug regulatory authorities of importing countries can obtain assurances from the national drug regulatory authorities of the exporting country that the respective drug product has been licensed for sale in the exporting country or obtain information why the marketing authorization was rejected with a simple administrative procedure. Moreover, the importing country can obtain assurances that the manufacturing plant is regularly inspected by the national drug regulatory authorities of the exporting country and that the manufacturing plant complies with the requirements of national regulations. The importing country can also obtain all information as well as labelling on packaging and package inserts which the manufacturer provided to the national drug regulatory authorities of the exporting country as well as the dates of their approval. Under this scheme the importing and exporting countries exchange information on inspection and control systems as well as on any serious quality defects. However the quality of the product certification is only as reliable as the national drug regulatory authority which issues the certification and manufacturing plants which exclusively produce for exportation may not be scrutinized as carefully as those producing for the domestic market (Quick, J.D. (ed.) 1997, 279).

Importing countries can request the marketing authorization, statement of licensing status of pharmaceutical products and batch certificates of pharmaceutical products.

The World Health Organization also endorsed the "Guidelines for implementation of the WHO Certification Scheme on the Quality of Pharmaceutical Products Moving in International Commerce" (WHO 1996d, Annex 10).

23.2.3 Internationally controlled drug products

Drug products such as some anaesthetics, analgesics, narcotics, stimulants, sedatives, hypnotics and tranquilizers which can be abused and can cause a state of dependence are governed by special international conventions which regulate importation and exportation.

The conventions listed in table 23.3 concern the illicit use of narcotic drugs and psychotropic substances as well as drug products which can be abused for the manufacture of illicit substances covered by the conventions and has, as of July 2007, 183 signatories.

- Single Convention on Narcotic Drugs, 1961 (amended 1972) → *Yellow List*
- Convention on Psychotropic Substances, 1971 → *Green List*
- United Nations Convention against illicit Traffic in Narcotic Drugs and Psychotropic Substances, 1988 → *Red List*

Table 23.3 Conventions regarding internationally controlled drug products

States which have acceded to these conventions must adopt national legislation and administrative regulations which ensure implementation of the convention's provisions.

Fundamentally the conventions ensure that narcotic drugs and psychotropic substances are imported and exported only with the knowledge and written consent of the importing and exporting state. This prevents diversion by legally exporting internationally controlled drug products from one country and illegally importing them in another country while avoiding unnecessary delays in licit (lawful) trade.

Customs clearance of internationally controlled drug products requires applying for and obtaining a written authorization for importation from the competent authorities of the importing country. Upon presentation of the original import certificate (for narcotic drug products) or import authorization (for psychotropic substances) by the exporter the competent authorities of the exporting country may issue a permit for exportation.

Upon exportation as well as importation copies of the respective documents must be presented to the customs authorities which will ensure that the drug products and quantities of the importation and exportation documents correspond to each other. Moreover the competent authorities will inspect consignments, determine the type and quantities of drug products and compare them with the shipping documents as well as the respective importation and exportation permits.

The importation and exportation permits should contain the international nonproprietary name of the drug products, the dosage form, their respective quantities, the name and address of the importer and exporter as well as the validity of the importation and exportation permits. In addition the export permit should indicate the number and date of the corresponding importation permit and the name of the competent authorities of the importing countries by whom they were issued. The competent authorities of the importing country may indicate the point of entry where the respective consignments must be imported in the importation permit.

The conventions are administered by the International Narcotics Control Board which compile and publish annual statistics.

The conventions also applies to any kits which contain drug products covered by the convention.

The "Single Convention on Narcotic Drugs" ("1961 Convention"), amended by a protocol in 1972, aims at reducing the spread of the illicit use of drugs while ensuring the availability of narcotic drug products for treatment of medical conditions. Parties to the convention furnish reports to the International Narcotics Control Board on production, manufacture, consumption, importation and exportation as well as stocks of drug products regulated by the convention. States should ensure that trade and distribution of the concerned drug products are carried out under licence.

Each importation or exportation of a consignment of drug products covered by Schedule I and II should require a separate authorization and the government issuing the export authorization should send a copy to the Government of the importing country. The importing country should indicate the actually imported quantities and return the endorsed export authorization to the government of the exporting country once the importation is completed or if the period fixed for importation has expired. Any consignment entering or leaving the territory of a party to the convention without appropriate documentation should be detained by the competent authorities.

The competent authorities should control persons and enterprises engaged in as well as establishments and premises used for trade and distribution of drug products. Any dispensing of or supply to patients should require a medical prescription.

The carriage of limited amounts of internationally controlled drug products on aircraft or ships for providing emergency medical treatment are not considered as importation, transit or exportation. However measures must be taken to prevent improper use and diversion.

The competent authorities must ensure that all licence holders are adequately qualified for carrying out the provisions of the law. Authorities, manufacturers, traders and hospitals must record each receipt and issue as well as disposal of drug products and maintain such records for at least two years.

The drugs covered by the convention are divided into four classes called "schedules" and the "Yellow list" is amended from time to time. All measures of control apply to drugs listed in Schedule I of the convention.

Under the convention drugs in Schedule II do not require prescriptions for supply or dispensing to individuals.

Drug molecule	Use	Class
Fentanyl	Opioid analgesic	Schedule I
Morphine	Opioid analgesic	Schedule I
Pethidine	Opioid analgesic	Schedule I
Codeine	Opioid analgesic	Schedule II

Table 23.4 Examples of drugs covered by the 1961 Convention

In general the convention applies to narcotic drugs as well as any preparations or drug products containing these narcotic drugs. However preparations which contain narcotic drugs in concentrations below defined levels and which are listed in Schedule III are exempted from some provisions. For example they do not require importation and exportation under licence and states need to provide only limited statistics reports to the International Narcotics Control Board .

States may prohibit the production, manufacture, exportation, importation, trade and possession of narcotic drugs in Schedule IV.

Parties to the "Convention on Psychotropic Substances" ("1971 Convention") should limit the manufacture, exportation, importation, distribution, storage, trade, possession and use of psychotropic substances to medical and scientific purposes and take all practical measures to prevent abuse. Drug products are subject to the same measures of control as the psychotropic substances which they contain. The substances covered under the convention are updated from time to time and published in the "Green List".

Any importation or exportation should require a separate authorization stating the international nonproprietary name, the quantity, dosage form and strength of dosage unit, the name and address of the exporter or importer as well as the period for which the authorization is valid. In addition export authorizations should state the number and date of as well as the authority which has issued the import authorization. The issuing of an export authorization should require presentation of an import authorization. Every consignment should be accompanied by the respective export authorization. The competent authorities of the importing country should indicate the imported quantity on the export authorization and return it to the government of the exporting country.

The manufacture, trade, storage, distribution and possession of psychotropic substances listed in Schedule I should be under licence and persons obtaining licences must be adequately qualified. The amounts of psychotropic substances supplied to authorized persons should be limited to the quantity required for this authorized purposes. Any establishments used for trade or distribution should be controlled under licence and the competent authorities should ensure that security measures are taken at such establishments to prevent theft or other diversion of stocks.

Health professionals should be obliged to keep records on acquisition and use of drug products containing psychotropic substances and keep such records for at least two years. Supplying or dispensing drug products for use by individuals should require a medical prescription.

Any authorized person holding a licence as well as health care facilities should be obliged to maintain records which indicate the date, quantity, supplier or recipient for each receipt and stock issue as well as the stock on hand.

Drug molecule	Use	Class
Pentacozine	Analgesic	Schedule III
Clonazepam	Sedative, anticonvulsant, antiepileptic	Schedule IV
Diazepam	Sedative, anticonvulsant, antiepileptic	Schedule IV
Phenobarbital	Anticonvulsant	Schedule IV

Table 23.5 Examples of drugs covered by the 1971 Convention

Parties may prohibit the importation and exportation of certain psychotropic drugs altogether and notify all the other parties. All other parties should consequently take measures

to prevent exportation of these psychotropic drugs which are listed in part four of the "Green List" to the state which has prohibited its importation.

Except for psychotropic substances of Schedule I, the transportation across international borders of limited quantities intended for emergency medical treatment on aircraft and ships should not be considered as importation or exportation. The administration of drug products containing psychotropic substances in medical emergencies does not require a prescription.

Parties to the convention should ensure regular inspection of premises, stocks as well as records of manufacturers, exporters, importers, wholesalers, retail distributors as well as health care facilities.

The International Narcotics Control Board should receive annual statistical reports on the manufactured, imported, exported and stocked quantities.

The "United Nations Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances" ("1988 Convention") intends to promote cooperation in preventing international illicit traffic.

Under the convention states are required to establish national legislation which makes any contravention against the Single Convention on Narcotic Drugs as well as the Convention on Psychotropic Substances a criminal offence. Moreover the possession of equipment and materials which can be used for the illegal manufacturing of drugs should also be prohibited under domestic law and such equipment and materials should be confiscated.

This convention is significant for health care logisticians as some drug products contain precursors and some diagnostic reagents contain chemicals which can be abused for the illicit manufacture of narcotic drugs or psychotropic substances. For example ephedrine is a precursor for methamphetamine and ergometrine can be used for the illicit manufacture of lysergic acid diethylamide (LSD). However the following provisions explicitly do not apply to drug products which are compounded in a way that the contained substances cannot be easily used or recovered.

Drug molecule	Use	Class
Ephedrine	Prevention of hypotension during spinal anaesthesia	Table I
Ergometrine	Oxytocic drug product	Table I
Ergotamine	Antimigraine drug product	Table I
Acetone	Laboratory chemical	Table II
Hydrochloric acid	Laboratory chemical	Table II
Potassium permanganate	Topical anti-infective, antifungal	Table II

Table 23.6 Examples of substances covered by the 1988 Convention

Parties should take measures to prevent the diversion of substances listed in Table I and II which are updated from time to time in the "Red List". Measures should be taken to monitor international trade of these substances and notify concerned parties if there is reason to believe that importation or exportation of such substances are destined for illicit manufacture of narcotic drugs or psychotropic substances.

Imported and exported consignments should be properly labelled and transportation, shipping and customs documents must indicate the respective substances and their quantities as well as the name and address of exporter, importer and consignee. All documents must be maintained for at least two years and made available for inspection by the competent authorities.

The World Health Organization (WHO) has tried to address the problem of a sudden increase in needs and and for quick importation of internationally controlled drug products after natural or manmade disasters with a proposal for a "Model guidelines for the international provision of controlled medicines for emergency medical care" (WHO 1996c). Compliance with international regulations requires time and the competent authorities in the country of importation may not be available or accessible.

In emergencies, these model guidelines would allow certain commercial suppliers to make international shipments of internationally controlled drug products at the request of recognized humanitarian organizations without obtaining import permits (WHO 1996c, 2). A limited number of competent suppliers of high quality drug products which have sufficient stock, have the experience to assess the request by the respective humanitarian organization and have knowledge of the applicable international convention would engage in a standard agreement with and be controlled (only) by the competent authorities of the exporting country.

The humanitarian organization ("operator") must be credible, provide a statement of the nature of the emergency as well as the (un)availability of the competent authorities in the receiving country (WHO 1996c, 5).

While the need for an import permit or authorization would not be required, the competent authorities in the country of importation would have to be notified as soon as possible by the regulatory authorities of the exporting country.

23.2.4 Managing the effects of sanctions

In order to maintain or restore international peace and security, the United Nations Security Council may impose sanctions under Chapter VII of the United Nations Charter rather than resort to the use of armed force.

- Iraq/Kuwait 1990, 1991.
- Former Yugoslavia 1991, 1992, 1993, 1994.
- Haiti 1994.
- Sudan 1996.

Table 23.7 Examples of sanctions which affected humanitarian assistance

Sanctions may concern communications, culture and sports, development assistance, diplomatic contacts, finances, arms and military cooperation, trade as well as transportation (Minear, L., et al. 1998, 8).

While the political changes intended by sanctions may or may not be achieved, the population in general will inevitably be negatively affected and humanitarian assistance can be hampered or delayed even if usually provisions for "humanitarian exemptions" are made in the sanction regimes.

- **Communications**: Telephone, Internet, postal services.
- **Diplomacy**: diplomatic and political isolation, visa restrictions, travel restrictions, withdrawal of diplomatic. personnel, withdrawal of international organizations.
- **Development assistance**: reduction or cancellation of programmes, withdrawal of funding.
- **Finances**: freezing of assets, restriction of loans, prohibition of investments.
- **Trade**: restrictions on importation and/or exportation.
- **Transportation**: restrictions or prohibition of air travel, restrictions on sea transportation, blocking of international borders.

Table 23.8 Type of sanctions which may affect humanitarian assistance

Humanitarian organizations must abide by the United Nations Security Council resolutions and follow the procedures for obtaining exemptions from the United Nations Sanctions Committee or regional sanction authorities.

The exportation and importation of humanitarian assistance goods covered by the sanctions from and into countries on which sanctions have been imposed requires obtaining a permission from sanction committees authorized by the United Nations Security Council. However it may be sufficient for humanitarian organizations to simply notify the sanction committees or sanction committees may grant blanket exemptions for humanitarian assistance goods in general or for certain humanitarian organizations.

International organizations can approach the sanctions committee directly while NGOs have only indirect access through member states of the United Nations.

Donors might also require more accurate reporting by humanitarian organizations in order to ensure that their donations are not abused by the sanctioned state for circumventing sanctions.

23.3 Selection of mode of transportation

At the level of supply chain planning, selection of a mode of transportation will depend on the situation and context in the country or area where humanitarian assistance programmes are being implemented, availability of means of transportation, customer service requirements as well as characteristics of consignments and health care goods (Larragán, A.A., et al. 1998, 67).

For international distribution, which requires intermodal transportation, decisions on the mode of transportation and the length of their respective legs are required.

The same mode of transportation may be used for entire consignments or differ according to certain characteristics of health care goods.

While the selection of modes of transportation is also an operational decision, tactical decisions are necessary where mid- or long-term contracts are concluded with carriers (Chopra, S., and P. Meindl 2007, 399). Apart from the traditional modes of motor transport by road, rail, water and air (Pfohl, H.Ch. 2000, 167) transportation with bicycles, pack-animals and transporting by people need to be considered (23.3). Pipelines are practical only for transporting water over short distances. Advantages and disadvantages of different modes of transportation are summarized in table 23.9.

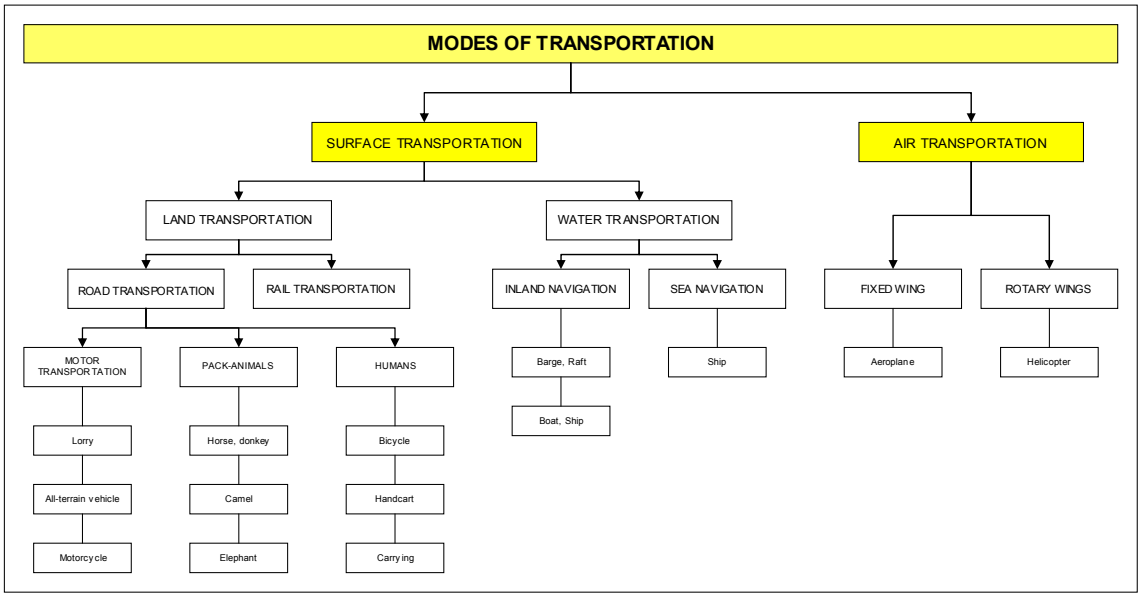

Figure 23.3 Modes of transportation

Road networks, although of varying extent and quality, as well as motor vehicles, fuel and drivers are available in most inhabited places in the world. However road conditions may restrict the size of motor vehicles which can be used and for some routes only expensive all-terrain vehicles can be used. National legislation and regulations concerning vehicles and drivers, with which humanitarian organizations must comply, may pose constraints but are often weak and not enforced.

Figure 23.4 Sealing of ISO shipping container

In terms of capacity, routing and scheduling, road transportation offers the greatest flexibility (Larragán, A.A., et al. 1998, 69). Road transportation can cover long distances, is comparatively cheap, fairly fast and allows transporting large consignments from the supplier directly to the customer without any need for further handling or any restrictions on

schedules. Door-to-door delivery also reduces the risk of parcels being lost or shipped to the wrong destination.

Temperature sensitive goods can be transported in heated or cooled compartments. Large, heavy and bulky goods as well as dangerous goods such as compressed gases or flammable liquids can be transported by road. Trucks allow quickly moving and transporting entire unit loads such as pallets or ISO shipping containers.

Mode of transportation	Advantages	Disadvantages
Motor transport	General availability of road networks. General availability of vehicles and drivers. Low cost. Fairly fast. Flexibility. Point-to-point delivery. No restrictions on type of goods. Transportation of large volumes and weights. Possibility of temperature control. Possibility to move pallets and containers. Security of consignments.	National legislation and regulations. Often poor quality of road networks. Congestion of roads. Congestion of border crossings. Often no transportation during the night possible. Vulnerable to attacks and looting. Vulnerable to mines.
Pack-animals	Low cost. Do not require roads. No need for fuel or replacement parts.	Slow. Limited capacity. Need to split consignments. Special protection of consignments from weather required.
People	Availability. Low cost. Do not require roads.	Hard work. Requires providing sufficient water and food. Limited capacity. Need to split consignments. Difficulty of tracking consignments.
Rail transport	Very low cost. Fairly fast. Transportation over long distances possible. Transportation of large volumes and weights. Exact schedules. Reliability. Low probability of congestion.	Limited networks. Possibly high prices through monopolies. Often poor quality of services. Possibly infrequent services. Only terminal-to-terminal delivery possible. Damage through shunting. Risk of blocked routes. Vulnerable to attacks and looting.
Water transport	Low cost. Reliability. Transportation of large volumes and weights.	Slow. Dependency on schedules. Requires multiple handling. Limited to water ways and the sea. Requires seaports. Dependency on meteorological conditions.
Air transportation (fixed wing)	High speed. Can cover long distances. Can overcome obstacles.	Limited number of airports and airstrips. Dependency on schedules. Possibly low frequency.

	Reliability. Safety of consignments. Little danger of damage to consignments. Security (compared to land transportation).	Dependency on meteorological conditions. Limited capacity of small aircraft. Strictly regulated industry. Requires overflight and landing permission. Requires registration and licensing. Requires air traffic control services. Dependency on authorities. Requires high quality fuel. Requires sophisticated maintenance. Potential problem of airline safety. Vulnerable to attacks. High costs for war risk insurance. Potential congestion at airports. Requires multiple handling of consignments. Possible delays through custom clearance.
Air transportation (helicopters)	Fairly high speed. Flexibility. Independence from infrastructure.	Very high cost. Low pay loads. High maintenance requirements.

Table 23.9 Advantages and disadvantages of different modes of transportation

Consignments are fairly well protected from theft as vehicles can be sealed, the driver is accountable for complete delivery and goods cannot be lost during change of mode of transportation.

Transportation times can be increased significantly by congestion, especially at border crossing points as well as adverse weather conditions. Poorly maintained roads increase safety risks for drivers and may require use of expensive all-terrain vehicles.

Roads can easily be mined or blocked by parties to the conflict or criminals, motor vehicles are vulnerable to military attacks and looting and use of road transportation during the night is often too dangerous.

Where roads are not available, pack-animals such as horses, donkeys, mules, camels or elephants allow to transport goods through mountainous or dessert terrain and shallow rivers at low cost. Transportation is independent of fuel and replacement parts although fodder might have to be carried to feed the animals along their itinerary.

However, pack-animals are slow, their load capacity is limited (PAHO 2001a, 112) and consignments have to be split into small loads and loaded on each pack-animal.

People can transport goods on bicycles, carts (UNHCR 2000, 256) or by carrying loads. People are always available, no assets or infrastructure are required and transportation costs are low. While goods can be transported in remote areas, through jungles or steep terrain, the capacity is limited, transportation is slow and distances limited. The splitting of consignments into many small parcels (Dörner, G. (ed.) 1992, 26) makes tracking and tracing difficult. Moreover people must be well nourished and be provided with adequate and sufficient water and food.

Rail transportation is fairly fast, independent of road networks and their quality, very cost efficient and allows transporting large volumes and weights over long distances (Ehrmann, H. 2003, 25 and Stabenau, H. 2004, 214). Transportation is carried out according to predetermined schedules and rail networks are not as prone to congestion as road networks.

However, rail networks are often limited and inflexible in less developed countries, loading and unloading is restricted to railheads and the quality of equipment and services is often poor (Larragán, A.A., et al. 1998, 70). Humanitarian organizations are dependent on schedules and possibly infrequent services. Where a single operator, for example a state company, offers services, prices may be unreasonably high. Transportation from a supplier to a customer requires at least three legs, multiple handling and goods are prone to damage through shunting shocks (Rushton, A., J. Oxley, and Ph. Croucher 2000, 341).

Rail roads can easily be damaged and blocked, and, unlike vehicles, trains cannot drive round obstacles and are vulnerable to attacks and looting.

Water transportation is very cost efficient over long distances can move large volumes and weights (Larragán, A.A. et al. 1998, 70), is fairly reliable and, except for canals, waterways do not require maintenance. Small boats are very flexible and a fairly fast means of transportation.

However transportation by ships and boats is limited to navigable rivers, lakes, canals as well as coastal water and the sea (Lambert, R.S., and J.R. Stock 1993, 173), may be restricted by water levels and meteorological conditions, is fairly slow and usually dependent on schedules. Larger ships require port infrastructure for loading and unloading, consignments must be double-handled and significant delays can be caused by port operations as well as customs clearance (Chopra, S., and P. Meindl 2007, 391).

The main advantages of air transportation are its speed and reliability which allow reducing safety stocks (Pfohl, H.Ch. 2000, 172) as well as the ability to cover long distances. Moreover aircraft can overcome obstacles such as mountains or damaged roads, can travel directly to their destination and operate in remote areas without any other transportation infrastructure (Jones, K. 2005, 92).

The danger of damage to and pilferage of consignments is comparatively low and less sturdy packing is required (Pfohl, H.Ch. 2000, 172). Except during take-off and landing, aircraft are not very vulnerable to attacks with unsophisticated weapons.

However air transportation is expensive, limited by available airports and airstrips and dependent on meteorological conditions (Larragán, A.A. et al. 1998, 67). The frequency of scheduled flights may be quite limited for certain routes and significant delays can occur when transportation is postponed due to lack of transportation capacity. Small passenger aircraft, which are often used by humanitarian organizations, have limited capacity for cargo and flights can be restricted by meteorological conditions. Where helicopters are not available in the country, movement across a large distance for deployment may either take days or weeks or incur high transportation costs for shipment in a fixed wing cargo aircraft.

Air transportation is a heavily regulated industry and the use of airspace requires approval of the respective state authorities (Kummer, S., and H.-J. Schramm 2004, 218). Air operations generally require air traffic control services and aircraft as well as crews require registration and licensing in the country of operation. Consequently the operation of aircraft is heavily dependent on authorities who can deny or revoke overflight and landing rights at any time.

Aircraft require careful maintenance by qualified staff as well as high quality fuel. For every hour of flight, helicopters require several hours of maintenance and therefore significant human, technical and financial resources. Where national authorities are absent or do not enforce regulations, use of commercial air carriers can be risky. Aircraft are very vulnerable to attacks, even with unsophisticated weapons, during take-off and landing and the high cost of aircraft incurs high costs for war risk insurance. Some goods cannot be transported for security reasons at all (for example compressed gases) or only in limited quantities.

International transportation is delayed by customs clearance (Rushton, A., J. Oxley, and Ph. Croucher 2000, 341) and overall transportation time is increased by the need for multiple handling for transporting consignments to and from airports. Especially in acute emergencies airports often are bottlenecks which become congested and can cause significant delays for transportation.

Criteria for selecting a mode of transportation can be related to external factors, customer service requirements as well as physical attributes of goods and consignments (Rushton, A., J. Oxley, and Ph. Croucher 2000, 343). The characteristics of different modes of transportation will also influence their selection in a given context and under given constraints.

The availability of infrastructure such as road and rail networks, ports or airports as well as transportation means, operators such as pilots, maintenance facilities and fuel are external constraints for the selection of means of transportation. Humanitarian organizations may be forced to use cheaper and slower modes of transportation due to lack of funding (PAHO 2001a, 110) or may prefer using scarce financial resources for other purposes.

The ease of obtaining and the risk of revocation of permits such as licences for vehicles or overflight and landing rights are important considerations even where means of transportation are readily available. For example, the use of aircraft is more prone to interference by authorities or parties to the conflicts than road transport. Delays for customs clearance at international airports as well as multiple handling can lead to overall longer transportation times than using road transportation for the same route.

The primary concern in selecting modes of transportation is the security of staff, goods and assets. The ease and likelihood of attacks as well as theft of goods need to be considered. Depending on the situation, air transportation may be safer where attacks on road convoys are likely or more unsafe where parties to the conflict have the means of attacking aircraft.

Safety of staff is a further important consideration. For example humanitarian organizations may refrain from using commercial air carriers because of their poor safety records.

The complexity, required resources, capacity and cost for operating different means of transportation can also be a determining factor. Although aircraft, especially helicopters, may be the preferred mode of transportation in a given context, the required resources for ensuring safe operations, air traffic control, obtaining clearances, managing the aircraft, providing replacement parts and high quality fuel may be prohibitive.

In cases where the capacity of different means of transportation is limited, the importance of speed will decrease. While aircraft travel faster the capacity of helicopters and light aircraft is limited, possibly requiring many rotations over a period of several days. Consequently a vehicle or convoy which can transport the entire consignment at once may overall be faster.

The flexibility, frequency of scheduled transportation and reliability are also important considerations (Bowersox, D.J., and D.J. Closs 1996, 325). Road transportation is much more flexible than air transportation since it does not require obtaining clearances. The use of small aircraft may be the preferred means of transportation but limit the size and load unitization of goods. The use of daily road transportation services may be faster than commercial air transportation with unreliable schedules or which is available only once a week. Air transportation schedules are prone to changes at short notice due to changes in priority of consignments.

The overall convenience of the entire transportation operation from the supplier to the customer as well as the environmental impact of means of transportation also need to be considered.

Selected modes of transportation, especially for the final leg, must be effective and allow serving a customer in a given location. In extreme situations pack-animals or small boats may be the only means of transportation which allow serving a customer.

The distance between supplier and customer as well as the lead time required by customers also determine the selection. The need to accurately track and trace (critical) goods favours use of express services even where lead time is not critical.

MODE OF TRANSPORT / REQUIREMENT / ATTRIBUTE	ROAD	RAIL	WATER	AIR
Availability of infrastructure				
Availability of transport means				
Availability of operators				
Availability of fuel and maintenance				
Scarcity of donor funds	●	●	●	
Restrictions by authorities and difficulties to obtain permits	●	●	●	
Ease of and time for custom clearance				
Security				
Safety				●
Low resources and complexity of operating transport means	●	●	●	
Requirement for large transport capacities				
High cost-efficiency	●	●	●	
Flexibility				
Frequency				
Reliability				
Overall convenience				
Environmental impact		●	●	
Effectiveness				
Long distance between supplier and customer		●	●	●
Requirement for short customer lead times	●			●
Need to reduce stock levels				●
Need for tracking and tracing	●			●
High annual transport volume and weight	●	●	●	
Unpredictability and high criticality				●
High volume and weight of items	●	●	●	
High value density				●
Requirement for special packing (dangerous goods)	●	●	●	
Susceptibility to damage by temperature	●			●
Susceptibility to physical damage				●
Perishability and short remaining shelf life				●
Susceptibility to theft and looting				
HIgh weight and volume of consignments	●	●	●	
Load unitization	●	●	●	

● Favours

Depends on context and situation

Figure 23.5 Selection criteria for modes of transportation

Unpredictability of demand (Pfohl, H.Ch. 2000, 173) and high criticality of items favour use of faster means of transportation. As discussed above, maintaining a customer service level below 100% requires a fast distribution mode, even at higher costs. While routine

consignments for stock replenishment are shipped with a slow mode, expediting goods for which the hastening level is reached or urgently requested non-stock items require a fast mode of transportation combined with direct shipment to the end-user. Combining two modes of transportation allows benefiting from lower transportation costs for the majority of demand while maintaining responsiveness by using a fast mode of transportation when needed (Moinzadeh, K., and St. Nahmias 1998, 761).

The volume and weight of annual demand rather than for an individual item, as well as annual transportation costs are important considerations. Heavy and bulky, but rarely ordered items such autoclaves may warrant use of air transportation while slower and cheaper modes of transportation will be preferred for small and light items, such as single use syringes with high annual transportation volumes. However the trade-off between annual transportation and annual storage costs (Chopra, S., and P. Meindl 2007, 400) as well as requirements to minimize stock levels must also be considered.

The volume, weight, size and shape of items need to be considered (Gattorna, J. (ed.) 1990, 326) and may exclude certain modes of transportation such as the use of small aircraft or pack-animals. In general high value items will warrant use of more expensive modes of transportation. The density and value density rather than the volume or weight per item unit may determine the mode of transportation (Rushton, A., J. Oxley, and Ph. Croucher 2000, 338). For example air transportation may be warranted for an expensive vaccine but not for a low value item with the same weight such as a bandage. On the other hand light weight and bulky but expensive items may nevertheless warrant air transportation. Road transportation will be preferable for light but bulky items such as single use medical devices.

Air transportation of health care goods with certain characteristics such as compressed gases, volatile anaesthetics, flammable or corrosive goods may be prohibited or limited to maximum amounts. Even where air transportation is possible, the availability and cost of specialized packaging may favour surface transportation.

The susceptibility of certain health care goods to temperature and humidity (Dörner, G. (ed.) 1992, 17) as well as a short remaining shelf-life favours faster means of transportation while susceptibility to physical damage favours more gentle transportation by air or small vehicles. Goods prone to theft, such as valuable items or internationally controlled drug products, require transportation with the most secure mode of transportation.

The overall weight and volume of consignments as well as the load unitization also determine suitable modes of transportation.

Logistics managers need to first consider the most secure and safest modes of transportation and then select the mode of transportation which allows providing the required customer service at the lowest possible cost (Rushton, A., J. Oxley, and Ph. Croucher 2000, 336).

Outside the crisis area the most efficient mode of transportation should be chosen. Within the crisis area the safest rather than the fastest or most efficient mode of transportation should be selected. For example, air transportation may be safer than crossing through the conflict area by road. On the other hand civilian aircraft may easily become targets and therefore be unsafe to operate.

The main objective of logistics managers in the crisis area is to minimize the risk for staff, assets and goods during distribution. The priority is avoiding conflict related risks but safety risks caused by poorly maintained infrastructure such as roads or airports as well as unsafe means of transportation, especially aircraft, must also be considered. The security and safety of transportation takes priority over minimizing transportation distances or transportation time. Long detours, even taking several days, may be warranted to avoid security risks or the

use of unsafe infrastructure such as a damaged bridge. Road transportation may be preferred to available air transportation if either aircraft or airport infrastructure are considered unsafe, even if transportation time increases significantly.

Maintaining the quality of transported goods throughout the physical distribution process is also a priority. Sensitive health care goods must be protected from adverse effects such as heat, cold or physical damage during transportation, requiring use of faster modes of transportation or use of special means of transportation such as refrigerated containers.

Since availability of modes of transportation and the context will change as goods are distributed throughout the supply network, generally several modes of transportation will be used and require a decision where to change between modes of transportation. Some considerations for selecting modes of transportation are summarized in figure 23.5.

In order to avoid dependency, wherever possible an alternative mode of transportation should be planned in case the preferred mode of transportation is not available.

If slower modes of transportation are used for routine replenishment of medical stores and health care facilities, provisions for expediting urgently needed consignments must also be established.

In a given context and situation, long distances between suppliers and customers, the requirement for short lead times and reduction of safety stock levels, the need to track and trace consignments, high unpredictability of demand, high value density, small consignments as well as susceptibility of goods to damage favour shorter transportation times and therefore air transportation. However because of its high cost the use of air transportation should be considered carefully (Ockwell, R. A. 1994, 435), at least for transportation between neighbouring countries as well as for domestic transportation.

High volumes and weights of items as well as annual distribution volumes, transportation of hazardous goods, transportation of palletized goods as well as the need to reduce transportation costs favour the use of surface transportation.

For several aspects such as reliability, flexibility or the susceptibility to theft and looting the most suitable mode of transportation will depend on the circumstances and situation of the respective humanitarian assistance programme.

23.4 Outsourcing of transportation capacities

Even humanitarian organizations which have taken a strategic decision to acquire and maintain their own means of transportation, will rarely rely on in-house transport for distribution of all humanitarian assistance goods throughout their entire supply network. On the other hand complete outsourcing of all transport will not always be possible due to unavailability of means of transportation or lack of security for commercial carriers.

While the criteria discussed in chapter 11.4 are valid, the context and situation will influence the tactical decision what transportation operations throughout the supply network to outsource. The geographic area and distance, local legislation and regulations, characteristics of shipped goods, required transportation capacity, length of operation, security situation as well as quality, cost and efficiency of available services are possible criteria for partial outsourcing. Carriers may be paid per consignments or shipment (contract hire) or humanitarian organizations may contract means of transportation for exclusive use for a certain period of time (dedicated services), such as chartering an aircraft.

Except for charter flights during the initial emergency phase, humanitarian organizations could not afford operation of their own aircraft and ships for all international transport.

Because of the variability of transport volumes and lack of cargo on return trips, operation of transportation means would also not be cost-efficient. Consequently humanitarian organizations need to use commercial transport up to the country where humanitarian assistance is provided and possibly for domestic transportation to the crisis area.

Sourcing transportation services for each consignment has the advantage of being able to select the carrier offering the best price and service but is also time consuming, especially for a large number of small consignments. Alternatively all international transportation can be outsourced to a single carrier, provided the transportation network extends to all or at least most of the countries where humanitarian organizations are providing assistance. Using services of a single carrier may increase transportation costs for some shipments and lead to dependency, but also reduces time and resources for searching carriers and purchasing services. A single carrier can also be contracted for worldwide shipment of certain goods such as cold chain items.

Within the country and the crisis area where humanitarian assistance is provided, outsourcing of transportation services can be considered provided that carriers are available and the security situation allows them to operate.

However the complete outsourcing of all transportation also entails dependency on an often limited number of commercial carriers (UNHCR 2000, 255) and the sudden interruption of commercial transportation would stop supply to assisted health care facilities. Moreover humanitarian organizations may have the competency for limited transportation capacities in case of emergencies while commercial carriers might not be able to provide transportation services at short notices in case of emergencies. On the other hand relying entirely on in-house transportation resources also carries the risk of dependency and shortages in case of technical problems with transportation means or shortages of staff.

The compromise of combining in-house and outsourced transportation capacities should be considered (Chopra, S., and P. Meindl 2007, 410). In-house transportation capacities should ensure regular supply of assisted health care facilities at least with all essential health care goods even if transportation costs are higher than for commercial transport. Maintaining transportation capacities permanently also allows maintaining the resources and expertise for their operation. Minimal transportation capacities are also mandatory for ensuring an immediate response to emergencies as well as for evacuating or relocating staff at any time (Mayhew, B. 2004, 40).

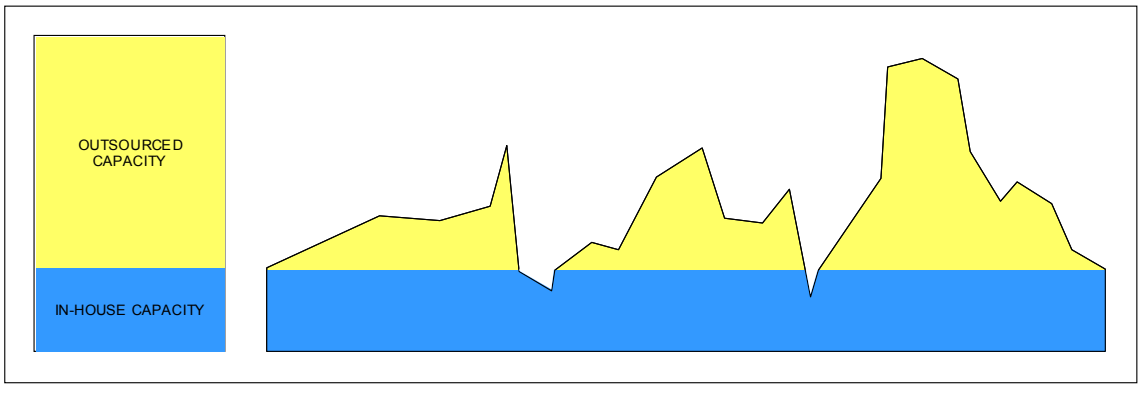

Figure 23.6 Outsourcing of transportation capacities

Maintaining transportation capacities which can cover only a part of overall transport requirements reduces the risk that transportation resources are not used and increases the overall utilization of in-house transportation. Transportation capacities can be planned

according to minimal needs while peaks are outsourced (Ockwell, R. 1994, 436) to commercial carriers (figure 23.6).

23.5 Selection of means of transportation

Among the many issues which need to be considered for selection of transportation means some have particular importance for the context of humanitarian assistance programmes. The selection of suitable and sustainable means of transportation is a complex issue which needs to be carried out by a qualified and experienced specialist. Generally the capacity and size of means of transportation will decrease the further humanitarian assistance goods move downstream through the supply network (UNDAC 2000, chapter L 2).

Wherever a choice is possible, the safest type of vehicle, boat and ship as well as aircraft should be selected. Safety is also of particular importance as any breakdown or accident in an insecure area increases the exposure to conflict related risks. As far as possible, the selected means of transportation should not be attractive in the area in order to reduce the risk of theft and car jacking.

The capacity of means of transportation should be adapted to the needs of health programmes in terms of average weight and volume of consignments as well as desired delivery frequency and facilitate loading of unit loads such as roll cage pallets or floor pallets. Means of transportation must be adapted to the characteristics of goods, type of loads and be suitable for maintaining their quality by maintaining adequate temperatures and protecting them from damage during transportation.

Selected types of transportation equipment must be effective, reliable and flexible in the context and under the circumstances in which humanitarian assistance is provided and comply with national legislation and regulations. Vehicles commonly used in the country may be more suitable to the road conditions than more sophisticated vehicles from abroad (Weeks, Ch. 2005, 37).

Among different types of equipment which are suitable in the context and allow providing the same quality of services, the most cost-efficient should be selected (figure 23.7).

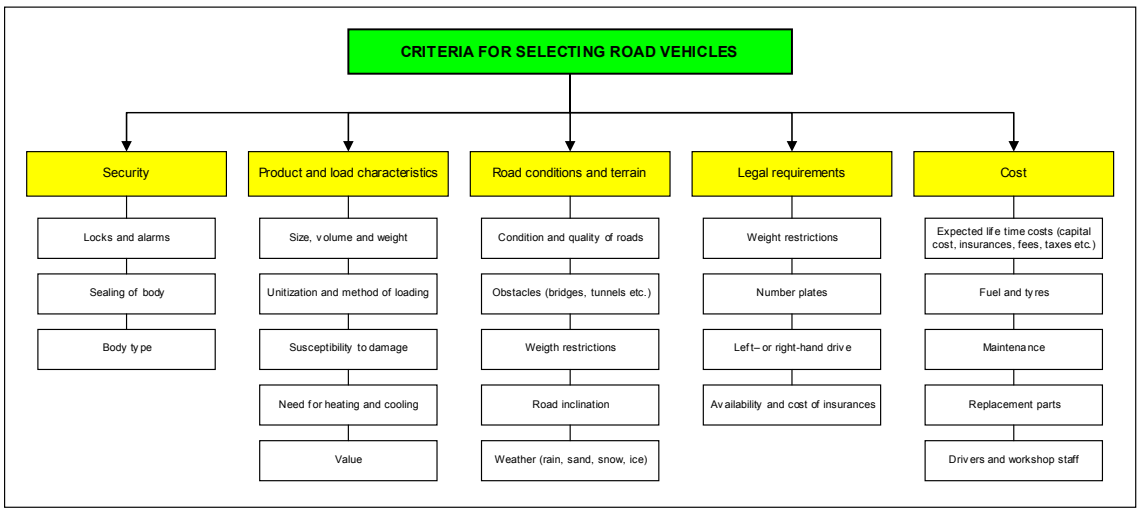

Figure 23.7 Criteria for selecting road vehicles

Safety of vehicles is of paramount importance as emergency services are unavailable in most places where humanitarian organizations work and it could take hours until victims are found

and receive medical assistance. Accidents or breakdowns in a conflict area increase the time that staff, assets and goods are exposed to the conflict as well as to criminal environments.

Unpredictability of demand (Pfohl, H.Ch. 2000, 173) and high criticality of items favour use of faster means of transportation. As discussed above, maintaining a customer service level below 100% requires a fast distribution mode, even at higher costs. While routine consignments for stock replenishment are shipped with a slow mode, expediting goods for which the hastening level is reached or urgently requested non-stock items require a fast mode of transportation combined with direct shipment to the end-user. Combining two modes of transportation allows benefiting from lower transportation costs for the majority of demand while maintaining responsiveness by using a fast mode of transportation when needed (Moinzadeh, K., and St. Nahmias 1998, 761).

Vehicle fleets should be standardized (UNHCR 2000, 255) in order to increase efficiency of purchasing, training, operations, maintenance and management of replacement parts as well as facilitate operation of vehicles in other sites. Nevertheless usually different types of vehicles such as passenger vehicles, light as well as heavy vehicles will be needed. Replacement parts, tyres, the correct type of fuel and lubricants as well as the expertise for maintenance and repair must be available (UNHCR 2000, 265). Preference should be given to manufacturers which do not change their models frequently.

Vehicles must be suited for protecting consignments from exposure to sunlight, rain and snow, heat and cold as well as physical damage. Lorries must be furnished with effective heating and in hot climates with refrigeration unites or refrigerated containers to ensure maintaining acceptable temperatures for drug products throughout the entire transportation time. Vehicles must also be fitted with locks and alarms and allow sealing of the load.

Lorries should allow loading of pallets with hand pallet trucks over a bridge plate, with a tail-lift or with counterbalanced forklift trucks from the side or the rear.

The appropriate selection of the body type (van body or curtain-sided) is critical for protecting goods from the environment as well as from theft. The use of rigid ISO shipping containers on flat bed vehicles provides good protection from the environment as well as theft.

White vehicle bodies and covers, or other light colours maximize reflection off sun light and therefore reduce internal temperatures. In hot climates where consignments of health care goods are transported over long distances, ideally insulated and refrigerated vehicles or ISO shipping containers should be used. The refrigeration unit should be able to run independently from the vehicle engine in case cooling is needed during breaks and over night stops. Likewise in cold climates transportation compartments may requiring thermostats and heating to avoid deterioration and freezing of consignments.

Vehicles must be adapted to average travelling distances, the terrain (mountains, desert, snow, ice), width and conditions of roads (dirt, paved, asphalt concrete), obstacles such as low bridges or narrow tunnels as well as weight restrictions of bridges. Vehicles must be easy to maintain and skilled mechanics as well as replacement parts must be available in the country of operations.

Especially when humanitarian organizations import their own vehicles, legal requirements such as size and weight, limits on the use of foreign number plates as well as the position of the steering wheel must be considered. In left-hand traffic, vehicles drive on the left side of the road and in right-hand traffic on the right side. Left-hand drive vehicle (usually right-hand traffic) and right-hand drive vehicle (usually left-hand traffic) configurations refer to the side of the placement of the driving seat and controls.

Figure 23.8 Cooling unit on refrigerated truck

Insurance with a national or, where unavailable, international agency which also covers war risks must be considered.

The whole life costs over the expected lifetime of vehicles operating under harsh conditions, including purchase price, fuel and tyre consumption as well as costs of maintenance and repairs must be considered (Rushton, A., J. Oxley, and Ph. Croucher 2000, 400).

All means of surface transportation must be furnished with telecommunication equipment (UNHCR 2000, 252) for security reasons. The selected type and colour of vehicles should differ from those used by armed or security forces to avoid confusion and all vehicles should be clearly marked with stickers and flags which identify the humanitarian organization (Mayhew, B. 2004, 33). Special technical means such as lights, infrared illumination, transponder signals, radar and underwater acoustic signals are necessary for aircraft and ships (Cauderay, G.C. 1995).

The usefulness and appropriateness of using armour on vehicles is controversial. Armour can protect against rifle fire and blasts but will not protect passengers from the direct hit of a mine. Armoured vehicles are heavy and require special driving skills (Roberts, D.L. 2005, 126). If humanitarian organizations and their work are not accepted by the conflict parties, the effectiveness of humanitarian assistance is questionable. Moreover the resemblance to military vehicles can raise doubts concerning the neutrality towards conflict parties.

If humanitarian organizations should happen to have the choice between different commercial rail operators, apart from costs, safety and reliability of equipment should be considered.

In principle the same considerations apply to selection of boats for local transportation. Apart from safety, flexibility, ease of operations as well as ease of maintenance should be considered.

Small aircraft must be able to operate without assistance of air traffic controllers and must be able to land on rough and improvised airstrips. Ships should be furnished with cranes which allow loading and unloading cargo without being dependent on port infrastructure.

23.6 Vehicle fleet management

Vehicle fleet management is a complex function (see table 23.10) which requires management by professional and experienced specialists. Vehicle fleet management is indispensable for any humanitarian assistance programme and therefore not specific to health care logistics. Therefore this chapter is intended only to give some insight into the main issues and point to the importance and complexity of this function as well as to the great responsibility vehicle fleet managers carry. A number of issues such as security, communications equipment, routing and scheduling as well as convoying are not included in this chapter as they are covered elsewhere.

"No operation can function without the use of vehicles for the transport of staff and goods" (IFRC 2003, 18).

The objective of vehicle fleet management is providing support to humanitarian assistance programmes by enabling timely, effective and efficient movement of goods and staff in a professional and safe manner while respecting internal policies and upholding the reputation of the respective humanitarian organization. Vehicle fleet managers strive to maintain the fleet in good operating conditions while considering its impact on the environment, adapt it to changing operational needs and ensure constant readiness as well ensuring the competency and safety-consciousness of all staff.

In all matters national legislation and regulations such as concerning safety, driving regulations, technical requirements for vehicles, roadworthiness, pollution, traffic laws, importation, insurance, registration and disposal must be respected and carefully complied with.

A) Safety

- Driving rules and regulations.
- Checking of vehicles.

B) Driver management

- Driving licence and authorization.
- Recruitment of drivers.
- Driver training.
- Working and driving hours.
- Driver evaluation.
- Driver files.

C) Vehicle management

- Requirements planning.
- Vehicle selection.

- Vehicle ownership.
- Importation and registration of vehicles.
- Vehicle identification and markings.
- Vehicle insurance.
- Measuring and monitoring performance.
- Vehicle files and documentation.

D) Vehicle dispatch

- Parking.
- Managing transportation requests.
- Driver assignment.
- Vehicle assignment.
- Vehicle pool system.
- Control of vehicle use.
- Dispatch planning.

E) Maintenance and repair

- Fuel management.
- Preventive maintenance.
- Replacement parts.
- Workshop management.
- Disposal of used parts and chemicals

F) Vehicle disposal

- Criteria for disposal.
- Types of disposal.
- Disposal procedures.

G) Other assets

- Forklift trucks.
- Motorcycles, motorbikes.
- Boats.
- Generator sets.
- Pumps.

Table 23.10 Scope of fleet management

23.6.1 Safety

Apart from security, safety of drivers, workshop staff, passengers and other road users must be the primary concern of vehicle fleet managers. The issues discussed below equally apply to forklift trucks and boats.

"Driving is a hazardous activity. People are often more at risk (of death or injury) from a road crash than any other potential cause" (IFRC 2003, 22).

The importance of road safety is even greater in countries with poor standards and conditions of roads as well as poor compliance and enforcement of traffic laws. Road safety

must be considered as one of the highest priorities which must not be compromised even during emergency operations.

Apart from the harm and damage that unsafe driving can cause, (marked) vehicles are highly visible and the negative implications of unsafe driving on the perception and reputation of the humanitarian organization must be considered. Moreover accidents, especially if people are harmed, can have serious security implications.

National traffic laws and regulations apply to all drivers. However, humanitarian organizations may issue and enforce more detailed and more stringent rules and regulations. For example a zero tolerance policy on driving under the influence of alcohol and other substances, lower speed limits, specific regulations for driving at night (such as illuminating cabins and flags) or specific equipment vehicles need to carry at all times. Seat belts should be worn on all seats in vehicles, motorcycle riders should wear helmets and humanitarian organizations usually issue special instructions for managing road accidents. All persons on a boat must wear life jackets.

Other rules and regulations may limit passengers to staff of the humanitarian organization itself as well as patients in order to ensure use of vehicles for their intended purposes as well as to avoid liability toward passengers in case of accidents.

Most humanitarian organizations strictly prohibit the carrying of any kind of weapons (including by injured combatants) in their vehicles and prominently display "No arms" stickers on their vehicles. Moreover no (personal) items which could be politically, culturally or religiously offensive in the country must be carried.

The respective driver is personally responsible for carrying out a complete inspection of the vehicle and its equipment before every departure or at least once a day. This inspection includes fuel, oil and water levels, batteries, conditions and pressure of tyres, steering and breaks, mirrors, lights, indicators and reflectors, windscreen wipers and washers as well as the horn. Drivers must also confirm working, functioning and completeness of telecommunication equipment, first aid kit and stretcher, fire extinguisher, tool kit (including all tools needed for changing tyres), warning triangle, spare fuel and if necessary snow chains and a shovel.

Apart from being an indispensable safety measure, these inspections are an essential part of vehicle maintenance, reduce overall vehicle maintenance costs and increase the lifetime of vehicles (IFRC 2003, 64).

Any documents such as vehicle registration or insurance certificates which must be carried in the vehicle at all times according to national legislation and regulations must be checked for their completeness.

23.6.2 Driver management

All drivers must hold valid national driving licences for the type of vehicle they drive. Truck drivers must be allowed and able to drive with and handle trailers. Staff which hold foreign driving licences may additionally need valid international driving licences.

In addition to holding valid driving licences, humanitarian organizations usually require all national as well as international staff to successfully pass an internal driving tests and sign the internal driving rules and regulations before authorizing them to use specific types of their own vehicles.

In countries where formal driver training and certification is insufficient, these driving tests ensure that drivers are safety-conscious and have all required skills for driving under normal as well as extreme road and weather conditions. International staff who have obtained their

licences abroad need to prove that they can cope with the prevailing road and traffic conditions and can safely drive the available type of vehicles.

Recruited drivers must hold the required licence(s), should be experienced and should be able to maintain vehicles and carry out simple repairs. National staff are usually preferred over international staff, as they speak the national language(s) and are familiar with traffic and road conditions as well as customs. Ideally they should also speak the language used by the humanitarian organization in order to be able communicate with everyone by radio, especially in emergency situations. Personal skills and attitudes such as honesty, courtesy and respect for rules should also be considered.

Well trained driver have less accidents, care for vehicles better, use less fuel and reduce maintenance and operating costs. Regular (refresher) training on defensive driving as well as on driving in extreme weather (for example heavy rain) or extreme road conditions (snow and ice) should be offered. Drivers of heavy vehicles should be trained on load security, national legislation and driving hours as well as on transportation and customs documentation.

The maximum permissible daily and weekly working and driving hours are usually stipulated by national laws. Otherwise drivers should take an one hour break after every four hours of driving and should not drive more than ten hours per day. The need for rests during the day and sufficient sleep must be respected not only to comply with laws and regulations but also to avoid accidents caused by fatigue.

Like for all staff, the work of drivers should be reviewed and appraised regularly. Quantitative aspects such as trips and travel distance, fuel consumption, maintenance costs of assigned vehicles and accidents as well as qualitative aspects such as safety awareness, reliability, punctuality and courtesy towards passengers should be considered.

A driver file with records of her/his personal history, identification, licences, results of driving tests, driving authorization, signed driving rules and regulations, job description, accident reports, appraisals and training records should be maintained for every driver.

23.6.3 Vehicle management

The effective management of vehicles is indispensable for ensuring the constant readiness of transportation resources.

During the initial set-up of logistics services, vehicle fleet managers need to carefully determine needs for different transportation services as well as the respective average and maximum transportation capacities. These will determine the type of vehicles such as passenger cars, all-terrain vehicles, pickups, trucks, buses or forklift trucks and their respective quantities.

The composition of the vehicle fleet needs to be regularly reviewed and adjusted to changing needs if necessary to maintain its effectiveness as well as (cost)efficiency.

A systematic vehicle replacement policy needs to be implemented in order to ensure readiness of the vehicle fleet at all times and to avoid a large financial burden by having to replace a large number of vehicles at the same time. Such policies need to balance the increasing maintenance costs against the decreasing resale value of second hand vehicles in order to minimize the overall cost of ownership over the entire time span during which a vehicle is used by a humanitarian organization.

A certain age and mileage as well as vehicle reliability and maintenance costs or a combination of these factors can serve as criteria for vehicle replacement.

Criteria for selecting road vehicles were discussed in chapter 23.5.

Vehicles may be rented with or without a driver, leased, purchased or a combination of these options may be used for establishing a vehicle fleet. The decision concerning ownership must be taken at the operational level but also depends on the general policy of humanitarian organizations discussed in chapter 11.4.

Domestic customs legislation and regulations need to be complied with when importing vehicles into the country of operation with particular consideration of their tax status and possibility of (temporary) exemptions from taxes and duties for humanitarian organizations. Registration of vehicles is usually a legal requirement and vehicles may be registered abroad (country of head offices or other country) or in the country of operations.

Usually vehicles receive an internal reference number for facilitating fleet management as well as a reference for radio communications. According to policies of the respective humanitarian organization, vehicles will be marked with logos on the bonnet, side, rear and roof in order to allow identification from all sides as well as the air. "No arms" stickers are often attached to the doors and the corner of window shields. In addition vehicles may be marked with flags attached to poles and large flags may be attached to the roof, side and back of large vehicles.

Insurance coverage for all vehicles is not only a mandatory internal requirement by humanitarian organizations but is often a legal requirement and must be in place before vehicles start operating.

Humanitarian organizations may purchase global coverage for all their vehicles worldwide from a commercial insurance company or self-insure their vehicle fleet, insure vehicles in the country of operation or combine both types of insurance. Insurance coverage for vehicles travelling to neighbouring countries must also be considered. National legislation may require insurance in the country even if vehicles are insured in another country.

Insurance should cover vehicles (accidents, theft), loads (damage, theft), drivers and passengers (physical harm and death), third party liability (material and personal damage) as well as war risks.

Vehicle fleet managers should measure and monitor the time and capacity utilization of vehicles as well as their performance in terms of availability (downtime), fuel consumption and operating costs (per kilometre, per tonne carried), preferably with an appropriate software.

A detailed, accurate and updated vehicle file needs to be established for each vehicle at the time of initiating the order, lease, rental or purchase for management purposes, for insurance purposes as well as legal reasons, for example consultation by tax authorities or the police. The vehicle file remains with the vehicle when it is transferred to another operation and is retained after the disposal of the vehicle for the period determined by national laws and regulations or internal policies.

Vehicle files contain an identification sheet, all documents related to their order, rental, lease or purchase, shipping and customs documents, vehicle registration and licences, tax and insurance documents, maintenance and repair records, accident reports, monthly utilization and performance records as well as documents related to their sale, donation, transfer and exportation.

23.6.4 Vehicle dispatch

For security reasons vehicles should be kept locked at all times and, wherever possible, b parked inside secure and guarded compounds and not on the street. Vehicles must not block

each other and all vehicles should be parked facing the exit in order to allow immediate departure in case of an emergency.

The use of transportation requests allow coordinating the use of vehicles and maximizing their utilization. Written transportation requests indicate the number of people or type and quantities of goods, destination, time and date the movement is required on a form. "Walk-in" requests, usually for transportation of passengers, are made verbally and not announced in advance and staff may also request transportation by VHF radio or telephone.

Wherever possible, exclusively professional drivers should be used as they have more experience, are more familiar with traffic and road conditions and drive safer. Especially in emergencies, other staff members focus on their work, may be stressed and therefore lack the required attention. Moreover foreigners involved in road accidents are likely to cause greater security implications and be more complex to settle than for citizens of the country of operation.

Ideally every driver should always use the same vehicle as they are made responsible and monitoring performance is made easier.

Often duty drivers are available after office hours for responding to emergencies or transporting staff.

Some vehicles may be assigned to specific departments or programmes. However, the coordination and utilization of vehicles is usually increased by a car pool system where any suitable vehicle can be assigned to any task.

One complete set of keys for daily use is controlled by the car dispatcher who hands them over to authorized drivers to ensure that vehicles are only used for the intended purposes and not misused such as for private purposes. A second spare set should be kept locked in a safe.

Every vehicle must be furnished with its own logbook for recording date and time of every trip, the destination, the name of the driver as well as her/his signature. In addition, security guards may record all vehicle movements as well as the mileage at departure and arrival in a register.

In a pool system the car dispatcher reviews all transportation requests, plans and coordinates all transportation operations and ensures economical use of transportation resources. S/he assigns appropriate vehicles and drivers, briefs them on the road, traffic and security situation, maintains contact with drivers, usually by VHF radios and records all vehicle movements. Car dispatcher should also ensure that drivers take breaks and do not exceed permissible working and driving hours.

23.6.5 Maintenance and repair

Fuel must be strictly controlled as it is expensive, sometimes in short supply, coveted and prone to misuse and theft. The fuel consumption of each vehicle must be monitored, fuel must be distributed only by authorized staff and fuel tanks must be locked and if necessary sealed.

The quality of fuel needs to be controlled by taking samples and asking suppliers for quality certificates as adulteration of fuel with water or other impurities can decrease the efficiency of or even cause damage to engines.

The uninterrupted supply of fuel is essential for maintaining transportation services and contingency stocks should be maintained for evacuations or other emergency situations.

Regular supply at the lowest price should be ensured by establishing longer term contracts with suppliers which provide fuel at their own fuel stations or make deliveries to a fuel store.

Humanitarian organizations may be able to benefit from tax exemptions on the fuel they purchase.

Fuel tanks should be set up in secure places and should always be surrounded by retaining walls for protecting the environment in case the tank leaks. The fire hazard to surrounding buildings should be considered and appropriate and sufficient fire fighting equipment must always be available.

Regular, systematic and meticulous maintenance extends the lifetime of vehicles as well as other assets and also increases their safety and reliability. Maintenance helps preventing minor faults becoming serious technical problems which will lead to failure of components and the breakdown of vehicles. Neglecting vehicle maintenance may save costs in the short run but will lead to high costs for repairs, temporary replacement of immobilized vehicles as well as earlier vehicle replacement.

All maintenance must be carried out according to defined standards and defined procedures. A maintenance plan for each type of a vehicle must be established according to manufacturer's recommendations and maintenance manuals. Depending on the climate and road conditions humanitarian organizations may define more stringent standards.

Maintenance of the entire fleet needs to be planned and coordinated according to the number of vehicles. Maintenance staff must be competent, qualified, but trained and supervised. If maintenance is outsourced, only workshops authorized for maintenance of the respective types of vehicles or trustworthy humanitarian organizations should be used. All maintenance work must be accurately and carefully documented in the vehicle logbook.

Maintenance includes preventive maintenance, minor and major repairs as well as overhauls which involve servicing or replacement of major components such as engines. Some maintenance work needs to be carried out regularly according to service schedules defined by the manufacturer which may be determined according to certain time periods or the number of kilometres travelled. Servicing includes daily vehicle checks, regular cleaning, lubrication (locks, doors, hinges, joints), adjusting and tightening screws, change of various liquids (oils, hydraulic and cooling liquids) and change of various filters.

Other maintenance works such as on the steering, tyres, break pads, suspension and shock absorbers battery and electrical system and lights as well as cooling and heating system are carried out following technical problems reported by drivers or regular inspections.

Other repairs may be necessary following vehicle breakdowns or when vehicles are damaged in accidents.

Sufficient stocks of tyres, replacement parts, lubricants and different oils required for maintenance and repair of all types of vehicles, generator sets, forklift trucks and other assets must be maintained.

Replacement parts must be genuine and should be purchased only from authorized agents in the country, trustworthy humanitarian organizations or be imported from authorized distributors abroad.

Replacement parts are valuable and may fetch high prices in the country. Therefore they need to be stored in a dedicated and secure store, access must be restricted, strictly controlled and complete physical stock counts should be carried out regularly.

Appropriate and effective workshop facilities for the maintenance and repair of vehicles, generator sets, forklift trucks and other assets which allow bodywork, welding as well electrical work must be established. These incur significant costs and may not be economical for a small number of vehicles. Commercial workshops or workshops run by other humanitarian

organizations may be contracted, provided that they work according to the same quality standards and are reliable. Workshops must provide detailed invoices, list the parts which were exchanged and should return any parts removed from vehicles after their replacement. all workshops need to carefully record and document any works carried out and any parts which were replaced.

Figure 23.9 Vehicle workshop

Qualified, competent and trained mechanics with clear responsibilities and job descriptions should be carefully supervised by professional mechanics. The use of dangerous hydraulic, cutting and other tools requires particular attention to occupational safety and staff must be provided with protective clothing such as safety shoes, overalls, gloves, eye and ear protection as well as masks. The storage and use of flammable liquids such as fuel, oil or lubricants as well as the use of open fire (welding) require implementing and maintaining appropriate and sufficient fire safety measures.

Used parts such as tyres, batteries or electrical components as well as liquids such as fuel, oil, coolants, lubricants, paints which contain environmentally hazardous substances need to be recycled, returned to suppliers or be disposed of in an environmentally friendly way according to national legislation and regulations as well as the instructions given by manufacturers. Any used parts must be made unusable to prevent fraudulent use and sale. Replacement parts which were exempted from duties and taxes during importation may require special consideration.

23.6.6 Vehicle disposal

Vehicles and other assets which are no longer needed for supporting a project or programme can be transferred to other locations or countries or be returned to a stock. However, export of assets may be restricted by national laws and regulations or transfers may not be economical and therefore require disposal in the country.

Most humanitarian organizations have a replacement policy for their vehicles depending on the age, mileage, cost of maintenance or a combination of these criteria. Assets may also require disposal if they are damaged beyond economical repair or if the manufacturers stops producing replacement parts, often after ten years.

Assets and replacement parts may be sold, donated, dismantled for use of their parts or be scrapped.

Before any kind of disposal, all telecommunication equipment, flags, logos and other stickers must be removed. The vehicle registration and all insurances must be cancelled and the assets should be written off in the accounting system. An authorization for disposal must be obtained from customs and finance authorities and any restrictions on the sale or exportation must be considered, especially if assets were exempted from duties and taxes during importation. A detailed record of the disposal and all related records must be kept as future references for the authorities and auditors.

Any sale must be carried out in compliance with national legislation and regulations. Humanitarian organizations should repay any duties or taxes and add these to the selling price before the sale to avoid any implications in case the buyer commits fraud or defaults on his obligations.

The residual value may be available from official price lists or be obtained through valuation from a recognized institution and should be clearly documented. The asset must be valuated in its current state, should not be repaired and no promises of maintenance or repair after their sale should be made.

The sale of assets should be advertised in local and national media such as newspapers to ensure transparency and avoid any preferential treatment or fraud and bidders should be able to inspect offered assets. Assets can be sold to the highest bidder in a tender with closed bids or through an auction. Auction houses will ensure impartiality and sell assets to the highest bidder.

A clear and detailed contract of sale including, among others, detailed descriptions of the assets and terms of payment (in advance) must be drafted. The seller should explicitly waive any responsibility and liability for any defects and repair costs or personal or material damage which may occur in the future and the buyer therefore bears the entire risk. Finally assets should be formally handed over to the buyer.

Assets may also be donated to other (humanitarian) organizations or government authorities. However the cost of maintenance and operations may be a burden, drain valuable and scarce resources from the recipient or create financial and technical dependency and (genuine) replacement parts may not be available or affordable. Moreover the variety of assets the recipients need to maintain increases.

23.6.7 Other assets

Other assets such as motorcycles, forklift trucks and other powered materials handling equipment, boats, generator sets and (water) pumps also require regular maintenance in order to ensure their safety, reliability, effectiveness and cost-efficiency.

In particular generator sets require regular maintenance among others of the mountings, engine and alternator, change of engine oil, change of filters (fuel, oil, air), cooling system, battery and control panel according to the manufacturer's instructions. All maintenance and repair works should be carefully documented and recorded in the respective logbook.

23.7 Dangerous goods

Dangerous goods regulations are particularly important for health care logistics as several commonly used substances fall in this category although they are not obviously dangerous.

Dangerous goods are defined as articles or substances which are capable of posing a risk to health, safety, property or the environment (IATA 2006, 5) and which are listed in the IATA Dangerous Goods Regulations.

The criteria for classifying substances as dangerous, the classifications of individual substances as well as the unique number assigned to each substance are determined by the United Nations Sub-Committee of Experts on the Transport of Dangerous Goods.

23.7.1 Classification of dangerous goods

The approximately 3,000 different dangerous goods likely to be shipped by air are divided into 9 classes which reflect the type of risk or hazard involved and some classes are further divided. The number of the "division" is indicated by a second digit, the order of divisions is chosen for convenience and does not imply their relative danger. Specific criteria are defined to determine whether a substance belongs to a certain class. Substances belonging to more than one class and division have a primary and subsidiary risk.

1	**Explosives**
1.1	Articles and substances having a mass explosion hazard.
1.2	Articles and substances having a projection hazard.
1.3	Articles and substances having a minor blast or projection hazard.
1.4	Articles and substances which present no significant hazard.
1.5	Very insensitive substances which have a mass explosion hazard.
1.6	Extremely insensitive articles which do not have a mass explosion hazard.
2	**Gases**
2.1	Flammable gas.
2.2	Non-flammable, non-toxic gas.
2.3	Toxic gas.
3	**Flammable liquids**
4	**Flammable solids, spontaneous combustible, dangerous when wet**
4.1	Flammable solid.
4.2	Substances liable to spontaneous combustion.
4.3	Substances which, in contact with water emit flammable gases.
5	**Oxidizing substances and organic peroxide**
5.1	Oxidizer.
5.2	Organic peroxides.
6	**Toxic and infectious substances**
6.1	Toxic substances.
6.2	Infectious substances (class A and B).
7	**Radioactive material**
8	**Corrosives**
9	**Miscellaneous dangerous goods**

Table 23.11 United Nations hazard classes and divisions

Class 1 which contains six divisions and 13 compatibility groups, includes any kind of explosive substances and detonation devices.

Flammable and non-flammable as well as toxic and non-toxic gases are grouped in class 2 and its respective divisions Aerosols, which can be flammable or non-flammable, belong to this group. Substances in this class can pose a hazard for several reasons.

Containers filled with pressurized or liquefied gas can explode or rupture if they are damaged or exposed to heat. Moreover if containers leak or rupture, gases will quickly spread in three dimensions, filling the available room and thereby extending their hazard, for example throughout an aircraft. Flammable gases can cause fires and ignite normally non-hazardous materials. Non-toxic and non-flammable gases can displace oxygen from confined spaces and suffocate people within a few minutes.

Some gases in division 2.2, such as oxygen, have the additional hazard of being oxidizers (division 5.1)

Class 3 comprises flammable liquids such as alcohols, acetone, methanol and xylene which are used for laboratory diagnostics. Flammable liquids are particularly hazardous because they spread quickly if their containers leak or break and therefore, compared to solid materials, fires will spread faster.

Class 5 contains oxidizers which may not be hazardous on their own but can strongly react with other chemicals.

Class 6 comprises substances which are health hazardous either because they are poisonous, such as pesticides or heavy metals, or infectious agents such as infectious blood or tissue samples. While many substances can be toxic when human beings are exposed over a longer period of time, they are only considered as hazardous if a short time exposure is liable to cause death or injury or they can harm human health if swallowed, inhaled or coming into contacted with skin.

Infectious substances are substances which are known or are reasonably expected to contain micro-organisms (bacteria, viruses etc.) which can cause disease in humans or animals. This division includes clinical specimen (or diagnostic specimen) of human or animal material such as excreta, secreta, blood and its components, tissue and tissue fluids as well as body parts which are being transported for purposes of research, diagnosis, disease treatment or prevention.

Exposure of infectious substances of category A can cause permanent disability, life-threatening or fatal disease to humans or animals. This concerns only a few micro-organisms such Ebola, Lassa or Marburg viruses as well as a larger number of laboratory cultures of micro-organisms.

Class B contains any infectious substances which does not meet the criteria for class A. Diagnostic specimen usually fall into this class which also includes medical or clinical waste.

Radioactive materials where the activity in the consignment exceeds defined values are contained in class 7.

Class 8 comprises corrosive substances such as acids, alkalis or mercury which through a chemical reaction can cause severe damage to living tissue, other goods or means of transportation. However corrosive substances usually pose a smaller hazard than other substances as they can only cause damage through direct contact and the chemical reaction is usually slow.

Class 9 contains any dangerous goods which are not covered by any of the other classes. Aviation regulated solids or liquids comprise any material which has narcotic, noxious, irritating or other properties which could cause discomfort or annoyance to crew members in the event of spillage or leakage. Materials with magnetic fields exceeding defined strengths as

well as large masses of Ferro-magnetic metals can interfere with aircraft instruments and navigation equipment.

"Hidden dangerous goods" are dangerous goods which are not easily identified as such, may not be apparent for shippers but fall within the definition and which they therefore fail to declare and fail to provide appropriate packaging for. For example cylinders of compressed oxygen for treating medical emergencies on aircraft, dental apparatus, electrical equipment (magnetic material, wet batteries), diagnostic specimen, fuel (sterilization equipment), laboratory materials, drug products, aerosols, photographic supplies, refrigerators (liquefied gases) or vaccines which may be packed in solid carbon dioxide ("dry ice").

2	**Gases**
2.1	Aerosols, flammable.
2.1	Aerosols, non-flammable.
2.2	Aerosols (for example anti-asthmatics such as salbutamol).
2.2	Compressed oxygen (also 5.1).
2.2	Nitrous oxide (also 5.1).
2.2	Oil spray (for surgical instruments).
3	**Flammable liquids**
3	Acetone (Gram stain, urine analysis).
3	Ethanol (tuberculosis diagnostic, detecting blood in urine).
3	Giemsa (contains methanol, diagnosis of blood parasites).
3	Methanol (Gram stain, blood parasites such as malaria).
3	Methylene blue (tuberculosis diagnostic).
3	Xylene (removal of immersion oil).
5	**Oxidizing substances and organic peroxide**
5.1	Calcium hypochlorite (disinfection of laboratory equipment).
6	**Toxic and infectious substances**
6.1	Ammonium oxalate (Gram stain, platelet count).
6.1	Giemsa (diagnosis of blood parasites).
6.1	Methanol (Gram stain, blood parasites such as malaria).
6.1	Phenol (tuberculosis diagnostic, disinfection of equipment).
6.1	X-Ray developer (hydroquinone, glutaraldehyde).
6.2	Clinical specimen of human or animal tissue for diagnosis.
8	**Corrosives**
8	Formaldehyde solution (preservation of specimen).
8	Hydrochloric acid (tuberculosis diagnostic, preservation of schistosoma haematobium eggs).
8	Mercury.
9	**Miscellaneous dangerous goods**
9	Halothan, narcotic or noxious substance (volatile anaesthetic).
9	Immersion oil, environmental hazard (microscopy).

Table 23.12 Examples of dangerous health care goods

23.7.2 Dangerous goods regulations

Dangerous goods can be transported on aircraft safely, provided the principles listed in table 23.3 are followed.

- Classification.
- Prohibition.
- Training.
- Packing.
- Marking and labelling.
- Documentation.
- Notification to Pilot-in-Command.
- Avoiding hidden hazards.
- Accident/incident reporting.

Table 23.13 Principles of safe transport of dangerous goods

Except for radioactive materials, which are dealt with by the International Atomic Energy Agency (IAEA), the United Nations Committee of Experts (CoE) develops recommendations for the transportation of all types of dangerous goods. These are published in the "Recommendations on the Transport of Dangerous Goods: Model Regulations" (UN 2009) which are applicable to all modes of transportation.

These recommendations were used by the International Civil Aviation Organization (ICAO) as a basis for developing the regulations for the safe transportation of dangerous goods by air. These are codified in Annex 18 of the "Convention on International Civil Aviation" (Chicago, 1944) and the associated "Technical Instructions for the Safe Transport of Dangerous Goods by Air" which are the actual legal basis under which dangerous goods can be safely transported by air.

However, in practice the "Dangerous Goods Regulations" published by the International Transport Association (IATA) are used which fully comply with the ICAO document, are more restrictive in some cases and take industry practices into account.

The importance of the shipper's responsibilities and compliance with the dangerous goods regulations cannot be over-emphasized. The shipper must ensure that employees are trained to process and handle dangerous goods. The shipper must determine whether articles or substances are prohibited for transportation by air as well as ensure that dangerous goods are correctly identified, classified, packed, marked, labelled and properly documented in compliance with the regulations. Shippers must not load undeclared or incorrectly declared dangerous goods on aircraft and must also check documents and consignments for any indication of "hidden dangerous goods".

Cargo acceptance staff of the operator or cargo agent must complete an acceptance checklist to ensure that the shipment complies with the dangerous goods regulations and should be alert to any marking or labelling on packages which may indicate "hidden dangerous goods". Operators or cargo agents are also responsible for appropriate storage, loading, providing information on dangerous goods shipments, reporting any dangerous goods accidents and incidents as well as retention of records.

Security plans only need to be established for dangerous goods which have the potential of causing mass casualties or mass destruction.

23.7.3 Limitations on the transportation of dangerous goods

Some dangerous goods have been identified as being too dangerous to be carried on any aircraft under any or only under exceptional circumstances.

Forbidden dangerous goods are considered to be too hazardous for transportation by air and must not be transported under any circumstances. These goods or substances are liable to explode, dangerously react, produce a flame or dangerous evolution of heat or dangerous emission of toxic, corrosive or flammable gases or vapours under normally encountered transport conditions.

Other substances are forbidden under normal circumstances but may be transported with specific approval of the respective state. On the other hand states and operators may impose their own restrictions which are called "variations". For example the carriage of clinical specimen in air mail may be allowed by national authorities provided that they comply with the dangerous goods requirements for example in terms of packaging.

Most dangerous goods can be safely transported on passenger aircraft provided that they meet certain requirements such as limits on quantities and special packing but some are restricted to transportation by cargo aircraft only.

The dangerous goods regulations indicate the maximum quantities which are permitted per package as well as the total allowed quantity on cargo or well as passenger aircraft.

Special provisions are made for dangerous goods carried by passengers or crew such as small gaseous oxygen cylinders which are intended for medical use.

"Dangerous Goods in Excepted Quantities" are very small quantities of dangerous goods which are exempted from the usual marking, labelling and documentation requirements. This concerns only certain classes and divisions of dangerous goods which are permitted on passenger aircraft. Each inner packaging is limited to 30 grams for solids and 30 millilitres for liquids and the total net quantity in each outer packaging is limited to 1 kilogram or 1 litre. These excepted quantities do not require any special handling or loading. However each package must be marked with a special red hatched label for ease of identification and any leakage or spillage must be reported.

Dangerous goods which are permitted on passenger aircraft and which belong to certain classes and divisions may be carried under the provisions for "Dangerous goods in limited quantities". Their packaging does not require approval by the United Nations Committee of Experts but must meet certain criteria and the gross weight of a package must not exceed 30 kilograms.

23.7.4 Packaging, marking and labelling

Generally the packaging of dangerous goods is an essential component in the safe transportation of dangerous goods by air. The special packaging requirements as well as the limitations on quantities of dangerous goods limit the risk in case an incident does occur.

The dangerous goods regulations specify the different types of packaging and their requirements in great detail. While the class of dangerous goods relates to the type of hazard, the packing group is related to the degree of the hazard. Packing group I covers substances which present a high danger, packing group II substances presenting medium danger and packing group III is foreseen for substances which present a low danger. Radioactive materials also require special packing.

Outer packaging can be made from plastic, fibreboard, plywood, timber, aluminium, steel or metal, must be large enough to fit all required markings and labelling. It must be of good quality, withstand handling and shocks of loading as well as vibrations normally encountered in transportation.

Liquids must not fill their container completely at a temperature of 55° C. Therefore sufficient ullage (outage) must left by the manufacturer at the top of containers during filling at room temperature to allow expansion without rupturing of the container should temperatures increase during transportation. Moreover containers of liquids filled and closed at 100 kPa (1 bar) must withstand a decrease in external pressure to 68 kPa (or 0.68 bar) without bursting.

Inner packaging such as glass or certain plastic materials which are liable to break or easily be punctured must be surrounded by appropriate cushioning material and be secured in an outer packaging. The protective properties of the cushioning material as well as the function of the outer packaging must not be substantially impaired by any leaked contents.

Containers with liquids must be packaged with absorbent materials which can absorb the entire quantity in case of leakage of the container and which must not react dangerously with the liquid. If the outer packaging is not liquid tight, it must be fitted with a means of containment such as a leak-proof liner or plastic bag

Liquid containers must be packed in an upright position with their closures on top. The packaging must be marked with the upright orientation or the words "This Side Up" on the top cover of the packaging.

Only staff having received special training is allowed to pack dangerous goods. Therefore once dangerous goods packaging is opened in a warehouse the contents can no longer be shipped by air whether as a whole or in parts.

Packaging with dangerous goods which are intended for onward shipment by air must never be opened under any circumstances!

Either entire packages are transhipped, provided that they are allowed on another aircraft or dangerous goods are shipped by other means of transportation.

Correct marking and labelling are essential in order to indicate the contents of the packaging, the nature of the hazard, indicate that packaging meets approved standards as well as provide handling and stowage information.

Each package or overpack containing dangerous goods must be at least clearly marked with the proper shipping name of the contained goods or substances, the applicable UN number as well as the full name and address of the shipper and the consignee.

All packages containing dangerous goods must be furnished with 10 x 10 centimetre large hazard labels to ensure that they can be recognized and identified without having to rely on any accompanying documentation, especially in case of accidents or incidents. Each class or division has a unique label and the class, and where applicable the division, must be shown in the bottom corner of the label. Containers are marked with the respective placards which are larger than the labels.

In addition packages may be labelled with handling labels.

Limited quantity packaging must be marked with "LIMITED QUANTITY" or "LTD. QTY.".

Hazard as well as handling labels must be printed or securely fixed on the package, must not be folded or attached in a way that parts appear on different faces of the packaging and must not be obstructed by part of the packaging.

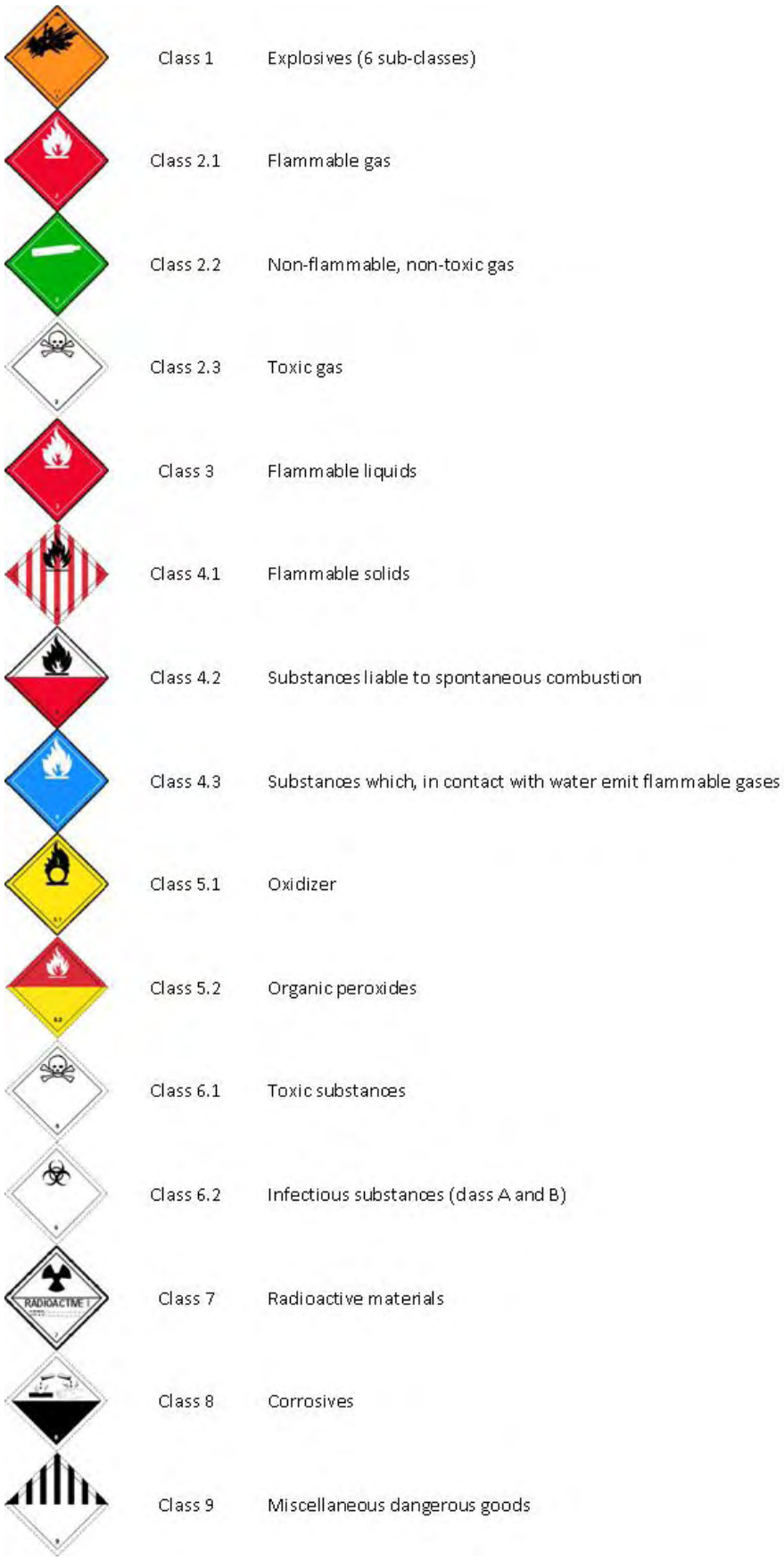

Figure 23.10 IATA dangerous goods labels

Several packages of dangerous goods may be consolidated in a larger overpack which itself does not have to meet the packaging requirements for dangerous goods as it is not intended to increase the integrity of any packaging it contains. However the overpack must bear the marking "Overpack" and the markings of the packaging as well as the net quantities of each class and division of dangerous goods it contains must be reproduced on the overpack. Unit load devices must also be clearly marked with dangerous goods sign and indicate the class(es) and division(s) of dangerous goods they contain.

Figure 23.11 Examples of IATA dangerous goods packaging

23.7.5 Documentation and acceptance

Detailed and accurate documentation of dangerous goods consignments is essential in order to ensure that everyone involved in the transportation and storage is aware of the dangerous goods as well as their hazards.

Staff, such as air crew, may not see dangerous goods consignments and their labelling and in an emergency it may be impossible to approach consignments for identifying their labels. Consequently all dangerous goods consignments must be accompanied by the "Shipper's Declaration of Dangerous Goods" (DGD) a document describing its contents, dangerous goods class and division as well as the name and address of the shipper and consignee. The document must be printed with diagonal hatchings along the full length of the left and right margin in red and be signed by the shipper. The document also serves as a legal document by which the shipper confirms compliance with the relevant provisions of the dangerous goods regulations.

In addition, an air waybill must be completed including the mandatory statement "Dangerous goods as per attached DGD" and, if applicable, "CARGO AIRCRAFT ONLY" (CAO) in

the handling information box. The number of parcels containing dangerous goods must be stated if non-dangerous goods are included in the same air waybill.

Cargo acceptance staff who must have undergo special training, must complete a formal checklist to ensure that the shipper has complied with the declaration requirements and verify that consignments are in full compliance with all relevant dangerous goods regulations.

Infectious substances of class B may be accepted by the operator as non-dangerous goods provided that the packaging is in full compliance with the respective regulations. Nevertheless accidents and incidents must reported as for dangerous goods consignments.

The operator of an aircraft must provide the pilot-in-command with accurate written or printed information concerning dangerous goods that are to be carried as cargo prior to departure in order to allow her/him to take appropriate measures in case of an emergency.

In any places where dangerous goods are handled staff must receive emergency response training and emergency procedures must be available. In case of an emergency the dangerous goods must be identified, if possible isolated and any contact with the contents of packaging avoided.

Accidents are occurrences related to the transport of dangerous goods which result in serious or fatal injury to a person or serious damage to property. Any other occurrences are called incidents. The operator must report accidents as well as incidents to the relevant authorities in order for them to carry out an investigation. Operators must also report any undeclared or incorrectly declared dangerous goods consignments which are found in cargo.

24 CUSTOMER SERVICE PLAN

The overall customer service strategy needs to be translated into customer service plans. These need to be tailored to humanitarian assistance programmes as well as the context within a country and consider the trade-off between customer service levels and required logistics resources.

Logistics managers need to develop customer service plans together with the managers of health care facilities as well as the responsible health programme managers in order to meet their service requirements.

The importance of individual customer service elements will depend on the type of assistance provided to health care facilities as well as the situation and context. During the emergency phase, lead times must be as short as possible while longer lead times will be sufficient in the development phase. Maximum stock availability will be important if a health care facility is supported by a single humanitarian organization but not be critical where only occasional support is provided in addition to other sources. Moreover stock availability should be maximized for all items included in the national standard list while all other items can be backordered to an upstream medical distribution centre or supplier.

Health programme managers need to consider the trade-off between higher customer service levels and higher costs when determining the importance and targets for individual customer service elements. These then need to be continuously measured by logistics managers to ensure that the required level of service is maintained (Rushton, A., J. Oxley, and Ph. Croucher 2000, 43).

If several health care facilities are benefiting from a humanitarian assistance programme, health programme managers should determine the criteria for prioritization of customers in case of shortages of goods or transportation capacities.

The fair share allocation (Bowersox, D.J., and D.J. Closs 1996, 289) ensures that all health care facilities receive some of the stock available at a medical distribution centre and can reduce stockouts which could interrupt services. Available stocks are in principle allocated among all customers to raise the coverage time at all health care facilities to the same level.

The needs and priorities will depend on the type of programme and for example differ between a mass vaccination programme, emergency assistance to a hospital in a conflict area and rehabilitation of health care facilities after the acute conflict has ended.

A staff member needs to be identified to serve as a contact point for requests and inquiries from customers as well as for receiving customer orders. A system which allows contacting and transporting all necessary staff to the medical distribution centre after office hours for providing services in case of emergency situations must be organized.

The range of goods which logistics services are required to keep in stock at all times needs to be established and laid down in national standard lists. Requirements for labelling and packing, which will also depend on national legislation and regulations, as well as documentation, need to be defined.

Customers need to be able to rely on a minimum remaining shelf-life of all expendable goods in order to avoid expiry of goods at health care facilities as well as for considering parameters of inventory control systems at assisted health care facilities.

Logistics services need to guarantee maximum lead times for stock items to allow implementation and maintaining of a rational and systematic inventory control policy as well as delivery frequencies and schedules must be agreed upon.

Special transportation needs such as distribution of cold chain loads or dangerous goods must be served. Logistics managers must define services which can be provided for installation, maintenance, service and repair of health care equipment as well as for training users and maintenance staff.

A customer service plan should also include data and information which logistics managers need to provide regularly to health programme managers for controlling their budgets as well as for donor reporting.

The customer service plan should be put in writing and be regularly reviewed and updated.

24.1 Developing a customer service plan

When working in a logistics department it is easy to forget that customers may not be familiar with supply chain management. They may not know exactly what services they can expect and what internal procedures need to be followed to allow effective and efficient supply chain management.

Customers need to be briefed about supply chain management in their humanitarian organization. This is particularly true for programme managers who are essential in providing information necessary to develop a supply chain strategy. Written guidelines can be a useful means of disseminating services, procedures as well as concerns and serve as a reference in the field.

A customer service plan is equally important as a reference for logistics staff. Services outlined in a customer service plan as well as their quality are the benchmark by which performance can be monitored. This will allow a more objective evaluation of quality of services than relying on a large number of customers all of which may have different expectations.

Ideally all staff and departments within an organization should see their colleagues and clients as customers and consequently try to constantly improve their services.

In formulating a customer service plan it is essential to make sure that services relevant to the customer are considered. However in determining the quality of services the necessary resources (which customers may not be too concerned about) need to be balanced against the quality of service which can be achieved with these resources.

A customer service plan is a written document which states the services customers can expect and should include the elements presented in table 24.1

A) Pre-transaction elements

- Frequency of meetings with Health programme managers.
- Contact details (departments, persons, addresses, electronic communication, telephone, "hotlines" for emergencies).
- Response time to inquiries and requests from customers.
- Procedures for ordering.
- Procedures for urgent orders.
- Updated information on stock list.
- Regular and updated information on available stocks.
- Stocks of replacement parts for health care equipment.
- Location, contents and quantities of contingency stocks.
- Contents of acknowledgment of customer orders (available stocks, lead time etc.).

B) Transaction elements

- Information on order size constraints (supplier packaging quantities).
- Target stock availability of stock items (customer service level).
- Target order lead time for contingency stock items.
- Target order lead time for stock items.
- Target order lead time for non-stock items.
- Measures in case of stockouts.
- Possibility for expediting consignments ("fast track").
- Labelling of consignments (language).
- Documentation provided with consignments (packing list, quality certificates).
- Capacity for distributing cold chain loads.
- Insurance during storage and transportation.
- Contents and frequency of order status information (especially backorders).

C) Post-transaction elements

- Information on claims procedures.
- Provision of data on past orders (for analysis by Health programme managers).
- After-sales services for health care equipment (maintenance, repair, training).
- Providing information on installation, maintenance, servicing and repairing equipment.
- Health care equipment for which reverse logistics services are provided.
- Provision of temporary replacement of health care equipment.
- Services for disposal of unwanted health care goods.

Table 24.1 Customer service elements

The contents of the stock list validated by health programme managers is one of the most important elements of a customer service plan and must be widely disseminated not only among staff members of the humanitarian organization but among managers and health professionals (particularly pharmacists) at assisted health care facilities.

24.2 "Push" and "Pull" concepts

Push, pull and push-pull are manufacturing concepts while push and pull ordering has a different meaning in humanitarian assistance.

"(Inventory, schedule or supply) Push" systems are commercial manufacturing systems which base their production plans on forecasts for finished goods and use materials requirement planning (MRPI) and manufacturing resource planning (MRPII) systems to "make to stock". In the extreme case of a new product without any knowledge of customer demand, the manufacturer will build up stocks and "push" the product on the market. The main disadvantage is that manufacturing plans do not depend directly on end-user demand and may lead to the accumulation of unneeded stocks.

"(Demand) pull" systems eliminate or at least reduce the waste associated with unnecessary stocking by manufacturing products only according to confirmed customer orders (end-user demand). Examples of these demand or market driven "pull" systems in their strict sense would be the make-to-order of satellites, handmade clothing or shoes tailored for a particular customer or complex health care equipment. The main disadvantage of "pull" systems is that customers must be willing to wait for the time the complete manufacturing process takes. In case of long production lead times "pull" systems cannot be responsive (Silver, E.A., D.F. Pyke,

and R. Peterson 1998, 642) do not allow reacting (quickly) to changes in customer demand and preclude benefiting from economies of scale in manufacturing and distribution.

The "push-pull" system is a hybrid system (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 208) which combines the advantages of reducing stocks while providing products within reasonable lead times. Upstream of the "push-pull boundary" (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 190) or "de-coupling point" (Christopher, M. 2005, 120) parts and components, such as for computers, paints or ingredients for a pizza, are manufactured according to a forecast and made to stock.

However, downstream of the "push-pull boundary" where safety stocks of parts and components are maintained, finished products are only assembled or customized upon confirmation of customer orders (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 541). For example a machine will blend paint and a few basic colours into an nearly unlimited number of different paint colours or music CDs are manufactured ("burned") on demand at a retail shop. A second strategy called postponement or delayed differentiation (Simchi-Levi, D., Ph. Kaminsky, and E. Simchi-Levi 2008, 190) manufactures "generic" products according to production plans but completes the production process, for example by colouring them, only upon receiving firm customer orders.

24.2.1 Pull- versus push-orders

Clearly, the concepts discussed above do not apply to humanitarian assistance in their original and strict sense as humanitarian organizations purchase finished goods and are not concerned with manufacturing concepts.

Moreover, throughout the supply network, health care goods are usually "pulled" and "pushed" at and between several stages of the supply network.

In pull-ordering, orders are calculated and placed at the stage of the supply network where stocks are being replenished or where goods will be used. For example the pharmacist at a health care facility will place an order to the upstream medical distribution centre or the manager of a medical distribution centre will place an order for stock replenishment with the next upstream medical distribution centre. Therefore the future (immediate) recipient of goods is placing orders.

Within a supply network, several (successive) stages can place pull-orders for stock replenishment.

Therefore push- and pull-ordering refers to whether the decision on the contents and quantities of replenishment orders is made at the same stage of the supply network where the ordered goods eventually will be received. Health care goods are received at the same stage where the pull-order was made while push-orders are decided and placed at any stage upstream of the stage of the supply network where the goods are eventually received and entered into stock or used.

Therefore in pull-ordering the origin of the flow of (ordering) information coincides with the final destination of the corresponding flow of physical goods.

The concept of pull- and push-ordering should not be confused with the concept of centralized and decentralized information or centralized and decentralized control. In principle push-orders could be based on the same demand data and forecast which would be used by a downstream medical distribution centre for a pull-order. However, in practice, push-orders are initiated when such information from downstream stages of the supply network is insufficient or not available at all and will therefore not be based on end-user demand.

The demand data on which forecasts and stock replenishment calculations are based may be derived from the same stage of the supply network (customer orders) or, ideally, from downstream end-user demand data. However, the origin of the demand data used for forecasting is not the determining criteria of a pull system. The types and quantities of health care goods "pushed" to a downstream medical distribution centre or health care facility could be identical to the type and quantities which would have been "pulled" from the downstream stage based on the same demand data and forecast.

Moreover, the concept of pull- and push-ordering should not be confused with the physical movement of consignments. In any supply network the great majority of health care goods flow downstream. Therefore "pushing" and "pulling" of physical goods is only a matter of perspective of the direction of the flows of goods depending on from which stage of the supply network the flows are observed.

In push-ordering the order is placed higher upstream in the supply network than the stage for which the goods are intended. For example staff at the head office may decide to place a push-order for shipment of health care goods to a national medical distribution centre without their prior approval or even knowledge. In the worst case, a donor will initiate push-orders for unsolicited donations to a health care facility without obtaining their consent.

Push-orders may be made for a medical distribution centre or health care facility at the next downstream stage or several stages downstream in the supply network.

24.2.2 Advantages and disadvantages of push-orders

Although pull-orders based on end-user demand must be the preference in general, pull-orders may not be possible in certain situations and push-orders also have advantages (see table 24.2) which justify their use in certain situations for a certain period of time.

In some situations, pull-ordering is not practical. Pull-ordering depends on the availability of end-user demand data and requires calculation and placement of orders by competent logistics or health programme staff.

In acute crises contacts with national drug regulatory authorities or staff at health care facilities requiring assistance might not (yet) be established or telecommunications infrastructure may be interrupted or unavailable.

Demand data may be unavailable at health care facilities, be incomplete, inaccurate or unreliable.

The (sudden) change of the epidemiology at the onset of an acute crisis may lead to large errors of forecasts which are based on historic end-user demand data. Large displacements of populations or an influx of a large number of patients can also suddenly change demand significantly.

Moreover, push-orders have several advantages. Establishing and maintaining contingency stocks would not be reasonable if they could not be "pushed" to health programmes in the initial stages of an acute crisis. Contingency stocks would either be unlikely to contain the exact goods requested by recipients or contingency stocks would have to contain a wide range of health care goods in order to ensure a reasonable stock availability.

Such contingency stocks are the precondition for an immediate response in case of an acute crisis and the shorter lead times for push-orders is the main and most important justification. Pull-orders require an assessment of competent staff at health care facilities or at least establishing contact with competent health professional or logistics staff. However, deployment of staff abroad and possibly in remote areas, takes time and inevitably leads to

delays of at least a few days. Moreover, sufficiently accurate estimates of the type and quantities of required health care goods may be possible by assessing the situation and detailed assessments may not necessarily be beneficial. For example in case of military operations the types of injuries and the required type of required health care can be reasonably accurately predicted according to the weapons used and historical analogies.

A Situations in which pull-orders are not practical

- Unavailability of contacts with authorities or end-users in health care facilities in need of assistance.
- Interruption of telecommunications infrastructure.
- Demand data at established health care facilities may be unavailable, incomplete or inaccurate.
- Significant changes in epidemiology.

B Actual advantages of push-orders

Lead time

- Allows holding contingency stocks at different stages of the supply network.
- Shorter overall lead times.
- Immediate shipment of consignments before access is possibly limited or impossible.

Effectiveness

- Recipients eventually receive health care goods which were announced.

Efficiency

- Avoids wasting resources for planning orders in situations where demand outweighs supply.
- Minimizes resources required by recipients for establishing logistics services.
- Reduction of complexity facilitates all logistics activities.
- Facilitates transportation consolidation and planning.
- Allows advance calculation and planning of required storage capacities.
- Facilitates budgeting and funding.

No need for data

- No (immediate) need for collecting demand data, demand analysis and demand forecasting.
- No constraints for obtaining detailed information from remote places.
- Allows serving all people in need, regardless of whether they have access to humanitarian organizations.

Competencies/appropriateness

- Ensures that provided health care goods are reasonable.
- Provision of a limited number of essential health care goods.
- Provided kits are known to be appropriate for the context and situation.
- Provision of health care goods according to a global view of the situation.
- Facilitation of coordination of humanitarian organizations at head office level.

Table 24.2 Reasons for preferring push-ordering

Only push-orders allow immediate shipment as soon as needs for health care goods become known or can at least be assumed with a high degree of probability.

The immediate shipment of health care goods may be vital in cases where there is an initial "window" for transport either before authorities restrict importation or before the security situation deteriorates and no longer allows transportation to or within the crisis area.

Pull-orders are only effective if all the requested health care goods are actually available. However, if requested health care goods are unavailable, requesters will not actually receive ordered goods and the subsequent revision of orders or lead times for sourcing and purchasing will delay provision of essential health care goods.

Health care goods which are "pushed" to assisted health care facilities as well as their funding are certainly available and recipients can be sure of the goods they will receive. Pull-ordered health care goods may not be in stock or the orders may exceed available funding.

In situations where demand greatly exceeds immediate available supplies of essential health care goods, waiting for detailed pull-orders would be a waste of resources and lead to unnecessary delays.

Push-orders minimize necessary resources recipients need to provide for establishing and maintaining logistics activities such as setting up information systems, establishing medical distribution centres as well as (frequent) transportation and reduce the complexity of logistics management.

Planning, consolidating and organizing downstream transportation is greatly facilitated as weights and volumes are known as soon as push-orders were place and eliminate the uncertainty of pull-orders and the stock availability of ordered health care goods.

Storage requirements at downstream medical distribution centres are also easy to calculate in advance.

Finally budgeting and appeals for funds are facilitated as the value of push-orders can easily be calculated.

Push-orders make collection and analysis of demand data as well as forecasting of demand unnecessary which can be time consuming and may significantly delay ordering.

Moreover demand data may not be available, especially from remote health care facilities or in situations where the telecommunications infrastructure is interrupted. This in turn allows, in principle, to serve any health care facility regardless of whether they are in contact with the respective humanitarian organization which furthers equal consideration of all people in need.

In principle it is justified to assume that health professionals at assisted health care facilities have the best information and knowledge on needs. However, there is also a danger that the prospect of donations may encourage exaggerated or even unreasonable requests. Moreover, experienced humanitarian helpers may have more experience with certain situations, such as armed conflict, displacement or an epidemic, than health professionals faced with the situation for the first time.

The push-ordering of standardized medical kits ensures that the number of health care goods is limited, they are all essential and suitable for the context and for the number of affected people. Push-orders should also avoid the potential problem of health professionals unnecessarily increasing the variety by ordering different items which could be substituted for each other.

Moreover push-ordering allows providing health care goods to a number of health care facilities in a region or country according to a global view of the overall situation rather than on needs of individual health care facilities.

Finally, push-orders greatly facilitates planning and coordination of flows of health care goods among humanitarian organizations.

Despite a number of advantages, push-orders also have important disadvantages (see table 24.3).

Decision makers at head offices or other sites upstream from recipients may lack the understanding of the country, (humanitarian) situation, prevailing epidemiology, the needs and their priorities. Health professionals and affected populations do not, or not directly,

participate in decisions on the types and quantities of health care goods which are being provided.

Recipients may not receive information on the consignments they will receive in advance or in due time and the flows of health care goods may exceed (unknown) capacities of the downstream supply network.

Push-orders incur the risk of sending essential, appropriate and required health care goods but in quantities which exceed current needs. Although they will eventually be used, these donations unnecessarily utilize scarce logistics resources and consume funds which could have been used on other health care goods or other humanitarian assistance goods.

The main risk of push-orders are all the potential disadvantages of unsolicited donations discussed earlier such as provision of health care goods which are inappropriate for the country, the context, the situation, the epidemiology and not adapted to standard treatment protocols as well as habits of health professionals. At the same time these donations may be useful for other health care programmes. Dubious donors may also abuse legitimate push-orders for off-loading and dumping unwanted stocks.

At the same time push-orders incur the risk that required health care goods are not delivered while funds and logistics capacities are wasted on other unwanted health care goods.

Push-orders also do not allow reacting to changes in needs and demand at all or only with (long) delays.

Finally, end-user demand data is not collected and therefore not available for demand analysis and forecasting.

- Decision makers may lack understanding of the country, situation, epidemiology and needs.
- No (direct) participation and involvement of recipients concerning decisions on items and quantities.
- End-users may not receive information on contents of consignments and time of arrival in advance.
- Flows may exceed (unknown) capacities of the supply network.
- Risk of sending health care goods which are appropriate but already overstocked.
- Risk of sending inappropriate health care goods.
- Possible delivery and wastage of health care goods which are inappropriate or not needed.
- All potential detrimental effects of unsolicited donations.
- Risk of dubious donors abusing legitimate push-ordering for "dumping" unwanted stocks.
- Failure to deliver essential health care goods which are needed.
- Inflexibility towards changes of needs and demand.
- No demand data is collected for future demand analysis and forecasting.

Table 24.3 Possible disadvantages of push-orders

24.2.3 Push-pull-orders

Pure push-orders have a number of significant disadvantages and situations where health care goods are selected and pushed downstream up to the end-user are exceptional, at least for health care goods.

Push-pull-orders allow to benefit from some of the advantages of push-orders as well pull-orders while avoiding the main disadvantages of push-orders. Moreover push-pull-orders are a

compromise in situations where pure pull-orders are not possible, not practical or immediate delivery is critical.

In an established supply network with stocks at all stages, every stage will calculate (monthly) replenishment orders and place pull-orders to the next upstream medical distribution centre.

The extreme case of pull-order would be the rather exceptional case that health professionals at an assisted health care facility place a pull-order directly with the manufacturer, for example for diagnostic imaging equipment or an anaesthesia machine. The opposite and likewise exceptional extreme would be a programme manager at a head office who places a push-order for delivery of health care goods directly to end-users, for example for vaccines during an epidemic. Beyond the internal supply network, the most extreme case of a push-order would be the donation of health care goods from a manufacturer which is facilitated by a humanitarian organization.

In between these two extreme case the push-pull boundary can be located at any stage of the internal supply network. Except for unsolicited and unannounced donations, suppliers cannot push goods without humanitarian organizations placing an order. On the order hand, humanitarian organizations will usually not authorize recipients to order health care goods without their approval.

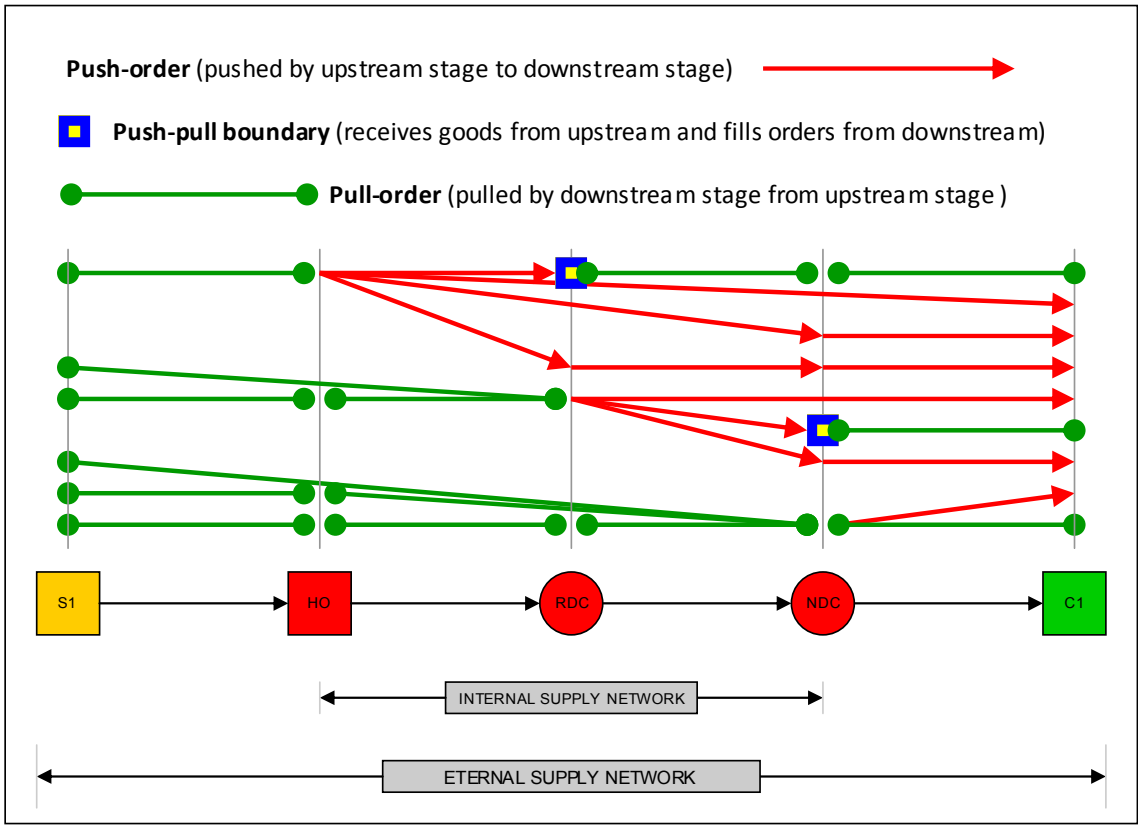

Figure 24.1 Push-pull-boundaries in supply networks

Push-pull-orders consist of two distinct phases. The push-order can be initiated at any stage if the internal supply network, which has either earlier initiated a pull-order or which received goods by a push order from upstream. In the first phase, any stage upstream from end-users, initiates delivery of health care goods to any downstream medical distribution centre or directly to an assisted health care facility. At this stage, stocks must be established and

maintained in the supply network, even if stocking time is short. In the second phase, stocks at the push-pull boundary are distributed to any downstream medical distribution centre or end-users according to a pull-order.

Push-orders may be followed by more than one subsequent pull-order. For example head offices may push-order health care goods to a regional medical distribution centre from where they are pull-ordered to the national medical distribution centre and pull-ordered from an assisted health care facilities.

Moreover (immediate) push-orders for example of standard kits, may be complemented by (subsequent) pull-orders which are based on additional information and more accurate assessments and forecasts.

Whenever routine pull-orders are (temporarily) replaced by push-orders, the stage and service which initiates push-orders must be clearly defined and communicated to all downstream stages of the supply network. It is also particularly important to clearly define and communicate the point in time when push-orders are stopped and pull-orders are resumed. Otherwise lack of coordination can lead to overstocks by simultaneous push- and pull-orders as well as shortages and stockouts because no orders are placed at all.

Push-orders can be initiated as soon as humanitarian organizations decide to provide assistance and sufficient and sufficiently accurate information is available to ensure at least a high probability that (most of) the ordered health care goods will be suitable for responding to the needs and providing appropriate health services.

The trade-off between providing essential health care goods based on incomplete information and judgemental forecasts very quickly and selecting health care goods according to detailed assessments and accurate demand forecasts but with significantly longer lead times must be made. This corresponds to the trade-off between providing health care goods which do not entirely meet the needs on time or providing exactly the required health care goods but too late (for saving lives). Emergency services which do not have any information on the kind of medical emergency which would immediately dispatch a specialist without any medical equipment who reports back on the type of equipment which is needed would allow providing optimal treatment, but too late. Instead emergency services carry a range of equipment which allow responding appropriately to the most common, most likely and most dangerous medical conditions.

As humanitarian workers and health programme managers move downstream towards end-users, the push-pull boundary also is moved downstream until the end-users are reached and pull-orders can be implemented. Push-orders are clearly only a temporary strategy for filling the time gap between the onset of a crisis and the completion of (rapid) assessments. One main task of the first humanitarian workers arriving is carrying out assessments, determining and forecasting humanitarian needs.

However, in practice, only the most essential health care goods needed for responding to immediate needs will be push-ordered to cover the time gap for completing assessments and obtaining detailed information on needs from end-users. Therefore, in principle, push-orders should be initiated as quickly as possible but should also be replaced by pull-orders from end-users as soon as possible.

The decision on the stage in the supply network where the push-pull-boundary is (initially) located must consider a trade-off. Pushing health care goods to stages further upstream from end-users increases the flexibility of selecting different end-users but increases the lead time for fulfilment of subsequent pull-orders. On the other hand, push-ordering health care goods further downstream in the supply network reduces lead time for final order fulfilment but

limits the flexibility of moving those health care goods to another location if they prove not to be appropriate for downstream health care facilities. For example, kits pushed to a regional medical distribution centre may be used (later) in another country while kits pushed to a national medical distribution centre may be difficult to export if they are (eventually) not needed.

Push-orders must not be mistaken for shipping "anything" available in medical stocks. Except in the unfortunate case of unsolicited donations, push-orders are always based on quantitative or at least qualitative (judgemental) forecasts. The demand data or other information which is used for forecasting may originate from end-users, any other downstream stage of the supply network or even any upstream stage in the supply network. For example, programme managers in a country may base their push-orders on information received from assisted health care facilities or, exceptionally, on general information on the overall situation received from the authorities, media reports or the head office.

In practice push-orders will be based on an overall assessment of the situation and health needs and forecasts will be derived from historical analogies of previous crises by experienced health programme managers. For example after an outbreak of armed conflict where reliable reports and information indicate a reasonably accurate estimate of the number of wounded or displaced people, suitable kits can be push-ordered from head offices. Another example would be push-orders for kits in the case of an epidemic outbreak such as cholera.

However apart from determining overall needs, available capacities in existing health care facilities as well as current and planned assistance of other agencies as well as humanitarian organizations also need to be considered.

In practice standard kits will be push-ordered in most cases for several reasons. Kits are, or should, be available as part of any contingency plan. Moreover, in situations where push-orders are justified, information on the exact items and required quantities is simply unavailable. In most cases decisions on push-orders will be based on typical emergency situations such as epidemics, large scale displacements or a large number of casualties from armed conflict. Finally, kits are designed to serve a certain number of people affected by a specific situation. For example the IEHK (Interagency Emergency health Kit) is designed for providing essential care to a population of 10,000 during three months.

Moreover, in practice health care facilities will often not be able to cope with all health needs and prioritize services they provide. For example, during an influx of a large number of wounded, health care facilities must limit services to life saving operations while elective and reconstructive surgery will have to be postponed until the required resources are available again.

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25 LOGISTICS EVALUATION

The logistics evaluation is a tool for assuring the quality of the logistics systems at the tactical level of supply chain planning and covers logistics management at the national level over a mid-term time horizon of 1-2 years. It corresponds to the cGMP and GDP inspections and audits carried out by national drug regulatory authorities.

Logistics evaluations periodically assess compliance of structures, facilities, services, systems, procedures and processes with clearly defined standards and standard operating procedures (SOP). Furthermore the availability of resources and capacities are assessed.

Any observed deviations from defined standards should be documented in a report together with detailed proposals for corrective action.

The overall objective of carrying out logistics evaluation is to prevent deterioration of health care goods from the time of receipt from commercial suppliers until delivery to end-users as well as ensuring that all resources and procedures are in place for enabling provision of excellent customer services.

	Logistics evaluation	**Performance measurement**
Management level	Tactical	Operational
Supply chain management	Supply chain planning	Supply chain operations
Time horizon	Mid-term	Short-term
Geographic scope	National	Local
Aspect	Set-up (static)	Flows (dynamic)
Measurement	Qualitative	Quantitative
Scope	Comprehensive	Selective
Analysis of	Structures, facilities, services, systems, procedures, processes, resources, capacities	Effectiveness and efficiency of procedures and processes
Measurement of	Inputs	Outputs
Measurement against	Standards and Standard Operating Procedures	Performance targets
Measurement aspect	Compliance	Performance
Frequency	Periodically	Continuously
Information	Snapshot	Development over time
Instruments	Inspection, audit, observation, interviews (asking questions)	Measurement of indicators
Results	Implementation rate	Measurement values

Table 25.1 Comparison of logistics evaluation and performance measurement

25.1 Objectives

Logistics evaluations must not be seen as tests, personal evaluations or critique although managers and others staff must nevertheless be held accountable for any shortcomings and failures which are revealed. Instead the focus and overall objective must be identifying possibilities of improving the set-up, processes and procedures which will in turn enable improving customer service.

The first of several objectives (see table 14.2) is the systematic and objective inspection and examination of facilities, services, systems, procedures and resources. While available resources and facilities can be inspected and examined, a logistics evaluation can only determine whether procedures are defined, documented and in principle known to staff. However a logistics evaluation cannot determine whether all procedures are actually complied with. This is comparable to a cGMP audit where compliance with standards is examined but the quality of manufactured drug products is not tested by auditors and it is therefore not known, whether the required quality standards of manufactured products are achieved.

A logistics evaluation only determines whether the resources and procedures which are required for providing excellent services are appropriate and sufficient but does not measure the actual quality of provided services. However, the absence of or shortcomings in facilities and certain procedures may make provision of the respective services impossible and therefore allow to infer poor quality services. For example, the absence of thermometers makes monitoring of the room temperature impossible and lack of appropriate cold chain equipment inevitable means that the cold chain is not maintained. Therefore the presence of resources and procedures only allows to ascertain that high quality logistics services can be (in principle) provided while the absence of resources and procedures may allow to infer that the high quality of some logistics services cannot be provided.

In a next step the observations are compared against the standards defined by the humanitarian organization which should be documented in internal guidelines such as a quality assurance policy as well as in complete set of standard operating procedures for all relevant activities. Only this comparison against objective references ensures that the results of logistics evaluations are repeatable.

This comparison allows detecting the presence of discrepancies or shortcomings as well as their extent. However the logistics evaluation is ineffective if it were limited to identifying problems, faults and failures.

Determining the reasons for discrepancies such as lack of knowledge or lack of required resources in turn allows determining appropriate corrective actions which will then allow ensuring future compliance with the defined procedures and standards.

- Detailed evaluation of resources and procedures.
- Comparison of set-up and procedures against defined standards.
- Identifying any discrepancies and their extent.
- Identifying reasons for discrepancies.
- Determining appropriate corrective actions.
- Documenting findings and recommendations in a report.
- Improving set-up, processes and procedures in order to improve services.

Table 25.2 Objectives of logistics evaluations

The findings of the inspection as well as the recommended corrective actions should be systematically documented in a detailed report for future follow-up and as a reference. Eventually compliance with the recommendations needs to be assessed by carrying out a further logistics evaluation.

25.2 Types of evaluation

Evaluations can be carried out by external evaluators which are independent from the humanitarian organization or by staff from inside the respective humanitarian organization, either from the service that is being audited or from another service or location. Self-inspection is a special form of internal audit where staff members audit their own resources and procedures.

External and internal evaluations both have advantages and disadvantages (see table 25.3).

Internal evaluations do not require evaluators to become familiar with the organization as well as the context of their work and they may even be familiar with the location as well as the service. Evaluators will also be familiar with available resources and standard operating procedures.

Internal evaluators may be less intimidating and staff may talk more openly to them than to external evaluators. On the other hand, staff may be afraid of expressing criticism if the evaluators are directly or indirectly in a hierarchical position.

The absence of (fear of) sanctions from an external report may increase the willingness to acknowledge and discuss shortcomings.

In addition, self-evaluations have the advantage that staff members recall, review and study the standard operating procedures, can participate in detecting shortcomings in their own work and contribute towards finding ways for improvement. The audit process itself is likely to instigate and encourage discussions about their work among staff members and should increase their sense of responsibility for their work.

On the other hand, internal evaluations have several disadvantages. The evaluators may lack sufficient knowledge of services and procedures and may lack the skills and experience required for carrying out evaluations.

Internal evaluators will have difficulties remaining objective, are prone to bias and may be overly critical towards their colleagues. Moreover evaluators from the same organization may be prone to blindness to company failings.

In addition, self-evaluations have the disadvantage that they may lack rigour and thoroughness and may be less objective than evaluations by staff members from other services or locations.

External evaluations have the advantage that the evaluators are better skilled, have experience in carrying evaluations and can fully dedicate themselves to the evaluation.

External evaluators are generally more objective, can take a fresh and unbiased look at the organization and services and can relate their observations to evaluations of other services or organizations.

External evaluators will not have any personal interest in biasing the results as they are independent from the power structure of the humanitarian organization and staff members may be more open to express criticism towards outsiders, at least if they are confident that they will remain anonymous.

On the other hand, external evaluations may be expensive and and an official report may be intimidating and cause anxiety among staff.

	Advantages	Disadvantages
Internal evaluation	• No need for evaluators to become familiar with organization. • Better knowledge of resources and processes. • Staff may talk to evaluators more openly. • Less intimidating for staff. • Absence of sanctions will lead to greater willingness to acknowledge shortcomings.	• Possibly lack of sufficient knowledge, skills and experience. • Difficulty of remaining objective and danger of bias. • Danger of staff being overly critical towards their colleagues. • Prone to blindness to company failings. • Fear of expressing criticism and self-censorship.
Self-evaluation	• Active learning process. • Allows staff to participate in detecting shortcomings and finding solutions. • Instigates and encourages discussions among staff members. • Increases the sense of responsibility of staff.	• Possible lack of rigour and thoroughness. • Lack of objectivity.
External evaluation	• Evaluators more skilled and experienced. • Evaluators dedicated to the evaluation only. • More objective. • Fresh look at the organization and services. • Experience allows to compare with other organizations. • Absence of personal interest in the evaluation results. • Independence of evaluations from power structure of the organization. • Staff may be more open to express criticism towards outsiders.	• May cause anxiety among staff and lead to intimidation. • May be expensive.

Table 25.3 Advantages and disadvantages of internal and external evaluations

25.3 Reasons for carrying out evaluations

Logistics evaluation may be necessary or justified for several reasons (see table 25.4).

Logistics evaluations should commence during the setting-up of new facilities and services in order to ensure that all required standards are met upon completion and a final logistics evaluation should be carried out after completion. This applies to new services which are planned in advance as well as logistics services established at short notice during acute crises and emergencies.

All logistics services should be routinely evaluated as part of the quality assurance system for logistics services, for example twice a year in order to ensure that achieved standards are maintained.

Whenever corrective action is proposed as a result of a logistics evaluation, another logistics evaluation must be carried out soon after to confirm that all recommendations have been followed. Possibly further logistics evaluations are necessary until full compliance with defined standards and standard operating procedures has been achieved.

Significant changes in facilities or services whether increases or downsizing, should be followed by a complete logistics evaluation in order to ensure that the standards have been maintained despite the undertaken changes.

During handing over a complete logistics evaluation should be carried out by the outgoing supervisor or manager in order to document the current state of services as well as achievements. The incoming supervisor or manager should also participate in the logistics evaluation in order to document her or his starting point as a reference for future logistics evaluations.

Whenever performance measurement targets are not reached, a logistics evaluation should be carried out in order to determine whether shortcomings in facilities or procedures are at fault or a contributing factor. Likewise repeated and justified complaints from customers about poor services or shortcomings in certain services elements a logistics evaluation should be carried out. Customers, staff members or visitors may also raise concerns which may need to be followed up.

- Setting up new facilities and services.
- Regularly (routinely) as part of the quality assurance system.
- Follow-up on corrective action proposed during previous logistics evaluations.
- (Significant) increases or changes of facilities and services.
- Downsizing of facilities and services.
- Handing over.
- Poor performance of logistics services.
- (Repeated) justified complaints from customers.
- Concerns raised by customers, staff or visitors.

Table 25.4 Reasons for carrying out evaluations

25.4 Evaluators

Internal evaluators as well as external evaluators which may be contracted by humanitarian organizations, donors or be inspectors from the national drug regulatory authorities should fulfil a number of requirements.

Evaluators must have integrity and credibility since otherwise their findings and recommendations will not be taken serious.

Analytical thinking and a systematic approach are important in order to identify problems and carry out comprehensive logistics evaluations effectively and efficiently.

Evaluators should have experience in carrying out evaluations and must have expertise in the field of logistics and supply chain management as well as a good knowledge of humanitarian

assistance and humanitarian organizations. They must also be sensitive to the context in which humanitarian organizations work and the complexity of humanitarian assistance operations.

Finally evaluators must carry out their inspection and analyses objectively and impartially without being influenced by pressures from humanitarian organizations or other stakeholders.

- Integrity.
- Credibility.
- Analytical thinking.
- Systematic approach.
- Experience.
- Expertise.
- Sensitive to the context and complexity of humanitarian assistance.
- Objectivity.
- Impartiality.

Table 25.5 Requirements for evaluators

25.5 Planning logistics evaluations

In order to conduct logistics evaluations effectively and efficiently they must be well planned (see table 25.6).

Depending on the reasons, the objectives and terms of reference must be clearly defined. The stakeholders, all persons who take a direct or indirect interest in the logistics evaluation, should be identified as they will need to be considered or involved at some stage during the logistics evaluation.

Staff members who are needed for interviews and assisting in the logistics evaluation need to be identified in advance to ensure their availability.

The stakeholders who will study and use the report and implement the corrective action should be determined as this may influence the focus of the logistics evaluation as well as the presentation of the report.

A complete and updated set of precise and clearly defined standards as well as standard operating procedures is indispensable as the main reference for the entire logistics evaluation. Accordingly, the logistics evaluation checklist should be updated.

Previous logistics evaluations and proposed corrective actions should be carefully reviewed as these should be a focus of the logistics evaluation.

The scope and exact contents of the logistics evaluation should be clearly defined. Logistics evaluations can be comprehensive and cover all logistics activities and services or may be carried out in several stages at different times. In case time is limited and further logistics evaluation are not possible in the near future, as far as possible all areas should be covered partially rather than studying only some aspects in great detail.

Some consideration should also be given to the records and documents which will be required and their availability and accessibility should be confirmed.

A detailed plan of the facilities and services which need to be inspected and visited, where necessary a travel schedule as well as a time table should be established for the entire logistics evaluation.

Finally the costs for the logistics evaluation should be estimated.

An office space should be made available to evaluators for reviewing documents, carrying out their analyses and preparing their report.

- Clearly define objectives.
- Define terms of reference.
- Identify stakeholders.
- Identify staff who can assist in carrying out the logistics evaluation.
- Determine who will study and use the report.
- Determine who will implement the corrective action.
- Obtain updated standards and standard operating procedures.
- Update logistics evaluation checklist (questionnaire).
- Review previous logistics evaluations and proposed corrective actions.
- Determine contents and scope of logistics evaluation.
- Consider required records and documents.
- Plan inspections and visits of facilities and services.
- Establish time table.
- Estimate costs.
- Prepare workplace.

Table 25.6 Planning logistics evaluations

25.6 Conducting logistics evaluations

Before starting the actual evaluation, the evaluators should introduce themselves to the staff which are concerned by or involved in the logistics evaluation and explain the importance, objectives as well as the process of the logistics evaluation. It is essential for the evaluators to seek cooperation with staff and explain that the logistics evaluation is not an exam but has the sole objective of improving logistics services. Staff should be encouraged to express their concerns and ask questions.

The logistics evaluation itself must be carried out systematically according the predetermined plan and by following the standardized logistics evaluation checklist (questionnaire) step by step which will ensure that the results are comparable to other logistics evaluations. Every item on the logistics evaluation checklist should be rated as completely compliant, partially compliant (some improvements required) or non-compliant. For all items which are not completely compliant detailed comments on the observations made should be recorded as explanation.

All inspections should be carried out with a clear view of making recommendations and proposing improvements rather than detecting shortcomings and faults for their own sake or getting lost in analyses which are of no practical relevance.

Special attention should be given to items where shortcomings were found during previous logistics evaluations in order to determine whether the corrective action was carried out.

Interviews should be carried out in a polite, friendly and constructive atmosphere and must not embarrass or blame staff members or subject them to an examination. Evaluators should ask open-ended questions, listen, give interviewees sufficient time for answering and explaining as well as restate responses to make sure they have understood them well.

Evaluators will rely on the information received from staff members but may double-check by posing the same question to a different staff member.

Where observations are required, evaluators should "go and see" for themselves rather than rely only on verbal information. Likewise, where necessary records and documents should be carefully reviewed and analysed by the evaluators themselves.

25.7 Logistics evaluation questionnaire

Logistics evaluations should assess compliance with defined policy standards as well as standard operating procedures. Policies are the result of strategies, standards are established for "static" issues such as the set-up of medical storage facilities and standard operating procedures apply to activities ("dynamic" aspect).

While the topics covered by the logistics evaluation questionnaire (see table 25.7) focus on tactical issues, the clear separation from strategic and operational issues can be difficult.

Supply network design is generally a strategic issue but within a country the need for each medical storage facility must nevertheless be questioned regularly.

At the operational level the performance measurement system will measure the effectiveness and efficiency of various logistics activities. However the logistics evaluation must nevertheless determine whether standards and standard operating procedures which enable efficient operations are established and known to staff.

As the evaluation of many issues requires qualitative measurements, a rating scale needs to be established. The simplest option would be "yes" (full compliance) or "no" (not compliant). More detailed ratings are possible with rating scales for example from 1 to 5 or 1 to 10. However, in order for the results to comparable and obtain the same results by different evaluators, a detailed list of criteria would have to be established for each question and each rating. Therefore, a good compromise is to use three ratings with 0 (not compliant), 1 (partially compliant) and 2 (fully compliant).

	Logistcs evaluation topics	Policy	Standard	SOP
A	**Staff management**			
1	Recruitment of staff		●	
2	Staff management		●	
3	Handing over			●
4	Support mission			●
B	**Item selection**			
5	National standard list		●	
6	Contingency stock plan	●		
C	**Sourcing**			
7	Purchasing methods	●		
8	Domestic purchase	●		
9	Supplier selection		●	
10	Tender process			●
11	Purchasing contracts		●	
12	Purchase transactions			●
13	Supplier evaluation			●
D	**Storage**			
14	Facility network planning	●		
15	Selection of sites and facilities for stores	●		
16	Set-up of medical storage facility		●	
17	Setting up a cold chain		●	
18	Warehouse and stores management		●	
19	Record keeping and filing		●	
20	Fire safety		●	
21	Warehouse and stores operations			●
22	Management of cold chain items			●
23	Measures to minimize demand distortion		●	
24	Demand analysis		●	
25	Forecasting and collaborative planning			●
26	Inventory control	●		
27	Stock replenishment			●
28	Stock positioning	●		
29	Managment of shortages and stockouts			●
30	Product recall			●
31	Disposal of unusable health care goods			●
E	**Transport**			
32	Distribution systems	●		
33	Importation and exportation			●
34	Selection of mode of transport	●		
35	Selection of means of transport	●		
36	Transport and distribution to customers			●
37	Protection of health care goods during transport			●
38	Transport of dangerous goods			●
F	**Customer service**			
39	Customer service plan		●	
40	Treating customer orders			●
41	(Stock replenishment at assisted health care facilities)		●	
G	**Logistics controlling**			
42	Logistics evaluations	●		
43	Supply chain performance measurement		●	

Table 25.7 Contents of logistics evaluation questionnaire

25.8 Corrective action

After completing the logistics evaluation checklist, the results are compared with the policies, standards and standard operating procedures in order to determine any discrepancies and their extent. Wherever possible, the causes and reasons for the discrepancies and the underlying problems should be identified.

The corrective actions required to reach the defined standards (again), such as improving utilization of resources, provision of additional resources or training of staff and managers follow from the determined discrepancies. All corrective actions must follow from defined policies and standards, be conclusive as well as focus on improving services, be feasible and constructive.

The urgency and priorities of measures, especially in terms of preventing deterioration of the quality of health care goods and preventing stockouts at assisted health care facilities, should be assessed. Where available resources are limited, possibly a trade-off between different measures will have to be considered or all measures will have to be implemented in phases over a period of time.

Staff and managers responsible for implementing each measure as well as a detailed time table should be clearly defined. Where possible, they should be assisted for obtaining the required support and resources.

Finally, a time must be set when the implementation of all corrective action will be followed-up by a further logistics evaluation.

25.9 Evaluation report

Every logistics evaluation should be well documented in a final report. The report should indicate the name of auditors and the author of the report, the person who requested the logistics evaluation, the terms of reference and objectives, contents and scope of the evaluation, the time period during which the evaluation was carried out, the methods used, visited places and facilities the persons interviewed as well as the records which were reviewed.

The main findings and recommendations should be summarized in an executive summary at the beginning of the report.

The logistics evaluation questionnaire, the findings and recommendations (corrective action) will make up the core of the report. The indication of corrective actions separately for each instruction of standards or standard operating procedures will greatly facilitate following them up point by point rather than writing the corrective actions in a long narrative. The report should be easily understandable and the conclusions must be logical and be supported by the logistics evaluation.

Comments may be added with any relevant explanations such as constraints or special circumstances explaining the findings. The entire report should be written in a constructive way which looks forward to improved services rather than lingering and elaborating on mistakes and failures in the past. The report should also indicate logistics activities and services which are well managed.

The misuse of reports for advocating or defending particular positions or justifying measures already taken should be avoided.

The report should be presented to and discussed with staff members concerned by the logistics evaluation and not be considered as confidential. The proposed corrective action as well as the time table should be discussed.

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26 PERFORMANCE MEASUREMENT SYSTEM

Regularly conducted logistics assessments (as the "static" component) ensure that appropriate resources and sufficient capacities are in place which are a precondition for providing high quality logistics services and carrying performance measurements (as the "dynamic" component).

The objectives for logistics services can be derived from the objectives of humanitarian organizations (see chapter 2). Suitable performance metrics must be selected for repeated measurement of actual performance and for comparison with defined performance standards and targets.

Traditionally more attention has been paid to selection and use of individual performance metrics rather than the measurement system as a whole. However a haphazard assortment of performance metrics will not achieve the objective of improving decision making.

Rather the individual performance measures and performance metrics as building blocks should be carefully selected and assembled in order to design a coherent, consistent, complementary and comprehensive performance measurement system. The performance measurement system should include quantitative as well as qualitative measures, measure effectiveness as well as efficiency and provide decision makers with a complete and balanced picture of all logistics activities.

The reasons for any discrepancies between actual and intended performance need to be identified and analysed in order to propose corrective action as well as to improve overall planning and management. The ultimate goal of performance measurement is the ability to guide and influence decision making processes (Caplice, Ch., and Y. Sheffi 1995, 65). Finally, performance measurements need to be reported and communicated.

26.1 Metrics

Quantitative measures can be separated into statistics as well as quantitative performance metrics.

26.1.1 Statistics

Unlike performance metrics, statistics are merely numerical facts such as results from counting, measuring time spans or determining costs. These measures of activities or quantities in itself do not allow deriving the related performance. For example the absolute stock level of an item itself does not provide any information on coverage time or stock availability and the number of received customer orders treated in a certain period of time does not provide any information on provided customer service.

Statistics are of particular relevance for planning required logistics resources and capacities such as determining the required storage capacity or number of staff.

Many of the statistics in table 26.1 can be measured for the various dimensions discussed earlier and most statistics are self explanatory.

	Statistics	Time measures	Financial measures
Health care goods	Conformity to required product specifications. Number of recalls.	Total shelf life. Remaining shelf life.	Product price. Cost of ownership.
Sour-cing	Number of suppliers.	Supplier lead time.	Purchase costs.
Inventory control	Forecasting error. Number of replenishment orders. Number of order lines. Number of line items on hand. Number of backordered line items. Number of stockouts (shortages). Excess stock (line items). Stock levels (units/ weight/volume).	Duration of stockouts. Frequency of stockouts. Stock turnover (in units). Turnover per line item (in terms of value). Aggregate stock turnover (in terms of value).	Stock value. Value of excess stock.
Storage	Consignments picked. Line items picked . In- and outbound flows (parcels/weight/volume).	Stocking time. Order picking time.	Stores operating costs. Value of goods damaged in stock. Value of expired stock. Value of flows.
Transport	Number of consignments. Transported volume. Transported weight. Transportation distance . Documentation. % of transport by mode.	Frequency of deliveries . Transportation time. Time for customs clearance.	Value of consignments. Value of damaged goods. Transportation cost. Cost of expedited transport.
Customer service	Number of orders received. Number of order lines.	Customer inquiry response time. Order lead time.	Value of orders received.
Total supply network	Total flows (parcels/ consignments/ weight/ volume).	Order to delivery lead time (for line items not in stock).	Total supply network cost Value of distributed health care goods.

Table 26.1 Statistics

The stock turnover, also called inventory turn rate (ITR) is calculated by dividing the flow of goods during a defined period of time (often a year) through the average stock on hand during

the same period of time. For example if 200 units of an item were distributed during a year and the average stock level during the same year was 100 units, the annual stock turnover is 2.

$$\text{Annual stock turnover} = \frac{\text{Annual value of stock issues}}{\text{Average stock value}} \qquad \text{Eq. 26.1}$$

In other words, the entire stock has been "turned over" twice during the year. The same calculation made in terms of total value of flows and average stock value will yield the same result.

The aggregate stock turnover is usually calculated by dividing the total value of (annually) distributed health care goods by the average stock value.

26.1.2 Requirements for performance metrics

Like the performance measurement system as a whole the individual performance metrics must fulfil certain requirements (see table 26.2).

Performance metrics must be meaningful, relevant and important for further analysis as well as be helpful for making management decisions and improving services ("actionable"). Measurements of performance metrics simply for the sake of measuring or because data is available should be avoided.

The precision and level of detail appropriate for the situation and decision maker must be selected. For example order fill rates can be aggregated over line items, orders as well as over time.

The exact data elements as well as formulas and algorithms of performance metrics must be clearly defined in order to avoid accidental or intentional misinterpretation.

It must in principal be possible to carry out an accurate measurement of the performance metric by counting or measuring its factors or elements or at least with an acceptable rate of error.

The validity of performance metrics refers to the ability and accuracy of measuring only what the performance metric purports to measure as well as avoiding distortion by factors which are not relevant to the performance metric.

The data required for carrying out the measurement must be available or it must at least be possible to generate or obtain the data with reasonable resources. Ideally all data should be available in the information and reporting system and not require additional work for collection.

Performance metrics should be reasonably simple to measure for example without having to manually analyse a large number of records or carry out complicated mathematical analysis.

The performance measures taken at different times at the same site or of the same service should be comparable among each other as well as to the same measurements taken at other locations or of other services. Ideally the performance metrics should also allow comparison with other humanitarian organizations and industry standards.

Repeated measurements of the same set of data or information und the same circumstances, even by different persons, must yield the same results and must be interpreted by different people in the same way.

- Relevance.
- Must be "actionable".
- Appropriate level of detail.
- Clarity.
- Allow accurate measurements.
- Validity.
- Availability of data.
- Reasonably simple to measure.
- Comparability.
- Reliability (repeatable).

Table 26.2 Requirements for performance metrics

The main trade-off between requirements for performance metrics which requires consideration is between validity and comparability. The more specific and the more adapted to a specific situation a performance metric is, the more difficult the comparison with other services and locations becomes.

26.1.3 Quantitative performance metrics

Unlike statistics, performance metrics (see table 26.3) measure the quality of performed activities. Performance metrics are often expressed in fractions or percentages and require relating at least two different statistics.

Although performance metrics give an indication of how well activities are carried out, their evaluation requires relating them to a set target or benchmark.

Table 26.3 does not list all the possible dimensions discussed earlier which can be applied to the respective performance metrics.

The percentage of batches or value of health care goods which are returned from customers because their quality does not conform to defined quality standards is an indicator for the quality of the quality control system.

The percentage of remaining shelf life upon delivery to customers is a measure for the quality of purchasing as well as inventory control management. Health care goods should be purchased with a minimum percentage of remaining shelf life and stock levels must be maintained which limit stocking time and therefore the loss of remaining shelf life during storage.

The number of line items purchased per supplier as well as the value per purchase contract indicates the extent to which purchases are consolidated. However, while purchasing several products from the same commercial suppliers improves purchasing efficiency, purchasing a small number of products directly from the manufacturer may be preferable in terms of quality assurance.

The more batches are purchased per line item the greater the resources required for storage and documentation are.

The percentage of on time deliveries from (commercial) suppliers as well as the consistency of delivery lead times are important measures for evaluating suppliers.

The average purchase costs per purchased line item as well as per unit of currency are indicators for the overall efficiency of purchasing.

	Performance	Time	Cost
Health care goods	• % of batches returned by customers. • % of value returned by customers.	• % of remaining shelf life.	•
Sourcing	• Number of line items per supplier. • Number of batches purchased per line item.	• Supplier on time delivery. • Supplier delivery reliability.	• Value per purchase contract. • Purchase costs per line item. • Purchase costs per price.
Inventory control	• Forecasting accuracy. • % of target stock level. • % of stock items out of stock. • % of stock items in stock. • Number/value of rush replenishment orders.	• Coverage time. • Ready rate. • Stockout rate. • (Average) stockout duration.	•
Storage	• Capacity utilization. • Space utilization. • % mispicked line items. • Accuracy of stock records	• Picking rate. • Lead time for picking and packing consignments.	• Stock holding costs. • Cost per dispatched line item. • % of damaged stocks. • % of expired stock. • % of stock losses.
Transport	• Completeness of documentation. • Accuracy of documentation. • Transportation capacity utilization.	• Consistency of transport time.	• Cost per tonne/km. • % of damaged goods.
Customer order fulfilment	• Customer service level • Backorder time. • % of wrong line items or quantities shipped. • Accuracy of labelling and marking of consignments. • Accuracy of documentation. • % of consignment damaged on arrival.	• Consistency of order lead time. • % of on-time deliveries. • % of on-time, in-full deliveries. • % on-time, in-full and error-free deliveries. • % of quality, on-time, in-full and error-free deliveries.	•

Table 26.3 Performance metrics

All inventory control measure are heavily affected by the variability of customer demand and therefore not only measure the performance of the forecasting and inventory control system.

The various measures for forecasting accuracy are indicators for the quality of forecasts.

For each stock item, the percentage of target stock level indicates under- or overstocking of the respective line item.

The percentage of stock items (line items which should be in stock at all times) which are out of stock at a given time provides an indication for the general availability of stock. For example at a certain time out of 200 stock items 2 line items, or 1% may be out of stock. However this indicator does not provide any information on how long the stockouts have lasted already as well as whether any customer orders for line items out of stock were received and had to be backordered rather than be filled from stock. Moreover the percentage of stock items out of stock does not give any indication on the criticality of the stocked out line items.

The complementary measure, the percentage of stock items currently in stock, is a general measure for stock availability. In the above example 198 out of 200 line items are in stock and the stock availability is therefore 99%. However, any stock item with at least one unit in stock is counted and this measure therefore does not allow inferring the exact order fill rate. On the other hand, this performance metric considers all stocked out line items even if no backorders are recorded.

The number as well as the value of rush (replenishment) orders is a measure for the quality of forecasts as well as for the inventory control system in general.

The coverage time (Silver, E.A., Pyke, D.F., and Peterson, R. 1998, 368), also called runout time, is defined as the ratio between stock on hand and average (monthly) demand. The coverage time indicates for how long customer orders can be filled from current stock on hand without considering future stock entries. The coverage time calculated in days corresponds to "days of supply" (DOS).

It is important to note that the coverage time is based on the assumption that (average) future demand will equal (average) historic demand. Therefore the actual coverage will be less than the calculation if future demand exceeds historic demand and will be higher than predicted, if future demand remains below historic demand.

The coverage time is inversely proportional to the stock turnover, the larger the coverage time the lower the stock turnover and vice versa.

$$\text{Coverage time} = \frac{\text{Stock on hand}}{\text{Average (monthly) demand}} \qquad \text{Eq. 26.2}$$

One measure for the availability of stock is the ready rate which is defined as the specified fraction of time during which net stock is positive (Silver, E.A., Pyke, D.F., and Peterson, R. 1998, 245). With other words, the fraction of time during which stock on hand is positive without any backorders for the respective line item. If the performance metric was defined as the time during which stock on hand is positive, actual (poor) performance could be easily disguised by withholding filling backorders until further stock on order arrives. By artificially maintaining stock on hand above zero the false impression of providing good customer service would be given.

The ready rate is complementary to the stockout rate which therefore is the fraction of time during which net stock is not positive. For example if the ready rate is 0.95 (for example if net stock was positive during 95 out of 100 days), the stockout rate is 0.05 (net stock was zero or below for 5% of the time period under consideration).

The frequency of stockouts or the number of stockout occasions during a defined period of time is not very meaningful as this statistics provides no information on the duration of each stockout period.

The (average) stockout duration gives an indication of the capacity to quickly replenish stocks in case of a stockout.

The capacity utilization is calculated by dividing the current volume of stock on hand by the total available storage capacity and allows determining to what degree available capacities are being utilized. Such calculations can be based on the actual volume of packaging. However, because different batches must be stored separately and volumes of batches are unlikely to fill pallets or shelves exactly, alternatively the number of occupied storage positions on shelves or floor pallets can be counted.

$$\text{Capacity utilization} = \frac{\text{Current stock volume}}{\text{Total available storage capacity}} \qquad \text{Eq. 26.3}$$

For floor pallets the space utilization can be calculated by dividing the number floor pallets of all stock on hand by the number of pallet positions on the floor or on adjustable pallet racking.

The percentage of mispicked line items is calculated by dividing the number of line items for which either the wrong line item or the wrong quantity were picked by the total number of line items picked during the same period of time (for example one month).

$$\text{Ratio of mispicked line items} = \frac{\text{Mispicked line items}}{\text{Total number of line items}} \qquad \text{Eq. 26.4}$$

The accuracy of stock record can be measured by comparing written or electronic stock records for all stock or for a selected sample (spot check) with the actual stock on hand. The percentage of stock records corresponding to actual stock counts is calculated by dividing the number of corresponding stock records by the total number of inspected line items. However, this performance metric gives no indication on the extent of the discrepancies and whether they were positive or negative.

The ratio of stock variation is calculated by dividing the absolute value of the variation by the recorded quantity.

$$\text{Ratio of stock variation} = \frac{(\text{Recorded quantity} - \text{physical stock count})}{\text{Recorded quantity}} \qquad \text{Eq. 26.5}$$

The ratio (or percentage) of stock variation can also be averaged of the variation of several individual line items. However, the ratio of stock variation for one stethoscope missing out of two is the same as for 50,000 tablets missing out of 100,000. Therefore, alternatively, the positive values of the differences between the value of the actual stock on hand and the recorded stock on hand (based on the same unit value) can be added for the individual line items under consideration.

The picking rate corresponds to the number of line items picked per hour or per working day and can be measured for individual storekeepers as well as for the entire warehouse team.

The lead time from receiving a picking list until consignments are ready for shipment can be calculated by line item as well as consignments.

Stock holding cost are calculated by dividing the average stock value (weight or volume) over a period of time by the total storage costs (weight or volume) during the same period. However this ratio does not provide any information on the flows of health care goods.

Warehouse costs can also be calculated in terms of average total warehouse operating costs per dispatched line item.

The percentage of damaged, expired or lost health care goods can be calculated by dividing the respective values by the average total stock value over the same period of time.

$$\text{Stock holding costs} = \frac{\text{Average stock value}}{\text{Total storage costs}} \qquad \text{Eq. 26.6}$$

The completeness of shipping documents can be measured by determining the number of shipments without any complaints of missing documents and their accuracy by dividing the number of correct shipping documents (no claim received) by the total number of issued shipping documents.

The transportation capacity utilization is measured by dividing the actual shipping volume (or weight) by the total available transport volume and can be measured for individual transportation operations as well as averages of a certain period of time. Transportation capacity utilization should be calculated separately for different modes of transportation. Usually the volume is the limiting factor but air transportation the capacity utilization may be measured in terms of weight.

The variation of transportation lead times over the same transportation routes are an indication for the reliability of transportation operations.

$$\text{Transport capacity utilization} = \frac{\text{Actual transport volumes}}{\text{Total available transport volume}} \qquad \text{Eq. 26.7}$$

Transportation costs can be calculated per tonne per kilometre of distance travelled. The percentage of value of health care goods damaged during transportation is an indication of the quality of the packaging as well as for the care taken during loading and transportation.

Since filling customer orders is the ultimate objective of logistics services, the customer service level is one of the most important performance metrics for measuring customer service but giving an exact definition and the calculation are more difficult than it may seem.

Customer service levels are broadly defined as the proportion or percentage of customer demand, which is represented by customer orders, filled from stock at the time or shortly after logistics services receive customer orders.

Customer service levels refer only to the availability of ordered goods in the medical distribution centre at the time of ordering but do not consider the time required for picking, packing, transportation as well as actual delivery to customers. While high customer service levels are an indispensable precondition for providing good service, high customer service levels alone are not sufficient as these also depend on the effectiveness of warehouse and transportation operations.

Customer orders or part of them which are filled at a later stage when medical distribution centres receive their replenishment orders and fill backorders are not considered in this measure.

Customer service levels should be well distinguished from stock availability. The stock availability refers to the proportion of stock list items for which at least one unit is on hand while service levels refer only to ordered lines.

Although generally speaking higher stock availability increases the probability of the capability to provide higher service levels, the exact relation depends on the kind and quantities of ordered items.

Despite a 100% stock availability the quantities ordered by a customer may exceed the stock on hand for one, several or all line items. Moreover, even in the case of a high stock availability, a customer might happen to place an order only for the few line items which are out of stock, resulting in a 0% service level. On the other hand, in the case of a stock availability of only 50%, the customer service may still be 100% if the customer happens to order only line items which are in stock and the ordered quantities are not larger than the stock on hand for the respective line item.

Nevertheless, assuming that eventually all stock list items are ordered, the service level averaged over several customers and several customer orders will approximate stock availability. Furthermore stock availability will be the upper limit for the service level calculated for all customers over a longer period of time.

Although customer service levels depend on stock availability, customer service levels also depend on the variability of customer orders. Despite accurate forecasts and effective stock replenishment, customer service levels will be low if the frequency of ordered line items is very erratic and the variability of customer demand is high. Therefore service levels to some degree also measure the quality of customers' ability to plan and replenish their stocks systematically and regularly.

High customer service levels imply the potential to provide good customer service. However, even if goods are on hand, customer lead times also depend on the effectiveness and efficiency of warehouse and stores as well as transportation operations. Customer service levels also do not provide any indication of the length of stockouts.

Except for cycle metrics, in general service level measurements do not provide any information on the frequency of stockouts. For example a medical distribution centre with a 92% service level for a specific line item will and receiving a customer order every month will be out of stock once during the entire year. However, if the same customer places weekly orders, the medical distribution centre will face four stockouts during the year.

This frequently mentioned criticism points to the difference between using customer service levels metrics retrospectively or prospectively that is as the probability that future customer orders will be filled. The use of service level metrics for measuring historic performance is valid and unambiguous as the medical distribution centre as well as customers are aware of the number of customer orders and can relate them to the performance. However if assuming that medical distribution centres will provide the same customer service levels in future, customers must be aware that they can only be extrapolated if the customer order patterns remain similar. However, for any given customer the provided customer service levels will always depend on the number and scope of future orders from other customers which are not known. Therefore historic customer service levels can always be only an indication of future customer service levels.

Customer service levels treat all line items equally and do not differentiate according to the criticality of line items.

Customer service levels can be measured by a variety of different "order fill rates" (see table 26.4). In this case filling refers only to the availability of stock (which is not reserved for

another customer) and to the ability to immediately pick, pack and ship the respective goods but does not refer to actually carrying out these processes and delivering to customers. Filling a number of units of order lines or entire line items means that at the time of treating the customer order the respective quantities are indicated on a picking list and do not have to be entered into the backorder record.

A) Performance metrics individual line items

- Line item unit fill rate (filled quantity / ordered quantity).

B) Performance metrics for customer orders

- Aggregate line item unit fill rate (item unit fill rate aggregated over all order lines).
- Partial line item fill rate (partially or completely filled order lines / order lines).
- Line item fill rate (completely filled order lines / order lines).
- Value fill rate (value of filled goods / value of ordered goods).
- In-full rate (number of completely filled customer orders / number of customer orders).

C) Performance metrics aggregated over time

- Cycle aggregate item unit fill rate (item unit fill rate aggregated over all orders during the period).
- Cycle partial line item fill rate (at least partially filled order lines / order lines during the period).
- Cycle line item fill rate (completely filled order lines / order lines ordered during the period).
- Cycle value fill rate (value of filled goods / value of ordered goods during the period).
- Cycle in-full fill rate (completely filled customer orders / customer orders during the period).

Table 26.4 Order fill rate metrics

Fill rates can also be measured with or without consideration of suitable substitutes accepted by the customer. Order lines which are out of stock but are replaced immediately by accepted substitutes can be considered as filled.

Fill rates can be measured for units of line items, entire line items or whole customer orders. Although a high line item unit fill rate implies a high aggregate line item fill rate, these two performance metrics are not proportional to each other. For example if all line items are in stock but the ordered quantities exceed the stock on hand, the line item fill rate will be zero although the line item unit fill rate for each line item will greater than zero.

The line item unit fill rate is calculated separately for each line item by dividing the quantity on hand by the ordered quantity.

At the next level fill rate metrics are calculated for one or several customer orders of one or several customers.

The line item unit fill rate can be aggregated over all order lines by averaging the proportions or percentages of the individual order lines. This measure has the advantage that it allows considering partially filled order lines. However, percentages may be added for very different order quantities. For example the line item unit fill rate is 50% for 1 out of 2 stethoscopes as well as for 100,000 out of 200,000 tablets. Alternatively the stock on hand for all order lines can be simply added up and divided by the sum of quantities of all order lines.

The partial line item fill rate is calculated by dividing all order lines for which at least one unit is on hand by the total number of order lines. This performance metric makes no distinction whether only one unit or almost the entire order quantity was filled and is therefore less meaningful than the line item unit fill rate. However it is more discriminative than the line item fill rate. As the main concern of customers is avoiding stockouts at their health care facilities, a

partially filled order will at least postpone the stockout and reduce the stockout time at the assisted health care facility.

The line item fill rate (LIFR) is calculated by dividing the total number of completely filled order lines by the total number of order lines. All order lines which are not completely filled are not considered, regardless of whether the line item is stocked out or the stock on hand is only one unit short of the ordered quantity.

One way of overcoming the undiscriminating behaviour of the above performance metrics is to calculate the proportion or percentage of filled orders in terms of their values. The value of all ordered goods which are on hand is divided by the total value of the order. However this measure gives greater weight to more valuable line items which are not necessarily more critical than lower value line items.

The in-full rate is calculated by dividing the number of completely filled customer orders (without any backorders at all) by the total number of customer orders. The in-full rate is the least discriminative because it disregards customer orders even if only a single unit of an order line has not been filled.

The in-full rate is an indirect measure of stock availability but also heavily dependent on the number of ordered line items. As any single order line which is not on hand means that the customer order as a whole is not filled, the probability of failing this performance metric increases with every order line (see figure 26.1). For example if the stock availability is 90% then the probability of filling orders with a single line item in full is also 90%, assuming that the stock on hand exceeds the ordered quantity. The probability of filling an order with two order lines in full is 0.9 x 0.9 and this percentage drops to 59% (0.9^5) for 5 order lines and to only 35% (0.9^{10}) for 10 order lines. These low percentages drop even further if the ordered quantity of any order line exceeds the stock on hand.

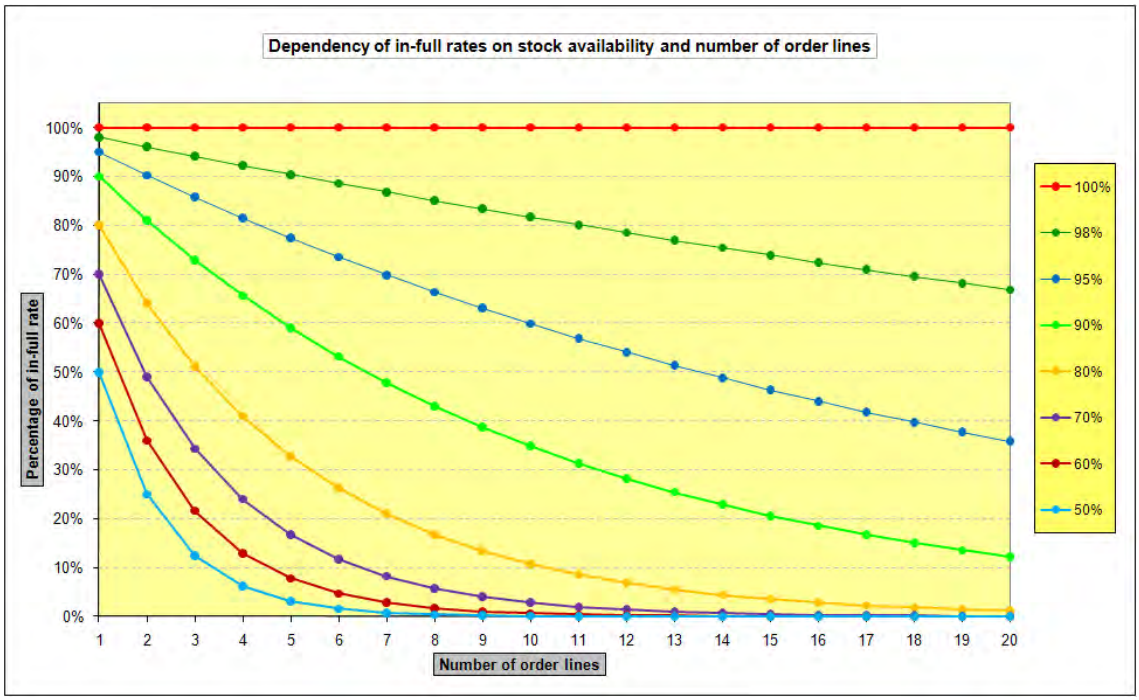

Figure 26.1 Relation between stock availability, ordered lines and in-full rates

At the next level, the fill rate metrics from individual customer orders from all served customers served by a specific medical distribution centre can be aggregated over a defined period of time such as a month or a year to calculated cycle customer service levels.

If cycle customer service metrics are included in customer service plans, the time period over which they are calculated must be indicated in order to allow interpretation and estimating the frequency of stockouts by customers.

Cycle customer service metrics must aggregate the fill rates of all customer orders treated during the defined period but must calculate fill rates only at the time of treating the customer order for the first time and disregard any backorders filled later during the same time period.

The item unit fill rates from all customer orders treated in the respective time period are aggregated to calculate their average, minimum and maximum values as well as (standard) deviation.

More detailed analysis can also be carried out on specific customers as well as for identifying the line items with the lowest item unit fill rates.

Likewise the partial line item fill rates and cycle line item fill rates can be aggregated over the respective time period.

The cycle value fill rate is calculated by dividing the value of stock on hand at the time of treating customer orders (which corresponds to the aggregated value of issued picking lists) by the total value of the same customer orders. This performance metric gives greater weight to high value line items (which does not necessarily correspond to their criticality) but has the advantage of being very easy to calculate directly as there is no need to first calculate a value for each order line or customer order.

The cycle in-full fill rate is calculated by dividing the customer orders filled completely from stock after receipt by the total number of customer orders received during the respective time period. As discussed above, this performance metric is a tall order since a single unit of a single order line which is not on hand will disqualify the entire customer order.

In theory the cycle in-full fill rate could be zero even if the cycle line item fill rate is 99% if all customer orders happen to include one or two stockouts. On the other hand the cycle in-full fill rate may be quite high despite a low cycle line item fill rate in the case that a large number of customer orders with a small number of order lines with small quantities are received which happen not to include stocked out line items.

As indicated earlier, the various order fill rates do not provide any information on how long stockouts lasted. The backorder time is the time period between the time when the customer order was treated, the respective order line or part of its quantity were out of stock and the respective order line was recorded in the backorder until the order line was eventually filled. The backorder time can be measured for individual customer orders, individual customers or can be aggregated over all current backorders.

The backorder time indicates how effectively shortages and stockouts are managed and how quickly backorders are filled.

The accuracy and effectiveness of order treatment, warehouse operations as well distribution can be measured by calculating the proportion or percentage of wrong line items received by customers for which claim reports were received. This performance metric will depend on the number of errors made during receiving and entering customer orders, by mispicking of line items as well as by missending consignments.
The accuracy of labelling and marking can be measured by counting the number of individual parcels for which customers have sent claims because of errors. Inaccurate labelling and marking may also lead to delivery to the wrong customer.

The accuracy of documentation is measured by the number of claim reports received from customers complaining about receiving the ordered goods in the ordered quantities but for which product names, batch numbers, expiry dates etc. were not correctly documented.

The percentage of line items, parcels or value of consignments which were found to be damaged upon inspection by the customer are a measure for care taken during warehouse operations as well as during transportation.

Irrespective of the requested and actual order lead times, the consistency (variability) of order lead times is a measure for the reliability of logistics services which is often more important than the actual length of order lead time. The customer order lead time is the time elapsed between the customer placing an order until the last unit of the last order line is physically delivered to the location requested by the customer.

The proportion of on-time deliveries can be measured as units of line items, partial line items, complete line items or order value delivered before the requested delivery date. Unlike customer service level metrics, on-time deliveries consider only consignments delivered on time to the location requested by customers.

While the order lead time is an objective statistic, the proportion of on-time deliveries is arbitrary to some degree as it measures the capacity of customers to anticipate and plan as well as the responsiveness of logistics services. The proportion of on-time deliveries may be very low despite short order lead times if customers consistently request (unrealistically) short due delivery dates. On the other hand, on-time deliveries may be satisfactory despite poor services if customers plan well ahead and allow for long order lead times.

In order to overcome this shortcoming, the due delivery dates requested by customers should be recorded and analysed separately before comparing them to on-time delivery performance.

Unlike customer service level metrics, on-time delivery metrics allow considering later deliveries of backorders and are therefore less rigorous. Even in case of stockouts, effective management of shortages and stockouts may allow replenishing stocks and delivering backorders before the due delivery date.

The proportion of on-time, in-full deliveries (OTIF) considers only entire customer orders which are filled without any backorders before the due delivery date. Again this measure is a tall order because a single unit of a single line item will disqualify the respective customer order from the count.

As a next step only the "perfect customer orders" delivered on-time, in-full and without any errors in the documentation and labelling of consignment as well as the absence of any damages to the delivered goods or their packaging.

This standard is very difficult to fulfil as the measure is calculated by multiplying the proportion of on-time, in-full as well as error-free deliveries. For example if 90% of customer orders were delivered on time, 90% were delivered in-full and 90% were error-free then statistically only 73% were delivered on-time, in-full and error-free.

A logical extension of the above concepts is the proportion of quality, on-time, in-full and error-free deliveries. Although the quality of health care products may be implicit in the specifications provided by the customer, its inclusion underlines the importance of quality. Especially since customer order lead times can often be significantly shortened by purchasing domestically but at the same greatly increasing the risk of delivering poor quality, substandard or even counterfeit health care goods.

Identifying performance metrics which measure the performance of the entire supply network is difficult. In principle the ratio between total logistics costs and the total value of health care goods can be measured as a financial metric. However this total supply network costs depend greatly on the type of ordered health care goods as well as the average size of customer orders.

The supply network ends with the health professional applying or the patient using a product and the ultimate objective of logistics services is to ensure availability of health care goods at assisted health care goods. Therefore the ultimate performance metric is stock availability at the assisted health care facility. Stockouts at any upstream stage of the supply network need to be treated as an emergency but they do not necessarily lead to a stockout at assisted health care facilities. On the other hand providing excellent logistics services does not prevent stockouts at assisted health care facilities if their stocks are not replenished systematically and regularly.

Although this performance metric measures the ability of assisted health care facilities to manage and replenish their stocks as well as the quality of services provided by humanitarian organizations, ultimately for patients suffering from shortages the cause of the shortage is irrelevant and stocked line items must be replenished as quickly as possible.

The ultimate performance metric for humanitarian supply networks is the number of stockouts at assisted health care facilities.

26.1.4 Qualitative performance metrics

Qualitative metrics are used for logistics assessment, evaluations as well as for customer satisfaction surveys. They all require establishing rating scales such as "Yes" or "No" or for example from 1 to 10.

Qualitative measures are more subjective than quantitative measures. Nevertheless for customers the (subjective) perception of (the quality of) logistics services forms their "reality" and may be more relevant than some "objective" performance metrics. When identifying measures for improving customer service, the correction of false perceptions or misunderstandings may be an important component.

Apart from quantitative performance metrics, customer satisfaction also depends on other elements (see table 26.5) which are subjective and can be measured only qualitatively through interviews and surveys. "Logistics gives an intangible service, and its quality relies to a large extent on subjective evaluation" (Waters, D. (ed.) 1999, 141).

One element is the perception and feeling of customers that logistics services sincerely focus on customers and their needs as well as the suitability and appropriateness of customer service plans which are adapted to the needs of individual health programmes and customers.

Another important element are the courtesy (friendliness), politeness and respectfulness of logistics staff towards customers as well as their approachability, ease of access and contacting.

A further customer service element is the ability to listen to and understand customers, the context in which they work, their situation as well as their problems.

The availability of a single (order) contact point, the simplicity of the ordering process as well as the ease of ordering are further important elements.

Another element is the expertise of logistics staff, their ability to provide (technical) information on health care goods as well as their knowledge on suitable substitutes in case of shortages and stockouts.

While the response time to customer inquiries can be measured quantitatively, the quality of the response can be measured only qualitatively.

The consistency of provided logistics services can be measured objectively while the perceived reliability of and trust in logistics services remains subjective.

Another important element of service quality is the flexibility and responsiveness of logistics services and the ability to quickly adapt to changes of situations as well as customer needs.

The readiness, accuracy and general quality of order status information as well as keeping customers informed in general are other customer service elements.

Finally the feeling of customers that their complaints and claims are taken seriously, treated promptly and followed up carefully are also important customer service elements.

- Customer focused logistics services.
- Appropriateness of customer service plans.
- Courtesy towards customers.
- Approachability, ease of access and contact.
- Understanding of customers.
- Single (order) contact point.
- Simplicity of ordering process and ease of ordering.
- Expertise and ability to offer substitutes.
- Quality of responses to customer inquiries.
- Reliability of logistics services.
- Flexibility and responsiveness of logistics services.
- Readiness, accuracy and quality of order status information.
- Treatment of complaints (claims).

Table 26.5 Qualitative customer service elements

26.1.5 Time based process mapping (TBPM)

As time in general and customer order lead time in particular are of pre-eminent importance for logistics activities and in providing customer service, their analysis deserves particular attention. Moreover time is such an important consideration because it is difficult, and possibly very expensive, to make up for any lost or wasted time.

"Time waste differs from material waste in that there can be no salvage. The easiest of all wastes, and the hardest to correct, is the waste of time, because time does not litter the floor like wasted material" (Ford, H. 1926, 101).

As order lead times and other logistics activities are composed of several (and often many) components which are usually under the responsibility of different departments, there is a great danger of "diffusing the responsibility" for poor performance. Often the overall lead time will be unsatisfactory although the individual processes (components) are carried out fairly efficiently.

Therefore general statistics such as order lead times or performance metrics such as on-time deliveries are of limited value in identifying the causes of poor performance and helping in identifying appropriate measures for improving services.

The basic idea of time based process mapping (Gregory, I.C., and S.B. Rawling 1997, 152) is to break down the process into its smallest components and to distinguish value-adding from non-value-adding time for each process. It is very important to keep in mind that the objective of time based process mapping is not to "identify the culprit" and blame her/him for the overall delay of the process but rather to identify causes as well as possibilities and potential for improvement.

Subsequently time compression can be used to eliminate or at least reduce non-value-adding activities and time which have been identified as much as possibly.

Time based process mapping is simple yet very powerful. First the entire process, for example of filling a customer order, of preparing consignments in a medical distribution centre or importing consignments is broken down into their individual components by "walking" through the process. One can imagine a stopwatch being attached to the customer order, being set off at the time the customer order is forwarded to the logistics service and returned to the customer together with the delivered consignment. Then the time spent for each of this processes is measured and mapped. In a next step the value-adding time is distinguished from the non-value-adding time for each process components. Adding up the value-adding time of each component allows determining the time the entire process would take if all the waste (non-value-adding time) were removed.

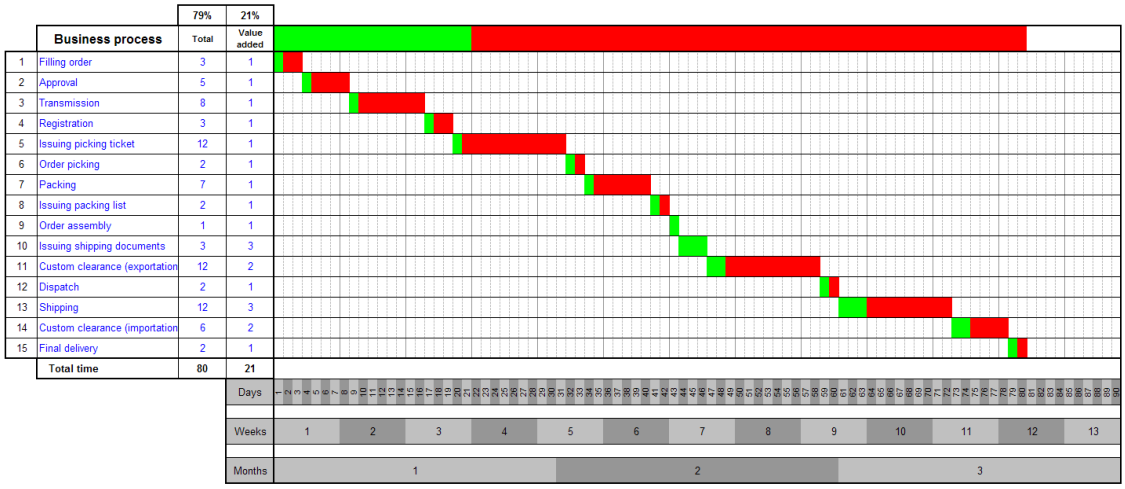

Figure 26.2 Example of a Time Based Process Map

Ideally the process should be mapped from the time when needs at assisted health care facilities arises rather than only from the time a customer order is placed. This allows to identify waste of time through lack of collaborative planning and coordination between health programme managers and logistics services or delays caused by obtaining funding.

The visualization of the time each process takes is simple but nevertheless powerful. Often it will turn out that non of the components of the process are very inefficient but that the, possibly small, waste of time in each process step adds up to a very significant overall waste in time.

Time Based Process Maps can be drawn up for average as well as maximum process durations.

26.2 Performance measurement

Performance measurement needs to be well planned and first of all requires establishing a system for collecting relevant data and information as well establishing a regular reporting system. From the large number of available performance metrics suitable measurements need to be selected and among those a few key performance indicators need to be identified. Internal or external benchmarks need to be identified and targets for the selected performance metrics need to be determined.

26.2.1 Selecting key performance indicators

As there is an abundance of performance measures and performance metrics, measuring and analysing a large number of them is not practical. Moreover not all of the measures may be relevant in any given situation.

Instead a small number of key performance indicators (KPI) which can be collected with reasonable resources, cover all critical elements and functions and provide the relevant information for making decisions should be carefully selected.

Selection of key performance indicators will depend on the situation, context as well as the user.

- Quality of delivered health care goods: percentage of batches returned by customers.
- Inventory control: percentage of stock items out of stock.
- Transportation capacity utilization.
- Customer service:
  - customer service level.
  - requested order lead time (statistic).
  - actual order lead time.
  - percentage of stock items out of stock at assisted health care facilities.

Table 26.6 Proposal for a set of key performance indicators

In addition the rating of results of customer satisfaction surveys may be added as key performance measurement.

26.2.2 Determining benchmarks

Benchmarks are measurements of various quantitative and qualitative measures achieved by other services inside an organization or in other organization which can serve as reference points or standards for comparison as well as orientation and goal for the own performance.

The objective of searching for benchmarks is identifying best practices and the "Best in Class" in order to learn from these practices and improve management and performance.

Internal benchmarks are collected from the past average and best performance of services within the humanitarian organization. These can be collected from the same service, other services in the same location as well as services at other locations.

External benchmarks can be collected from logistics services of other humanitarian organizations as well as average and best performance of commercial organizations providing health care goods. The performance of some services of other industries as well as industry

standards may also serve as benchmarks. For example the transportation lead time of an express carrier could serve as a best practice benchmark for international distribution.

26.2.3 Setting performance targets

After having selected key performance indicators and determined appropriate benchmarks, performance targets which must fulfil a number of requirements (see table 26.7) must be set for each of the key performance indicators. Targets must be defined before performance measurements are carried out in order to avoid simply "adjusting" targets to measured performance.

Performance targets which must be set for quantitative as well as for qualitative measures then serve as internal standards and references which logistics services try to achieve and maintain.

If the discrepancy between actual and desired performance is large, step by step increases of performance targets may be set according to a defined time schedule.

The performance targets should be discussed with customers, documented in the customer service policy and communicated to all customers.

First of all, performance targets must be meaningful to customers. Logistics services must ensure that the performance targets for different activities and functions are determined according to the importance given by customers. This will avoid wasting resources on (further) improving service elements which are of less importance to customers and focus resources on the services which are most important to customers.

While health programme managers will generally not object to any improvement of any services, they eventually have to bear and justify the higher costs which are generally associated with better services. Consequently health programme managers will have to balance the possible improvement of services with the resources required to achieve such improvements.

Customer expectations are determined by direct consultations and discussions as well as with surveys.

In order to allow future comparison with actual performance, performance targets must be clearly defined and be well documented. Performance targets may be defined as absolute values, a range as well as minimum or maximum values.

The performance targets set for each of the measures should be realistic and achievable as unattainable performance targets will de-motivate staff. However it should not only be realistic to achieve them but also to maintain them.

On the other hand, performance targets which are easily achievable or (arbitrarily) set at the actual performance level do not provide any motivation for people to improve services.

It may be necessary or useful to set different performance targets for different customers or different categories of health care goods. For example setting higher service levels for emergencies than for routine supply of health care facilities, higher service levels for stock list items than for others and higher service levels for critical than for non-critical items.

The performance targets must also consider external constraints which are beyond the control of logistics managers, humanitarian organizations or cannot be overcome with reasonable resources.

For example order lead times may be extensive due to long customs clearance procedures or transportation constraints caused by poor infrastructure or lack of security.

On the other hand, constraints such as the poor security situation must not be used as a "pretext" or excuse for not trying to improve services.

The same performance targets may be set for all services in different locations but may require adaptation to local capacities, resources and capabilities.

The attainment of performance targets must not become a means in itself, rather they should be regularly reviewed, updated and adjusted to possible changes of customer requirements and priorities.

- Meaningful to customers.
- Clearly defined and documented.
- Realistic and achievable.
- Differentiated.
- Consider constraints.
- Adapted.
- Regularly reviewed.

Table 26.7 Requirements for performance targets

26.2.4 Performance monitoring

Performance monitoring is a continuous process accomplished by systematically and regularly measuring, recording and graphically representing key performance indicators and other key performance measures.

Regular measurements and updating of key performance measures allows detecting any changes of received and provided services, improvements as well as deterioration. The analysis of trends allows the early detection of any deterioration of customer service even if the performance measures are still within the desired ranges defined by the respective performance targets. The early intervention in case of deterioration of services requires less time and resources than for rehabilitation of services when waiting until services have dropped below acceptable levels.

On the other hand performance monitoring allows determining the impact of implementing any corrective action.

Performance monitoring can also serve as motivation for staff who are trying to improve services.

- Detecting changes of performance measures.
- Trend analysis.
- Early detection of deterioration (of services).
- Determining the impact of any corrective action.
- Assessing whether goals for improving services have been met.
- Motivation of staff.

Table 26.8 Objectives of performance monitoring

26.3 Analysis of results

The analysis of performance measurements can be carried out by staff in charge of providing services, their supervisors, other logistics managers or staff at the head office.

Performance measurement values can be analysed individually or be related to each other. The analysis of performance measurements must also consider available resources, the services received from upstream distribution centres as well as any external constraints.

Overall, the analysis must focus on identifying causes of poor performance and possible solutions for improvements rather than on identifying "culprits" and assigning blame.

26.3.1 Comparison with performance targets

The performance measurement values are first compared with the performance targets of the selected key performance indicators laid down in the customer service policy in order to determine whether the performance targets were met or not.

If the performance targets were not met, the extent of the deviation or failure must be determined in order to determine the urgency of the required corrective action.

If the performance is better than required, logistics managers must ensure that they are not wasting resources on service aspects which are not important to customers.

26.3.2 Time series analysis of values

Regardless of whether performance targets were met or not, the individual values should not only be analysed in isolation but rather the graphs of values over time (time series) should also be analysed.

Time series analyses of performance measurement values allow determining minimum, maximum and average values as well as distributions (standard deviations) as measure of the variation of values. These values in turn can be used for benchmarking and re-evaluating performance targets.

A certain variation and randomness of measurement values is inevitable even where performance is fairly steady and not every (small) deviation is already an indication of a (long-term) trend. Only placing individual measurement values in a longer time context allows identifying patterns and trends. Likewise, a one-off drop (dip) in performance may not necessarily be an indication of a (starting) trend.

On the other hand, time series analysis allow the early detection of decreasing performance and its extent even at a time when performance targets are (still) being met and taking pre-emptive action rather than waiting until performance targets are no longer being met.

Moreover extrapolating the deterioration of performance allows to forecast when the performance targets will no longer be met and how urgently corrective action needs to be taken.

As meeting performance targets is a dichotomous variable (met or not met), monitoring of performance measurement values allows detecting improvements of performance if the performance targets have continuously not been met for some time.

Finally monitoring of performance measurement values allows determining the impact of any pre-emptive or corrective action on the performance.

- Determining minimum, maximum, average values and distributions.
- Identifying patterns and trends.
- Distinguishing one-off drops from (starting) tends.
- Early detection of deteriorating performance.
- Implementation of pre-emptive action to maintain performance above performance targets.
- Forecasting the time when performance targets will no longer be met.
- Detecting improvements in performance where performance targets have not been met.
- Evaluating the impact of corrective action.

Table 26.9 Value of time series analysis of performance measurements

26.3.3 Comparison with other services and locations

Although the benchmarks for evaluating performance are the previously clearly defined performance targets which are documented in the customer service policy, comparison with other services and locations may be helpful in improving services.

Comparing performance with other services or locations which are subject to similar constraints as the own, are particularly valuable because assessing the extent of the impact of constraints on performance is difficult to quantify.

Comparison with other services, locations, countries and regions allows determining the services which are performing best and promise the greatest benefits for learning lessons from. The best performing services can also serve as future benchmarks for the country, the region and possibly the entire humanitarian organization.

Performance measures could also be compared with other humanitarian organizations in order to identify the services which provide the best services and which again promise insights in how to improve own services.

26.3.4 Identifying causes of poor performance

Identifying causes of poor performance is a condition for determining and implementing effective corrective action. However the search for causes must be genuine and must not be limited to identifying and "blaming" external constraints which cannot be influenced. Eventually, regardless of the extent of external constraints, logistics managers must ensure that good customer service is provided, performance targets are met and the focus of the analysis must not be lost.

The analysis must attempt to identify reasons and underlying causes of poor performance rather than just describe the symptoms which possibly requires further analysis and inquiries beyond studying performance measurement values.

While all identified problem should be taken serious, they should not only be analysed in isolation. Rather the interrelations between shortcomings of performance and problems and how one problem impacts on and may even cause other problems should be considered.

Poor or deteriorating performance may be caused by external factors which are beyond the control of logistics managers or by internal factors (see table 26.10).

External constraints such as poor security (blocked roads), poor infrastructure (roads and airports blocked by rain), delays in customs clearance, delays in obtaining permissions for importation or changes in government regulations must be considered. Although they are

outside the control of logistics managers they can cause poor services as well as their deterioration, especially when constraints change suddenly and unexpectedly.

Erratic and irregular orders from customers which cause large variations in demand generally make it more difficult to provide good services.

The increase of customer demand through an increased number of assisted health care facilities, increasing number of orders, increasing order quantities as well as additional customer orders for acute crises are likely to decrease the quality of provided services. Especially when increases in customer demand are sudden and if aggregated order quantities exceed safety stocks.

The (unexpected) deterioration of services received from commercial suppliers can lead to (temporary) deterioration of stock availability at least until alternative suppliers can be found.

Many causes of poor performance are internal ("home made"). The deterioration of services received from upstream medical distribution centres can quickly impact on services provided to customers. While logistics managers can, to some degree, hedge against the variability of replenishment lead times, receiving poor quality or damaged health care goods may be impossible to compensate.

Lack of resources, especially of a sufficient number of qualified staff, will lead to delays in order fulfilment and is also likely to increase the number of errors. A lack of storage capacity will make orderly storage more difficult and increase the time required for order picking and, again, decrease accuracy.

However, available resources may also be sufficient but may be used inefficiently.

Poor management or mismanagement may be caused by negligence, incompetence, lack of knowledge and certain skills as well as lack of appropriate and sufficient training.

Poor performance such as high error rates or delivery of damaged health care goods may be caused by disregard for standard procedures for treating customer orders as well as management of medical storage facilities.

External

- Constraints (poor security, poor infrastructure, delays in customs clearance).
- Erratic ordering of customers.
- Increase in demand.
- Deterioration of services provided by commercial suppliers.

Internal

- Deterioration of services received from upstream medical distribution centres.
- Lack of resources.
- Ineffective use of available resources.
- Poor management.
- Lack of adherence to standard procedures.
- Lack of motivation and commitment to providing excellent customer service.
- Lack of monitoring performance.

Table 26.10 Possible causes for poor performance

Logistics services and staff are unlikely to perform well if they lack the motivation and commitment to provide excellent customer service and constantly finding ways for improvement.

Finally, the lack of a sound performance measurement system will contribute to poor services as staff will be unaware of their actual (poor) performance.

26.4 Presentation of measurements

Measurements can be included in narrative reports or be presented in tables and figures (see chapter 4.3.1).

Dashboards are specially designed, visual panel displays for presenting a limited number, of essential information and key performance indicators in compact tables, charts and dials. Usually around one dozen of measurements are presented in a compact and user-friendly way allowing to convey information at a glance (Eckerson, W.W. 2011, 11).

Dashboards clearly show whether performance metrics are within the desired ranges and deviations from targets can be specially marked as alerts.

Strategic dashboards (also called scorecards) are often designed like report cards with tables.

26.5 Reporting and communicating results

Performance measurement reports should indicate the measured service and its location, the date the report was issued, the period of time the analysis covers as well as the person(s) responsible for the analysis and compilation of the report.

The performance measures for which values are represented must be clearly defined, the recent measurement values must be indicated and tabulated together with historic values. The recent values should also be presented in the form of graphs together with the recent measurement values.

The report should briefly indicate any major changes in relevant constraints as well as point out significant changes.

The first objective of compiling and issuing reports (see table 26.11) is the accurate documentation of measurement values for future reference, comparison and basis of monitoring.

Performance measurement values are also a basic tool for general management and decision making mainly at the operational but also at the tactical level.

Certain performance measurements are indispensable for planning. For example actual replenishment lead times are a critical element for calculating replenishment orders and actual order lead times allow customers to plan stock replenishment at assisted health care facilities.

The most recent values as well as past measurement values are the basis for discussing, elaborating and planning corrective actions.

Quantifiable and verifiable performance data can help to correct misperceptions by customers who may generalize a limited number of occasions where their expectations were not met.

Compiling and issuing performance reports also demonstrates the commitment to continuously improve services towards customers.

However, presenting performance measurement data which exceeds performance targets may also raise (false) hopes and expectations as customers may consider the best historic performance as the future benchmark regardless of current performance targets.

- Accurate documentation for future reference.
- Basis for management and planning.
- Basis for planning corrective action.
- Presenting objective performance data.
- Demonstrating the commitment to continuous improvement to customers (and donors).

Table 26.11 Objectives of performance measurement reports

Performance reports should be communicated both within (internally) and outside (externally) of the humanitarian organization (see table 26.12).

First of all staff members who are responsible and have contributed to the performance should be informed through meetings and posting on notice boards and, if necessary, participate in discussions about the results. Moreover logistics staff of other services as well as logistics managers should also be informed.

Health programme managers and assisted health care facilities must receive copies of reports in order to be able to plan their own work realistically, especially replenishment of pharmacies.

Finally, head office staff may analyse reports and reports may also be requested by donors in order to evaluate the logistics effectiveness and efficiency of the respective humanitarian organization.

Internal

- Staff responsible for providing the logistics services and the respective performance measures.
- Other logistics staff.
- Logistics managers.
- Downstream medical distribution centres.
- Health programme managers.
- Head office staff.

External

- Customers (assisted health care facilities).
- Donors.

Table 26.12 Target audiences for performance reports

26.6 Corrective action

Determining and implementing appropriate and effective corrective action is the ultimate purpose of performance measurement. If no effort is made to improve (poor) performance all efforts for establishing a performance measurement system, measuring and monitoring performance would be in vain.

Any corrective action must address the underlying causes of problems rather than only the symptoms. In general, corrective measures should aim at removing non-value activities and simplifying procedures rather than increasing the complexity of the set-up or of procedures.

The possible causes of poor performance presented in table 26.10 can be addressed by corresponding corrective action (see table 26.13).

Upstream medical distribution centres can be requested to improve their services by providing shorter order lead times, higher fill rates and reducing the amount of damaged health care goods.

If improving the utilization of available resources is not sufficient, additional resources such as additional staff or additional storage capacity may be required.

Implementation or strengthening of standard procedures may, for example, help to reduce deterioration of health care goods during storage or reduce error rates of warehouse operations.

The performance of managers can be improved by coaching and training while staff motivation can improve their overall performance.

In general, the effectiveness and efficiency can be improved by improved management.

Providing regular feedback to all staff members on their performance will increase their awareness of successes and mistakes and generally be a source of motivation.

Where possible, the reduction of external constraints or searching for alternatives should be considered. For example domestic purchase may be an alternative to long lead times for customs clearance and obtaining importation permits from national drug regulatory authorities.

Improving stock management and inventory control at assisted health care facilities can greatly decrease the variability and erraticness of customer demand which in turns allows improving forecasting accuracy and providing better services.

In the case of discrepancies between the objective performance in terms of order fill rates or lead time and the ratings by customers, discussions and presentation of performance measurement data may help to correct misperceptions of received services.

Poor services by commercial suppliers can be addressed by requesting improvements or, eventually, purchasing from alternative suppliers.

Internal

- Request improvement of services provided by upstream medical distribution centres.
- Improve utilization of available resources.
- Provide additional resources.
- Ensure full implementation of standard procedures.
- Improve management through coaching and training.
- Improve efficiency of staff through better management.
- Improve motivation of staff.
- Ensure that all staff regularly receive feedback on their performance.

External

- Where possible, address alternatives to work around constraints.
- Improve stock management and inventory control at assisted health care facilities.
- Discuss, and where necessary correct, perception of services by customers.
- Encourage commercial suppliers to improve their services.
- Change commercial suppliers.

Table 26.13 Possible corrective action measures

Any corrective action must be realistic and feasible and often several measures will need to be implemented together. All concerned staff should be engaged in discussions, encouraged to contribute towards finding feasible solutions and participate in their implementation.

Any corrective action must avoid sub-optimization which is caused by optimizing one aspect and factor which may however incidentally reduce efficiency of other factors. Instead the benefits from improving different aspects and factors must be balanced against each other and the overall improvement of customer service must always guide decision making.

Another trade-off may need to be considered where the available (additional) resources, such as additional staff members, are limited and must be carefully allocated to different aspects or services.

When considering trade-offs, improvement of services important to customers must always be given priority. Consequently services which are rated highest by customers but receive the poorest performance ratings must be addressed as a priority while fewer resources should be allocated to services which are considered as less important by customers, even if the performance is equally poor.

In any case ensuring provision of high quality health care goods and minimizing the number of stockouts at assisted health care facilities can always serve as guidance for deciding between available alternatives.

For future reference, the findings as well as clear and precise recommendations for corrective action should be documented in a report together with a clearly defined time frame for their implementation. Depending on the extent of discrepancies between actual and desired performance levels, improvements of performance may only be possible in steps.

The corrective action as well as the report should be presented to and discussed with all concerned managers and staff members.

26.6.1 Time compression

Time compression is a method which aims at reducing, and where possible eliminating, time wasted on non-value-adding processes activities in order to reduce overall process or lead time. "Time compression is not about making people work faster . . ." (Wilding, R. 1999, 16) or increasing resources but rather about ". . . removal of wasted time throughout the business . . ." and people ". . . working smarter not harder" (Wilding, R. 1999, 17).

"Time compression is not about making people work faster . . . [but] about removal of wasted time throughout the business . . ." (Wilding, R. 1999, 16f.)

The first step is to break down the entire process, for example order fulfilment, into its components (steps, activities) and map the process with a time based process map. The next step consist of distinguishing between value-adding and non-value-adding activities or possibly distinguishing between the time required for value-adding processes and the time which is wasted on value-adding activities. Value-adding activities are processes which physically change the nature of goods, the process creates a value for the final customer and the process is completed correctly the first time while queuing, reworking (correcting mistakes) and time waiting for management decisions are non-value adding (Wilding, R. 2003, 32).

The next step lies in improving processes and management by eliminating or at least reducing time spent on non-value-adding activities as well as time wasted on value-adding

activities. Some processes such as importation could be considered as non-value adding but are nevertheless essential.

The elimination process should start with the "low hanging fruits" that is the processes which allow eliminating much waste easily. Efforts to compress time should focus on the processes or activities with the largest proportion of non-value-adding time. Attempts to eliminating small amounts of wasted time with considerable resources would only lead to sub-optimization.

Ideally the final result of compressing time would be a process where all activities or their parts add value for the customer.

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27 ORDER PLACEMENT

The type and quantity of ordered health care goods will be determined by health professionals at assisted health care facilities as well as by health programme managers, among others, according to needs, the level of care as well as staff skills. The national standard list should cover the majority of health care goods, which are regularly used. However, the selection of goods for individual health care facilities should also consider some implications for logistics management.

Order quantities should be calculated systematically and according to a clearly defined inventory control policy at the assisted health care facility in order to minimize the problems of subsequent demand distortion throughout the upstream supply network. The pharmacies at assisted health care facilities must have the capacity to receive and properly store the ordered quantities. Overstocking will require the return and safe disposal of health care goods, which have expired before they can be used while shortages will lead to urgent orders, which require (possibly) expensive expediting.

All orders for drug products should indicate commonly used and understood international nonproprietary names rather than proprietary names which are specific to each manufacturer (PAHO 1983, 71). Before ordering cold chain items the feasibility and ease of delivering them to health care facilities should be considered (PAHO 1983, 72).

Where applicable, ordered health care goods must be compatible with other single use medical devices as well as existing health care equipment, which health care facilities might be receiving at the same time from different sources. The use of single use medical devices reduces the required capacity for sterilization but increases the need for resources for regularly replenishing and storing goods.

- Order (reference) number.
- Date.
- Requester (name, location, function).
- Item code and description for every item.
- International nonproprietary name for drug products.
- Unit of measurement.
- Ordered quantity.
- Urgency of order.
- Price (value).
- Currency.
- Delivery address.
- Due delivery date.
- Packaging requirements.
- Labelling.
- Required customs documents.
- Mode of transportation.
- Acceptance of partial deliveries.
- Financial information.

Table 27.1 Required customer order information

For orders of health care equipment, availability of after-sales services by qualified technicians as well as service and replacement parts must be considered (Cheng, M. 2003, 7). Moreover, the availability of required energy sources such as electricity, gas or kerosene must be considered. Where reliable energy sources are not available providing generator sets or delivering appropriate fuel will be necessary.

Since, at least during the emergency phase, humanitarian organizations will provide health care goods according to their own standards, health care facilities may have to substitute health care goods they were commonly using before being assisted. However, the respective national standard list should cover all essential needs.

The approval or validation of customer orders by the respective humanitarian organization will be subject to internal procedures. A hierarchical system may be established according to which different staff members are allowed to order different health care goods and up to different values.

Approval of customer orders must be organized in an efficient way to avoid delays especially when approvers of orders are at a different location from the person who submits an order.

Authorized staff must approve customer orders by (electronic) signatures and hereby take the responsibility for committing resources for treating customer orders as well as concluding, usually irreversible, purchase contracts.
Customer orders should be detailed and unambiguous in order to avoid unnecessary delays for clarifying orders, misunderstandings or mistakes.

Prepared and approved customer orders should be transmitted to logistics services as quickly as possible, wherever possible electronically.

28 PURCHASING TRANSACTIONS

Purchasing, the process of buying health care goods, is one of the most critical processes in supply chain management in terms of quality assurance, stock availability as well as controlling costs. It is usually the process through which goods and services enter the internal supply network of humanitarian organizations.

Especially in acute crises where demand exceeds available stocks, the ability to quickly purchase goods and services of good quality is critical for a fast and effective response.

Purchasing is a complex topic and a profession in itself. This chapter does not intend to exhaust the topic but rather attempts to give a broad overview of purchasing and present some aspects which are of practical importance in regional or national distribution centres.

Purchasing activities must be well organized and follow established procedures to ensure fairness towards competing suppliers, transparency and reduce the likelihood of favouritism and corruption. Purchasing departments must keep in close touch with customers as well as staff in charge of inventory control in order to quickly react to changes in demand as well as urgent orders.

Purchasing procedures must also consider national legislation and regulations for example concerning tenders, accounting requirements or fiscal matters.

Good communications with suppliers are essential for any purchasing department and therefore appropriate and working facilities (telephone, fax, e-mail) must be made available.

Purchasing requires financial and human resources and therefore adds cost to the purchasing price of health care goods. However investing in professional management is warranted by the usually high value of health care goods as well as the dire consequences purchasing of substandard or counterfeit health care goods can have for patients.

Professional management is particularly important for quality assurance of purchased health care goods. Investing in researching the market and maintaining good relations with suppliers is also justified by the usually high value of health care goods.

Purchasing is a profession in itself and must be undertaken by professional, trained and skilled staff. They must have experience in purchasing health care goods as well as a good knowledge of the domestic market. A professional pharmacist should be employed in order to provide technical expertise as well as ensure that only high quality health care goods are purchased.

However, the scale of purchases may not always warrant employing a full-time purchaser and general logisticians may have to carry out these responsibilities. In these cases purchasing must be supervised by a specialist in an upstream distribution centre.

28.1 Transparency of purchasing

As purchasing can involve considerable amounts of money and health care goods of high value, it is prone to fraud and corruption.

Humanitarian organizations must ensure that all purchasing is carried out in a transparent manner for several reasons. Humanitarian organizations are accountable towards their donors who may reserve the right to audit purchasing records at any time without prior notice. In order to attract suppliers of high quality health care goods it is equally important to ensure that all suppliers are treated fairly and suppliers and products are selected according to clearly

defined and transparent criteria, which are accurately documented and recorded. The number of suppliers and offered health care goods will decrease if suppliers perceive the purchasing processes as poorly managed, unfair or even corrupt and as a consequence of reduced competition, prices are likely to increase. Finally, transparent purchasing procedures are needed to protect purchasing staff in general and from being tempted by supplier corruption in particular.

Any personal interest and influence by purchasing staff as well as any bias, prejudice, preferential treatment, bribery, fraud or corruption by purchasing staff must be avoided.

All purchasing policies, processes and procedures must be clearly defined and documented in writing in a purchasing manual, which is used as a reference by all purchasing staff.

Another essential means of ensuring professional purchasing is the separation of different tasks, functions and responsibilities in the purchasing process, assigning them to different staff members, departments or committees and holding all of them accountable. For example, the functions of quality assurance and purchasing must be clearly separated.

A single staff member with the authority of selecting products and suppliers can commit fraud far more easily than several purchasing staff, which would all have to cooperate and collude to commit fraud.

However, separation of responsibilities and introducing checks and balances must not result in a complicated, inflexible, bureaucratic and time-consuming system, which is inefficient and incurs high costs.

28.2 Purchasing objectives

Apart from acquiring the required quantities of the required health care goods or services, purchasing has several other objectives (see table 28.1), irrespective of the selected purchasing method.

The attempt to acquire health care goods at the lowest possible price would inevitably lead to acquisition of poor quality products. Instead all purchased health care goods must comply with the minimum quality requirements defined in the standard item catalogue.

Purchasers should negotiate favourable conditions with the supplier such as payment only after receipt and inspection of consignments or favourable after sales services for health care equipment.

- Acquiring required quantities of required health care goods (or services).
- Ensuring conformity of purchased products with quality requirements.
- Favourable conditions of purchase contract.
- Good supplier services.
- Timely supplier delivery.
- Lowest product price (without compromising quality).
- Lowest possible cost of ownership.
- Best use of human and financial resources.
- Ensure fairness and transparency of all processes.
- Compliance with purchasing procedures.

Table 28.1 Objectives of purchasing

Suppliers should deliver goods at their cost, within short lead times and on time.

For products that comply with defined quality requirements the lowest purchasing price or lowest cost of ownership should be negotiated.

The overall purchasing process should be effective as well as efficient and make the best use of human and financial resources. All processes must be transparent, fair and comply with well documented, written procedures.

28.3 Obtaining requirements

The health care goods and the quantities, which are required for replenishing stock list items, are calculated by the inventory control system, which also determines the frequency of stock replenishment. In addition any backordered non-stock list items need to be ordered or purchased. The selection of health care goods must be primarily based on customer requirements rather than on products available in the market.

The decision whether to order these from an upstream medical distribution centre or purchase them domestically is determined by the purchasing strategy of the humanitarian organization.

The applicable specifications of standard items are available from the standard item catalogue. For any other health care goods, specialists must determine specifications which comply with the humanitarian organization's quality requirements.

28.4 Selecting purchasing method

The choice between or combination of direct purchase, competitive negotiation, restricted or open tender (WHO 1999f, 14) will mainly depend on the importance of quality and the purchasing value of each item as well as the purchasing strategy and policies of the respective humanitarian organization.

Likewise the selection of an open or closed tender as well as a national or international tender will be determined by the purchasing policy. However, except for low purchasing values and emergency purchases, competitive methods should be used and in general prequalification and restricted tenders are preferred for recurrent purchasing (WHO 1999f, 17).

28.5 Tender process

A bid is a formal offer of a supplier (bidder) for supplying specific goods or services at a stated cost and other conditions which is sent in reply to an invitation to tender (ITT) made by an organization which would like to acquire these goods or services.

The formalized rules and written procedures of the tender process as well as explicit criteria for awarding contracts ensure transparency and equal treatment of all tenders and bidders. The exchange of formal written documents de-personalizes the process and avoids fraud and corruption.

In order to ensure equal treatment of all bidders and tenders and avoid favouritism the entire tender process must be managed by a committee rather than an individual.

All invited suppliers receive the same written information in the invitation to tender, which may be published for open tenders. According to the invitation to tender, bidders must provide the same details of their offer in their written bid in order to allow their objective and

fair comparison. No bidder has the possibility of later amendments, corrections or negotiations. The tender process ensures that no bidder has any information about bids of any other bidder before the bids are opened.

- Obtaining requirements.
- Selecting tender format and scope.
- Supplier selection.
- Preparing tender documents.
- Issuing invitation to tender.
- Receiving and opening of bids.
- Assessing samples provided by bidders.
- Evaluation and comparison of bids.
- Awarding contracts and notifying bidders.

Table 28.2 Steps in the tendering process

28.5.1 Supplier selection

If a restricted tender is chosen, only the prequalified suppliers are invited to participate. In an open tender, all known suppliers are invited and, if necessary, additional suppliers can be found by conducting a market assessment.

According to the "rule-of-five", prices for multisource drug products reach their minimum if five bids are received while additional bids generally do not lower prices any further (WHO 1999f, 15).

28.5.2 Invitation to tender

The invitation to tender (ITT) is a comprehensive document, which contains all information which is necessary for bidders to prepare their bids (offers) and determine their selling price (see table 28.3). Certain information may be provided in a separate document such as the humanitarian organization's general conditions of purchasing or a quality assurance policy.

The invitation to tender must include the name, address, telephone and fax number and a brief description of the buying organization as well as the name and contact details of the contacted supplier.

The document must include detailed specifications of the required health care goods such as dosage form, strength of dosage unit, unit of measurement, volume, weight, size etc. The international nonproprietary name rather than the proprietary name must be indicated for all drug products (WHO 1999f, 14). For drug products, the pharmacopoeial standard as well as quality standard (cGMP) and for medical devices the respective norms may be listed.

Where applicable, the packaging quantity should be indicated, for example whether blister packaging or hospital packaging for drug products.

Labelling requirements should indicate the language, the international nonproprietary name, where applicable in addition to any proprietary name, the name of the manufacturer, the country of manufacture, manufacturing and expiry date as well as required storage conditions.

The buyer should indicate the requirements concerning the minimum remaining shelf-life at the time of delivery in terms of defined time periods or percentage of the total shelf-life upon manufacturing.

The required quantities in clearly defined units of measurement must be provided.

Where necessary, for example for health care equipment, which needs to be transported over long distances and on poor roads, special packaging requirements should be stated.

The invitation to tender must also indicate any documents, which must be provided with delivered health care goods such as batch certificates or warranty documents and technical manuals.

While the specifications of required health care goods must be as precise as possible, they must not be too specific since this will reduce the number of products, which can comply with the requirements. Especially for health care equipment, invitations to tender must not be tailored to a specific product, which would favour a particular bidder while excluding any other bidders.

Finally, the location of delivery must be clearly indicated in case the supplier is responsible for delivery.

In order to allow objective comparison, the invitation to tender must explicitly state the information that bidders must provide in their bids. For exampled detailed product specifications, manufacturer, country of manufacture, price and maximum delivery lead time or after-sales services.

The commercial terms must indicate the type of purchase contract for example volume or system contract. The invitation to tender must clearly indicate the validity period during which the supplier should maintain the quoted prices.

The INCO terms need to be stated as they influence cost for transportation and insurance the bidder has to factor into his selling price.

The currency in which bidders should quote as well as the conditions and terms of payment (cash, check, bank transfer etc.) should be indicated.

The invitation to tender should inform bidders of the conditions of contract which will be signed with the successful bidder.

The document should include a confidentiality clause assuring all bidders that their bids will be treated as confidential.

Bidders must be provided a detailed postal address where bids must be submitted as well as required means (usually mail or courier service).

The closing date and time until which bids must be submitted, the period of time for which offers should be valid as well as the date of opening of bids must be indicated. Depending on the number of required items and the volume, bidders are usually given two to eight weeks for submitting their bids.

The format requirements for bids may include, for example, the need to submit bids in writing in sealed envelopes and printing "tender" on envelopes.

Bidders should be informed about the criteria for evaluating bids as well as the procedures for awarding contracts. They should also be informed whether unsuccessful bidders will be informed in writing.

Finally, the buyer should list any documents included in the invitation to tender, for example the general conditions of purchasing.

A) Organization

- Name, address and contact of buyer.
- Brief description of buying organization.
- Tender number.
- Name, address and contact of bidder.

B) Goods

- Specifications of required health care goods.
- INN for drug products.
- Manufacturing standards.
- Quality standards.
- Packaging quantity.
- Labelling requirements.
- Minimum remaining shelf-life.
- Quantities and unit of measurement.
- Packaging requirements.
- Requested product documentation and information.
- Location of delivery.

C) Product specifications bidders must provide in their bids

- Product specifications.
- Manufacturer.
- Country of manufacture.
- Price.
- Maximum delivery lead time.
- After-sales services (for health care equipment).

D) Commercial terms

- Type of purchase contract.
- Validity period.
- Applicable INCO terms.
- Currency of stated price.
- Conditions of payment.
- Terms of payment.
- Conditions of contract, which will be signed with the successful bidder.

E) Information concerning tender

- Confidentiality clause.
- Postal address for submission of bids.
- Means of transmission of bids.
- Closing date and time for submitting bids.
- Period of time for which bids should be valid.
- Format requirements for bids.
- Date of opening of bids.
- Criteria for evaluation of bids.
- Procedures for awarding contracts.
- Information of successful and unsuccessful bidders.
- Listing of any documents provided with the invitation to tender.

Table 28.3 Information provided in an invitation to tender

In order to ensure fairness, identical invitations to tender should be signed and sent to all invited bidders. However, in case a range of health care goods is being tendered at the same time, the range of goods may be limited to the product range of the respective supplier. Moreover, suppliers offering a wide range of health care goods might only be qualified for certain products.

All invitations to tender must be sent to all suppliers at the same time with reliable means such as courier services.

In case of mistakes, omissions or the request from a specific bidder for more information, any clarifications or additional information must be sent to all suppliers.

28.5.3 Receiving and opening of bids

All bids and samples received from bidders, which must be received in sealed envelopes, or boxes must be checked for the integrity to ensure that they have not been opened. Their receipt must be logged in a ledger indicating the name of the bidder, the date and time of receipt as well as the name of the person who has received the bid.

Immediately after registration, all bids must be deposited in a locked and sealed tender box to prevent any opening and tampering before the closing date. Bulky cartons with samples must be safely locked in a dedicated storage place.

Any bids received after the closing time and date must be disregarded.

After the closing date and time, in order to prevent manipulations, a committee of at least three people must open the tender box. Under no circumstances must any bid be opened before the closing date as this could allow other bidders to adjust their selling price according to known offers of competitors.

The envelopes of all bids must be signed, numbered and dated by committee members in order to prevent that bids, which were not in the tender box at the time of opening, are added later.

The names of bidders must be entered in a record, which is signed by all members of the committee. This list is later compared with the list of invited suppliers. If any bid is missing an inquiry should be made with the supplier to ensure that he has received the invitation to tender and his bid was not lost or deliberately withheld.

The committee opens the sealed envelopes and each page of each document submitted by the bidder is again signed to prevent that documents or pages are added later. Likewise all samples provided by bidders must be registered, marked and signed for later identification. All documents and information must be treated as strictly confidential and none of the bidders may have access to any information provided by other bidders.

28.5.4 Evaluation criteria for bids

All bids are first reviewed for compliance with formal criteria such as the requested format of bids. Any bids which do not comply, for example because they were not submitted in a sealed envelope or because they do not clearly indicate details of the bidder, are eliminated from further processing. If a closed tender was issued, any bidders which were not invited are also excluded.

Likewise bids which are incomplete, ambiguous, do not indicate the requested information or do not include product samples are excluded. Bidders of health care equipment which are unable to offer any after-sales services are excluded likewise.

Each of the bids needs to evaluated separately before they can be compared to each other. The three main criteria for evaluation are the health care products themselves, costs and services provided by the bidder (see table 28.4.).

- Conformity to specifications.
- Quality of health care products.
- Selling price.
- Cost of ownership.
- Supplier services.

Table 28.4 Criteria for evaluating bids

All bidders must provide samples of the health care goods which they are offering. All samples must be recorded and marked with a unique number for recording their quality ratings.

The samples must then be carefully evaluated by a qualified, skilled and experienced pharmacist. In order to ensure fairness, wherever possible the assessors of samples should not be aware of the name of the bidder which has submitted them.

The specifications of health care products offered by the bidder must first of all comply exactly with the specifications of the standard item catalogue or the specifications indicated in the invitation to tender. Although this may seem obvious, bidders may simply make mistakes or may, for example, offer the requested drug product but in another dosage form or another strength of dosage unit. Bidders, which do not offer the requested health care goods, may submit samples of substitutes without clearly indicating this in their bid.

Any samples which do not fully comply with the required specifications, do not need require any further consideration, regardless of any other conditions of the offer.

The quality of each sample product is then compared with the quality requirements laid down in the standard item catalogue or in the invitation to tender. The minimum requirements such as markings of drug products with manufacturer, country of manufacture, batch number or expiry dates should be checked and recorded by a pharmacist according to a standardized check list.

While a visual inspection cannot eliminate substandard or counterfeit health care products with certainty, a careful evaluation can greatly reduce the likelihood of accepting poor quality health care goods. Often obviously poor quality health care goods can be quickly identified and eliminated from the further evaluation process.

Analytical laboratory testing of drug products or sterility testing of sterile single use medical devices is usually prohibitively expensive. Furthermore conformity of samples with quality requirements does not guarantee that any batches which are purchased later also comply. As bidders select the samples, they will make every effort that they meet the required quality standards (Quick, J.D. (ed.) 1997, 277) but these samples are not necessarily representative for the product quality in general.

As no compromises can be made concerning the quality of health care goods, the sample products are either accepted or rejected regardless of other conditions of the offer such as the selling price.

As bidders may offer products in different packaging sizes and in order to be comparable, selling prices must be calculated for one unit such as one tablet, pair of gloves, syringe etc. of each product.

If different dosage forms and strengths of dosage unit of drug products are accepted according to the invitation to tender, then the costs for one course of treatment rather than one tablet, capsule etc. must be compared.

The quoted selling price is only part of the total cost of ownership which the humanitarian organization incurs by a purchase.

Apart from the selling price, the costs for transportation, insurance and customs clearance which, depending on the INCO terms, may or may not be included in the tender must be considered in order to be able to compare prices. To facilitate comparison of prices, a specific INCO term should be indicated in the invitation to tender.

For health care equipment the cost of installation, commissioning, training, conditions of the product warranty as well as overall operating costs must also be considered in the comparison. Moreover the costs of each offered piece of health care equipment must be related to its expected lifetime. More expensive but more durable health care equipment, for example surgical instruments, may be more cost effective than cheaper instruments which last only a few months.

For evaluating supplier services the minimum remaining shelf-life bidders are willing and able to guarantee for drug products and single use medical devices needs to be considered.

The delivery frequency as well as maximum guaranteed supplier lead time are important criteria. Bidders may offer a wide range of health care goods but not keep all of them in stock and therefore have to order them from abroad incurring long lead times.

The willingness of bidders to agree on system contracts, fixed purchasing prices without determining the purchase quantity or maintain consignment stocks for customers are important considerations as they offer customers great advantages.

Special consideration must be given to the offered after-sales services whenever health care equipment is purchased. The costs for transportation, installation, commissioning, training as well as servicing can be considerable and it therefore makes a great difference for the cost of ownership whether these costs are included in the selling price.

The criteria of quality, cost of ownership and supplier services should be rated for each product and each bidder. This facilitates comparison especially if many bidders have bided for many different products.

A rating scale is defined and each criteria is given a defined amount of points. The rating may use the same or different scales for each of the criteria. Although rating the criteria gives the semblance of objectivity, assigning the ratings is itself inevitably subjective to some degree (Quick, J.D. (ed.) 1997, 243).

Another fundamental problem is adding ratings of different criteria and calculating a total score as this implies that equal weight is given to the different criteria. Moreover a total score makes no difference between a product which rates average for all criteria and another product with a high rating for some criteria but very poor rating for other criteria.

28.5.5 Comparison of bids and award of contract

The comparison of products and offers must be made under the assumption that all bids are accurate and bidders will actually offer the services they promise. While the quality of

products can be assessed to some degree, the reliability of supplier lead times cannot be assessed unless health care goods were purchased from the respective supplier in the past.

For each item, the bids are collated in a selection table, indicating all the product specifications and information provided by the respective bidder, the results of the sample evaluation as well as any ratings which may be applied.

The collation and ranking of bids according to the applied criteria allows comparing all bids. If a rating system is used, all offers for each item can be ranked according to the total score.

For comparing prices, international references such as the International Drug Price Indicator Guide (Frye, J.E. 2008) or not-profit-making suppliers may be used.

In order to ensure fairness and transparency, products and bidders should be selected according to clearly defined criteria. Among several bidders offering products which comply with the minimum quality and service requirements, humanitarian organizations must consider the trade-off between quality, service and price (ECHO 2003, Annex V, 2).

From all products which comply with requested specifications and quality requirements, the product with the lowest price or where applicable lowest cost of ownership, is selected (WHO 2007a, 42). Another logical strategy would be to simply select the products with the best quality. However, this strategy is likely to be unaffordable.

All bids should be ranked in order of their preference for later reference in case the selected bidder is unable to deliver, changes his price or does not deliver products of acceptable quality.

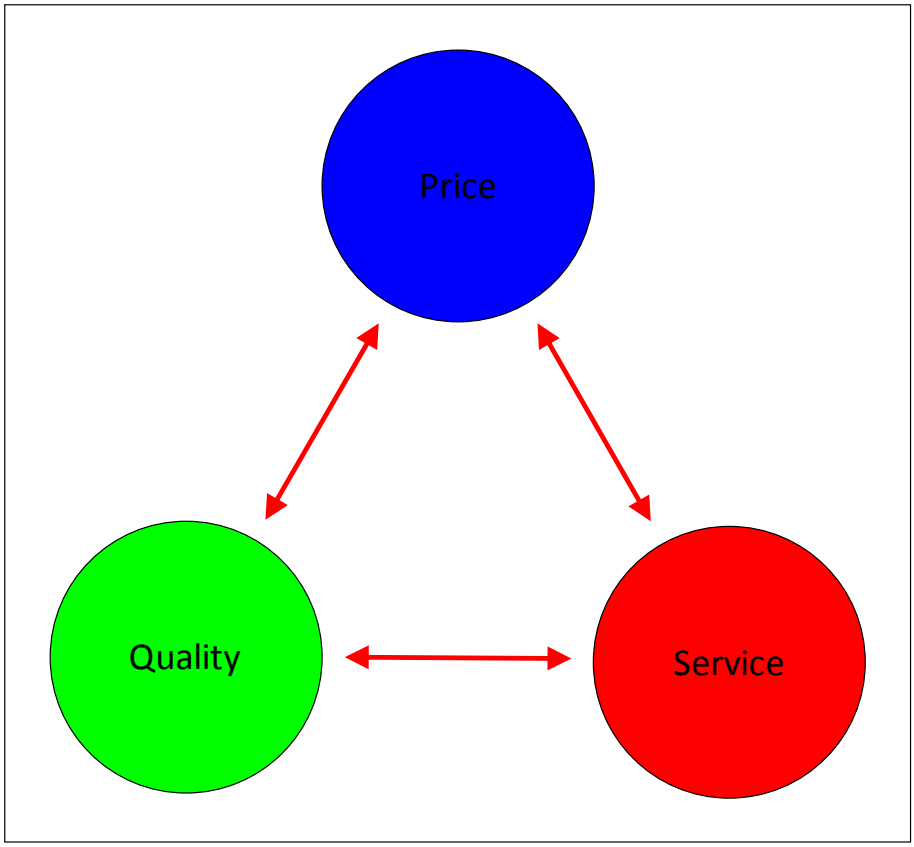

Figure 28.1 Trade-offs between selection criteria

However, while minimizing costs is important, at the same time the products with the best quality should be given preference. Therefore, the different criteria will need to be balanced

against each other and at times, a slightly more expensive product of higher quality or with shorter supplier lead time may be selected. In such cases, the decision must be clearly stated and documented for justification and later audits.

Finally, for each product the contract is awarded to the selected bidder. The choice must be clearly documented and all members of the committee who are accountable for this decision must sign the selection table.

In some case, splitting of tender awards between different bidders may be considered in order to reduce dependence on a single supplier, especially for critical health care goods or very large quantities. Another reason may be to hedge against the risk of one supplier becoming unable to deliver in case the security situation in the country deteriorates.
Bidders, which have been awarded the tender for a specific item, must be formally notified in writing. The unsuccessful bidders should also be notified in writing. However, no reason must be given why they were not successful and prices or other conditions of competitors must not be disclosed.

28.6 Purchase contracts

Finally a purchase contract is issued whenever a stock replenishment is necessary or, for (annual) system contracts, a purchase contract is issued for all stock items at the same time. The purchase contract includes several conditions and issues not included in the invitation to tender (see table 28.5).

Except for direct purchasing, all purchasing must be based on a formal written document which is in fact a legal contract. A contract is a legally binding document between the purchasing organization and the supplying company which specifies the rights and obligations of both contracting parties.

Because purchase contracts are legally binding and the seller may sue the buyer, they must be written with great care. Lawyers should be consulted for drafting standard contracts as well as advising on legislation and regulations concerning purchasing in the country.

Purchase contracts must be as detailed and precise as possible. A small mistake in the specifications, price or INCO terms can lead to substantial financial losses as well as lengthy litigation.

For purchase contracts which are based on an invitation to tender, the seller must agree to the terms and conditions stated in his bid. Any change or opportunity for re-negotiating any terms and conditions would be unfair to all other bidders.

A) Contracting parties

- Buyer name, address and contact.
- Supplier name, address and contact.

B) Goods and services

- Specifications of ordered health care goods.
- International nonproprietary name for drug products.
- Proprietary name.
- Manufacturer.
- Country of manufacture.
- Manufacturing standards.
- Quality standards.

- Packaging quantity.
- Labelling requirements.
- Minimum remaining shelf-life at the time of delivery.
- Ordered quantities and unit of measurement.
- Manufacturer packaging requirements.
- Requested product information and documentation.
- Language of labelling and documentation.
- Statement that delivered health care goods must correspond to samples provided with bids.
- Conditions and period of warranty (for health care equipment).
- After-sales services (for health care equipment).

C) Delivery

- Delivery address.
- Contact to inform prior to delivery.
- Maximum delivery lead time after signing of contract.
- Delivery quantities and schedule.
- Acceptance of partial deliveries.
- Maximum number of batches per delivered item.
- Transport packaging requirements.
- Processing of damaged and rejected goods.

D) Commercial contract terms

- Reference to general conditions of purchasing.
- Applicable law.
- Arbitration.
- Force majeure.
- Type of purchase contract.
- Date of signature of purchase contract.
- Validity period of purchase contract.
- Applicable INCO terms.
- Selling price.
- Currency of stated price.
- Adjustment of selling price to inflation.
- Inclusion or exclusion of taxes.
- Conditions of payment.
- Terms of payment.
- Invoicing address.
- Penalties in case of supplier default.
- Requirements for communications (in writing).
- Signature of purchaser.
- Signature of supplier.

Table 28.5 Contents of purchase contracts

The purchase contract must clearly indicate the full name, address and contact of the buyer as well as the seller (supplier).

The purchase contract must precisely specify the ordered health care goods in order to avoid that suppliers sell health care goods, which are only similar to the ones they bided for and are possibly of inferior quality. The purchase contract can either give the full specifications or refer

to another attached document such as the quality assurance policy or the standard item catalogue of the humanitarian organization.

For drug products, the purchase contract must specify the international nonproprietary name as well as the proprietary name, the manufacturer as well as the country of manufacture. Multinational companies may manufacture the same drug products in different countries and according to different quality standards.

The required manufacturing standards, such as CE markings, cGMP or pharmacopoeial standards should be indicated in the contract.

For the purchase of complex health equipment all components, any accessories, auxiliary equipment, special tools as well as operating supplies must be clearly defined.

The packaging quantities must be indicated as part of the product specifications as, for example, drug products in blister packaging and in large hospital packaging are very different products.

For the labelling requirements the purchase contract can refer to an attached quality assurance policy or the Good Manufacturing Practices (WHO 2007g). In any case, labels of secondary supplier packaging must at least bear the International Nonproprietary name, proprietary name, batch number, manufacturing and expiry date, manufacturer and country of manufacture.

The requested minimum remaining shelf-life at the time of delivery can be indicated in absolute terms, for example number of years or months, or as percentage of the total shelf-life at the time of manufacturing. For example, at least two years remaining shelf-life or 75% of total shelf-life for health care goods with a total shelf-life of less than two years (Quick, J.D. (ed.) 1997, 262).

The order quantities as well as the unit of measurement must be indicated without ambiguity. Since supplier packaging quantities may change and in order to avoid misunderstandings, quantities should be stated in the smallest useful unit of measurement such as a tablet, syringe, roll of gauze, sheet of x-ray film etc.

For systems contracts the estimated total quantity for the specified period, such as 6 months or one year need to be indicated although the buyer is not obliged to purchase the total quantity.

The packaging of health care goods should comply with the standards of the Good Manufacturing Practices (WHO 2007g).

In accordance with the WHO Certification Scheme on the Quality of Pharmaceutical Products Moving in International Commerce (WHO 1997b), the buyer may request a Certificate of Pharmaceutical Product (product certificate), a Statement of Licensing Status of Pharmaceutical Product(s) and a Batch Certificate of a Pharmaceutical Product, which is issued by the manufacturer. Alternatively a certificate of analysis, which is not issued by the manufacturer may be accepted.

When health care equipment is purchased installation, operating, service and repair manuals as well as lists of replacement parts must be provided.

The language of product information (labelling and package inserts) and accompanying documentation should be stated to ensure that they are understood in the recipient country.

If health care goods are purchased following a tender, the purchase contract should state that the supplied products must be identical with the samples provided with the bid of the

respective supplier. If suppliers are (temporarily) unable to provide the product they bided for, they must submit samples of the substitute and obtain approval by the buyer before delivery.

Purchase contracts for health care equipment must state the length of the warranty period as well as warranty conditions such as coverage of the warranty and replacement parts which are supplied free of charge.

Likewise after-sales services such as installation, commissioning and free servicing must be clearly stated in purchase contracts for health care equipment.

The purchase contract must state exact details of the delivery address or possibly different delivery addresses, as well as a contact for informing the buyer on delivery dates and times.

The maximum delivery time quoted by the supplier in his bid must be clearly indicated in the purchase contract to ensure that the buyer can cancel the purchase contract in case of late deliveries.

In case of system contracts or consignment stocks the purchase contract should indicate a delivery schedule with the quantities, which ought to be delivered at specified dates.

The purchase contract must indicate whether partial deliveries in terms of items as well as quantities of items are accepted. Refusing partial deliveries will increase supplier lead time while acceptance incurs the risk of receiving a large number of partial deliveries, which are time consuming in terms of receipt as well as accounting and payment.

The maximum number of different batches, which are accepted for each item, should be indicated as the time required for inspection and subsequent documentation increases with every batch.

Any requirements for special transport packaging for example for international transportation, transportation on bad roods, for dangerous goods or cold chain loads should be indicated.

Except for health care equipment, the maximum acceptable weight of any parcel or carton should be indicated, usually 25 kg.

The obligation of the supplier to take back and replace any consignments or health care goods, which do not comply with the requested specifications, should be stated. Likewise, the supplier should be obliged to take back any damaged goods unless the carrier or the insurance is liable according to the stated INCO terms.

Instead of listing all obligations and rights of buyer and seller, documents valid for contracts such as general conditions of purchasing of the humanitarian organization or reference to international laws concerning purchasing can be made. In this case, a complete copy of the general conditions of purchasing must be attached to the purchase contract unless the respective supplier has already acknowledged receipt during the registration process.

As disputes about alleged defaults on contractual obligations may arise, the purchase contract must clearly state the commercial laws, which are applicable in case of litigation. This may be the laws of the country of the buyer, the seller or a third country.

Moreover, the purchase contract should state the place and institution for arbitration in case of disputes.

The purchase contract should include a "Force majeure" clause, which states that neither party is liable for any delay in performing or failure to perform any of its obligations under extraordinary events or circumstances such as labour disputes (strike, lockout), riots, civil unrest, unforeseen implementation of restrictions by the government, closure of borders or disruption of transportation.

The purchase contract must clearly state any special conditions such as system contracts or consignments stocks maintained by the seller.

The date of signing of the contract by the buyer as well as seller must be stated as it has implications for the validity period or the latest delivery date.

In case the conditions of the contract are valid for a certain period, for example, when system contracts are agreed upon, the validity period or the date until which the contract is valid must be clearly stated. Such contracts are often valid for one year although shorter validity periods may be inevitable in countries with high inflation rates unless selling prices are indicated in another stable currency.

The INCO term as well as the version (year) for example "INCO terms 2000" must be indicated in order to define the division of responsibilities, risks and costs between the seller and the buyer.

The purchase contract must state the selling price, which must be agreed upon beforehand between the buyer and seller and is stated in the bid or quotation received from the seller. The selling price must clearly relate to the unit of measurement, preferably pieces but possibly units of supplier packaging.

The currency of the selling price must be clearly stated. For domestic purchase the domestic currency will be used but a commonly used international currency may be chosen instead.

In countries with high inflation and the use of domestic currencies, a clause concerning adjustment of prices to the rate of inflation may be included.

The purchase contract must clearly state whether the indicated selling price includes or excludes taxes such as VAT (value-added tax). Humanitarian organizations may be exempted from various taxes and the seller may be able to reduce the selling price accordingly. In other cases, the humanitarian organization may have to pay the full price and be eligible for reclaiming taxes later on.

For direct purchases, the buyer usually has to pay upon receipt of goods. Often the seller and buyer will agree on deferred payments where the seller has to pay the seller only within a specified period, often one month, after receipt of consignments. In fact, the period of deferred payment corresponds to an interest free loan (for the buyer) and the seller may be at a disadvantage in case of inflation.

In countries with poor legal security, advance payments should be avoided, as it may be impossible to recover them in case the seller does not deliver on time or does not comply with other contractual obligations.

The purchase contract must clearly state the terms of payment such as cash, by check or bank transfer.

The buyer must indicate the exact address to which the seller must send his invoices.

The purchase contract may indicate financial penalties for defaulting on contractual obligations such as late deliveries. However, in practice such penalties may be difficult or impossible to enforce.

The purchase contract should clearly state that any communications, which may be important in case of litigation, must be made in writing and not in person, by telephone or email.

Like any other contract, the purchase contract enters into force only once it is signed by both contracting parties, the buyer as well as the seller.

Purchase contracts for complex health care equipment, which should cover related services, need to include some additional contract terms (see table 28.6).

The purchase contract should state that competent, trained and qualified technicians carry out all specified works.

Details of the required works such as installation of health care equipment, calibration, testing, commissioning as well as training of operators and users must be specified. For each of these obligations completion dates or periods from the time of installation should be agreed upon.

The frequency of servicing as well as the exact works carried out must be indicated. Likewise, any maintenance or repair work, which the seller is obliged to carry out free of charge, must be indicated. The validity period or the date on which the service contract ends need to the specified.

The conditions under which the warranty is applicable need to be specified. For example, the seller will usually not be liable for any damage caused by inappropriate operation of health care equipment or by servicing or repair by other than its own technicians.

The scope of the warranty as well as the replacement parts which will be provided free of charge need to be indicated. Possibly the warranty period will differ for different parts of the health care equipment or accessories.

The length of the overall warranty period or the date on which it ends must be clearly stated.

A) Services

- Qualifications of staff carrying out works.
- Installation.
- Calibration.
- Testing.
- Commissioning.
- Training.
- Completion date or period of various services.
- Servicing (work and frequency).
- Maintenance.
- Repairs.
- Validity period of service contract.

B) Warranty

- Conditions of warranty.
- Scope of warranty.
- Replacement parts provided free of charge.
- Length of warranty period.
- Availability of qualified and trained technicians.

C) Terms of payment

- Advance or down payments.
- Inspections after completion of defined works.
- Partial payments after completion of defined obligations.

Table 28.6 Additional contract terms for purchasing services

The purchase contract must clearly state that a competent, qualified and trained technician must be available on the site of installation within a specified period of time. This clause is of particular importance if equipment is installed in countries in which an armed conflict is taking place.

The terms of payment require particular attention. Often sellers will require an advance or down payment as they incur expenses and risks during installation. Furthermore, partial payments are usually conditional on completion of defined works.

The purchase contract should specify who carries out the inspection and certifies satisfactory installation, calibration, testing and commissioning.

Compliance of the seller as well as the buyer with all terms of the purchase contract needs to be monitored in order to ensure that the purchase contract is fulfilled as well as decision criteria for awarding future contracts.

Among others, on time delivery, quantity and quality of delivered health care goods as well as the selling price need to be compared with the purchase contract at the time of delivery. The default on any of the seller's obligations should automatically lead to a cancellation with notification of the seller and issuing of another purchase contract with another supplier.

Likewise the buyer must ensure that the seller is paid in due time according to the terms and conditions of payment stated in the purchase contract.

If large quantities of goods or expensive equipment are purchased the buyer may carry out the inspection at the supplier before shipment.

28.7 Supplier evaluation

The performance and compliance with contract terms of all current suppliers should be evaluated regularly and be formally appraised. The results of this evaluation are important for comparing the services of suppliers during the next tendering process. Very poor services may also lead to removal of suppliers from the list of regular suppliers as well as exclusion from future tenders, regardless of the assessment during the tendering process.

In order to avoid bias and accusations of corruption, the evaluation of suppliers must be done systematically, objectively and according to defined and, wherever possible, quantifiable criteria.

The quality of delivered health care goods can be monitored by recording the number and quantities of items which are rejected after inspection for whatever quality defect. The remaining shelf-life at the time of delivery can be measured in absolute terms as well as percentage of total shelf-life. Likewise delivery of consignments without the requested product information and documentation such as batch certificates or operating manuals should be noted.

Any inability of suppliers to deliver despite having signed a purchase contract must be documented and recorded.

The average as well as the maximum supplier lead time should be measured for each item of each purchase contract with the consistency (standard deviation) being more important than the average. However compliance with the lead time promised by the supplier and delivery before the due delivery date are more indicative about supplier reliability.
Deliveries received from suppliers without a due advance shipping notice should be recorded.
Likewise any deliveries with incomplete shipping documents should be noted.

A) Quality of delivered health care goods and services

- Number and quantity of rejected items (for any reason).
- Remaining shelf-life at the time of delivery.
- Percentage of deliveries lacking requested product information and documentation.

B) Delivery

- Number of cancelled items (inability to deliver).
- Consistency of delivery lead time (standard deviation).
- Absolute delivery lead time (maximum and average).
- Percentage of items delivered after the due delivery date.
- Percentage of deliveries without advance shipping notice by supplier.
- Percentage of deliveries with incomplete shipping documents.
- Number of times goods are damaged due to poor quality of transport packaging.
- Average number of partial shipments per item.
- Number of batches per delivered item.
- Number and extent of short shipping.
- Speed of replacement of damaged or non-compliant health care goods.
- Percentage of invoices rejected because of inaccuracies.
- Percentage of invoiced prices, which differ from quoted selling prices.

C) Services

- Number of attempted or affected withdrawal of bids or quotations.
- Willingness and ability to expedite orders.
- Willingness and ability to treat emergency orders.
- Regular provision of accurate order status information.
- Response time to inquiries.
- Quality of response to inquiries.
- Quality of follow-up on any kind of complaints.
- Scope and quality of after-sales services.
- Availability and lead time for replacement parts.
- Availability of qualified technicians (for health care equipment).

Table 28.7 Criteria for evaluating supplier services

The number of times consignments were damaged during transport due to inappropriate transport packaging is a further criteria. This includes inappropriate packaging of cold chain loads or dangerous goods.

The average number of partial shipments should be recorded for each purchase contract and related to the number of ordered items.

The number of batches delivered for filling an item needs to be related to the ordered quantity.

The number of times and extent to which suppliers short-shipped items or shipped wrong items should be recorded.

For health care goods or consignments which were rejected the lead time for replacing the respective goods can be measured.

The percentage of invoices which are rejected because of inaccurate prices, product specifications or quantities should be considered.

The percentage of invoiced prices which differ from the selling prices quoted by the supplier which usually should lead to the rejection of deliveries, should be measured.

Some supplier services cannot be easily measured and quantified but should nevertheless be taken into consideration.

Any attempts of suppliers to withdraw offers quoted in bids or quotations indicate a lack of reliability. The willingness and ability of suppliers to expedite customer orders as well as to treat emergency orders is an important measure of their responsiveness and flexibility.

The reliability and frequency of provided order status information should be noted.

The speed of response to any inquiries by customers as well as the quality in terms of completeness and accuracy is another relevant criteria.

The quality of supplier follow-up and his actions taken when receiving any kind of complaints is an important criteria for the quality of supplier services.

For health care equipment the lead time for delivering replacement parts as well as the call-out time for qualified technicians are important service criteria.

28.8 Information management

Careful management and storage of data, information and records is of particular importance for purchasing, especially since some are legal documents.

A separate file with all documents received from the time of registration must be maintained for each supplier.

A complete record containing all relevant documents must be maintained for each purchase contract and filed for several years after closure for future reference.

A detailed product file which contains technical specifications and information on quality, should be maintained, at least for all regularly purchased health care goods.

The large number of data and information, which needs to be received, stored and processed warrants using computerized management information system with a wide range of functionalities (see table 28.8).

The management information system must maintain a database with specifications and suppliers at least of the commonly purchased health care goods. The supplier database contains names and contacts, registration details, visit and audit reports, range of offered products, past purchase contracts as well as statistics on past supplier performance.

The management information system should also manage the entire tender process as well as individual purchase contracts and their follow-up, including detailed order status information.

All communications with suppliers should be recorded and managed in a database which allows quickly retrieving past communications.

All accounting related to purchase contracts should also be managed in the same information system, including follow-up of supplier payments.

Finally, the management information system should allow generating any kind of reports for analysis, planning and general management as well as allow monitoring the performance of the purchasing department.

- Product database.
- Supplier database.
- Supplier performance monitoring.
- Management of tenders.
- Purchase contracts and order status information.
- Communications with suppliers.
- Accounts receivable and payable.
- Generation of reports.
- Monitoring of performance of purchasing department.

Table 28.8 Functionalities of a management information system for purchasing

29 WAREHOUSE AND STORES MANAGEMENT

Warehouse and stores management concerns security and safety, management of warehouse staff, housekeeping and maintenance, record keeping as well as protection and storage of goods.

Conscientious management of medical storage facilities is a prerequisite for preventing damage to health care goods and allowing their effective and efficient management.

29.1 Objectives

Good warehouse and stores management ensures that the best conditions for warehouse operations are provided. Security and safety of staff, facilities, assets and goods must be maintained. Storage facilities must be kept clean and adequate storage conditions as well as accurate stock records must be maintained.

- Security of stores and warehouses as well as stored goods.
- Safety of staff and prevention of accidents.
- Availability of qualified staff and maintaining adequate staffing levels.
- Cleanliness of stores and warehouses.
- Good order of stock.
- Protection of goods from vermin and pests.
- Maintenance of building, facilities, storage and materials handling equipment.
- Accurate record keeping.
- Preventing theft of goods.
- Preventing deterioration of goods caused by inappropriate storage conditions.
- Preventing expiry of goods in stock.

Table 29.1 Objectives of warehouse and stores management

29.2 Warehouse security

Ensuring and maintaining the security of staff, medical storage facilities as well as stored goods is the primary concern of logistics managers.

- Shooting (small arms, automatic rifles).
- Attacks.
- Artillery (mortar fire, howitzers, heavy artillery, rockets).
- Aerial bombing.
- Theft of goods and equipment.
- Looting.
- Vandalism and sabotage.
- Blockade, sit-in, occupation.
- Expropriation.
- Confiscation of goods, equipment and facilities.

Table 29.2 Possible risks for stores and warehouses

Risks from acts of war, unauthorized entry and intrusion as well as theft must be considered.

29.2.1 Protection from acts of war

Warehouse and stores managers are exposed to dangers from acts of war such as bombing and shelling. Even if the location is selected carefully, the dynamics of armed conflicts might turn a safe place into a dangerous place over night. Moreover, in conflict areas there is no absolute security. However, various security measures can reduce the risk of injury to staff and damage to medical storage facilities and stored goods.

Warehouse managers should be aware that any storage facilities may be attacked at any time and they must take precautions for such an event. The objectives of security measures are to reduce the risk of an incident occurring as well as to reduce the consequences if an incident nevertheless occurs.

Humanitarian organizations should maintain contacts with the authorities as well as all parties to the conflict and explain the importance of medical storage facilities for assisting the populations.

Humanitarian organizations which are not well accepted, by the authorities, the population as well as the conflict parties have an increased risk of being targeted by combatants or being looted. There is little purpose in conducting humanitarian assistance programmes in a hostile environment and without the participation or at least acceptance of the population.

Neutrality towards all parties to the conflict and the behaviour of all staff is vital. Otherwise, storage facilities might be perceived as enemy assets and therefore be considered as legitimate targets.

Medial storage facilities may be affected by acts of war purely because of their vicinity to the area of fighting or be actively targeted by parties to the conflict. Buildings can be targeted or they may be hit accidentally when attempting to hit a nearby target. They may also be hit by indiscriminate shelling.

The risk of maintaining the medical storage facility must be balanced against the benefit its services provide to the affected population. Humanitarian organizations must monitor the security situation and take a timely decision to close or move the medical storage facilities when the risks become too big.

- Careful selection of the site.
- Notification and information of authorities and parties to the conflict.
- Visual identification.
- Physical protective measures.
- Insurance of facilities and goods.
- Contingency plans for emergencies.

Table 29.3 Measures to improve the security of stores and warehouses

Preventive measures intend to prevent the occurrence of security incidents while protective measures try to limit the consequences if an incident could not be prevented. The general considerations and measures discussed in chapter 5 also apply to warehouse security.

The careful selection of the site is of utmost importance. In case the security situation deteriorates, there will be a reluctance to move the medical storage facility and the evacuation may severely disrupt the assisted health programmes.

The site should not be located near military installations or facilities (bridges, strategic roads, power plants etc.) which may become targets in case of combat.

The authorities and all parties to the conflict should be notified of the geographic location as well as the coordinates of medical storage facilities. In case of increasing intensity of the conflict or major changes in the military situation, parties to the conflict should be reminded of the location of these facilities.

Especially in modern warfare (high altitude bombing, the use of missiles) and especially during the night, means of visual identification will not be visible for combatants and will therefore not offer any protection. Moreover, during combat, combatants may not pay attention to visual signs.

Medical storage facilities should be clearly identified by signs or flags to avoid being mistaken for military targets. Means of identification must be visible from all sides as well as from the air. Illumination of the identification during the night can be considered. Any signs should be maintained, kept clean and must not be obstructed by objects such as containers or vehicles.

When using signs any political or religious significance of colours or signs, which may be considered as offensive or be interpreted as being partial in the conflict, should be considered.

In some situations identifying buildings may increase the risk of being targeted, especially by criminals. In this case, a non-distinct facility, which resembles the surrounding facilities, helps to keep a low profile.

Shooting, shelling and bombing can occur any time without prior notice and must be anticipated. Therefore, shelter facilities, which can accommodate all staff, expected to be at the medical storage facility must be available at the site. Depending on the conflict and the weapons, which are being used, blast walls may be sufficient or underground shelters may be needed. Shelters must be large enough to accommodate all permanent warehouse staff. They must be furnished with telecommunication equipment, water, food as well as first aid equipment.

Care must be taken that protective facilities are discreet and do not appear as military installations which could trigger an attack.

In case of an attack, warehouse managers must ensure that all staff is accounted for. This includes permanent staff as well as visitors or other staff, such as drivers, which happen to be in the facility.

Any hazardous materials such as liquid or gaseous fuels must be stored at a safe distance from any buildings as well as shelters to prevent injuries in case hazardous material is ignited by weapons fire.

Insurance for war risks can be taken out for the medical storage facility (buildings) as well as for stored goods if they are affordable and fees are reasonable. Insurances do not reduce any risks and do not limit the consequences of acts of wars but can at least limit the financial losses.

If goods or covered by an insurance, stock records must be updated regularly in order to be able to submit accurate claims to the insurance company.

Warehouse managers must be prepared for emergencies. Reliable means of communication must be maintained to be able to receive warnings of imminent attacks, to inform the radio room of any attacks and to call for assistance.

29.2.2 Prevention of unauthorized entry

Measures to prevent unauthorized entry should be taken at several levels. Facilities must be protected by perimeter fences or walls and strict measures for access control of vehicles and people must be implemented at the main gate. Windows and doors of medical storage facilities must be barred and no unauthorized staff, especially visitors and drivers, should have access to stores through loading bays. Ideally, docks and loading bays should be visible from the office area. Finally access to the storage area should be controlled.

The main gates must be closed at all times and opened only for vehicles authorized to enter or exit. All persons entering the premises must report to the security guards at the main gate. Any visitors must be registered, be issued a visitors card and receive permission by authorized warehouse staff to enter.

The storerooms as well as the warehouse must be locked whenever no staff is present. The warehouse manager is responsible for checking the integrity of doors and locks every day when closing the store.

Night guards should also be obliged to check doors, windows and locks during regular rounds during the night as well as during the daytime when the warehouse is closed.

29.2.3 Theft control

Many health care goods have a high value, are in demand and can easily be sold and made to money.

Staff, intruders and visitors or staff entering premises and stores temporarily (drivers, maintenance staff etc.) may commit theft. Theft may also be committed by staff with the help of security guards (insider job).

Health care goods such as health care equipment, which are valuable, which are in high demand (for example antibiotics), in short supply in the market and easy to hide (small) as well as controlled substances are most likely to be stolen.

Theft ("shrinkage") may occur as occasional petty pilferage by individuals, as slow and chronic small-scale "leakage" or as major break-ins, possible with the assistance of insiders. Thieves may try to (temporarily) conceal theft by removing goods from containers and returning the empty containers on the shelves.

Removing a small quantity of health care goods from large packaging makes detection of theft difficult. In large medical storage facilities, it is not possible to check every parcel and missing items or quantities can later be blamed on the supplier or supplying warehouse.

- Poor security in stores (open windows, unlocked doors etc.).
- Access to the store by unauthorized people.
- Untidy and disorderly stores.
- Inaccuracy and poor maintenance of stock records.
- High turnover of stock.
- Shortage of health care goods in the local market.
- Low salaries of employed staff.
- Lack of sanctions against staff who have been found guilty of theft.

Table 29.4 Factors encouraging theft

Theft may occur at any stage during warehouse and stores operations, during delivery of goods from suppliers, in the receipt area, from the storage area, from the dispatch area or during loading of vehicles.

Several factors encourage theft (see table 29.4).

Theft of health care goods causes financial losses but also can lead to shortages and stockouts, which in turn can lead to inappropriate treatment of patients. Theft also leads to loss of trust by donors. Theft of internationally controlled drug products can lead to abuse.

Measures to prevent theft can be taken at several levels (see table 29.5). However, the cost of measures to prevent theft must be balanced against the financial losses, which are expected to be prevented by these measures.

A) Limit and control access

- Control of all visitors and staff at the main gate.
- Control of access to the warehouse (especially through loading bays).
- Control of access to stores.
- No visit of friends and family members.

B) Control on exit

- Control of any goods which leave the warehouse as well as the compound.
- Parking of all visitor vehicles outside the compound.

C) Physical barriers

- Keep all storerooms locked when no staff is present.
- Keep keys locked in a key box.
- Lock controlled and valuable health care goods in cupboards.
- Maintain door locks as well as bars on windows and other openings.
- Attach seals to locks when warehouse is closed.
- Purchase of goods in tamper evident packaging.
- Sealing of parcels.

D) Measures to facilitate detecting theft

- Regular independent physical stock counts.
- Careful follow-up of any irregularities between physical stocks and stock records.

E) Other measures

- Clearly define who has the authority to release stock.
- Keep store tidy and in good order.
- Pay staff salaries, which allow them to live on.
- Destroy expired or damaged health care goods.

Table 29.5 Measures to prevent theft

One of the most important measures is implementing and maintaining strict access control to the facility as well as the medical store itself. At the main gate, all people and vehicles must be checked for their authorization to enter. Visitors should be accompanied by staff and not be allowed to enter the warehouse and stores alone. Vehicles of visitors should be parked outside the compound since otherwise they have to be carefully checked by security guards upon leaving.

Ideally, the warehouse manager can overlook the entrance as well as loading bays from her/his office to ensure that only authorized people enter. The number of staff who has access

to stores should be limited and it should be clear who would be held responsible in case any health care goods are missing.

All staff and especially vehicles must be controlled on leaving stores and the compound. The changing rooms should be located outside the storerooms so that staff cannot move goods to their lockers unnoticed.

Strict procedures must be in place for authorizing release of stock. Only the logistics manager should have the authority to release stock and should personally sign every picking list. Otherwise fake picking lists can be submitted to warehouse staff, giving the false impression that picking and shipment has been authorized. The warehouse manager should supervise and monitor loading of vehicles to ensure that all shipments are authorized. Otherwise, staff could move goods out of the compound together with authorized consignments.

Suppliers should be requested to enter the compound only with goods they intend to deliver in their vehicles and should leave with empty vehicles. Otherwise, it will be difficult to verify whether the goods in the vehicle all belong to the supplier and whether they were brought into the compound earlier.

Bars or metal gratings must protect windows and other openings and doors must be fitted with proper locks. All storerooms and the warehouse must be locked if no staff is present. The responsibility for opening and locking the warehouse as well as depositing the key in a locked key box after closing the warehouse must be clearly assigned. Access to the key must be clearly regulated.

An additional safety measure is to fit the main entrance with a numbered seal when the warehouse is being locked. Whenever a lock is fitted to a door there is never certainty that there may not be some copies of keys, which are kept by unauthorized people. The number of the seal is recorded and checked the next morning when the warehouse is opened. Although it is not impossible to forge the number seal, it creates an additional obstacle to breaking in without leaving any trace.

Purchasing goods in tamper evident packaging also discourages theft. Fitting parcels with tamper evident seals after inspection makes theft more difficult and facilitates detection. Entire parcels can still be stolen but it is more difficult to remove a small quantity from a parcel unnoticed.

Health care goods which are likely to be stolen, such as internationally controlled drug products or valuable drugs, should be locked in steel cupboards or safes.

Procedures should be in place to detect any theft and determine the point of theft as soon as possible since this will be a deterrent for future theft. Regular physical stock counts or at least spot checks should be performed by staff, which is not working in the store or warehouse. This allows detecting discrepancies and serves as a deterrent to theft by staff itself since they know that any irregularities are likely to be detected quickly. If frequent physical stock counts are necessary, they should focus on valuable and coveted health care goods to minimize the required resources.

Stock records must be maintained meticulously. Frequent discrepancies of stock records, for whatever reason, allow staff to conceal theft and explain it with mistakes in stock records. All stock records must be crosschecked and consistent with each other and must be compared during spot checks. Otherwise, goods can be stolen and the respective quantity can be added to the last stock issue on the bin card. Theft can then only be detected by comparing items and quantities on orders, picking lists, bin cards, stock cards and packing lists. A record on any detected discrepancies should be maintained. Occasional errors are unavoidable but constant discrepancies or sudden surges should be quickly investigated. Certain drug products or other

health care goods, which are known to be coveted, in short supply, high demand, expensive and easy to hide should be particularly carefully monitored.

Especially in warehouses with high throughputs and without a computerized information system, mistakes are inevitable. However any discrepancies must be followed up quickly to detect the reason. Otherwise, staff may be encouraged to make more "mistakes". Keeping the store and stock in good order also facilitates accurate record keeping.

Expired or damaged goods as well as any packaging and labelling must be destroyed by incineration or inertization.

Staff should be paid salaries which are comparable to salaries paid in the domestic private sector for similar positions and which allow staff to sustain their families.

Every theft or suspected theft should be fully investigated and documented in a report. Where possible a police investigation should take place and nothing should be touched or removed until the investigation has been completed. The stolen health care goods and their quantities must be identified by a physical stock count. The security guards who were on duty during the suspected time of theft should also submit a report.

The method used for the theft should be determined to detect shortcomings and allow improving security measures. The perpetrators must be identified and despite the hardship it will cause for them, any staff found guilty of theft as well as any staff who have assisted, must be dismissed immediately. Depending on the value and circumstances, an insurance claim may be filed together with the police report.

Every breach of security should be carefully investigated. Theft may be uncovered by anonymous information or physical counts. However, any accusations must be investigated discreetly as they may be unfounded and aimed at discrediting individual staff members for personal reasons.

Medical stores are less likely to be looted than food stores for example. However in case of looting the priority is to prevent any injury to staff. If available, the authorities should be asked for assistance. If looting cannot be prevented, at least damage to the store and equipment should be prevented or at least limited.

29.3 Warehouse safety

Safety is often not taken as seriously as it should until an accident occurs. National regulations on safety may not be existent or not be enforced. Nevertheless, it is the responsibility of warehouse managers to prevent injuries of staff as far as possible.

In many countries in which humanitarian organizations work, staff are not covered by any kind of health insurance. Apart from the injury and possible disabilities, injuries, which lead to the loss of capacity to work, can lead to the loss of livelihood for the staff member as well as her/his family.

General considerations concerning safety risks and measures have already been discussed in chapter 5.

29.3.1 Staff safety

Risks of occupational injury may emanate from handling of goods, materials handling equipment, electrical faults as well as dangerous goods (see table 29.6).

Occupational injuries can be caused by lifting (too) heavy loads and from falling, tripping and slipping, especially while carrying loads.

Staff must refrain from climbing on shelving without using proper equipment such as ladders. Another danger is goods, which fall off trucks, forklift trucks or shelves. A further cause of injuries is protruding nails or splinters from timber pallets.

Staff may also be injured by mechanical or powdered handling equipment such as forklift trucks as well as (reversing) trucks in docks.

Handling of dangerous goods as well as electrocution are other potential causes of injuries.

A) Handling of goods

- Injuries from lifting or carrying (too) heavy loads.
- Injuries from falling, tripping and slipping while carrying loads.
- Injuries from falling from ladders, steps and storage equipment.
- Injuries by falling objects (goods, storage equipment etc.).
- Crush injuries (especially of hands and feet) from pallets or goods.
- Injuries from splinters or protruding nails on timber pallets.

B) Materials handling equipment

- Injuries by (reversing) vehicles.
- Injuries by powered materials handling equipment (forklift trucks etc.).

C) Dangerous goods

- Exposure to dangerous goods.
- Explosion of gases or fires of flammable liquids.

D) Electrical faults

- Injuries by faulty electrical appliances (lighting, heating, cooling equipment etc.).

Table 29.6 Possible safety risks for warehouse staff

Injuries can be prevented by various measures (see table 29.7). Safety of stores and storage equipment must be considered already during building or setting up of of medical storage facilities.

All staff should wear proper shoes and be provided with gloves. Boxes, sacks, parcels etc. which are handled manually should not be heavier than 25 kg or be handled by two people. Heavier goods should be unloaded with mechanical handling equipment, placed on a pallet immediately after unloading and remain on the pallet, which is handled with mechanical or powered equipment. Sufficient materials handling equipment should be provided so staff does not have to lift and carry heavy loads.

Staff must refrain from climbing on storage equipment and must use ladders and steps instead. Proper equipment such as ladders and stepladders must be made available to staff.

Any spilled liquid such as water, oil or fuel must be removed immediately to prevent slipping.

Safety guidelines should be issued and sanctions imposed if staff does not comply.

Floors should be fitted with non-slip surfaces to prevent slipping, especially in areas outside stores and warehouses, which may be exposed to rain and snow.

Timber pallets must be properly maintained and repaired as soon as any damage is noticed.

Materials handling equipment should be regularly inspected for faults and be maintained. Staff must be trained in the safe and proper operation of materials handling equipment and operators should be aware that they carry the main responsibility for the safety of pedestrians. Ideally, areas for use of powered materials handling equipment should be separated from pedestrian areas.

Dangerous goods must be stored and handled carefully and according to instructions by the manufacturer. Warehouse staff must be trained on measures in case of spills of dangerous goods.

Electrical installations must be carried out by competent and professional electricians and be maintained regularly.

A) Staff

- Provide proper shoes and gloves.
- Train staff not to lift loads heavier than 25 kg manually.
- Provide appropriate and sufficient materials handling equipment for handling heavy loads.
- Provide appropriate ladders and steps for reaching goods off the floor.
- Immediately remove spilled liquids (water, oil, fuel etc.) to prevent slipping.
- Issue safety guidelines and sanction non-compliance.

B) Equipment

- Fit floors with non-slip surfaces.
- Carefully maintain storage equipment (especially pallets).
- Regularly inspect materials handling equipment for any faults.
- Maintain materials handling equipment.
- Train staff in the proper use of materials handling equipment.
- Dedicate areas for powered materials handling equipment and pedestrians.

C) Dangerous goods

- Ensure proper storage of dangerous goods.
- Handle dangerous goods according to instructions by the manufacturer.
- Train staff on measures in case of spills of dangerous goods.

D) Electrical installations

- Ensure installation by qualified electricians.
- Maintain electrical equipment.

Table 29.7 Measures to prevent occupational injury

Many health care goods especially liquids such as infusions, are very heavy. Staff can be injured by lifting heavy loads or by loads falling from storage equipment. Therefore storage equipment must be set-up in a safe way to ensure that goods cannot fall and injure staff.

Storage equipment, especially pallets, must also be carefully maintained and repaired if damaged (WHO 2007a, 52) to prevent injuries for example from protruding nails or splinters.

A complete and regularly checked first aid kit must be available and must be placed in an easily accessible and very visible place. If dangerous goods are handled emergency washing facilities may be needed.

29.3.2 Fire safety

Fires are a danger in any building but medical storage facilities are particularly in danger. Most health care goods are packed in paper and plastic and repacked in corrugated cardboard boxes while pallets are usually made from timber.

- Cigarette fire.
- Use of open fire (heating, cooking, welding, maintenance).
- Electric faults (lights, electric heaters, cooling equipment, voltage regulators).
- Overheating of electrical equipment.
- Lightning.
- Dangerous goods (flammable and explosive goods).

Table 29.8 Possible causes of fires in medical storage facilities

Any small fire will quickly spread and be very difficult to bring under control. The lack of water and often the lack of a fire brigade will increase the difficulty of controlling any fire.

Apart from the danger of injuring staff, damage to the store and goods, a fire can lead to shortages of a wide variety of health care goods, which can lead to inappropriate treatment of patients.

Measures must be taken to prevent fires from breaking out (see table 29.9), ensuring that staff can safely escape, preventing fires from spreading, early detection of fires as well as fighting fires. Taking out insurance will limit the financial damage. The warehouse manager should be made responsible for fire safety and his duties laid down in her/his job description. All staff members as well as security guards should be aware of the measures, which should be taken in case of a fire.

Smoking must be strictly prohibited in medical storage facilities (WHO 1997a, 52) and smoking areas should be dedicated outside the buildings. Littering must be prohibited, stores should be kept clean and any rubbish must be removed from stores at least once a day.

Packaging materials, such as cardboard boxes and fillers should be stored in a separate room as they are highly flammable.

Electrical wiring and electric equipment must be installed only by a professional electrician and must be carefully maintained. Special care must be taken with the correct and safe installation as well as regular maintenance of any kind of heaters. Kerosene and gas refrigerators must be properly installed if they have to be used.

Highly flammable goods should be stored in a separate building or at least in tightly closing metal cupboards. Any doors inside the medical storage facility must be kept closed at least during the night and weekends in order to reduce the speed at which fires and smoke can spread.

In large medical storage facilities, escape routes must be clearly marked and if necessary, the store must be furnished with additional fire escape doors. Emergency exits must be reachable within a reasonable distance and time from any place inside the store or warehouse. All emergency exits should be marked with signs and fitted with emergency lighting.

Smoke detectors should be installed in every storeroom and connected to a central fire alarm system. Smoke detectors are inexpensive and raise the alarm at a stage of the fire where it can still be brought under control. Smoke detectors and alarms must be connected to bells or horns which will alert security guards during times when the store or warehouse is closed.

Security guards must regularly carry out rounds during the night and on weekends in order to be able to detect fires as early as possible.

A) Preventing fires from breaking out

- Strictly prohibit smoking anywhere in medical storage facilities.
- Dedicate smoking areas outside the warehouse.
- Prohibit littering and keep stores clean.
- Remove any rubbish from medical storage facilities at least daily.
- Separate storage of packaging material.
- Ensure proper installation of electrical wiring and electric equipment.
- Carefully maintain electric equipment.
- Ensure proper installation and regular maintenance of heaters.
- Proper installation and handling of kerosene and gas refrigerators.

B) Preventing fires from spreading

- Store highly flammable goods separately in metal closets and outside the main building.
- Keep all doors inside medical storage facilities closed.

C) Detection of fires

- Install smoke detectors in all storerooms.
- Installation of fire alarm system.
- Ensure that security guards carry out regular rounds during the night and weekends.

D) Measures for fighting fires

- Clearly mark escape routes.
- Provide instructions how to contact the fire brigade.
- Provide appropriate and sufficient fire-fighting equipment.
- Provide equipment for fighting electric fires.
- Regularly inspect fire-fighting equipment.
- Train staff in the proper use of fire-fighting equipment.
- Regularly perform fire drills.

Table 29.9 Measures to prevent fires and limit damages

Instructions for contacting the fire brigade must be displaced prominently in the medical storage facility near the telephone or radio base station. If a fire brigade is available, direct and automatic communications to the dispatcher should be considered.

Appropriate and sufficient fire fighting equipment must be provided, including for fighting electrical fires, and must be inspected regularly.

All staff must be trained in the proper use of fire-fighting equipment and must regularly perform fire drills. Fire extinguishers must be of adequate size and appropriate type to fight fires of solids, liquids or gases. In large stores wall hydrants with hoses and nozzles should be installed which must be fed from a reliable water supply or dedicated water tanks. Carbon dioxide or powder fire extinguishers should be located near refrigeration equipment to extinguish electrical fires.

In large stores, installation of automatic sprinkler systems should be considered. Sprinkler systems must be planned and installed by specialized technicians in order to ensure that they are efficient in fighting fires and do not cause unnecessary damage to the stock. However, sufficient water must be available and possibly a dedicated water tank needs to be installed.

29.3.3 Safety of electrical installations

Faulty electrical wiring, installations or equipment can cause electrocution as well as fire. Several simple measures can be taken to prevent or at least reduce safety risks (see table 29.10).

- Switch off any equipment when not in use.
- Cut the power supply to the store during the night and weekends (provided no refrigerators, fire or burglar alarms are connected).
- Never attach cables directly in electrical sockets, use only properly fitting plugs.
- Inspect equipment and plugs before using electrical equipment.
- Do not connect too many appliances to one electrical socket.
- Do not use any electrical equipment, which is obviously broken (especially broken plugs).
- Switch off electrical equipment when overheating is noticed.
- Keep electrical sockets and appliances dry.
- Prevent spraying electrical installations with water, especially during cleaning.
- Never handle electrical equipment or appliances with wet hands or gloves.
- Never touch light switches with wet hands.
- Do not install electric appliances near water sources (sinks, taps etc.).
- Use extension cords of sufficient dimensions to prevent overheating.
- Check extension cords before use and repair immediately if damaged.
- Place extension cords in a way that they will not be damaged by pallets, tools, forklift trucks or vehicles.
- Ensure that only professional electricians carry out any work on electrical installations or equipment.
- Outdoor lighting must be purpose built equipment and must protect electric circuits from water (rain, snow, dew).
- Use adequate tools and materials for repairs.
- Never bridge fuses in electrical equipment.
- Regularly check and service fuses.
- Regularly inspect all electric appliances.
- Remove old and unused electrical installations and equipment.
- Repair any broken casings of electrical equipment immediately.
- Repair any loose contacts immediately.
- Switch off and disconnect any electrical equipment from the power source when inspecting or repairing.
- Switch off (or remove) fuses before any work on electrical installations.

Table 29.10 Measures to prevent accidents with electricity

Fuses are important safety devices which cut off power when equipment is in danger of overheating or electric circuits are overloaded by connection of too many appliances. Fuses also switch off the power supply in case of short circuits and are therefore an important means of preventing fires.

29.4 Warehouse staff

Effective and efficient operation of stores and warehouses requires qualified and competent staff (see figure 29.1).

A warehouse manager should have the overall responsibility for all staff, facilities and warehouse operations and be assisted by a deputy. S/he is also responsible for all aspects of safety and security.

A pharmacist may have to be employed in order to comply with national pharmaceutical legislation and regulations. The pharmacist is in charge of all aspects of quality assurance and is in charge of inspecting all arriving consignments and health care goods. S/he is also responsible for supervising appropriate storage, handling, packing and shipment of health care goods.

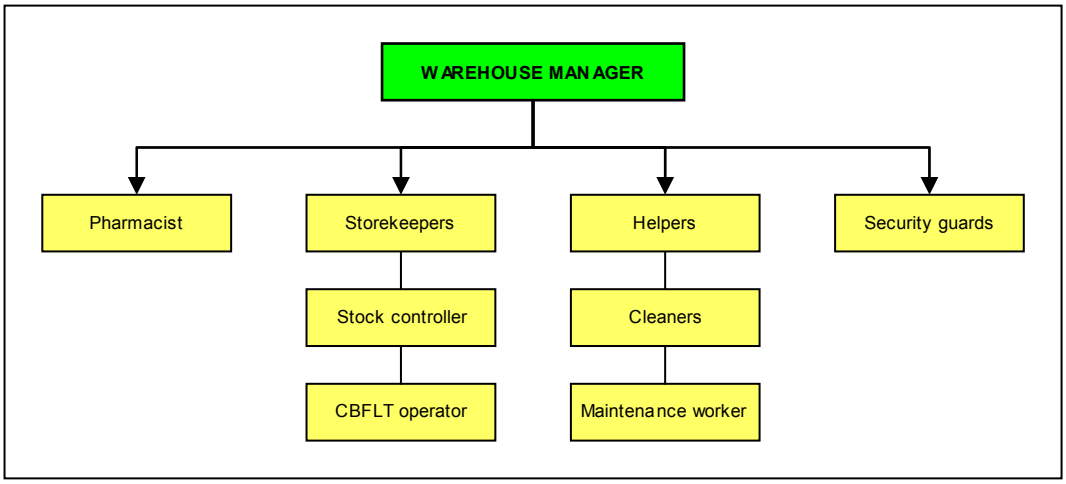

Figure 29.1 Warehouse staff

The stock controller is responsible for maintaining stock records and performs physical stock counts.

The storekeepers are in charge of receipt of health care goods, inspection and put-away as well as order picking, packing and dispatching of consignments. In large stores, different staff members may be dedicated to different functions. Storekeepers may operate materials handling equipment or be assisted by dedicated operators. In large medical storage facilities, (storekeeper) helpers assist storekeepers. Helpers may be in charge of cleaning or be assisted by full time cleaners.

The number of storekeepers that are needed depends on the throughput as well as the materials handling equipment, which is used. The appropriate number can be estimated from the items, which are picked every month. About the same amount of time should be calculated for receipt and put-away of stock. The medical storage facilities should be staffed sufficiently for treating large orders and unexpected emergency orders quickly.

Maintenance staff is in charge of servicing equipment and carrying out minor repairs.

Security guards ensure the security of the medical storage facility and control access as well as exit of people and goods.

Every staff member should receive a formal and signed job description and have clearly defined responsibilities.

A written procedures manual with job descriptions, record management, standard operating procedures as well as health and safety measures should be elaborated.

29.5 Housekeeping and maintenance

Housekeeping is an important means of maintaining cleanliness and order in medical storage facilities. It is also an important means of preventing fires and makes theft more difficult.

Pest control is import for ensuring that health care goods are not contaminated or damaged.

Maintenance of buildings, storage equipment, materials handling equipment and utilities is essential to maintain their function and prevent occupational injuries.

Warehouse and store managers must regularly inspect all stores to detect any litter, dirt, pests, water damage or damage to facilities and equipment.

29.5.1 Cleaning

Responsibilities for cleaning must be explicitly assigned to specific staff members and be formally laid down in a detailed job description. Otherwise, the unpopular job of cleaning will be put off by all staff and eventually be neglected.

However keeping the store tidy, refraining from littering as well as removing any unused packing material is the responsibility of all staff.

All floors should be cleaned from litter and rubbish and swept every day. A more extensive cleaning, including storage equipment and sanitary facilities should be done every week.

A detailed cleaning schedule should be established and followed. Sufficient and adequate cleaning equipment and material as well as a sufficient source of water must be provided.

Dead stock, broken equipment and damaged goods must be removed and disposed off immediately and all rubbish bins must be emptied once a day. Accumulation of unused goods is a waste of storage capacity and a potential fire hazard.

29.5.2 Pest control

Meticulous pest control is necessary to prevent damage of health care goods and facilities. The more advanced pests, are the more difficult they are to control.

Pests such as insects, rodents and other animals (see table 29.11) can cause physical damage to packaging and goods and contaminate health care goods with excrements.

- Insects: weevils, flies, moths, grasshoppers, cockroaches, ants, termites.
- Rodents: mice, rats, bats.
- Other animals: birds, cats.

Table 29.11 Possible pests

Passive pest control measures, which can be carried out by warehouse staff, aim at preventing pests from spreading in the first place.

- Ensure that surrounding walls and fences are intact.
- Keep the area around stores clean and any grass short.
- Bar all openings with fine-meshed grills to prevent entry of insects, birds and rodents.
- Do not keep any food in the store (for distribution or private consumption).
- Meticulously clean all stores at least once a week.
- Treatment of timber pallets for protection against termites.

Table 29.12 Passive pest control measures

Active pest control measures intend to eliminate or at least reduce existing pests and should be carried out be trained staff who use the necessary protective clothing (masks, gloves) and take the necessary precautions.

If insecticides are used they must not contaminate health care goods. Depending on the extent to which pests have infested medical storage facilities, it may be necessary to remove all stock before cleaning and use of insecticides or pesticides.

- Remove nests from premises.
- Spray the area around the store with insecticides.
- Set up and maintain traps for rodents.
- Put down baits and poisons for rodents.
- Regularly spray stores with insecticides or lay out powder.

Table 29.13 Active pest control measures

29.5.3 General maintenance

Preventive maintenance is an importance means of ensuring that equipment and assets are kept in working condition. In addition, any broken equipment or damage to facilities must be immediately repaired. Qualified and competent technicians must carry out any maintenance.

All facilities and equipment should be inspected and checked regularly according to a maintenance plan in order to detect any defects.

A maintenance history should be maintained for every major piece of equipment with a record of any technical problems, servicing and repairs.

Regular maintenance ensures safety and allows detecting faults early when repair is still cheap.

A) Building

- Roof: undamaged, not leaking.
- Gutters: no leakage, no blockage.
- Walls, columns: no cracks, no moisture, paint in good condition.
- Ceiling: not sinking, no traces of water or moisture, clean.
- Floors: smooth, unbroken, no cracks.
- Windows: frames, glass, mosquito mesh, bars or metal gratings.
- Doors: frame, door panel, hinges, locks.

B) Storage equipment

- Pallets: no broken boards, no protruding nails.
- Shelves: shelves not sinking, no splinters, no scratches, paint in good condition.
- Cupboards: tightly closing, locks working.
- Adjustable pallet racking: no structural damage, properly fixed to floor, no rust, paint in good condition.
- Refrigerators, ice-pack freezers: in working condition, clean, no build up of ice, no rust, doors close tightly.

C) Materials handling equipment

- Hand and platform trucks: no damage, wheels oiled.
- Hand pallet trucks: no damage, hydraulic mechanism in working condition, wheels oiled.
- Counterbalanced forklift trucks: regular servicing and checks (like for any vehicle).

D) Utilities

- Electrical wiring and fuses: no damage, no overheating.
- Wall sockets: in working condition, no loose parts.
- Lighting: in working condition, no flickering.
- Ventilators: in working condition, clean, security mesh.
- Heating and cooling: safe electrical connections.
- Sanitary installations (water, sewage): no leakage of water.

Table 29.14 Facilities, which should be included in the maintenance plan

29.5.4 Maintenance of refrigerators and ice-pack freezers

Refrigerators and ice-pack freezers need to be maintained regularly to ensure safe storage of health care goods as well as to extend the lifetime of equipment. Breakdowns of refrigerators and ice-pack freezers can damage health care goods and may lead to stockouts of essential drugs, vaccines or diagnostic tests.

Refrigerators and ice-pack freezers should be regularly checked to ensure that they are positioned level and sufficient distance is kept to walls as well as the ceiling to allow free circulation of air. Electric installations, connections and voltage regulators should be checked regularly as well.

Regular monitoring of the internal temperature allows checking that the thermostat is working.

The outside of refrigerators and ice-pack freezers should be checked for any damage. Where necessary, paint should be replaced to prevent corrosion. The tubing of the condenser, which is usually fitted to the back of refrigerators or ice-pack freezers, should be checked for any corrosion and leaks. Kerosene absorption refrigerators should be checked for any signs of yellow ammonia crystals and any smell of ammonia, which indicates a leak (WHO 1989, 35). The condenser should be cleaned regularly to remove dust and cobwebs.

Only a qualified technician must carry out any service or repairs of the cooling unit since the unit contains chemicals, which are under pressure.

The entire refrigerator should be checked for any signs of rust or corrosion.

The cabin lining of refrigerators and ice-pack freezers should be checked regularly in order to detect any cracks. The door seal must be cleaned regularly and checked for any damage and the door must close tightly. The seal of the door or lid of a refrigerator or ice-pack freezer can be checked by opening the door or lid, placing a paper strip over the seal and closing the door or lid. If the paper strip can easily be pulled, the door or lid requires adjustment. The procedure should be repeated in several places around the door or lid with special attention to the corners (WHO 1988b, 21).

Refrigerators and ice-pack freezers should be regularly cleaned inside as well as outside. The outside of refrigerators should be regularly wiped clean with a damp cloth and the inside of the cabin cleaned with water and a mild detergent. Scouring powder or steel wool may damage the cabin and should never be used.

Dust can be removed from the cooling unit and condenser with a brush but refrigerators and ice-pack freezers should be switched off before.

- Maintain level position.
- Ensure sufficient distance to walls and the ceiling.
- Check electrical installations, connections as well as the voltage regulator.
- Check the function of thermostat by regularly monitoring the temperature.
- Check tubing of condenser for any corrosion or leaks.
- Check entire refrigerator and ice-pack freezer for any signs of corrosion.
- Check lining of the cabin for any cracks.
- Regularly clean the door seal and check for any damage.
- Check that the lid (door) closes tightly.
- Check the lid (door) joints for any damage.
- Regularly clean outside and inside of refrigerators and ice-pack freezers.
- If necessary, defrost refrigerators when the layer of ice on the evaporator exceeds 5 mm.

Table 29.15 Maintenance of refrigerators and ice-pack freezers

The photovoltaic array must be given special attention since shade, dust or dirt will immediately reduce the produced electric power. Photovoltaic arrays must be cleaned regularly, preferably in the early morning or evening. The entire array must be safely accessible. Photovoltaic arrays should be cleaned with water and a clean, soft cloth or sponge starting from the highest point (WHO 1988b, 16). Leaning or stepping on the photovoltaic array must be avoided since this may cause damage or breakage. The photovoltaic arrays must also be checked for any damage.

The installation must also be checked at least three times during sunlight hours for any shadows, which may be cast on the photovoltaic array, especially caused by any objects, which may have been placed in front of the array. Any (growing) trees or other plants, which cast shadows, must be cut back regularly. If new buildings cast shadows, the photovoltaic array may need to be relocated.

The installation must also be checked regularly to ensure that the photovoltaic arrays are still firmly mounted and that cables, wiring and connections have not be damaged and are properly attached.

Batteries must be maintained according to manufacturer recommendations.

All equipment should be registered in an asset register and a maintenance and repair record (see table 29.16) should be kept for every piece of equipment for documenting maintenance as well as repair work.

The surface of evaporators are cooler than the other cabin surfaces and therefore water vapour which enters the cabin when the refrigerator or ice-pack freezers is opened, condenses on the evaporator and covers it with a layer of ice. They higher the humidity of the air in the room where the refrigerator is placed, the quicker ice will build up. Whenever the layer exceeds 5 mm, the refrigerator should be defrosted since the ice acts as an insulator, reduces the efficiency of the refrigerator and increases energy consumption. If refrigerators require frequent defrosting it might be opened too frequently, the door might not be closing tightly or the door seal may be damaged.

If refrigerators with a freezer compartment (which are not recommended) are defrosted, both compartments should be defrosted.

Before defrosting, all health care goods from refrigerators must be moved to another refrigerator or cold boxes lined with conditioned, frozen ice-packs. The refrigerator is then

switched off and the door kept open to allow all ice to melt. The ice should never be chipped, scraped, scratched or plied away with sharp tools (knife, ice pick) as this may damage or even puncture the evaporator or the cabin. After all ice has molten, the water should be mopped up and the cabin should be thoroughly cleaned again. The refrigerator is switched on again and before returning the health care goods to the refrigerator the temperature must be checked to ensure that the required storage temperature has been reached.

- Name of equipment.
- Manufacturer, make, model and year of production.
- Location of equipment.
- Routine maintenance schedule.
- Department (person) responsible for maintenance and repair.
- Date of inspection and maintenance.
- Date and nature of technical fault.
- Person who carried out maintenance or repair.
- Work performed.
- Parts repaired or replaced.
- Date of repair.

Table 29.16 Contents of maintenance and repair records

29.6 Record keeping

Accurate and efficient management of information is an indispensable prerequisite for efficient management of the flow of goods. However, only data and records which are actually used should be maintained, duplication of data in different records should be avoided as far as possible and record keeping should be as simply as possible.

All item descriptions must use nonproprietary rather than proprietary names. Proprietary names may not be commonly known and may change whenever health care goods are purchased from other suppliers. Nonproprietary names are familiar to all warehouse staff as well as medical staff and do not change.

Manual or electronic records can be maintained. Manual stock records are an efficient system for managing stores. Even if electronic records are maintained, manual records should be kept as a backup. Electronic records are not necessarily more efficient, require expensive computers and software, require skilled staff and are prone to power failures, hardware and software failures. Manual records are also more difficult to manipulate unnoticed.

- Stock list.
- Bin card.
- Stock card.
- Goods inward register.
- Copies of incoming packing lists and waybills.
- Goods outward register.
- Copies of outgoing packing lists and waybills.
- Claim reports.

Table 29.17 Records used in medical storage facilities

Records are maintained at the item level (bin and stock cards) as well as for consignments (packing lists). Stock records should allow tracing the flow of every item from its arrival at the store until its distribution.

Stock records are the primary information source for the inventory control system, reporting to donors as well as for accounting purposes. Accurate and systematic stock records are also an import means of detecting any theft.

- Item description of drug products: international nonproprietary name, strength of dosage unit, dosage form.
- Item description of single use medical devices and health care equipment: size, dimensions, weight, material etc.
- Item code.
- Special storage instructions: temperature, internationally controlled drug products, dangerous goods.
- Unit of measurement.
- Batch or serial number, expiry date.
- Manufacturer, supplier, country of manufacture.
- Weight and volume per unit.
- Price.
- Location of item in the store.
- Date of receipt.
- Quantities (receipt, in stock, stock issues).
- Stock losses (expired, unaccounted for).
- Customers (name, address, destination).
- Person responsible for carrying out activity (receipt, order picking, physical stock count etc.).

Table 29.18 Information maintained and provided in stock records

Stock records should be arranged and kept according to the same logic and in the same order as the physical stock.

Unless an imprest system is used, stock records should not give any indication of safety stock, reorder levels or order-up-to levels. They are unlikely to be updated regularly and the figures will quickly become obsolete.

29.6.1 Stock list

It is vital for warehouse staff to know what items are permanently held in stock and what items are held temporarily until further distribution. The stock list contains all items, which are regularly replenished according to the inventory control system.

Establishing a stock list is essential to prevent accumulation of a large number of different health care goods, which are no longer used and eventually expire in the store. Any items, which are not included in the stock list, should be immediately distributed and neither put away nor held in stock.

Items, which are not included in the stock list but nevertheless entered into stock, tend to be forgotten and are likely to expire in stock.

29.6.2 Bin card

A bin card is filled in for every batch of every health care product on arrival and kept in the store together with the respective batch.

A Headers (applies to entire batch)

- Item description.
- Item code.
- Batch number.
- Expiry date.
- Supplier.
- Manufacturer.
- Country of manufacture.
- Order or purchase reference.
- Date of stock entry.

B Entries for each stock transaction (stock entry or issue)

- Date of stock movement (receipt or stock issue).
- Reference document (picking list, packing list number).
- Issued quantity.
- Balance.
- Signature or initials of storekeeper.

Table 29.19 Information which should be contained in bin cards

When the entire batch of the respective bin card has been issued, the bin card should be kept in the archives for future reference.

29.6.3 Stock card

Stock cards are the central and indispensable record of any medical storage facility, provided that no software application is used. One stock card is maintained for every item and every stock movement (entry or issue) is recorded.

Stock cards are kept in the office of the medical storage facility and maintained by a stock controller or a storekeeper. They should be ordered first by group/family and then alphabetically by item description.

Stock cards can be kept as vertical file cards in a card file or as sheets of paper in a file. Keeping stock cards in a loose-leaf binder (rather than a card file) prevents them from being mislaid, misplaced or being replaced in the wrong order.

Printing stock cards from a database ensures that item codes and item descriptions correspond to the standard list and are well readable. Stock cards printed on ordinary sheets of paper can be kept in a ring binder. They require less space and there is no danger of stock cards being confused.

The responsibility for maintaining and updating stock records should be clearly assigned to a staff member who can be held accountable.

A Header (applies to all movements of the respective item)

- Item code.
- Item description.
- Unit of measurement.

B Entries for each stock transaction (stock entry or issue)

- Date (of stock entry or stock issue).
- Packing list number (from suppliers or to customers).
- Origin (supplier) or destination (customer) of consignment.
- Supplier reference (purchase or order reference number).
- Manufacturer.
- Country of manufacture.
- Batch number.
- Expiry date.
- Received or issued quantity.
- Balance (stock on hand).
- Signature or at least initials of storekeeper.

Table 29.20 Information which should be contained in stock cards

Accurately maintaining stock cards enables batch tracing. In case a batch of drug products or other health care goods is recalled for quality concerns, the stock cards allow finding out whether items from this batch have been entered into or issued from stock. It allows identifying all customers who have received this item and need to be informed of the recall.

29.6.4 Shipping documents

All documents of received and dispatched consignments must be kept and filed for future reference.

- (Air) Waybill number.
- Packing list number.
- Type of goods (health care goods, equipment, fuel etc.).
- Date of arrival.
- Means of transportation.
- Truck (and trailer) or aircraft number.
- Number of parcels.
- Weight of consignment.
- Value of consignment.
- Origin.
- Completeness of shipment or claim report.

Table 29.21 Information in goods inward and goods outward registers

A goods inward and a goods outward register should keep records of all received and dispatched consignments in chronological order.

In addition, all received and issued packing lists waybills and supplier invoices should be filed in chronological order.

29.6.5 Accuracy of stock records

All stock records, manual or electronic, should be updated as soon as any stock movements occur but at least at the end of the day. Stock records are the main information source of any inventory control system and mistakes will inevitably lead to stockouts and excess stock, which expires. Accurate stock records are also an important means of detecting theft and other irregularities.

The responsibility for maintaining stock records must be clearly assigned to one person who is held accountable for any discrepancies or errors.

Stock records must be carefully checked against actual physical stock levels during regular physical stock counts and any errors must be reconciled.

Mistakes in bin cards and stock cards should be detected during physical stock counts. The level of accuracy can be quantified by measuring the weighted average inventory variation.

- Large number of data entries.
- Manual entries (rather than uploading).
- Illegible handwriting on documents used for recording.
- Similarity of names.
- Use of drug products with same name in different dosage forms and strengths of dosage unit.
- Accidental double entries by receiving two copies of the same consignment.
- Movement of stock without recording.
- Calculation errors.
- Miscounting during entry inspection or order picking.
- Counting errors due to changes in packaging sizes.
- Theft.

Table 29.22 Factors which contribute to inaccuracies of stock records

29.6.6 Reports

Stock records are the basis for compiling reports which summarize important information, usually at the end of the month. Some reports, such as a list of all stockouts, must be updated every day.

Reports are used for inventory control, reporting to donors as well as monitoring performance of the medical storage facility. In addition, warehouse managers will routinely submit reports on their staff (leave, performance etc.).

- Monthly demand per item.
- Total stock value.
- Stock on hand.
- Stockouts.
- Stock availability.
- Customer service levels.
- Batches of health care goods with short remaining shelf-life.
- Batches of health care goods suspected of expiry before use.
- Lead times (customer and replenishment).
- Arriving consignments (quantity, number of parcels, weight, value).
- Prepared consignments (quantity, number of parcels, weight, value).
- Discrepancies noted during physical stock counts.
- Reports on losses (expiry, theft, damage).
- Quantity and value of unwanted stock.
- Stock awaiting disposal.
- Store utilization.
- Warehouse operation and stock holding costs.
- Reports on accidents and security incidents.

Table 29.23 Information compiled in reports

29.7 Protection of goods

Health care goods in general and drug products in particular, can be adversely affected by chemical, biological, environmental as well as mechanical influences (figure 29.2). When active pharmaceutical ingredients decompose, the efficacy of drug products is reduced, the toxicity and risk of allergies can increase and the remaining shelf-life is reduced (Dörner, G. (ed.) 1992, 33).

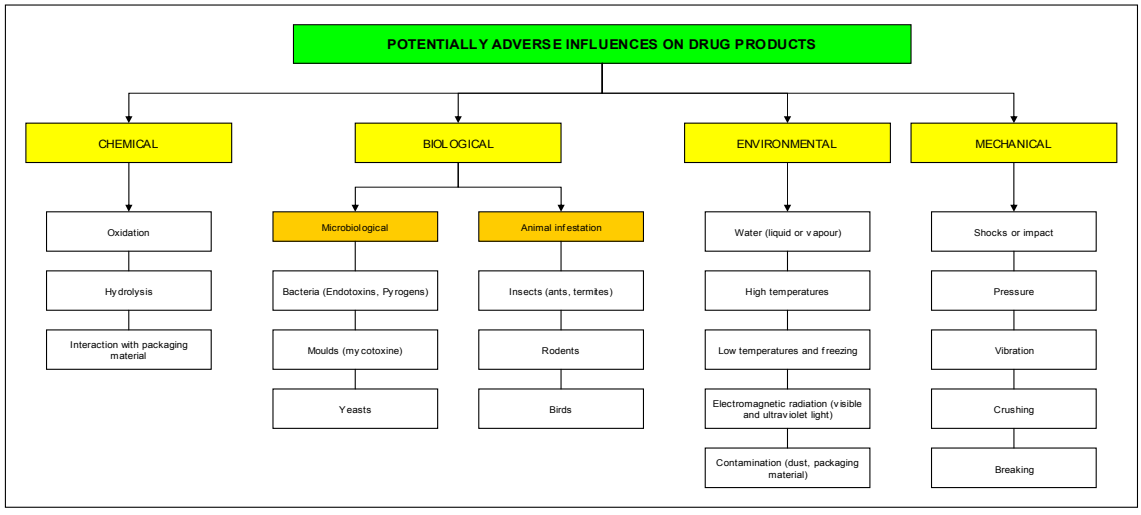

Figure 29.2 Potentially adverse influences on drug products

The deterioration and spoilage of some drug products will be obvious through discoloration or production of gas and odours while in other cases the active pharmaceutical ingredient degrades without any visible signs (Aulton, M.E. 1988, 483). Some health care goods are very

sensitive and can be destroyed by incorrect handling or even by a brief period of inappropriate storage (Dörner, G. (ed.) 1992, 6).

One of the main purposes of medical storage facilities is to prevent deterioration of and damage to health care goods. Health care goods may be susceptible to different influences and require different storage conditions.

Damage of health care goods causes loss of valuable resources, must be justified towards donors and can lead to shortages or stockouts, which in turn can cause inappropriate medical care of patients.

Health care goods may be damaged by a variety of environmental influences. Most health care goods will be susceptible to these damaging environmental influences, at least to some degree. Even if manufacturers do not explicitly state specific storage conditions or harmful influences, all health care goods must be protected from physical damage, dirt and dust, excessive humidity, heat and cold pests and vermin.

29.7.1 Protection from mechanical damage and contamination

Goods are prone to physical damage during handling in medical storage facilities as well as by inappropriate storage.

Packaging and health care goods can be crushed, broken, torn, punctured or cut.

Damage can be caused during handling by dropping parcels, crushing with materials handling equipment or by falling from storage equipment.

Sharp tools such as box cutters may also damage health care goods when packaging is opened for example for inspecting goods upon receipt. Sharp edges as well as nails or splinters protruding from storage equipment may perforate packaging.

Like health care goods packaging can be damaged by impacts, breaking, tearing, vibration and crushing as well as be punctured or cut by sharp objects. Mechanical forces can cause abrasion of labels, which may lead to loss of important information. Damage to pressurized containers such as inhalers will incapacitate the drug delivery system and make them unusable.

Damage to packaging can cause leakage of liquids, spillage of powders, contamination of drug products and removes protection from radiation, oxygen and humidity. Sterility of products will be compromised as soon as packaging is damaged (Cheng, M. 2003, 5) for example by perforation with sharp objects. Paper material, which is used for packaging some sterile materials, only provides a barrier against micro-organisms as long as it remains dry.

Drug products, such as tablets, can be damaged by rough handling such as dropping or by impacts during transportation. Mechanical damage may also be caused by compression and crushing of drug products by heavy loads stacked on them.

Drug products contaminated with bacteria cause infections, especially after parenteral administration and contaminated ophthalmic preparations have caused blindness.

Drug products can be contaminated by packaging material such as plastic or glass particles as well as dust and sand from the environment.

Physical damage can be prevented by careful handling, use of materials handling equipment instead of carrying loads as well as careful storage and securing on storage equipment. The weight of all health care goods stacked on the lowest packaging must not exceed the maximum permissible load. Stacking boxes crosswise spreads the load on the surface and

reduces the load on individual packaging and boxes. Any sharp health care goods such as surgical instruments or protruding parts should be covered and protected if these items are stored together or even stacked upon others.

Careful maintenance of storage equipment, especially timber pallets and shelves, avoid damage by splinters or protruding nails. Any sharp edges from storage equipment or materials handling equipment should be removed.

Packaging should be opened carefully with short blades.

29.7.2 Protection from dust and dirt

All health care goods must be protected from dirt and dust. It should be kept in mind that eventually all health care goods will be used at health care facilities, which have strict hygiene rules, and many health care goods are used in operating theatres.

Especially packaging of sterile materials (for example sterile gloves or syringes) must be kept clean as the dust may contaminate the goods on opening. Dirt (containing moisture) can also soil materials and contaminate sterile packaging, since the contents of sterile packaging only remains sterile if the packaging is kept dry.

Buildings should be designed to minimize dust infiltration and should be kept clean. Windows and doors should be kept closed at all times to prevent dust from entering the store. Walls and floors should have smooth surfaces and be painted or plastered to prevent the surface from crumbling.

Stores must be cleaned regularly. Sweeping may lead to dispersal of dust on the goods. In this case, soap and water should be used for cleaning.

In very dusty and sandy environments all health care goods, even if they are already packed should be kept in closed corrugated cardboard boxes for additional protection.

29.7.3 Protection from high humidity, moisture and water

Health care goods can be damaged by high humidity, which is often prevalent in tropical climates, direct contact with moist floors or walls as well as direct exposure to water from cleaning or leaking roofs, walls and plumbing.

By default drug products should be stored in rooms with a relative humidity below 60% (WHO 2006r, 246) unless the manufacturer indicates more stringent storage conditions.

Liquid water or water vapour can cause hydrolytic reactions, which are one of the major causes of drug degradation (Aulton, M.E. 1988, 242) and may result in the formation of inert or toxic by-products (Aulton, M.E. 1988, 363).

Water like other liquids or vapour, can induce decomposition by chemical reactions, cause physical changes, such as softening or hardening, facilitate growth of bacteria and moulds (Aulton, M.E. 1988, 217) and reduce the remaining shelf-life.

Very sensitive drug products are usually packaged in blister packaging or waterproof containers with desiccants. However, these protective measures are only effective as long as the seals of the packaging have not been opened.

Sterile paper packaging is damaged as soon as the paper is wet and packaged goods can then no longer be considered as sterile. Infectious agents may have crossed the barrier while it was

wet and contaminate the inside of the packaging, even if the packaging later dries. Humidity can also cause corrosion of health care equipment.

Direct exposure to water can be prevented by ensuring proper maintenance of water pipes, plumbing as well as roofs, walls and floors. Goods must never touch walls, floors or ceilings. Care should be taken during cleaning not to sprinkle or spray health care goods with water. Food and drinks could soil goods and must anyway not be consumed in medical storage facilities (except in dedicated resting areas).

Drug products requiring protection from moisture but without any detailed requirements concerning humidity should not be exposed to more than 60% relative humidity and be packaged in moisture-resistant containers by the manufacturer (WHO 2003c, 136). Health care goods sensitive to high humidity are often also sensitive to high temperatures. Any measure to reduce the room temperature will automatically reduce the absolute humidity of the air. In very humid climates, dehumidifiers as well as air-conditioning can be used.

Especially in medical storage facilities with large temperature fluctuations, all health care should be stored in a way to allow free circulation of air and good ventilation to prevent condensation of humidity on packaging.

However, the use of (ceiling) fans has no cooling affect whatsoever on health care goods.

29.7.4 Protection from high temperatures

Heat can cause deterioration of drug products, melt ointments, creams and suppositories and reduce their shelf-life as well as degrade materials such as latex.

Thermal energy generally increases the rate of chemical reactions and a 10° Celsius raise in temperature will increase the rate of decay of ingredients two to five times (Aulton, M.E. 1988, 243). Exposure to high temperatures can cause separation of phases in an emulsion, which leads to inhomogeneous distribution of active pharmaceutical ingredients and administration of incorrect dosages (Aulton, M.E. 1988, 294). Cold chain drug products, such as vaccines, must be stored between + 2° to + 8° C from the time of manufacturing until administration (Dörner, G. (ed.) 1992, 28), will be damaged or destroyed by warming and may be destroyed by freezing.

Temperature fluctuations can also cause the deterioration of drug products or packaging as well as condensation, which in turn can encourage growth of bacteria and moulds (Aulton, M.E. 1988, 217).

Temperatures in storerooms can be reduced by blocking the entry of sunlight with screens and shades in front of windows or closing any window openings, good insulation of walls and roofs as well as ensuring that building surfaces (roof, walls) reflect as much sunlight as possible

Temperatures in stores can be reduced to some degree by passive and active means of ventilation, especially in climates with large day-night fluctuations of temperature. Good ventilation of the store will prevent building up of heat in specially exposed places and "pockets".

Especially outside walls which are directly exposed to sunlight during long periods of the day, radiate heat to the inside of storerooms. Goods should therefore never be stored directly against (outside) walls and be kept at a distance of at least 10 cm.

29.7.5 Protection from low temperatures and freezing

Except for certain vaccines all drug products should be protected from freezing even if the manufacturer does not explicitly note this. Drug products which are marked only with a maximum storage temperature, must not be exposed to temperatures below + 2° C (WHO 2006r, 246).

Freezing can lead to deterioration or damage of drug products and freezing liquids can cause containers to burst.

Accidental freezing is a particular danger when storing health care goods in refrigerators.

Low temperatures and freezing can be prevented by good insulation of buildings, preventing direct contact of any health goods with floors and walls and by heating stores. When stores are heated an even temperature distribution should be ensured by ventilation to avoid cold "pockets".

29.7.6 Protection from light and radiation

Exposure of health care goods especially of drug products, to (sun)light leads to high temperatures, which can cause deterioration and damage. Direct and even diffuse light itself can cause deterioration of light-sensitive drug products. Some drug products can be damaged by ultraviolet radiation contained in sunlight.

Electromagnetic radiation from sunlight, sky light, artificial and in particular, fluorescent tube as well as ultraviolet light can induce chemical reactions, which cause photolysis and photodegradation of drug products (Aulton, M.E. 1988, 254). Light can catalyze oxidation and hydrolysis or the energy is converted to heat, which in turn can cause deterioration.

Health care goods should be protected from direct sunlight by frosted glass or by covering windows with shades or curtains. However ideally medical storage facilities are windowless in the first place.

All health care goods must be kept in their original packaging at all times, as this will also protect them from sunlight.

The manufacturer must package drug products, which are sensitive to light, in light-resistant packaging such as opaque containers or dark glass bottles. Injectable drug products sensitive to light must be packaged in ampoules made of coloured glass but even then, they must be stored in additional packaging which protects them from light.

Some vaccines can be damaged by light from fluorescent tubes.

29.7.7 Protection from air and oxygen

Some drugs can be damaged by oxygen contained in the air. They must be packaged in airtight containers, which must be kept closed throughout their storage and transportation.

Exposure to atmospheric gases can cause oxidation of ingredients and carbon dioxide can lead to a shift of the pH which in turn may adversely affect stability (Aulton, M.E. 1988, 218).

29.7.8 Protection from vermin and pests

Packaging and health care goods themselves can be damaged directly by vermin and pests such as rodents, birds or insects. Health care goods can also be contaminated by animal excrement.

Health care goods should not be stored together with food in the same store or warehouse. Food may attract vermin and pests which can damage health care goods. Food is also prone to infestation, which requires regular fumigation with toxic chemicals, which may deposit on health care goods.

The intrusion of rodents and birds must be prevented by covering any openings with mesh and installing strip doors at loading bays and docks.

Stores and health care goods must be inspected regularly and measures taken immediately against any pests, which are detected.

Any goods damaged by vermin or pests must be destroyed.

29.7.9 Ventilation

Good ventilation of stores and warehouses reduces temperature differences within rooms and prevents hot and cold pockets. Ventilation prevents stagnant air and reduces build up of condensate.

In places where temperatures outside the building are lower in particular during the night, ventilation can reduce the temperature. Ventilation can be enabled by constructive measures such as ventilation vents below the roof. As the sun or hot roofs heat air, it will naturally move upward and lead to circulation of air. However, this passive ventilation is only acceptable if dust is prevented from entering through ventilation openings. If passive ventilation is inadequate, fans should be installed.

Artificial ventilation requires expensive equipment and electricity. However, it may be necessary especially in moist underground stores.

29.8 Storage of health care goods

Different health care goods require specific storage conditions to prevent deterioration, which must be stated by the manufacturer on the individual packaging.

Health care goods must never be stored directly on the floor or touch walls since this may cause damage from humidity and high or low temperatures. All goods should always be stored in a ways that allows free circulation of air around them.

29.8.1 Drug products

In general, drug products must be protected from physical damage, dust and dirt, humidity, high temperatures, freezing, direct sunlight as well as pests and vermin. Some drug products must also be protected from oxygen and natural or artificial light.

The manufacturer must state the required storage conditions on the outer packaging. Since drug products with the same international nonproprietary name, same dosage form and same strength of dosage unit but from different manufacturers may differ in their composition (especially excipients), they may require different storage conditions.

Drug products with are sensitive to oxygen or humidity will be packaged in special airtight containers by the manufacturer. They must not be opened or damaged throughout their storage.

Not maintaining the required storage conditions can cause deterioration of drug products, which can reduce their efficacy, reduce their stated shelf-life and even increase their toxicity.

The reduction in efficacy may lead to underdosing drug products and, in the case of antibiotics, can encourage development of resistant strains. The active pharmaceutical ingredient in creams, ointments and suppositories, which have been exposed to heat and which have melted, will no longer be homogeneously mixed with the excipients.

Such deterioration may or may not lead to a visible change of the drug.

If no specific storage conditions are stated, drug products should be stored in a dry and well ventilated place at a temperature of + 15° to + 25° C or, depending on climatic conditions, up to 30° C (WHO 1997a, 56).

29.8.2 Single use medical devices

Single use medical devices such as sterile gloves, catheters, syringes etc. must be kept in clean and dry conditions.

Packaging of sterile products must not be damaged and not become soiled. The sterility of sterile products can only be guaranteed if the packaging does not become moist or wet. Even if wet packaging is later dried the inside, once contaminated, will remain contaminated.

Health care goods containing latex or rubber such as gloves and catheters must be protected from heat and direct sunlight.

29.8.3 Health care equipment and replacement parts

Health care equipment and replacement parts must be stored in dry and clean conditions and be protected from shocks and vibration. Packaging must ensure protection from damage.

Dropping or impacting with materials handling equipment or other supplies must be prevented as this can cause damage and malfunction.

Health care equipment must be kept in protective wrapping and packaging provided by the manufacturer and kept in closed boxes. Sensitive equipment (for example microscopes) should be stored in solid timber boxes for better protection.

29.8.4 Storage at controlled temperature and controlled humidity

Many health care goods and especially drug products, require storage within a specific temperature range. This may require intermittent or permanent cooling or heating of storerooms.

Temperature range	
Deep freezing	< - 15° C
Refrigeration (cold storage)	+ 2° to + 8° C
Cool storage	+ 8° to + 15° C
Room temperature	+ 15° to + 25° C

Table 29.24 Temperature ranges (The Stationery Office 1999, 19)

Even drug products which do not require storage at controlled temperatures, should be kept below + 25° C. Drug products can usually be stored at temperatures below the required storage temperature without being damaged provided they are not frozen. Drug products

which require refrigeration must never be frozen unless explicitly required by the manufacturer.

Substances with a low boiling point should be stored in a cool place to prevent evaporation, especially if the substances are flammable.

In hot climates, the temperature in storerooms can be reduced by constructive means and air-conditioning. For cold chain goods which require storage between + 2° to + 8° C, ice-lined refrigerators or purpose built cold rooms are needed.

Air-conditioning, which reduces temperatures as well as absolute humidity, can be run continuously or intermittently during the hottest hours of the day. Air-conditioners are often fitted with thermostats, which switch the air-conditioning on or off to maintain a preset room temperature.

Air-conditioners must be fitted with automatic switches which will ensure that they are switched back on automatically when electrical power is restored after a power failure or after switching between the public mains electricity supply and a generator set or vice versa.

- Insulin.
- Ergometrine for injection.
- Vaccines.
- Antitoxins.
- Sera and blood products.
- Diagnostic tests.

Table 29.25 Drug products which usually require refrigeration

If measures for controlling humidity and temperature are taken, the temperature and humidity must be measured and recorded at least twice a day (see figure 29.4). Since the temperature may vary greatly over a night-day cycle, the minimum, maximum as well as the current temperature must be measured and recorded. After every measurement, the device for recording the minimum and maximum temperature respectively must be reset. The humidity can be measured with a hygrometer.

The temperature should be measured in at least two different places of each storeroom which are representative for the overall storage temperature. If stores are not well ventilated or if cooling or heating equipment is unevenly distributed, significant temperature differences can occur within the storeroom. Even if the temperature at the place where it is being recorded is maintained within the required range, the temperature in other places of the store may be too high or too low.

After every measurement, the settings of cooling or heating equipment may need to be adjusted and any adjustment should be recorded.

Electronic devices, which set off an alarm if the temperature falls below or exceeds the preset range, may be used.

ROOM TEMPERATURE CONTROL SHEET

MEDICAL STORE [LOCATION] ROOM MONTH

DAY	MORNING				AFTERNOON				AIR CONDITIONING SETTINGS				SIGNATURE
	TIME	MIN.	MAX.	CURRENT	TIME	MIN.	MAX.	CURRENT	A/C 1	A/C 2	A/C 3	A/C 4	
1													
2													
3													
4													
5													
6													
7													
8													
9													
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Without air conditioning keep temperature below 30° C at all times. With air conditioning keep temperature below 25° C at all times

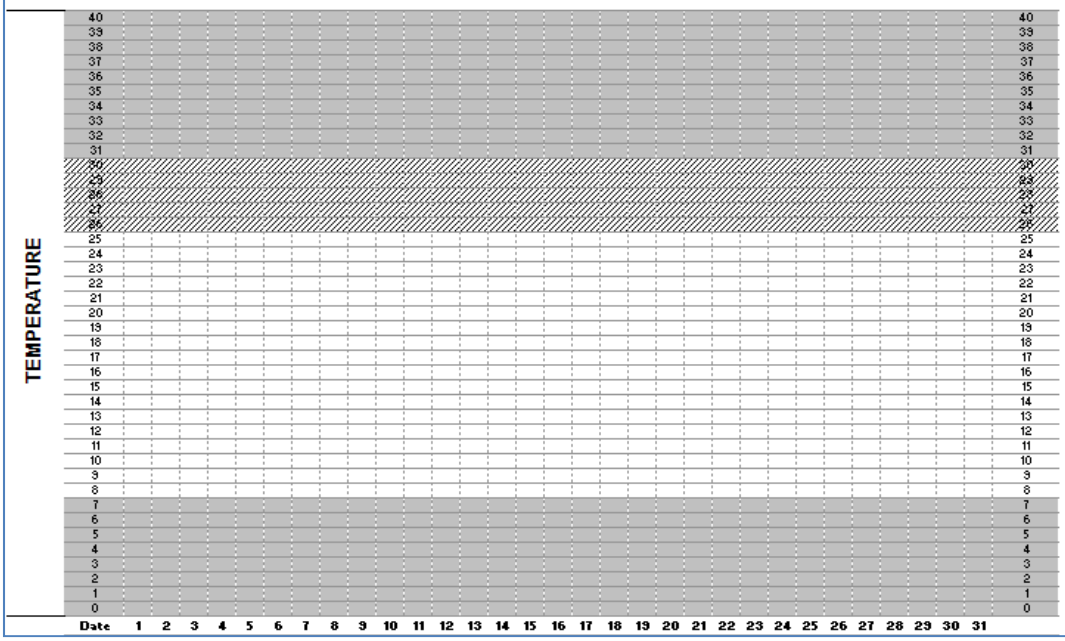

Figure 29.3 Sheet for recording and monitoring room temperatures

Figure 29.4 Minimum-maximum thermometer and temperature control chart

29.8.5 Storage in refrigerators

In order to avoid loss of cold air, refrigerators and ice-pack freezers should be opened as little as possible, only when this is really necessary and only for as long as possible. Vaccines for example can be damaged by short exposure to high temperatures as well as by small amounts of heat over a long period of time. As a rule of thumb, refrigerators should not be opened more than three times a day (WHO 2004a, 24).

Accurate stock records should be maintained which provide information on stock on hand without the need for frequent physical counts. Refrigerators should be labelled with the group of goods, which are stored inside, for example, vaccines, diagnostic tests or drug products and bin cards can be attached to refrigerators to avoid opening for consultation. This will avoid storekeepers opening several refrigerators or to find a specific item. Storekeepers should consider necessary handling of health care goods before opening equipment and carry them out swiftly. Thermometers with external scales allow monitoring internal temperatures without opening refrigerators or ice-pack freezers for taking thermometer readings.

Neither food nor drinking water must be stored in refrigerators or ice-pack freezers, which are used for storing health care goods or ice-packs. Apart from the possibility of contamination, the main problem is that refrigerators and ice-pack freezers will be (frequently) opened for gaining access to the food or water and lead to loss of cold air. Ice-pack freezers or freezer compartments must not be used to produce ice for cooling drinks etc.

Refrigerators and ice-pack freezers must always be closed tightly to avoid leakage and loss of cold air. Goods must not be stored in refrigerators ("stuffed") which prevent easy closure of doors. The gasket must be clear of any packaging material, which could prevent complete closure. A sufficient number of refrigerators must be available to store all cold chain loads without the need for crowding. Separate refrigerators should be dedicated for storage of received goods that are kept in quarantine as well as goods, which have been picked and are awaiting shipment. This will prevent mixing of goods and allow keeping good order.

Where free capacity is available in refrigerators and ice-pack freezers, the thermal mass should be increased by placing water containers (unfrozen water packs, closed bottles, Jerry cans etc.) in refrigerators and ice-packs in freezers or freezer compartments (WHO 2004a, 75). These water containers and ice-packs, which must be permanently left in place will increase the holdover time and decrease temperature fluctuations.

If large amounts of unfrozen ice-packs are placed in freezer compartments of domestic refrigerators, the internal temperature in the refrigerator cabin may increase and lead to damage of health care goods stored in the refrigerator compartment. Even if the internal temperature does not rise above the maximum allowable temperature, the holdover time in case of equipment or power failure will be significantly reduced.

However, domestic refrigerators should not be used for storage of health care goods and a dedicated ice-pack freezer should be available in every medical storage facility. If domestic refrigerators are used, ice-packs should remain permanently in freezer compartments to increase thermal mass. If a dedicated ice-pack freezer is not available, the maximum amount of ice-packs indicated in the operating instructions for freezing at any time should not be exceeded.

If domestic refrigerators are used (which is not recommended) health care goods must never be stored in the inside of refrigerator doors since they will be exposed to ambient temperatures instantly whenever the refrigerator is opened (WHO 2004a, 84). Any inserts and trays for holding eggs, butter and drinks should be removed immediately after setting up a refrigerator. Vegetable compartments in domestic refrigerators should also not be used for storage of health care goods since they usually have much higher temperatures than the rest of the refrigerator (WHO 1998b, 20). Instead, the glass or plastic cover should be removed to allow free circulation of air and the compartment should be filled with bottles or Jerry cans with water to increase thermal mass and increase holdover time.

Health care goods must never touch the floor or the walls of the inside compartment of the refrigerator as goods may freeze as well as to allow free circulation of air. In particular health care goods must never touch the evaporator usually at the back of refrigerators, as the temperatures are likely to drop below 0° C and health care goods can be frozen and damaged. Direct contact with the refrigerator floor or walls must be prevented by placing goods in mesh baskets with rims which must be provided by the manufacturer for top-loading refrigerators.

Health care goods should be stored systematically and orderly in refrigerators according to FEFO. In top-loading refrigerators health care goods can only be held in baskets. But even in front-loading refrigerators, health care goods which cannot be easily stacked should be held in baskets or containers. If no baskets are available, all health care goods should be stacked in columns on the shelves with approximately 15 mm of space all around each column to allow free circulation of air (WHO 1989, 3). About half of the total volume should be left empty for allowing air to freely circulate around the stored health care goods (WHO 2004a, 75).

Ice-packs in freezer compartments or ice-pack freezers must not be stacked too densely. Liquid ice-packs expand slightly during freezing and may become wedged between the walls during freezing. Ice may build up between ice-packs and between ice-packs and walls, which

can make it impossible to remove frozen ice-packs. Moreover, gaps should be kept between ice-packs to allow circulation of air and equilibration of the temperature.

Figure 29.5 Baskets for storing ice-packs in ice-pack freezers

The internal temperature must be monitored with a minimum/maximum thermometer and the reading recorded twice a day on a table attached to every refrigerator and ice-pack freezer (see figure 29.6). Kerosene absorption refrigerators need to be checked more frequently since they do not have thermostats and the temperature must be adjusted manually. The temperature settings of the refrigerator must be adjusted if the measured temperature exceeds or falls below the required range. Ideally, thermometers are mounted externally on the refrigerator cabin and with the sensor placed inside the cabin in order to allow monitoring temperature without the need for opening the door. Alternatively, dial thermometers can be placed inside the cabin. However, in any case a minimum/maximum thermometer must be used in addition. The temperature readings can either be entered into a table or indicated on a chart or both.

A variety of devices has been developed for monitoring the storage of vaccines. They should not replace regular monitoring with thermometers but can be used in addition and are also useful for evaluating the quality of cold chain management. STOP!Watch indicators are permanently placed in refrigerators and irreversibly indicate if the temperature has exceeded + 10° C or fallen below - 3° C. The STOP!Watch indicator can be used as long as the indicators have not changed (WHO 1990a, 28). These monitors can also be kept with larger cold chain loads as they move through the supply network as a monitoring device for the entire cold chain rather than in an individual cold box during a specific leg of transportation.

If any electronic thermometers or recording devices are used, the batteries must be checked regularly.

REFRIGERATOR TEMPERATURE CONTROL SHEET

MEDICAL STORE [LOCATION] REFRIGERATOR MONTH

DAY	MORNING				AFTERNOON				Thermostat setting	SIGNATURE
	TIME	MIN.	MAX.	CURRENT	TIME	MIN.	MAX.	CURRENT		
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
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*Maintain temperature between 2 - 8° C at all times. The ideal temperature is **5° C**.*

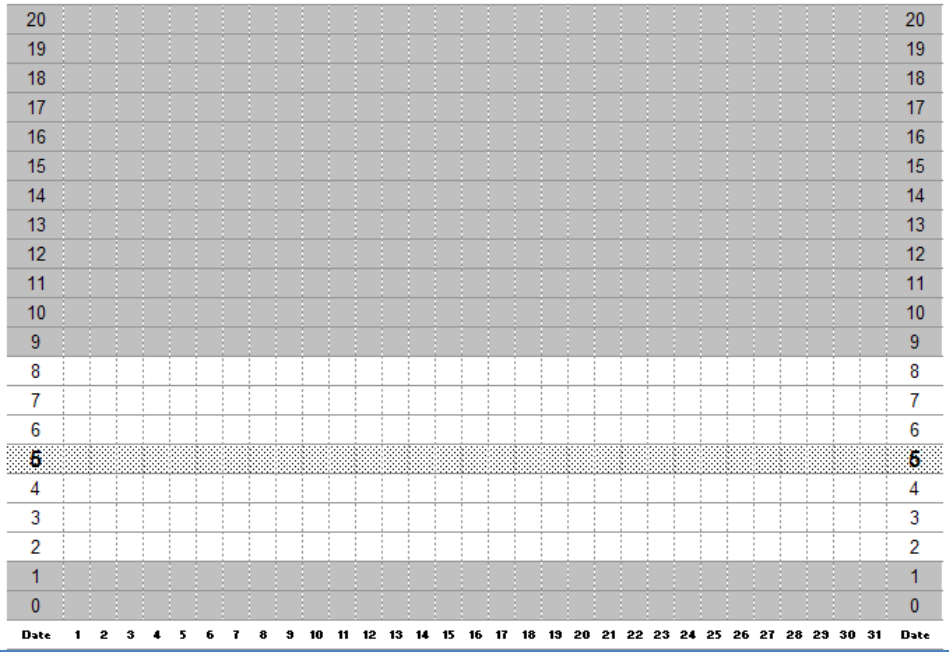

Figure 29.6 Temperature table and chart for refrigerators

Often the power supply will not be entirely reliable. Whenever health care goods are kept in refrigerators, a contingency plan in case of power failure must be elaborated. The value of cold chain loads, especially diagnostic tests and vaccines, is often high and damage can cause significant losses. Refrigerating equipment may fail because of technical faults or because of a power failure. If the electric power supply is known to be unreliable, the use of ice-lined refrigerators is mandatory although they should always be used anyway.

- When installing refrigerators or after switching them on again, allow sufficient time for the internal temperature to drop to the required level before entering any cold chain loads.
- Provide a sufficient number of refrigerators for storage of all cold chain loads without crowding.
- Use dedicated refrigerators for receipt, quarantine and dispatch of health care goods.
- Open refrigerators and ice-pack freezers only when really necessary.
- Open refrigerators and ice-pack freezers only for as long as really necessary.
- Never keep anything else in refrigerators dedicated for health care goods.
- Never store any food or drinking water in refrigerators used for health care goods.
- Liquids must be stored in tight containers to prevent leakage, which can cause corrosion.
- Always close refrigerators and ice-pack freezers tightly.
- Increase thermal mass by placing water containers in refrigerators and ice-packs in ice-pack freezers.
- Only freeze a limited number of ice-packs at a time.
- Use dedicated (fast) ice-pack freezers for freezing large amounts of ice-packs.
- Remove any inserts in refrigerator doors and never store anything in refrigerator doors.
- If domestic refrigerators are used, goods should never be stored in vegetable compartments at the bottom.
- Goods must never touch the side or back of refrigerators, especially not the evaporator.
- Store all goods in baskets.
- If not stored in baskets, at least store goods in vertical columns, which spaces of at least 15 mm on all sides.
- Keep goods in good order inside refrigerators.
- Store goods according to their expiry dates (FEFO).
- Do not crowd ice-pack freezers with ice-packs, as they may be difficult to remove when they are frozen.
- Inside ice-pack freezers, keep ice-packs in baskets.
- Measure internal temperatures twice a day with a minimum/maximum thermometer, record temperatures and adjust thermostat settings if necessary.
- Refrigerators and ice-pack freezers, which are not used for some time should be kept clean and doors should be left open.

Table 29.26 Storage of goods in refrigerators and freezers

If a single piece of equipment fails, goods can be accommodated in another piece of equipment until repairs are completed. In case of a power failure, refrigerators and ice-pack freezers must not be opened. The cold air will fall out and will be partially replaced by air with ambient temperature. The internal temperature may increase above the maximum level and instantly reduce the holdover time to zero. In case of power failure, do not open refrigerators or ice-pack freezers.

The holdover time of every refrigerator or ice-pack freezer must be known. As long as power can be restored within the holdover time, apart from keeping refrigerators and ice-pack freezers closed no further measures are necessary.

Cooling equipment fitted with dual power supply can be switched to the alternate supply, for example using the kerosene burner during failure of the electric power supply. If the public electricity supply fails, the backup generator set should be switched on.

In case power cannot be restored before the end of the holdover time, goods can be moved to another refrigerator, which is working. An alternative is to move goods to cold boxes, which have holdover times of up to 120 hours. In this case, a sufficient number of ice-packs must always be kept frozen.

An alternative may be to move goods to another site with functioning power supply for example the store of another humanitarian organization or a hospital etc.

29.8.6 Operation of kerosene refrigerators

The operation of kerosene refrigerators requires training and experience. Kerosene refrigerators must be operated according to the guidelines and instructions provided by the supplier. Kerosene refrigerators are potentially dangerous and improper use can cause fires and explosions (WHO 1992b, 21).

Refrigerators with dual power source must never be operated on two power sources simultaneously for example kerosene and electricity, since this may lead to overheating and damage of the cooling unit. If dual power refrigerators are operated on electricity or gas, a thermostat automatically controls the temperature.

If kerosene or gas is used for operating refrigerators, a sufficient amount must be stored at the site to allow continuous operation. Only pure kerosene (paraffin) and neither petrol nor diesel or kerosene contaminated with petrol or diesel must be used (WHO 1989, 14). During storage, kerosene must be kept clean and protected from any contamination. The tank should be filled to the indicated level with a funnel and not be overfilled. Any spilled fuel should be immediately removed.

The refrigerator must be maintained in a level position to ensure that the kerosene reaches the wick. If the refrigerator is not level, kerosene may collect in the corner opposite of the burner and the flame will extinguish. The tank should be cleaned regularly with clean kerosene.

The tank should not be allowed to run dry, especially during the night as the refrigerator will stop operating and the wick dries out and burns away. If the wick is dry, its end should be soaked in kerosene for at least two hours before lighting to allow the wick to become saturated with kerosene. Before lighting the wick, the gallery should be removed rather than raising the wick.

Since the burner is situated at the rear of the refrigerator, the flame reflector must be used to observe the flame. The wick is lit and raised or lowered until the flame appears completely blue. When the flame turns yellow it is too low and the wick must be raised. When yellow spikes appear above the flame, it is too high and the wick should be lowered. Otherwise, the wick will be carbonized and the cooling unit may be damaged.

In order to reduce the temperature of the refrigerator as far as possible, the flame should be raised until yellow spikes appear and then slightly lowered again. If the refrigerator is too cold, the wick should be lowered until the flame is almost out and yellow flickers appear on the edges. Then the wick is slightly raised until the flame appears blue (WHO 1989, 17). The flue baffle can also be lifted with a lever ("moon position") to reduce the efficiency of cooling unit if the internal temperature is too low during the night and lowered to the "sun position" during the day (WHO 1989, 4).

The internal temperature of kerosene refrigerators takes several hours to adjust. Whenever goods at ambient temperature are placed in the refrigerator ambient temperatures change, ice-packs are frozen or the refrigerator is opened and closed frequently, the temperature must

be checked frequently and the flame adjusted accordingly. Therefore, refrigerators, which are used for storing health care goods should not be used for (frequently) freezing ice-packs. If ambient temperatures are expected to decrease during the night, the flame must be adjusted accordingly in the evening.

The burner should be cleaned regularly and any carbon, lint or dirt removed with a soft brush. If the wick turner cannot be adjusted readily, the burner needs cleaning or the wick needs to be replaced.

While burning, carbon forms on the top of the wick which needs to be removed every two or three days for the first two weeks of operation. After that the wick needs to be cleaned at least once a month or if the quality of kerosene is poor at least once a week. The wick is cleaned with a special wick cleaner, which is placed on the surface and rotated clockwise to remove carbon, and frayed fabric threads (WHO 1989, 4).

The kerosene tank needs to be cleaned regularly especially if poor quality of kerosene is used. The flue system needs to be cleaned from soot with a special brush at least once a year and more often if poor grade kerosene is used which causes the burner to smoke (WHO 1989, 4).

29.8.7 Operation of photovoltaic refrigerators and ice-pack freezers

In addition to the general principles for operating refrigerators, photovoltaic refrigerators require some special considerations. Because the energy source is available only during the daytime, this limited resource must be used carefully. The storage of any non-health care goods must be strictly prohibited as it will waste energy for cooling as well as cause losses of cold air due to unnecessary opening of the refrigerator. The volume of stored cold chain loads must be strictly limited to the maximum limits specified by the manufacturer. The gaskets must be carefully checked regularly and the refrigerator or ice-pack freezer must be firmly closed to prevent loss of cold air.

Ice-packs must be frozen only in the morning and the number and size of ice-packs, which are frozen, must be strictly limited to the manufacturer's recommendations. Some equipment is fitted with indicator lights showing when ice-packs should not be frozen because of relative high internal temperatures and low currents (WHO 1988b, 12).

Sealed batteries do not require any maintenance and never require "topping up". The level of acid of unsealed batteries needs to be checked every six months. The maximum and minimum level of acid will be indicated on the battery with marks but in any case, the battery plates must be completely covered by and submerged in the acid and must not be exposed.

If the acid level is too low, distilled water, and never acid, must be added accordingly. During adding distilled water any naked lights, possible sources of sparks and heat must be kept well away as explosive gases may escape when the stoppers or lid of the battery are opened. The liquid acid (electrolyte) in the battery is corrosive and contact with the eyes, skin and clothes must be avoided. Distilled water is filled into each cell or compartment with a spout or funnel until the acid level reaches the upper mark. Overflowing of the acid must be avoided (WHO 1988, 20).

Never add acid *to unsealed batteries! Add* ***distilled water only.***

29.8.8 Secure storage

Specific drug products require storage under increased physical as well as procedural security. This may be necessary to protect drug products, which have a higher risk of theft, or to comply with national legislation.

The substances subject to international controls are defined in the respective conventions. However, in addition, national authorities may subject other drug products to special controls and therefore the complete list of drug products subject to national control varies from country to country. Logisticians should therefore obtain a list of drug products subject to special controls and regulations from the relevant authorities, such as national drug regulatory authorities or the Ministry of Health, when stores and warehouses are set up.

Drug products subject to national controls must be at least locked in a steel cupboard, cabinet or safe (preferably fitted with a double lock) to prevent access by unauthorized persons. For small quantities, a small safe can be fitted inside a locked cupboard. Cupboards and safes should be anchored to the floor and wall to prevent their theft. Depending on national legislation, the security situation and the stored quantities, drug products subject to national controls may require storage in a separate room built from reinforced concrete (Ferro-concrete) walls, floors and roofs with steel entrance doors. Ideally, a red warning light or bell will be activated whenever the cupboard or room is opened (Quick, J.D. (ed.) 1997, 350). The keys must be kept locked in a safe and access must be restricted. Staff members who have access to drug products subject to national controls and who are responsible and accountable for the stock should be designated (AHRTAG 1994, 11). The warehouse manager is responsible for regularly checking the integrity of cupboards or storage rooms as well as the locks.

Figure 29.7 Storage of internationally controlled drug products

Manufacturers are required to store drug products subject to national controls in safes or steel cabinets, which must be bolted or cemented against the wall or floor to prevent removal if they weigh less than 340 kilograms. Walls, floors and ceilings of vaults must be made from at least 20 cm thick reinforced concrete and fitted with electronic alarm systems. Steel cabinets as well as vaults must provide protection of at least 10 man-minutes against forced entry, 30 man-minutes against surreptitious entry and 20 person-hours against lock manipulations (United States Pharmacopoeial Convention 1995, 1868).

Staff who handles drug products subject to national controls should be carefully selected. The physical stock should be compared with the stock records after each stock movement and physical stock counts should be carried out frequently. Any discrepancy, which may be caused by a documentation error miscounting mispicking or theft, must be immediately investigated.

Depending on national legislation and regulations, authorities may have the right of unannounced inspections during which they may ensure that drug products subject to national controls are stored securely and that all stock issues have been accounted for through respective documentation. In case of violation of national laws and regulations, authorities may withdraw the permission to store health care goods in the store or warehouse.

29.8.9 Dangerous goods

Various health care goods used in health care facilities, especially in hospitals, are dangerous and require special care during handling and storage.

All dangerous goods should be stored separately from other health care goods in fireproof metal cupboards in a well-ventilated place, ideally in a separate room at the perimeter of the building. Dangerous goods must be protected from exposure to direct sunlight to prevent any increase in temperature and the build-up of explosive fumes. All containers (drums, Jerry cans, bottles etc.) with dangerous goods must be clearly marked with signs indicating the danger they may pose.

Containers with dangerous goods must be intact, closed firmly and should be placed in metal or plastic receptacles which are resistant to the contained goods. Receptacles prevent bottles from toppling as well as accidentally being knocked off the shelf. The receptacles will also prevent liquids or powders from spilling if the packaging should be damaged (leaking, broken etc.).

Large volumes of dangerous liquids, for example fuel, should be stored in separate buildings to prevent any fire from spreading to the main store. The store should be fireproof and well ventilated. The threshold must be high enough to retain all stored liquids. The building should be fitted with an “explosion hatch” in the wall or roof, which will allow the blast wave to disperse and prevent damage to the building (Quick, J.D. (ed.) 1997, 349).

Smoking and use of open fire in their vicinity as well as during handling must be strictly prohibited, as everywhere in medical storage facilities, and appropriate and sufficient fire-fighting equipment must be available near the exits.

The safety instructions of the manufacturer should be followed for handling all dangerous goods. Some handling may require wearing gloves and protective goggles.

During handling of dangerous goods, all containers must be kept tightly closed and damage of containers by dropping or knocking must be prevented. Containers containing dangerous goods should be moved in metal or plastic receptacles, which will prevent liquids or powders from spilling if the primary packaging is damaged.

The packaging of all dangerous goods as well as any packaging must be clearly marked with dangerous goods signs.

Leaking containers should be placed in a receptacle and moved out of the store to a safe place. Especially spilled liquids with a low boiling point can quickly evaporate and could cause a fire or even an explosion. Spilled goods, especially liquids must be immediately removed. Small amounts can be mopped up with a cloth or the spill is covered with sand, which will absorb the liquid and can be removed with a shovel.

Flammable items (for example laboratory items) must be kept in closed metal cupboards to prevent fires from spreading.

29.8.10 Medical gases

Medical gases may be toxic (nitrous oxide) or a fire hazard (oxygen). Gas cylinders weigh up to 100 kilograms and can cause severe injuries during handling. Gas cylinders are under very high pressures, which are very dangerous if the bottle, or valve is damaged and the gas suddenly escapes from the cylinder. Handling and storage of gas cylinders requires considering a number of safety issues (Compressed Gas Association 1999, 16 - 19).

The amount of pressurized gases in stores should be restricted to the necessary minimum. Pressurized medical gases (oxygen, nitrous oxide) bottles must be stored in an upright position and secured to a rack with at least two chains. Goods must never be stacked on gas cylinders and gas cylinders must never be used as a support or for any other purpose than storing and transporting gases. Pressurized medical gases should not be exposed to temperatures greater than specified by the manufacturer or + 45° C. They must not be stored in direct sunlight or near heaters and must be stored away from any flammable materials or sources of ignition (Skeet, M., and D. Fear 1995, 57 f.).

Gas cylinders and especially their base must not be exposed to water to prevent rusting. Additional precautions may be necessary depending upon the category to which the gas belongs (corrosive, toxic, flammable, pyrophoric, oxidant etc.).

Different gases should be stored separately and cylinders containing oxygen and oxidants should be stored at a distance of at least 3 metres from flammable gases or be separated by a fire resistant partition.

All bottles must be furnished with protective caps or cylinder valve guards to prevent damage to the valve, which must not be removed throughout transportation and storage. Valves must not leak and must be regularly maintained. Valves must never be opened without a regulator being connected which will reduce the pressure of the escaping gas, and gas must never be transferred from one cylinder to another. The contents of the gas bottles must be clearly marked and markings must never be removed or covered.

All staff handling medical gases should known the risks and be trained in proper handling as well as measures which should be taken in case of accidents. Equipment for first aid as well as containing the hazard must be available. Safety data sheets should be available and manufacturers should be able to provide any required information. Compliance with national legislation and regulations concerning storage, handling and transportation must be ensured.

Medical gas cylinders owned by the manufacturer and provided according to a contract must be maintained and serviced by the manufacturer while health care facilities will be responsible for maintaining gas cylinders they own.

Gas cylinders must be prevented from toppling and must never be dropped (for example during unloading) even from very small heights or knocked about. Staff should wear stout

gloves and good shoes during handling of gas cylinders. Other materials handling equipment is not suitable as the gas cylinders are not protected from toppling and falling. Large gas cylinders should never be handled by a single person as they are very heavy and should only be moved with cylinder trucks, even over short distances, and should not be carried or rolled.

Gas cylinders must never be lifted by the valve, cap or guard. For heavy gas cylinders, special handles can be attached with straps for handling since the round and slippery cylinders are difficult to grasp and hold.

On arrival at the store, all gas cylinders should be checked for any visible or audible signs of leakage. Cylinders with different gases should be segregated and stored separately according to the danger they pose. Full and empty cylinders should be stored separately and full cylinders should be picked strictly according to FIFO. Gas cylinders, which are kept in the store, should be periodically checked for their general condition as well as for detecting any damage or leakage.

Oxygen is the medical gas used most frequently in hospitals, mainly in anaesthesia and postoperative care. Oxygen does not burn itself but vigorously supports combustion even of materials, which do not normally burn in air. At atmospheric pressure, a content of up to 60% of oxygen in the air is harmless. Higher contents of oxygen are harmful and toxic to people if it is breathed continuously for several hours. Pure oxygen causes coughing after 6 hours and increasing breathlessness after 25 hours.

Oxygen cylinders must be stored away from any combustible materials, especially fuel, and the use of open flames and smoking must be strictly prohibited. The store must be well ventilated to prevent a build-up of oxygen in case of a leak.

On receipt, valves should be checked for any leaks by applying appropriate leak detection solutions. Any bubbles indicate a leak.

Cylinders and especially the valves must be kept clean and free from any oil, grease, solvents or tarry substance since the oxygen will support rapid combustion in case of ignition. Any clothing as well as equipment or tools used for handling must also be free of oil and grease.

Oxygen is slightly denser at ambient temperature and considerable denser when colder than air and will collect on the ground. Oxygen, which escapes from a pressurized container, will cool as it expands.

In case of exposure to oxygen, clothing should be ventilated in the open for a few minutes as clothing may be enriched with oxygen.

In case a leaking valve is detected on an oxygen cylinder, the valve must immediately be closed. Leaking oxygen cylinders should be immediately moved to an open space, away from people and combustible materials. Smoking and use of open fire must be strictly prohibited. Eventually all oxygen will escape from the damaged cylinder and disperse into the atmosphere.

In case of a fire the oxygen cylinders should be moved away from the fire if this is possible without placing staff at risk. Apart from measures to fight the fire, an attempt should be made to cool cylinders if this is possible from a safe distance. Fire fighters must be informed of the presence, number and location of oxygen cylinders since they may explode or turn into rockets.

- Store as little medical gases as necessary.
- Ensure compliance with national legislation and regulations.
- Ensure regular maintenance by the owner (supplier or health care facility).
- Store in a separate place away from other health care goods.
- Store different gases separately.
- Oxygen or oxidizing gases must be stored at least 3 metres away from other flammable gases.
- Flammable gases must be stored away from any combustible materials.
- Gas cylinders, and especially their bases, must not be exposed to water to prevent rusting.
- Goods must never be stacked on top of gas cylinders.
- Gas cylinders must never be used for any other purpose than storing and transporting gases.
- Gas cylinders should not be exposed to temperatures greater than + 45° C.
- All gas cylinders must be clearly labelled with their contents.
- Labels must never be removed or covered.
- Valves must be protected with cylinder caps, which fit cylinders tightly.
- Cylinder caps must not be removed throughout transportation and storage.
- Valves must never be opened without a regulator being attached to the valve.
- Never attempt to transfer gas from one cylinder to another.
- Staff must know the risks and be trained in handling gas cylinders.
- Safety data sheets should be available for all dangerous goods which are handled.
- First aid material and equipment for containing hazards in case of an accident must be available.
- Use of open flames and smoking must be strictly prohibited near gas cylinders.
- Gas cylinders must never be dropped, even from small heights or knocked about.
- Gas cylinders must only be moved with cylinder trucks and not carried or rolled.
- Staff should wear stout gloves and good shoes during handling.
- A single person should never handle large gas cylinders, as they are very heavy.
- Gas cylinders must never be lifted by their valve, cap or guard but rather by lifting the body.
- On arrival at the store, gas cylinders must be checked for visible or audible signs of leakage.

Table 29.27 Handling of medical gas cylinders

29.9 Physical stock counts

A physical stock count (also called stock taking or "inventory") is the process of physically counting the quantities of each batch of all items which are on hand in a medical storage facility. Stock on hand for each batch is then compared with bin cards, stock cards as well as electronic records to detect and reconcile any discrepancies. It is important to compare the physical stock count with all records which are maintained. Comparing, for example, the physical stock count only with bin cards but not with electronic records is not sufficient, as inventory control calculations will still be incorrect.

Physical stock counts must be performed regularly and accurately for several reasons (see table 29.28).

Even if stock levels are calculated by adding stock entries and subtracting stock issues, the stock records must be confirmed by a physical count. Simply calculating stock levels will not consider unnoticed losses through damage, loss, theft, miscounting during receipt and order picking or mispicking of items. However, accurate stock on hand figures are indispensable for inventory control and calculating replenishment orders correctly.

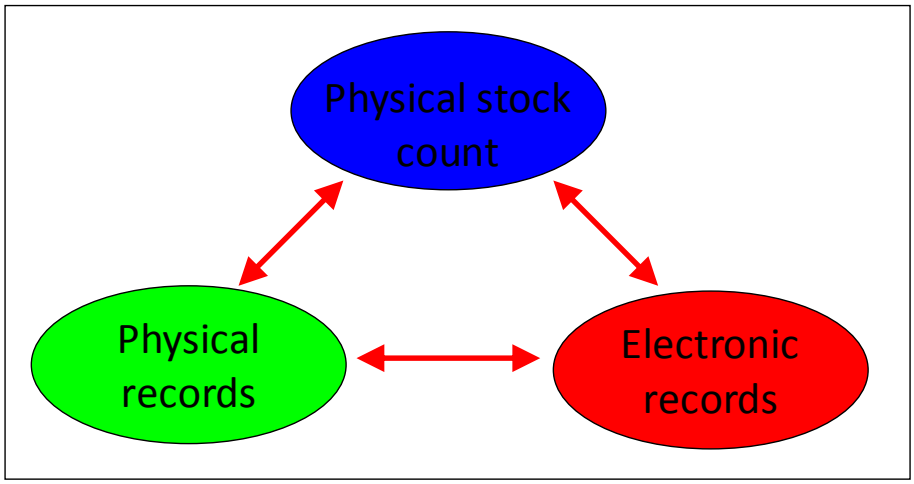

Figure 29.8 Consistency of physical stock counts with stock records

Accurate stock on hand figures as well as accurate stock values may be necessary for insurance purposes.

Regular physical stock counts help to prevent theft, as staff is aware that any discrepancies will be quickly detected. The registration and monitoring allows determining whether security measures are appropriate.

Incidentally, participation of supervisors, which are not carrying out stores operations, is very good practice as it allows to asses compliance with procedures, proper storage conditions as well as the quality of general warehouse management.

- Verification of stock records (especially stock cards).
- Ensuring that accurate stock on hand figures are available for inventory control.
- Preventing fraud and theft
- Ensuring that security measures are appropriate.
- Determining the exact stock value (for insurance purposes).

Table 29.28 Reasons for physical stock counts

Physical stock counts can either be formal, regular, scheduled and planned or informal and unannounced such as in spot checks.

Complete physical stock counts can either be performed periodically, usually once a month, or perpetually as continuous stock counts or residual balance counting.

In periodic stock counts, all warehouse operations cease for one or two days and the entire stock is counted, regardless whether any stock transactions have taken place since the last periodic stock count.

In continuous stock counts also called cycle counting or continuous counting, a certain number of items or batches are counted every day and the entire stock is physically counted over a certain period of time, for example over the period of one month.

In addition, partial stock counts can be carried out as residual balance counting and spot checks.

After order picking and put-away storekeepers must in any case record the remaining balance in the respective bin card which is calculated by subtracting the removed or adding the quantity which was put away. In residual balance counting (Ballard, R.L. 1996, 14) storekeepers actually count the complete batch of an item after each order picking and put-away and compare the result with the stock records. Storekeepers simply note the residual balance of each picked item in the picking list and compare them with the respective stock records after completion of order picking or put-away. There are several variations on this method such as recording and reporting only batches if the stock has dropped to zero during order picking.

The main advantage is that batches are counted only when transactions have taken place and avoid spending time on (periodically) counting batches without any turnover. As the probability of discrepancies increases with each stock transaction it is logical and desirable to increase the counting frequency accordingly. It is far easier to resolve discrepancies between physical stocks and stock records if they are detected immediately. Stock discrepancies which are discovered (only) at the end of the month or after a certain period of time are more difficult to reconcile as in the mean time several other stock transactions may have taken place.

Finally supervisors may carry out spot checks to verify the accuracy of physical stock counts as well as a deterrent to theft.

	Advantages	Disadvantages
Periodic	• Allows carrying out entire stock count efficiently in a short time. • No interruption by stock entries or (urgent) stock issues. • Allows reconciling records without having to consider ongoing warehouse operations.	• Complete interruption of warehouse operations for some days. • Scheduled time may coincide with large deliveries or urgent customer orders. • Discrepancies are detected only after the stock transaction where the mistake was made. • Batches are (repeatedly) counted even if no stock transactions have taken place.
Continuous	• Can be carried out when workload is low. • Does not require suspending all other warehouse operations for one or two days. • Avoids delays of order picking of urgent orders by scheduled stock counts.	• Stock counting may be interrupted by order picking of the respective batch. • Tends to be put off (repeatedly) because of ongoing warehouse operations.
Residual balance	• Immediate detection of any discrepancies. • Stock counts are carried out after each stock transaction. • Frequency of stock counts corresponds to frequency of stock transactions.	• Only batches where transactions have occurred are counted. • Theft or damage of stocks without stock transactions are not detected. • Mistakes may not be detected until a stock transaction occurs.
Spot checks	• Allows checking the accuracy of other stock counting methods.	• Cannot be used as a primary or sole stock counting method. • Covers only a fairly small number of batches over a long period of time. • Must be carried out by staff independent from the warehouse.

Table 29.29 Advantages and disadvantages of different stock counting methods

All stock counting methods have advantages and disadvantages (see table 29.29). However, ideally periodic stock counts by warehouse staff should be combined with residual balance counting and spot checks. In any case storekeepers must at least record and report any batches of which the stock on hand has dropped to zero during the order picking.

The more frequently physical stock counts are carried out, the faster discrepancies can be detected and corrected. Moreover, the less time has passed between the error and its detection, the easier the mistake can be found simply because less stock transactions will have taken place. More frequent physical stock counts allow detecting discrepancies faster and taking corrective action, such as placing or correcting replenishment orders, earlier. Any theft will be detected more likely and faster the more often physical stock counts are carried.

A complete physical stock count must be performed once a month and performed batch by batch (bin card by bin card). Ideally, physical stock counts should be carried out very shortly before calculating replenishment orders in order to be sure that accurate data is used for inventory control and stock replenishment. Of course, counting stock on hand when stock levels are low and just before receiving large deliveries ("low tide") reduce the workload and required time.

In theory, all stock should be counted. In practice, primary packaging is not opened and any sealed manufacturer packaging must not be opened, and does not need to be opened anyway. In practice, even the contents of unsealed secondary supplier packaging cannot be counted. For example, it is not practical to count all compresses or injection needles in each box. If problems with pilfering small amounts from secondary supplier packaging occur the secondary supplier packaging should be sealed after receipt, if necessary after verifying the contents. In practice, the number of secondary manufacturer packaging in master cartons can be verified during entry inspection and do not need to be recounted, provided that the master cartons have not been opened since after the entry inspection.

If any discrepancies between the stock on hand and the stock records are found, they must be investigated, clarified and reconciled. If no mistake is found a report must be issued to account for the missing or excess balance.

A) Recording errors

- Calculation errors.
- Stock movements recorded in the wrong record (bin card or stock card).
- Stock records not updated.
- Stock movements mistakenly not entered into stock records (yet).
- Stock movements mistakenly entered twice.
- Already recorded and later cancelled stock issues or not corrected in the stock records.

B) Warehouse operation errors

- Counting errors during entry inspection or physical stock counts.
- Stock count of one item kept in several places is not consolidated.
- Mispicking (wrong item or wrong quantity) during order picking.
- Stock issue without recording.
- Expired goods, which were disposed of without recording.
- Damaged goods, which were disposed of without recording.
- Theft.

Table 29.30 Reasons for discrepancies between stock on hand and stock records

There are several possible reasons for discrepancies between physical stock counts and stock records (see table 29.28). Generally, the error rate of stock levels should be less than 1% (Waters, D. (ed.) 1999, 229).

Discrepancies can be caused by errors in recording or warehouse operations. Mistakes in stock records can be caused by simple calculation errors. Stock entries or issues may be recorded in the wrong bin card or stock cards. Bin cards may not have been updated immediately after put-away or order picking or stock cards are not updated continuously or at least daily. Stock entries or issue may also be mistakenly entered twice and records of issued and later cancelled stock issues may not have been corrected.

Counting errors may occur during entry inspection after receipt of consignments from suppliers. Stock of one batch or one item kept in different locations (which is not recommended) may not have been added during physical stock counts. The wrong quantity of the right item or the wrong item may have been picked while the quantity was recorded for the ordered item. Stock may have been issued without any recording or may have been taken by customers without the knowledge of warehouse managers or storekeepers. Expired or damaged health care goods may have been disposed of without recording and finally stock may have simply been stolen.

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30 WAREHOUSE AND STORES OPERATIONS

Warehouse operations are not simply a matter of receiving, storing and issuing goods. Rather it is a complex process which requires meticulous care to enable effective and efficient operations while ensuring protection of goods. It is important to keep in mind that putting away goods is simple but that the put-away must be done in a way that each product can be easily and quickly found and retrieved.

A time-table and work calendar should be established for the date of stock taking, preparing large orders (for regular customers), cleaning of the warehouse and regular maintenance work.

Every morning a short meeting should with all warehouse staff and the responsible supervisor to plan the day's work should take place.

A) Receipt

- Preparation.
- Arrival of shipment.
- Unloading.
- Unpacking.
- Inspection (specifications quantity and quality).
- Accepting or rejecting.
- Payment.
- Recording.
- Repacking.

B) Storage

- Put-away.
- Selection of storage equipment.
- Selection of location system.
- Storage.

C) Stock issue

- Order preparation.
- Allocation of stock.
- Order picking.
- Packing.
- Marking and labelling.
- Weighing.
- Load unitization.
- Staging.
- Issuing documents.
- Loading.
- Dispatch.

Table 30.1 Stages of warehouse operations

30.1 Receipt of health care goods

Health care goods may be received from commercial suppliers, upstream distribution centres or from customers (returns, goods for repair etc.).

Regardless of whether consignments are shipped by the supplier by sea, air or land, the majority of them will arrive at medical storage facilities on road vehicles.

The collection of goods indicated on the same packing list is called a consignment while all goods transported by any means of transportation at the same time are called shipments. Shipments may therefore contain only one or several consignments.

30.1.1 Preparation

Receipt of goods is one of the major tasks of stores and any item issued from a store must first be received and put away.

Receipt of goods is time consuming, requires much attention and should therefore be planned in advance. Any supplier should be obliged to send the purchase office an advance shipping notice at least a few days before any scheduled shipment. This requirement should be stated in the purchase contract. The same requirement applies to upstream medical distribution centres in the same country or abroad shipping consignments.

In case goods are imported the clearing agent should also send an advice shipping notice, especially since there can be significant delays between arrival of consignments at (air)ports and their clearance.

Advance shipping notice should be detailed and contain all information (see table 30.2) for making necessary preparations for receipt of consignments. In addition the supplier may attach documents such as packing lists or (air)waybills.

- Supplier.
- Shipper.
- Carrier (s).
- Description of goods.
- Total weight of consignment(s).
- Total volume of consignment(s).
- Number of parcels.
- Type of packaging (bags, cartons, cold boxes, pallets etc.) and whether they must be returned.
- Mode of transportation.
- Number and type of vehicles for final delivery.
- Date of dispatch.
- Routing of shipment.
- (Expected) date of arrival.
- (Expected) time of arrival.

Table 30.2 Information contained in advance shipping notices

The receiving store needs to compare the advance shipping notice with their purchase or replenishment orders to make sure that the right goods are being shipped. If any mistake or discrepancy is noticed the warehouse manager can inform the supplier to withhold a shipment or correct its content.

The warehouse manager needs to plan staff and materials handling equipment for receipt. In small stores receipt and issue of goods may not be possible at the same time and customers need to be informed about possible delays of order picking and packing of customer orders.

The receiver will be liable to demurrage in case departure of vehicles, ships, rail wagons or aircraft or return of containers or trailers is delayed because goods are not unloaded immediately.

Coordination of deliveries from different suppliers is necessary for ensuring that the warehouse is not overwhelmed with deliveries and drivers do not have to wait for unreasonably long times for unloading their consignments.

The purchasing department should provide warehouse managers with copies of all purchase contracts as well as advance shipping notices from suppliers.

The contents of consignments should be carefully studied by logisticians processing and following up customer orders. Available packing lists must be carefully compared with the backorder record. Provisions must be made for any items expected to arrive of which customers are in urgent need or for which they are waiting, to be received first and immediately delivered to customers.

Heavy or bulky health care equipment might better be delivered directly to the customer to avoid timely unloading and loading at the warehouse.

30.1.2 Arrival of shipments

When shipments arrive at the warehouse documentation of the carrier should be reviewed to ensure that the consignment is destined for the respective humanitarian organization and has arrived at the right location and the right storage facility.

Purchase contracts should be crosschecked with delivery notes and packing lists before unloading to make sure that the delivered goods have actually been ordered.

The warehouse managers also needs to check that the shipment is directed to the right storage facility. Consignments may arrive for transhipment which must not be entered into stock. Obviously unloading consignments at the wrong location and even entering them into stock causes a lot of unnecessary handling and work for retrieval.

Before unloading any consignments the warehouse manager must check the documentation presented by the driver to identify whether any of the products are hazardous or require special storage conditions. For example cold chain consignments will require preferential treatment and must be unloaded and put away immediately .

Hazardous products, such as medical gases or flammable goods, need to be unloaded and stored in special stores before unloading the remainder of the consignment. This will reduce the risk of accidents and injury to the staff. When handling large quantities of hazardous products such as fuel, additional safety equipment might have to be made ready before unloading can start.

Another important consideration is identifying urgently needed items which need to be unloaded immediately, inspected and delivered to customers. The parcel numbers containing the respective items should be noted so they can be set aside during unloading rather than having to search for them later.

30.1.3 Unloading

Planning unloading can improve efficiency of warehouse operations and avoid double handling such as unloading consignments and later moving them to another storage facility.

The warehouse managers should inspect the arriving vehicle as well as the way the shipment has been packed in order to determine the most efficient way of unloading. A side-loading vehicle with all goods stored on pallets can be quickly unloaded with a forklift truck. On the other hand a closed truck with goods stacked from the floor to the ceiling can only be unloaded manually. This may require fixing ramps or stairs at the dock.

Heavy and bulky products such as autoclaves, operating lamps etc. may require hoists or cranes for unloading.

Sufficient staff as well as storage equipment must be available. For example if the number of empty pallets is not sufficient, goods will be stored on the floor and later have to be repacked on pallets. Wherever possible, entire pallets should be unloaded using appropriate materials handling equipment.

Figure 30.1 Unloading truck

If consignments are not palletized, the parcels should be stacked onto floor pallets during unloading in order to allow easy transfer to the receipt area.

During unloading the number of parcels must be counted and compared with the shipping documents. The number of missing parcels as well as any visible damage to parcels must be noted on the shipping documents before the warehouse manager confirms receipt.

After completing unloading, the warehouse manager confirms that the number of parcels indicated in the shipping documents has been delivered with his signature. This confirmation is a prerequisite for paying the supplier as well as the carrier. However claims for damage of goods may be submitted later if the inspection reveals that the contents of parcels does not correspond to the packing list or the contents is damaged

The details of every arriving consignment (see table 30.3), or at least each shipment must be registered in the goods inward record.

- Consecutive number.
- Date of arrival.
- Carrier.
- Mode of transportation
- Vehicle registration number.
- Name of driver(s).
- Name of supplier.
- Origin of consignment (location of supplier).
- Order or purchasing reference.
- Number of parcels.
- Total weight.
- Brief description of consignments.
- Indication whether a claim was issued.
- Signature of the storekeeper.

Table 30.3 Contents of goods inward record

In case goods are not unloaded in reasonable time, the receiver will be liable to demurrage. In case of large shipments the "free" time must be specified in the purchasing or transport contract, typically 48 hours. The charge levied usually increases with the length of the delay.

30.2 Acceptance sampling

While the receipt of small quantities of items, such as expensive health care equipment, allows complete inspection of each product, the complete inspection of large quantities of items is usually not practical or feasible. Instead a sample of each batch which is expected to be representative for the entire quantity will be selected and inspected. According to clearly defined rules the results of the inspection of the sample will determine whether the entire quantity is accepted or rejected.

Since there are no objective and universal criteria for acceptance in general, some basic definitions are essential for discussing the topic.

A standard can be defined as a ". . . prescribed set of conditions and requirements, of general or broad application, established by authority or agreement, to be satisfied by a material, product, process, procedure, convention, test method; and/or the physical, functional, performance, or conformance characteristic thereof" (Mitra, A. 1998, 7).

A specification is a set of conditions and requirements defined by the respective customer which provides a detailed descriptions of the required material, product or service and which includes specification limits ("tolerances") which are acceptable bounds on individual quality characteristics (Mitra, A. 1998, 7). Specifications, which may refer to standards such as ISO, DIN or pharmacopoeial standards, need to be precisely stated and documented by the customer.

Although the term quality may imply or be associated with "good quality" or "high quality", the required quality (or level of quality) which products or services must meet only need to satisfy (or exceed) customer requirements.

Therefore, the quality of products is neither good nor bad but is compliant with customer requirements or not. Different customers may define specifications differently and therefore

expect different levels of quality. The same customer may request different specifications of a product for different purposes, such as non-sterile and sterile compresses which are otherwise identical.

Quality is conformance to requirements (Crosby, Ph.B. 1979, 38-39).

Quality characteristics are the elements which together determine the quality of a product (Mitra, A. 1998, 6). Quality characteristics, such as the weight of a tablet or the size of a compress, which can be objectively measured with instruments such as scales, tape measures or by counting and can be objectively expressed as the value on a numerical scale are called variables (Mitra, A. 1998, 6). Other characteristics such as the printing of the batch number on the product packaging (or not) or the inclusion of an operating manual with health care equipment are called attributes.

A nonconformity is defined as a quality characteristic that does not meet the requirements defined in the specifications (Mitra, A. 1998, 6) and nonconformities may differ in severity and be, for example, minor or critical. A nonconforming unit has at least one nonconformity and the number of nonconforming units, for example in percent, is a measure of nonconformity.

The producer bears the risk of (unnecessarily) disposing of the conforming units of a batch which was rejected following inspection. Increasing the stringency of inspection increases the probability of rejecting conforming units but at the same time decreases the probability of accepting nonconforming units. As it is difficult or may not be economic to manufacture products without any nonconforming units, producers determine the acceptable quality level (AQL) or maximum proportion of nonconforming units they are willing to accept in a batch. For some critical products the manufacturer may not accept any risk and consequently carefully test and inspect every unit.

On the other hand the consumer bears the risk of acquiring or using a nonconforming unit contained in a batch which passed inspection by the manufacturer (unnoticed). Customers therefore define the limiting quality level which is the proportion of nonconforming units in a batch they are willing to accept.

While producers want to balance manufacturing and inspection costs as well as reducing or minimizing the producer's risk, consumers need to balance price and the consumer risk they are willing to accept.

30.2.1 Reasons for sampling

Ideally a complete inspection of each unit ("screening") of each item in a consignment would be undertaken by the receiving medical distribution centre, at least after delivery from a commercial supplier. However the required time, cost and other resources would be prohibitive (in most cases). Moreover, some inspections will require opening packaging which may render the products (such as all sterile products) unusable or reduce their shelf life, for example by removing seals which protect drug products from humidity.

Instead only a certain number of units are selected as a sample for inspection throughout the manufacturing process, upon receipt of health care goods from commercial suppliers, upon receipt from an upstream medical distribution centre as well as upon receipt at assisted health care facilities. In addition samples may be drawn from a batch of health care goods which has already been accepted in order to verify any quality complaints from downstream medical distribution centres or assisted health care facilities. Moreover batches may be

sampled if storage conditions were (temporarily) inappropriate and damage of health care goods is suspected or feared.

Samples may also be drawn by customs authorities and national drug regulatory authorities as part of the importation procedures.

The main advantage of sampling is the significant reduction of time required for inspection which in turn makes health care goods available sooner for put-away or distribution. Moreover costs as well as need for other resources such as qualified staff, workplaces and equipment required for inspection are reduced. The cost of complete inspection of all consignments is usually prohibitive and makes it impractical.

Complete inspections of all units is a highly repetitive and tiring occupation. The decreased concentration and attention will lead to inspection errors and acceptance of nonconforming units (Mitra, A. 1998, 422).

In cases where inspection requires opening containers and possibly damaging or destroying products, sampling reduces the financial losses. The opening of packaging of drug products which are highly sensitive to humidity will not destroy them but reduce the shelf life stated by the manufacturer. Inspection may also require removing tablets from blister packaging which makes them unusable. The inspection of the quality of peel pouches of sterile medical devices may require opening them and therefore makes the product unusable.

The rejection of entire batches even if only a small number of nonconforming units are found is an incentive for manufacturers to constantly improve the quality of their products (Mitra, A. 1998, 422).

- Greatly reduces inspection time and makes health care goods available faster.
- Limits cost and other resources for inspection (compared to complete inspection).
- Inspection is a highly repetitive task, quickly leading to fatigue and errors.
- Limits the cost of damages caused by destructive testing.
- The rejection or acceptance of entire batches is an incentive for improving manufacturing quality.

Table 30.4 Advantages for sampling

Despite the advantages, sampling also has several disadvantages (see table 30.5). The selection of appropriate sampling plans as well as conducting sampling requires planning and documentation.

The main disadvantage of sampling is the risk of accepting batches although they contain nonconforming units. No sampling method or plan can provide certainty that all units are conforming. Instead inspectors will have to contend themselves to determining a probability of detecting nonconforming units.

"Inspection is important, but quality cannot be inspected into a product or service"

(Mitra, A. 1998, 15)

On the other hand, sampling may lead to the rejection of batches which contain mainly conforming units. Moreover, despite using the same sampling method and sampling plan, of two identical batches one may be accepted while the other is rejected (Mitra, A. 1998, 422).

In principle sampling makes use only of part of the information on the batch and makes judgments on the entire batch based (only) on inferences from the inspection of samples.

- Selection of sampling plans and conducting sampling requires planning and documentation.
- Risk of accepting batches containing nonconforming units.
- No sampling method provides certainty that all units are conforming.
- Risk of rejecting batches of mainly conforming units.
- Possibility of accepting one and rejecting the other batches although they are of identical quality.
- Judgments on entire population of items are based (only) on inferences from samples.
- Sampling makes use only of part of the information about a batch.

Table 30.5 Disadvantages of sampling

30.2.2 Sampling concepts

Sampling is the operation of selecting a defined number of units from the batch of a health care product for inspection. The sampling procedure should be clearly defined and documented in writing.

The population (N) is the entire quantity of any product received at a medical distribution centre. For the purpose of sampling the total quantity of the manufactured batch has no relevance and does not need to be known.

A population parameter is a characteristics of the population such as their weight or marking with batch numbers.

Usually the individual product such as a tablet, syringe or suture is of interest but for some parameters (packaging information, indication of country of manufacture) observations will concern the smallest packaging unit.

A sample is a collection of sampling units which are selected from the population according to clearly defined sampling procedure. The sample must be selected in a way that it is representative of the population from which it is drawn as closely as possible (Mitra, A. 1998, 190).

Random sampling (probability sampling) requires selection of sampling units by a random mechanism in order to ensure that each unit of the population has the equal probability of being selected. Randomness of selection can be ensured by using random-number tables.

The sample size (n) is the number of selected sampling units. The sample size cannot be larger than the population but is usually far smaller. The sampling fraction is the proportion between the sample size and the population.

The quality characteristics of interest in the sample are usually determined by direct observation taken by an observer or by a measuring instrument.

A sample statistic (estimator) is a number that describes a characteristic of the sample (Sanders, D.H. 1995, 5). For example the percentage of vials in a sample which are broken or the average weight of rolls of cotton. Sample statistics usually vary between different samples taken from the same population (at the same time). Sample statistics and their standard deviations, which are known after inspection are used to estimated and make inferences on the corresponding population parameters which are not known.

Repeated sampling and calculation of sample statistics allows determining the sampling distribution which is the probability distribution of the respective statistic. The sample statistics are grouped into classes of equal width before counting the number of observations

or frequency in every class. Table 30.6 shows the weight of samples of compresses with a stated weight as well as a population mean of 10 grams and the frequency distribution of 20 samples.

Weight	Frequency	Percentage
7.5 < w ≤ 8.5	1	5%
8.5 < w ≤ 9.5	5	25%
9.5 < w ≤ 10.5	8	40%
10.5 < w ≤ 11.5	5	25%
11.5 < w ≤ 12.5	1	5%
	20	100%

Table 30.6 Example of a sampling distribution

The table above can also be represented in a frequency distribution diagram (figure 30.2) which resembles a normal distribution.

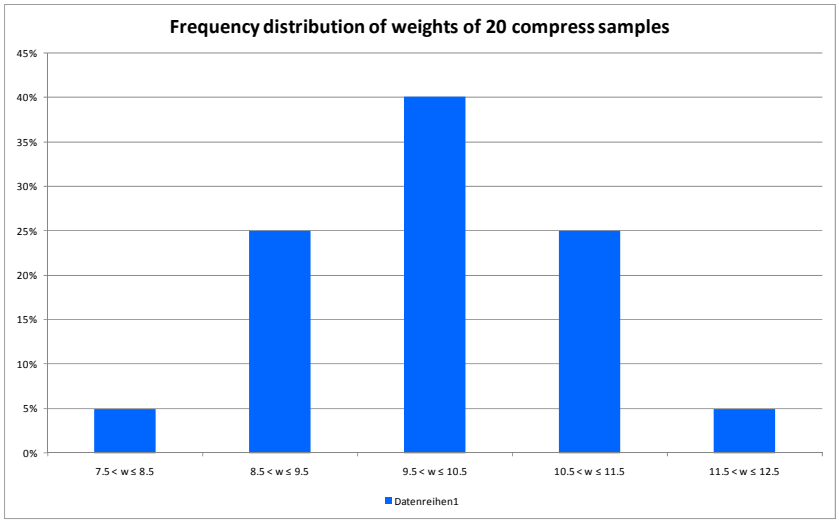

Figure 30.2 Example of a sampling distribution

Sampling plans are instructions on the number and sequence of drawing sampling units from the population for inspection.

In single sampling plans a defined number of random samples is selected from the population once for inspection. Single sampling plans are the simplest but, on average, require inspecting a larger number of sampling units, for the same probability of accepting batches with a certain proportion of nonconforming units.

In double sampling plans the result of the inspection of the first sample determines whether the batch is accepted, rejected or a second sample is drawn. If a second sample is drawn the decision on acceptance and rejection is based on the statistics of both samples. The concept of repeated sampling is extending in multiple sampling plans where several samples may be drawn before deciding whether to accept or reject the batch.

The sampling error is the difference between the sampling statistics and the true population parameter (Sanders, D.H. 1995, 235). Different samples will usually yield different sampling errors. In the example above the sampling units with a weight of 9 grams would have a sampling error of 10% as the true mean is 10 g.

30.2.3 Variable sampling plans

Determining the (minimum) sample size requires defining the probability (level of confidence) that the true population mean lies within a defined interval, expressed as multiple of standard deviations, above or below the value stated in the quality specifications (tolerable error bound). In this case only the consumer's risk is considered as all units of a product must comply with stated specifications and buyers can return any nonconforming unit.

In the example above the sampling plan could require a 95% probability that the true population mean lies between 9.5 and 10.5 grams. In other words, if a sample is taken 20 times, the true population mean will lie within the tolerable error bound 19 times.

Since the population standard deviation is not known, calculation of sampling sizes have to be based on the standard deviation of the sample. Based on the selected z-value (number of standard deviations above the mean which corresponds to the required level of confidence), the standard deviation of the quality characteristics of the sample and the tolerable error bound, the required sampling size can be calculated according to equation 30.1. The level of significance (α) is defined as 1 - level of confidence and the population parameter is assumed to be normally distributed.

$$n = \frac{z_{\alpha/2}^2 \, \sigma^2}{B^2} \qquad \text{Eq. 30.1}$$

Where n = sample size, $z^2_{(\alpha/2)}$ = z-value, σ = standard deviation of quality characteristics of sample, B = tolerable error bound (in the same unit of measurement as the quality characteristics).

The inspector will observe (measure) the quality characteristics of (at least) n random samples. If the mean lies within the tolerable error bound, the batch is accepted. If the mean lies outside the tolerable error bound, the probability that the true mean lies within the tolerable error bound is less than the specified level of confidence and the batch is therefore rejected.

Generally larger sample sizes allow higher levels of confidence and vice versa. However the relationship is not linear but rather the level of significance is inversely related to the square root of the sample size. Therefore, halving the level of significance requires quadrupling the sample size. Increasing sample sizes therefore decreases the difference between sample and the population mean but the larger the sample sizes the smaller the decrease of this difference becomes.

Note that the sampling error depends only on the sample size and neither on the population size or the sampling fraction.

30.2.4 Attribute sampling plans

Acceptance sampling plans for attributes concern quality characteristics which are either conforming or not conforming ("binomial"). Again we are exclusively interested in the consumer's risk. The risk of a single nonconforming unit in a large batch being drawn in the first sample and the entire batch being returned lies entirely with the supplier who would be obliged to replace the batch (or check the entire batch for any other nonconforming units).

A random sample size (n) is drawn from the population (N). If the number of observed nonconforming units is equal or less to the acceptance number, the whole batch is accepted

and if the number of observed nonconforming units exceeds the acceptance number the entire batch is rejected.

The probability of drawing a certain number of nonconforming units (k) is given by the equation 30.2. The probability of drawing a certain number of nonconforming units or less is calculated by adding the probabilities for 0 up to k nonconforming units.

$$P_k = \frac{\binom{p}{c}\binom{N-p}{n-c}}{\binom{N}{n}} \qquad \text{Eq. 30.2}$$

The probabilities are described by the hypergeometric distribution which takes into consideration that the drawn units are not returned to the population before drawing the next sample. If the population size is larger than approximately 20 times the sample size, the binomial distribution is a good approximation of the hypergeometric distribution. The binomial distribution gives the probabilities for drawing nonconforming units but with returning the drawn samples before drawing the next sample.

Unlike the sampling plans for variables, the number of nonconforming units in a sample does not allow to infer the proportion of nonconforming units in the population. Although this may seem counterintuitive, there is no correlation between the number of nonconforming units in a sample and the proportion of nonconforming units in the population and the number of nonconforming units in the sample has no predictive value for the proportion of nonconforming units in the (remaining) population (Mitra, A. 1998, 503). However, if the acceptance number is zero, estimating the proportion of nonconforming units in the population is irrelevant.

For example if the first sample drawn happens to be nonconforming, it may be the only one in the population and does not indicate a high proportion of nonconforming units. Likewise if the first ten drawn units are nonconforming, all the remaining units in the population may be conforming.

Consequently it is not possible to calculate the sample size which is required to ensure a defined probability that the number of nonconforming units is below a certain required proportion.

All that can be shown is the relation between the proportion of nonconforming units in the population and the probability of drawing less than the acceptance number of nonconforming units despite the number of nonconforming units in the population exceeding the acceptance number.

Operating characteristic (OC) curves show the relation between the probability of accepting the sample (that is the probability of not drawing any nonconforming unit) versus the proportion of nonconforming units in the population.

Assuming that the quality characteristics is part of the specifications, the acceptance number (c) is zero. This means that the entire batch is rejected even if a single bottle of infusion solution without a batch number or expiry date printed on it is found in the batch.

Figure 30.3 gives an example of a population of 1,000 units. The proportion of nonconforming units is plotted on the x-axis. The graphs show the probability of not drawing one of the nonconforming units when taking a sample of between 10 to 100 units. For example if from a population of 1,000 units containing 10 nonconforming units a sample of 20 units is drawn the probability of not drawing any nonconforming unit is 82%. In other words in 82 out of 100 times, no nonconforming unit would be drawn and the batch would be accepted despite containing 10 nonconforming units.

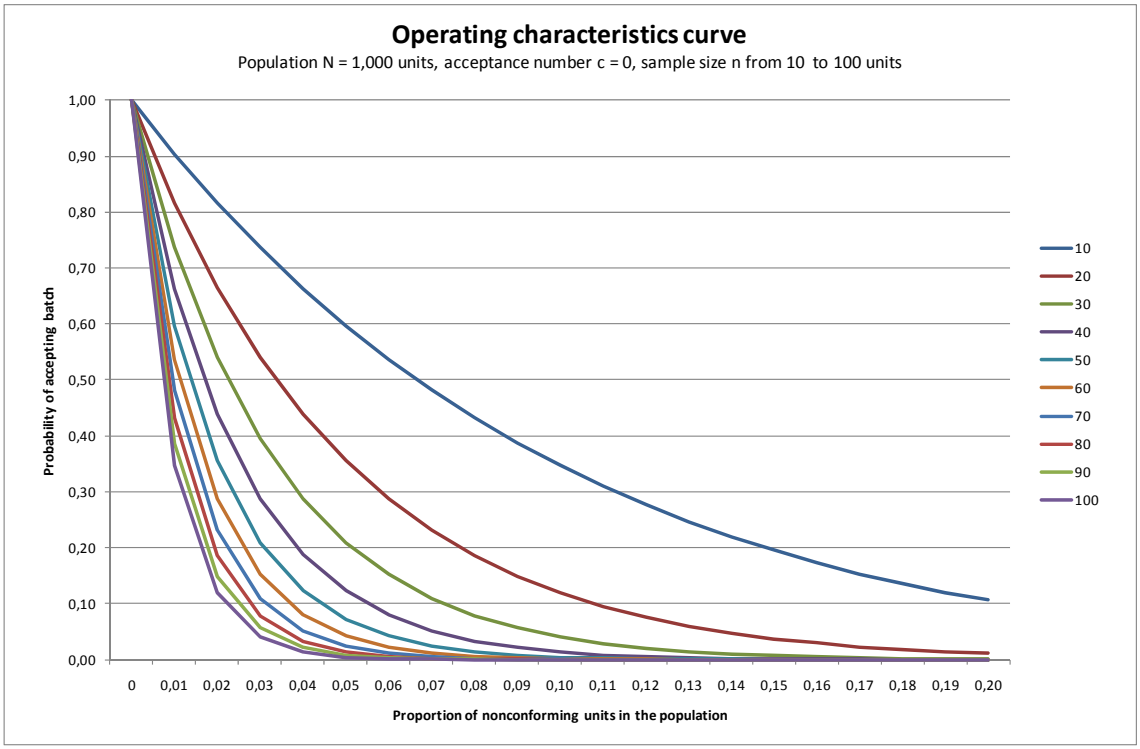

Figure 30.3 Example of an operating characteristics curve

The smaller the proportion of nonconforming units the greater the probability of not drawing a nonconforming unit and therefore accepting the batch despite the nonconforming units it contains. The probability of accepting batches also decreases as the sample size increases. The figure shows that the probability of accepting batches with nonconforming units is particularly high if the proportion of nonconforming units in the batch is very small and a very large sample size is needed to have reasonable confidence that the batch does not contain any nonconforming units.

In the case of quality characteristics which are included in the specifications the acceptance number is zero and no nonconforming units are accepted. For critical quality characteristics unreasonable large sample size would be needed to ensure a high probability of conformance of the sample. Therefore the quality assurance system must focus on purchasing health care products from suppliers with trustworthy process control and quality assurance systems rather than on sophisticated, extensive and expensive quality control upon receipt of consignments.

30.2.5 Criteria for selecting sampling plans

The selection of sampling plans first of all depends on whether the quality characteristic is a variable or an attribute.

For variable sampling plans the required level of confidence will depend on the criticality of the quality characteristic. For example a smaller than specified volume of a disinfectant solution is a purely commercial problem, provided that the concentration remains within the specified range. Generally speaking, sampling and testing critical quality characteristics, such as the strength of drug products, will require sophisticated laboratories.

Where quality characteristics of individual units, for example the weight of a roll of cotton, is not critical, an alternative to variable sampling plans is simple to determine the total weight of

several units. As long as the average of a larger number of units lies within the specifications, the weight of the individual roll of cotton, for example, is of less importance.

The inspection of attributes must consider whether the quality characteristic is part of the specifications, may change because of a variation in the manufacturing process or be caused by damage to the product after production.

For quality characteristics which are part of the product specifications, in principle determining the conformity or nonconformity of a single unit would be sufficient. For example if the batch number or expiry date is printed on individual blister packagings or individual syringes, it is fair to assume that the manufacturer generally complies with this specification. On the other hand, if no expiry date is found on any sample, it is fair to assume that the manufacturer is not printing expiry dates on products. At least homogeneity of batches is fair to assume. The only (unlikely) exception would be a (temporary) fault in the printing or embossing equipment.

Physical damage to products after manufacturing could be caused, for example, by breakage of ampoules, tearing of packaging of sterile medical devices or overexposed vaccine vial monitors. In these cases it is unlikely that damaged units will be randomly distributed in the batch. Instead, depending on their location in a consignment, units are more or less likely to have been damaged. In most cases transport packaging will indicate damage to goods and prompt inspection. If damaged units are found, further samples will need to be drawn to determine how extensively the consignment has been damaged.

30.3 Inspection

Before health care goods are put away, their specifications quantity, and quality must be inspected (see table 30.7). This is necessary to ensure that the delivered goods correspond exactly to replenishment or purchase orders and to advise the purchase department that commercial suppliers can be paid. In case of sampling, inspection measures the degree of conformance of the sample to a defined standard (Mitra, A. 1998, 15).

30.3.1 General inspection

Before and during inspection all goods must be kept in a designated area of the storage facility to prevent mixing and confusing with other goods.

If large consignments have to be inspected a commercial company may be hired for carrying out inspection, issuing a report and a certificate. Routine inspection should be carried out by qualified, skilled and competent warehouse staff. Consignments received directly from a commercial supplier should be inspected by a qualified pharmacist.

Ideally all consignments are inspected immediately. In case a large number of small consignments or very large consignments arrive, inspection may not be possible the same day. In this case the consignments must be held in a designated area and must not be mixed with the stock, picked goods or consignments ready for shipment.

Inspection of received health care goods is an essential element of the quality assurance system. It does not add any value to accepted products but adds value for the end-user by detecting and eliminating poor quality or damaged products.

Even if goods are received from an upstream medical distribution centre of the same humanitarian organization which has already carried out a detailed inspection, a simple inspection must be carried out to ensure that the right goods are received, the received

quantities correspond to the accompanying documents and goods were not damaged during loading or transportation.

A) Documents

- Packing list.
- Invoice (commercial suppliers).
- Certificates of analysis (drug products).
- Import certificates or import authorization.
- Product documentation and information (health care equipment).
- Warranty documents (for health care equipment).

B) Transport packaging

- Packaging of good quality.
- Appropriate cold boxes for cold chain loads.
- Appropriate packaging of hazardous goods.
- All parcels sealed.
- Parcels labelled.
- Parcels labelled with transportation and storage instructions.
- Maximum weight of parcels less than 25 kg.
- Damage to parcels.

C) Specifications

- Conformity with ordered or purchased health care goods.
- Nonproprietary name, dosage form, strength of dosage unit (drug products).
- Type of product, size, material (for single use medical devices).

D) Quantity

- Number of parcels.
- Quantity, weight, volume, surface area of each product.

E) Commercial terms

- On time delivery.
- Price (commercial suppliers).

Table 30.7 General inspection of received consignments

Inspection of health care goods should be performed according to a standardized checklist. The inspection should be carried out in a dedicated area near the receipt area. A large table is needed for opening master cartons and a working area for inspection and recording.

Every consignment must be accompanied by a detailed packing list indicating all delivered products, the product specifications, quantities, prices etc. Commercial suppliers must also provide a detailed invoice.

In case of partial shipments the packing list will not comprise all ordered items or the full quantity of items.

Other requested documents such as certificates of analysis for drug products, import certificates or import authorizations for internationally controlled drug products, or product documentation for health care equipment must be checked for accurateness and completeness.

Stretch-wrap pallets need to be unwrapped and each master carton needs to be opened one by one. However primary and secondary supplier packaging must not be opened unless it is visibly damaged or appears to have been tampered with.

Transport packaging must be of good quality, appropriate for the packed health care goods and all parcels must be sealed with tape, by strapping or by stretch wrapping.

Cold chain loads must be transported in appropriate and properly prepared cold boxes and furnished with cold chain monitors. Hazardous goods must be transported and delivered in appropriate packaging.

Each parcel must be labelled with the consignee, destination, order reference number, packing list number as well as the number of the parcel according to the packing list

Where applicable, each parcel must be marked with transportation and storage instructions.

Except for health care equipment, the maximum weight of any parcel must not exceed 25 kilograms.

All parcels must be carefully inspected for any visible damage such as crushing, breakage, punctures, tears, soiling, dampening or wetting.

Received products are checked against packing lists from suppliers for their conformity with the specifications indicated in purchase contracts or replenishment orders. For drug products not only the nonproprietary name, but also the dosage form and strength of dosage unit must be compared. For single use medical devices various details such as size or material which are part of the specifications, must be checked.

Master cartons containing different products are opened to identify the products one by one and compare them against shipment documents.

After identification of each product, the delivered quantities of each item must be determined by counting, by weighing or measuring (length and surface). Any short-shipping must be documented for follow-up with the supplier and carrier.

If secondary manufacturer packaging is sealed and seals are intact, the contents does not need to be counted. If manufacturer packaging is not sealed spot checks of randomly selected samples may be carried out as it may not be practical or feasible to open each packaging, for example of syringes or catheters, and count its contents.

However if a sample is found not to comply with the quality requirements all other items of the same as well as other products of the same supplier may be inspected.

Each consignment, or where necessary item, should be checked for compliance with the requested delivery date.

For deliveries directly from commercial suppliers, the prices indicated in the supplier documentation must be compared with the purchase contract.

30.3.2 Inspection for quality

Distribution centres receiving consignments from upstream distribution centres of the same humanitarian organization will carry out only a simple inspection to detect damages or short-shipping. However in case of long transportation times or long intermediate storage (for example at customs) careful attention must be paid to possible transport damages as well as deterioration due to improper intermediate storage.

At medical storage facilities receiving health care goods directly from commercial suppliers, a quality assurance pharmacist should carry out a complete and detailed inspection of all arriving consignments. Inspection and quality control is time consuming especially when many samples have to be assessed. However the inspection and quality control should be completed in reasonable time to make the goods available for put-away, picking and packing as well as not to unnecessarily delay payment of the supplier. Nevertheless the accuracy of the quality control procedure should not be compromised. Rather additional capacity of staff should be made available especially if the workload increases or is irregular.

During visual inspection, attributes and variables can be inspected. An attribute is either present or not such as a tamper evident seal, a label or the expiry date printed on packaging. A variable is a property of an item which needs to be measured such as the length, thickness or weight.

Depending on the quantities of items in a batch, sampling plans specify the number of samples which need to be drawn from consignments randomly for inspection. The number of selected items must be balanced against the resources necessary for this inspection.

Whenever a seal is broken in the course of the inspection, the respective product must be marked with a label signed by the quality assurance pharmacist to indicate to downstream distribution centres, pharmacies and end-users that no undue tampering has taken place.

The delivered health care goods are inspected against the specifications provided to commercial suppliers as well as against samples provided by suppliers with their bids.

A) Secondary manufacturer packaging

- Tamper-evident sealing (aluminium, plastic).
- Container lids replaceable (where applicable).
- Tamper-evident seals undamaged.
- Any visible damage (torn, punctured, squashed, soiled, wet etc.).

Labelling and marking

- Labels well attached to container.
- Nonproprietary name (of active pharmaceutical ingredient(s)).
- Proprietary name.
- Dosage form.
- Strength of dosage unit (quantity or concentration of active pharmaceutical ingredient).
- Pharmacopoeial standard.
- Route of administration.
- Batch number.
- Manufacturing date.
- Expiry date (in clear language, not coded).
- Name of manufacturer.
- Address of manufacturer.
- Country of manufacturing.
- Quantity of secondary manufacturer packaging.
- Required storage conditions.
- Warnings for dangerous goods (if applicable).
- "Not to be sold without a prescription" statement (if applicable).
- "Keep out of the reach of children" indicated.

B) Primary manufacturer packaging

- Opaque primary packaging for light sensitive drug products.
- Sturdy, unbreakable, watertight containers (for liquids).
- Dangerous goods packaged in appropriate containers with tightly closing lids.
- Any visible damage (torn, punctured, squashed, soiled, wet etc.).
- Any signs of leakage of liquids.
- Ampoules one-ended (not double-ended).
- Ampoules auto-breakable (or sufficient files are included).
- Protective seal on vials and infusions.
- Rubber stopper of vials undamaged.

Labelling and marking

- Well attached to primary packaging.
- Nonproprietary name.
- Proprietary name.
- Batch number (printed or embossed).
- Expiry date (printed or embossed, in clear language not coded).
- Unique identifiers (if requested).

C) Product information

- Language of labels and package insert in requested language.
- Package insert in every secondary manufacturer packaging.
- Directions for use.
- Instructions for reconstitution (if applicable).
- Shelf-life after reconstitution (if applicable).
- Indications.
- Contra-indications.
- Precautions.
- Possible side effects.
- Interactions with other drug products or substances (alcohol).

D) Drug products

- Two thirds of total shelf-life upon manufacturing remaining.

Solid dosage forms

- Homogenous (uniform) size, shape and colour of tablets and capsules.
- No spots or discoloration.
- Identical markings (scoring, lettering, numbering), where applicable.
- Breakable (if applicable).
- Coated (if applicable).
- Absence of defects (scratches, dents, cracks, breaks, chips, uneven edges, holes) on the surface.
- Absence of open or empty capsules.
- Absence of powder or broken pieces.
- Absence of adherent foreign matter.
- Absence of visible inhomogenities in powders.

Liquid dosage forms

- Liquids clear and homogenous.
- Absence of visible particles.
- Absence of visible inhomogenities.

Table 30.8 Quality inspection of drug products

Drug products, primary packaging, secondary packaging as well as the product information need to be inspected visually (see table 30.8).

Analytical laboratory testing is not an option for routine inspections for several reasons. It requires sophisticated laboratories with highly skilled staff which are often not available in less developed countries. Analytical laboratory tests are expensive and require holding all stock in quarantine until the test results are available.

However analytical laboratory tests may be appropriate in special case for example if there are doubts on the quality of the cold chain for a large amount of vaccines.

Single use medical devices can be inspected visually and in some cases simple measurements of length, surface area and weight may be appropriate.

A) Secondary manufacturer packaging

- Any visible damage (torn, punctured, squashed, soiled, wet etc.).

Labelling and marking

- Labels well attached to container.
- Name of single use medical device.
- Proprietary name.
- Specifications (dimensions, size, length, diameter, weight, volume etc.).
- Pharmacopoeial standard (where applicable).
- Material (where applicable).
- Clear indication whether single use or reusable medical device.
- Clear indication if medical device has been sterilized.
- Indication whether the item is x-ray detectable.
- Batch number.
- Manufacturing date (sterile medical devices).
- Expiry date (sterile medical devices, in clear language, not coded).
- Name of manufacturer.
- Address of manufacturer.
- Country of manufacturing.
- Quantity of secondary manufacturer packaging.
- Required storage conditions.
- Warnings for dangerous goods (if applicable).
- "Not to be sold without a prescription" statement (if applicable).

B) Primary manufacturer packaging

- Any visible damage (torn, punctured, squashed, soiled, wet etc.).
- Tears, cuts, punctures, soiling or wetting of sterile packaging.
- Blister packaging unopened.

Labelling and marking

- Well attached to or clearly printed on primary packaging.
- Name of single use medical device.
- Proprietary name.
- Specifications (size, length, diameter etc.).
- Material (where applicable).
- Clear indication whether single use or reusable medical device.
- Indication that medical device has been sterilized (where applicable).

- Sterilization indicator (where applicable).
- Indication whether the item is x-ray detectable.
- Batch number (printed or embossed, where applicable).
- Expiry date (printed or embossed, in clear language, not coded, where applicable).

C) Product information

- Language of labels and package insert in requested language.
- Directions for use (where applicable).
- Indications (where applicable).
- Contra-indications (where applicable).
- Precautions (where applicable).
- Possible side effects (where applicable).

D) Shelf life

- At least two thirds of total shelf-life remaining.

Table 30.9 Quality inspection of single use medical devices

Testing of health care equipment may require specific knowledge which might not be available at medical storage facilities. Moreover, opening of packaging of health care equipment may lead to the loss of the supplier warranty. In these cases, a complete inspection will be carried out after delivery to the respective health care facility.

An inspection report should be filled for each inspected batch or piece of health care equipment and filed for future reference. One copy of the inspection report is maintained in the medical storage facility and a further copy is sent to the purchase department.

Any short-shipping or poor quality must be indicated in the inspection report and at the same time a claim report must be issued to the carrier, supplier or insurance company.

A) Transport packaging

- Sturdy packaging appropriate for (international) transport.
- Original supplier packaging not opened.
- Any visible damage.

<u>Labelling and marking</u>

- Labels well attached to container.
- Name of health care equipment.
- Proprietary name.
- Specifications.
- Indication of industrial norms and standards (where applicable).
- Indication of registration, technical certification etc. (where applicable).
- Serial number.
- Manufacturing date.
- Name of manufacturer.
- Address of manufacturer.
- Country of manufacturing.
- Quantity.
- Required storage conditions.
- Warnings for dangerous goods (if applicable).

B) Product information

- Language of labels and package insert in requested language.
- Installation manual.
- Operating instructions.
- Service and repair manual.
- Replacement parts catalogue.

C) Health care equipment

- Information on required environmental conditions (temperature, humidity).
- Information on possible hazards and precautions during use.
- Information on voltage, current and frequency (where applicable).

Table 30.10 Quality inspection of health care equipment

30.3.3 Acceptance and rejection

Almost all of the criteria mentioned above are attributes rather than variables. It is unlikely that the attributes will differ among products of the same batch. For example it is unlikely that some ampoules are marked with their expiry date and others of the same batch are not. Therefore inspected health care goods either fulfil or fail to fulfil a specific requirement. Unlike variables, for attributes no tolerances are acceptable. For example it would not acceptable for 5% of items not to be marked with their expiry date.

In some cases, for example the weight of a roll of cotton or the length of a bandage, certain variances may be acceptable. In case of variances of certain specifications, the average must still be at least equal to the specifications indicated by the manufacturer.

Some discretion may be possible concerning damage of health care goods. They may be accepted if the damage is limited to secondary manufacture packaging or the quantities of damaged products is very small, for example a few broken ampoules in a master carton.

Minor damages to packaging which do not warrant a claim should nevertheless be recorded and discussed with the supplier and carrier since such damages are an indication that packaging or loading needs to be improved to prevent future damages.

If there are doubts on the quality and clarification from suppliers or manufacturers have to be sought, for example if the temperatures during transport have slightly exceeded recommended temperatures, the respective health care goods should be held in quarantine. They must be clearly marked and kept under lock to prevent accidental order picking and distribution to customers.

Any product which does not pass the quality control is rejected and returned to the supplier which can be a commercial company or an upstream medical distribution centre of the humanitarian organization.

In cases of high transportation costs for returning goods or consignments, the supplier should be contacted to agree on their return. For example in case of international transport, transportation costs may exceed the value of health care goods.

The products, quantity, supplier, delivery date, carrier and reasons for rejection must be carefully documented, suppliers or carriers must be notified in writing and a claim must be issued.

Likewise the supplier must be notified in writing and a detailed claim (see table 30.11) must be issued in case of short-shipping.

Every claim must be registered and copies sent to the carrier or supplier respectively. The purchase department needs to be notified to withhold any payment until the claim is settled.

- Arrival date.
- Carrier.
- Supplier.
- Person who carried out inspection.
- (Air)waybill and packing list reference.
- Description of health care goods.
- Quantity of rejected products.
- Detailed reasons for rejection.
- Value of rejected products.
- Indication whether physical replacement is required.

Table 30.11 Contents of claim reports

Suppliers or carriers must be notified in writing within the period of time specified in the purchase contract. If claims are not submitted on time suppliers or carriers may decline any liability.

A complaint should also be launched with suppliers if ordered health care goods are delivered after their due delivery date, if the respective order has not yet been cancelled altogether.

After the inspection has been completed, the accepted products are released from the receipt area and prepared for put-away.

The warehouse manager or quality assurance pharmacist must confirm completeness of consignments as well as passing inspection with their signature and inform the purchasing department. The purchasing department will either pay the supplier or notify them of any claim.

Depending on the type of claim, suppliers may be given the opportunity to replace the rejected products, for example in case of damage due to poor packaging or insufficient remaining shelf-life. Otherwise the rejection may lead to the cancellation of the purchase contract.

Suppliers must be paid within the period specified in the purchase contract. Timely and reliable payment of suppliers is important for maintaining their interests. In order to remain credible, humanitarian organizations must not only enforce the contractual obligations of suppliers but also fulfil their own contractual obligations accurately and reliably.

After the inspection is completed, a bin card is issued for every received batch and the respective products may also be entered into the electronic information system. In addition the stock card needs to be updated.

30.3.4 Acknowledgment of receipt

All receipts of consignments need to be acknowledged to the sender and confirmed in writing. The signature on waybills confirms the receipt of the number of parcels indicated in

the shipping documents but does not waive the right to submit claims after inspection has been completed. Any missing parcels or obvious damage by crushing or parcels which obviously are or were wet must be documented immediately.

An electronic message with the details of consignments (see table 30.12) should also be sent to the upstream medical distribution centre for confirming arrival.

After completing the inspection of consignments, the respective packing lists are signed and copies returned to the sender. If necessary, claims indicating missing items or missing quantities as well as any quality complaints need to be added.

- Place of receipt.
- Date and time of arrival and receipt.
- Name of person acknowledging receipt.
- Shipping document reference (packing list, (air)waybill etc.).
- Confirmation of completeness or indication of claims.

Table 30.12 Contents of acknowledgment of receipt

Acknowledging receipt of consignments is import for the shipper to know that the shipment has arrived safely and whether any parcels have been lost or damaged. This may be a precondition for paying the carrier.

30.4 Put-away

"Put-away is the physical process of taking goods received and placing them within the warehouse in the locations where they are to be stored" (Lambert, R.S., and J.R. Stock 1993, 276).

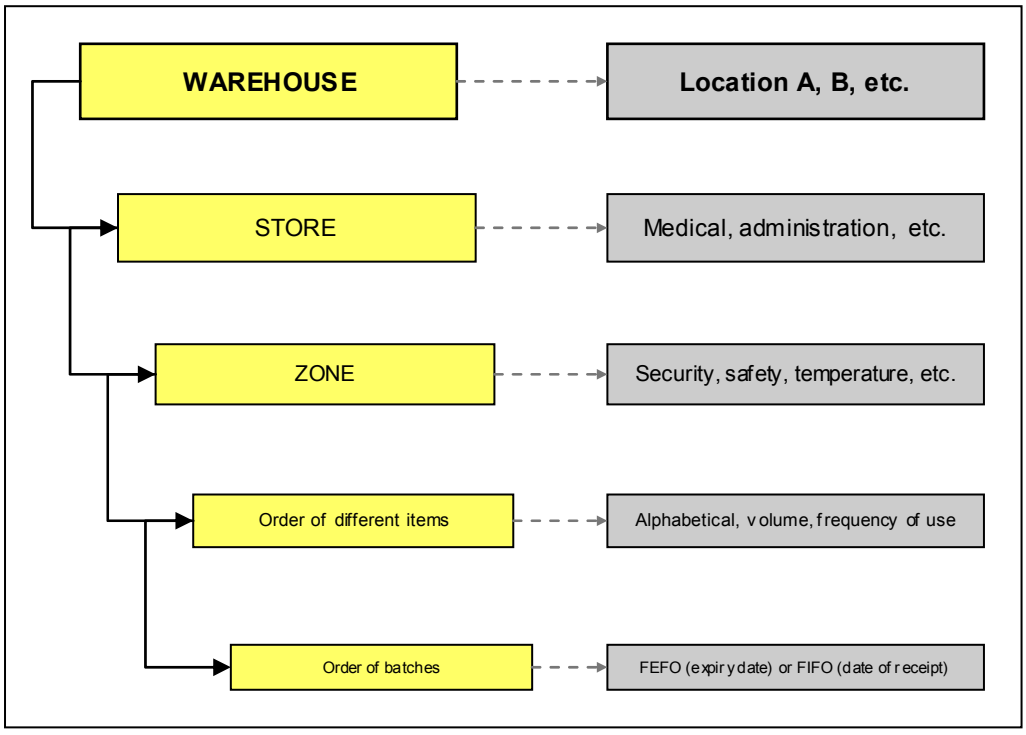

Figure 30.4 Different levels of placing stock

Various health care goods will require some kind of repackaging for different reasons.

Any packaging which was damaged during transportation needs to be replaced and health care goods need to be repacked, usually in corrugated cardboard boxes.

If several different lines items are packed in one parcel, all items and each of their different batches need to be separated and placed in individual containers with a bin card. The weight of small containers should be limited to around 10 kilograms to facilitate handling. Especially drug products packaged in glass ampoules are very heavy.

Every batch of small quantities of a health care goods should be placed in small containers for consolidation and be furnished with a bin card. Health care goods delivered in original manufacturer packaging usually do not need repackaging. In order to avoid the need for recounting its contents during every physical stock count, any open manufacturer packaging can be sealed. However if the entire quantity of a product is delivered in supplier packaging one of the parcels may be opened and placed in a small container for facilitating identification and order picking.

Each small container is then furnished with the respective bin card before put-away. Labelling small containers with the item description of health care goods should be avoided as the small containers will hold different health care goods at different times.

Small containers and other small quantities of parcels are moved to the respective storage place with hand trucks or platform trucks while pallets are moved with hand pallet trucks or forklift trucks.

Figure 30.5 Crosswise stacking of boxes on pallets

Large quantities of the same product which were not delivered on pallets may require palletizing before put-away. In principle only a single batch of a product should be stored on any pallet and different products or different batches of the same product should not be mixed on the same pallet. However, in some cases, a small number of different batches of the same product may be stored on the same pallet provided that the batches are separated

horizontally, for example with sheets of plywood. In this case the batch with the shortest remaining shelf-life must be placed on top.

Appropriate pallet load building must ensure that stacks are stable. Cartons or any other parcels must be arranged crosswise to maximize stability. Plywood dividers, fabric placed between layers or horizontally taping cartons can significantly increase stability of stacks.

The first layer of parcels stacked on the base of the pallet must not protrude any of the edges. The part of the parcel overhanging the pallet is not supported and the entire load rests on the remaining surface and edges. As the corners of corrugated cardboard boxes provide most of the stability, overhanging boxes are much more easily crushed (see figure 30.5).

Moreover pallet overhang increases the width required for storage and pallets with their loads and it may be impossible to place them between two other pallets.

Proper stacking will prevent goods from being crushed, falling and being damaged and is particularly important when pallets are stored on pallet racks since falling goods can cause serious injurious. Pallets can be shrink-wrapped to increase stability and prevent goods from falling.

After attaching a bin card to the pallets, they are moved to their storage place with hand pallet trucks or powered forklift trucks.

The selection of the storage zones as well as suitable storage equipment is determined by various criteria (see table 30.13).

- Required storage temperature and humidity.
- Size of product.
- Volume of batch.
- Weight of batch.
- Requirements for special storage equipment.
- Dangers posed by products.
- Required level of security.
- Requirements of national legislation.

Table 30.13 Criteria for selecting storage zones and storage equipment

30.4.1 Choice of warehouse zone and storage equipment

Every product must be put away in the zone with the storage conditions recommended by the manufacturer and indicated on the packaging as well as according to the requirements by national drug legislation.

While the storage in refrigerators or locked cupboards leaves no choice, many health care goods can be stored on floor pallets or on shelves. This choice is determined by the volume of the batch of each product.

Figure 30.6 indicates the required surface area for one floor pallet and on shelving unit.

Depending on the dimensions of the storage equipment, the height to which goods are stacked, the volume utilization of storage equipment as well as the aisle width, the volume of health care goods which can be stored on one square metre of warehouse surface area can be calculated and compared.

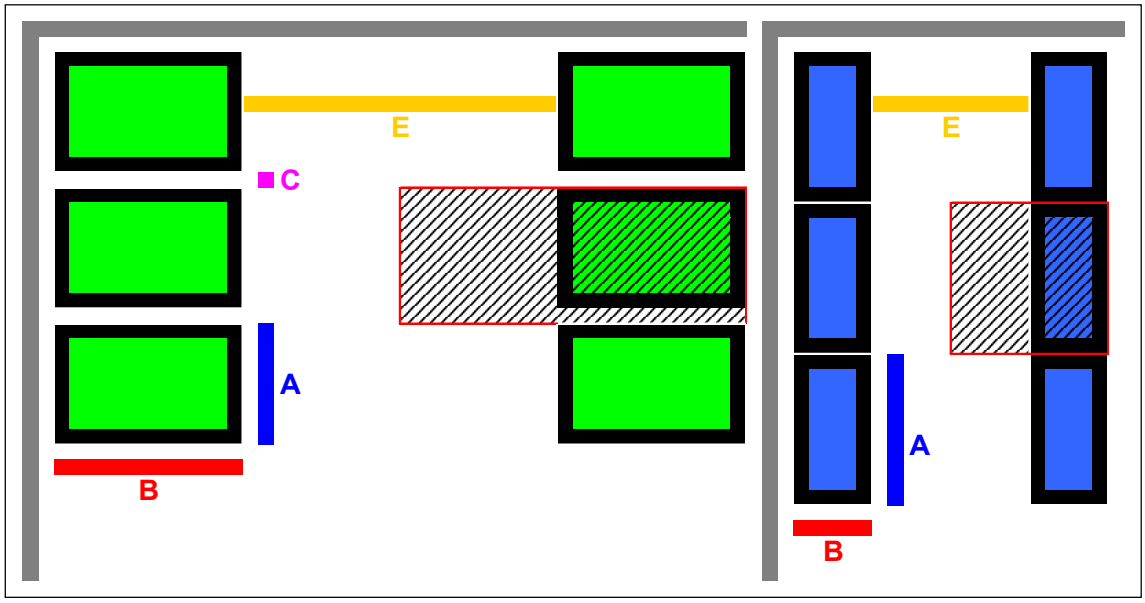

Figure 30.6 Comparison of required warehouse space for pallets and shelves

Parameter	Pallet		
A	Width	m	0.80
B	Length	m	1.20
C	Aisle between pallets (left to right)	m	0.10
E	Aisle width	m	2.00
	Storage height	m	1.86
	Volume utilization	%	1.00
	Warehouse surface per pallet position	m^2	1.98
	Storage volume per m^2 surface area	m^3	**0.90**

Parameter	Shelf		
A	Width	m	1.00
B	Depth	m	0.50
D	Aisle width	m	1.00
	Height	m	1.80
	Volume utilization	%	1.00
	Warehouse surface per shelf	m^2	1.00
	Storage volume per m^2 surface area	m^3	**0.90**

Table 30.14 Example of storage volume comparison

In table 30.14 the required warehouse surface area, including the aisles, are compared for a standard Euro-pallet as well as a shelf of 50 centimetres depth and 100 centimetres width. Assuming a one hundred percent volume utilization on the shelf, goods on a floor pallet would have to be stacked 186 centimetres high to achieve the same storage volume of 0.9 m^3 per square metre of warehouse surface area. With other words, any batch of health care goods with a height of less than 180 cm on a floor pallet is more efficiently stored on a shelf.

Repeating the calculations in table 30.14 for decreasing volume utilization of the shelves, results in the graph in figure 30.7.

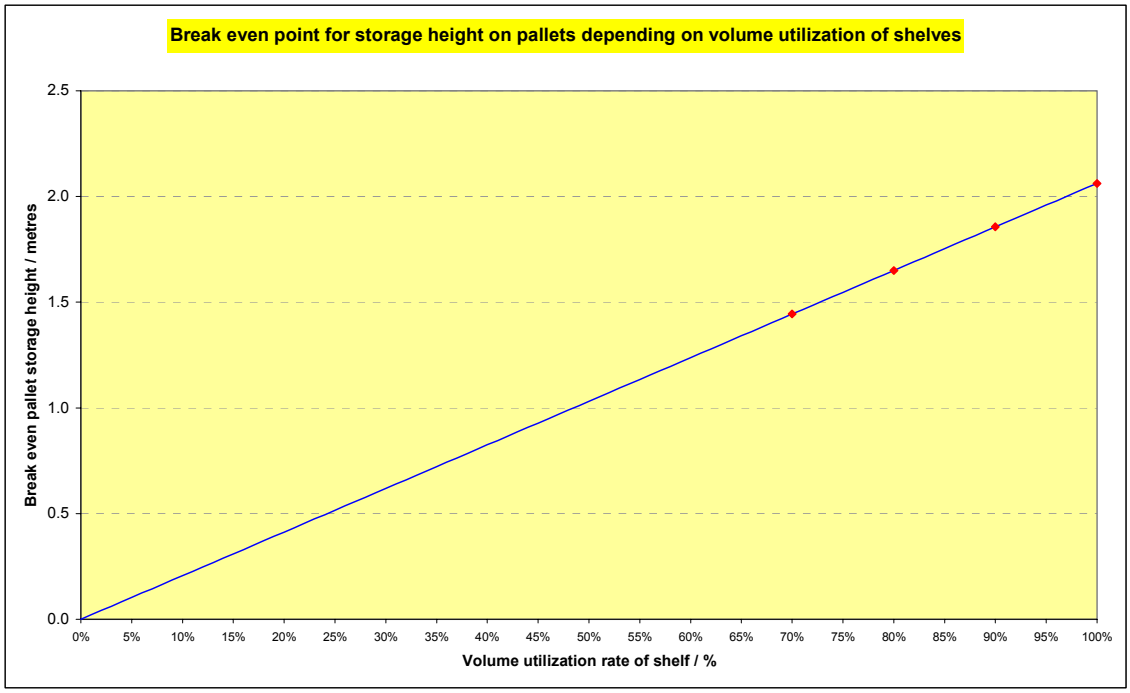

Figure 30.7 Break even point for storage on shelves and floor pallets

Overall storage on floor pallets is only more efficient for batches with volumes of between 1.5 - 2 m^3, depending on the shelf volume utilization this efficiency is compared against.

However the choice of storage equipment must also consider the time and effort which is required for manually arranging a large number of individual parcels on shelves as well as moving each carton separately during order picking while goods on pallets can be moved as an entity.

Moreover floor pallets can be unloaded, moved, stored and loaded without having to handle individual parcels at all. Especially stacking larger numbers of parcels containing bottles (infusions, disinfectants etc.) will be far easier than stacking them on shelves.

Availability of shelving, which is more expensive than floor pallets, may also be a criterion.

A reasonable, but nevertheless arbitrary, cut-off point which considers storage as well as materials handling efficiency is a volume of one cubic metre per batch.

Shelf < 1 m^3 (per batch volume) ≤ Floor pallet

Floor pallets also are used for heavy and bulky health care equipment.

30.4.2 Storage place allocation systems

After choosing the zone and suitable storage equipment, the exact storage place for the floor pallet or the container or parcel on the shelf have to be determined.

Storage place allocation system	Advantages	Disadvantages
Random	• Maximizes space utilization. • Minimizes travel distances for put-away. • Existing stock never needs to be relocated.	• Every storage place must be clearly marked. • Requires software for recording the storage place of each item. • Difficult to follow FEFO/FIFO. • In case of errors, stock may be "lost". • Vulnerable to interruptions of warehouse management systems.
Fixed	• Transparent and systematic. • Does not require moving stock. • Does not require warehouse management system.	• Inflexible. • Poor space utilization.
Semi-fixed	• Better space utilization than fixed storage place allocation system. • Relative position of batches and items to another is maintained in a logical way.	• Poorer space utilization than in a random storage place allocation system. • Batches may have to be moved to make space for received goods. • Not practical for pallet racking.
Split	• Reduces space needed for the picking face. • Allows placing all batches for order picking at a convenient height. • Reduces travelling distance.	• Requires replenishment of the picking face. • Difficult to follow FEFO/FIFO.

Table 30.15 Advantages and disadvantages of storage place allocation systems

In principle the random ("fluid") storage place allocation and fixed storage place allocation system can be distinguished. In a random storage place allocation system any received batch of a product is placed in the next available storage place in the appropriate zone (see figure 30.8). In order to minimize travel distances usually the next available storage place nearest to the receipt and dispatch area will be selected. Alternatively items with low turnover may be stored far from and fast moving items near to the receipt and dispatch area.

The random storage place allocation system has the advantage that it minimizes travel distances for put-away. However, this advantage is only relevant in medical storage facilities with very high throughputs. Moreover the travel distances for order picking are not necessarily minimized. The random storage place allocation system maximizes space utilization because none of the storage places has to be reserved for any specific item. However maximizing space utilization only has a real advantage if the medical storage facility is completely full and a lower utilization rate would require extending the storage facility. A further advantage is that batches of health care goods never have to be moved or relocated to maintain a certain order.

One disadvantage is that every storage place of the medical storage facility has to be clearly marked and must be easily identifiable. The main disadvantage is the difficulty of keeping track

of the storage place of all batches which makes the use of sophisticated warehouse management systems mandatory. These must assign a storage place to each arriving batch, keep an exact record of each batch and be able to provide the storage place of any batch for order picking. If a mistake is made during entering data or placing a batch in the store, it may be very difficult to locate. Different batches of the same item may be stored in different places which makes strict stock rotation and FEFO/FIFO management difficult. Considering all the disadvantages, the random storage place allocation system is not recommended for managing medical storage facilities in the context in which humanitarian organizations work, at least in the field.

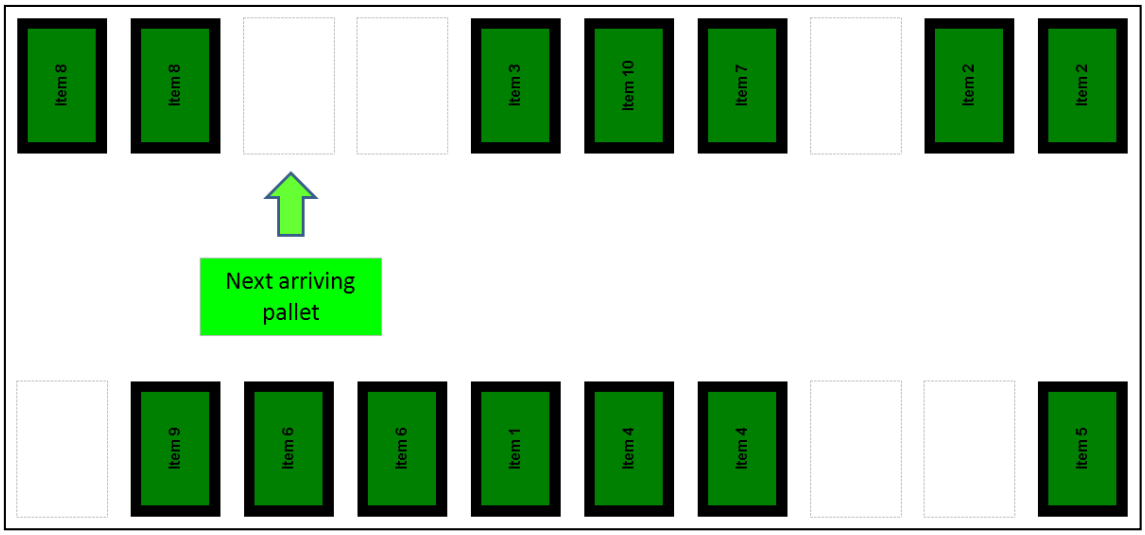

Figure 30.8 Random storage place allocation system

In a fixed storage place allocation system (see figure 30.9) the storage place of items and batches goods is determined according to a systematic order as well as the maximum stock on hand which is expected. Every item is assigned a certain floor pallet positions, shelves or area on a shelf. If the actual stock levels are lower than the planned maximum stock levels, the respective storage places are left empty.

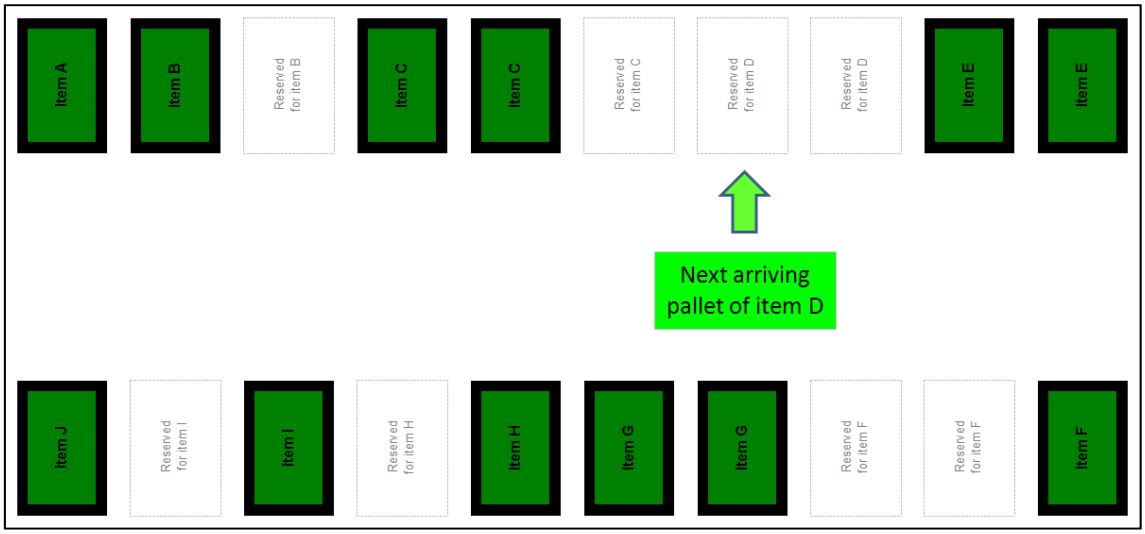

Figure 30.9 Fixed storage place allocation system

This system has the advantage of being transparent and systematic. The storage place of all items is fixed and can easily be found by storekeepers. A fixed storage place allocation system does not require any warehouse management system even in a large warehouse. As long as the stock on hand does not exceed the expected maximum stock levels, sufficient storage space is always available for put-away without the need for moving batches of other items for making space.

The main disadvantage is that this system leads to poor space utilization. Although stock levels of any item will increase and decrease, sufficient space must be allocated for the maximum expected stock level at all times. Even if the stock level of a specific item is low and the allocated storage space remains empty, no other item can be stored in the dedicated storage area. The fixed storage place allocation system is also inflexible to changes in the stock list, when items are added or removed, as well as changes in stock levels.

The space utilization of the fixed storage place allocation system can be improved by filling empty storage positions with the next item foreseen according to the fixed storage place allocation system (see figure 30.10).

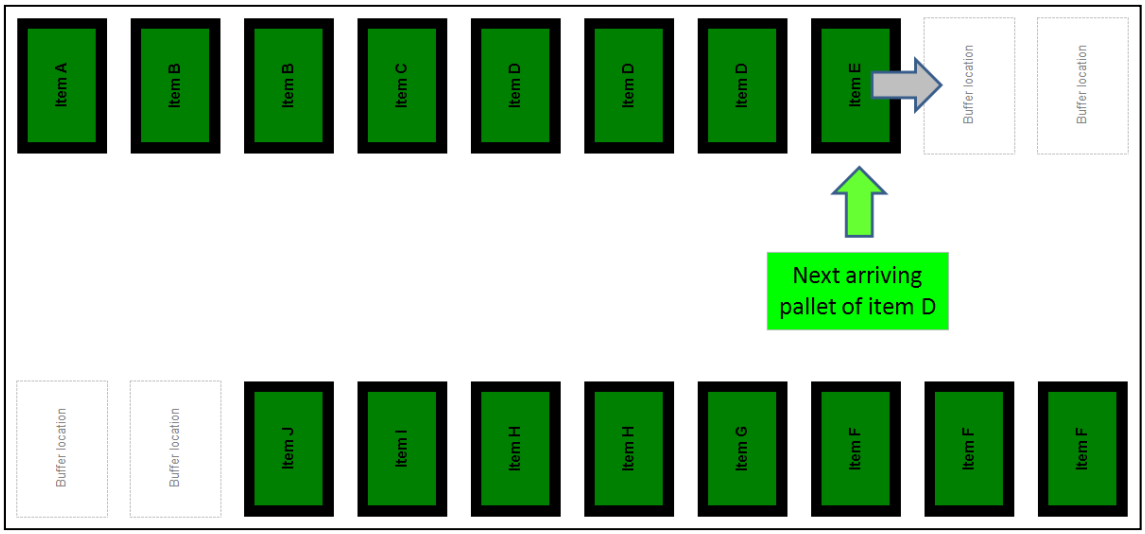

Figure 30.10 Semi-fixed storage place allocation system

Since the relative order of items and the order of their batches does not change but the storage place of each item and each batch can change, this storage place allocation system can be called "semi-fixed".

The semi-fixed storage place allocation system has the advantage that the space utilization is better than in a fixed storage place allocation system but still less than in a random storage place allocation system. Although batches may change their storage place, they can always be quickly located because their relative order does not change. For example Quinine tablets will always be located next to or after Penicillin tablets.

The main disadvantage is that in theory if no space was kept between batches, all successive batches would have to be moved every time a new batches of items are received (to make space for them) or batches of items are depleted and the respective small containers are removed (to close the gap). In practice this problem can be overcome by leaving some space between the last batch of an item and the first batch of the successive item or by leaving some storage places empty at the bottom of each shelf ("buffer positions"). Moreover storage places which are freed when a batch is depleted and the small container is removed, can simply be left empty.

Since the fluctuations of the total stock volume of, for example, all drug products is less than for individual items, arrival of new batches and depletion of other batches will compensate each other. Therefore, in practice only part of the batches will have to be moved whenever a new batch arrives for put-away.

The semi-fixed storage place allocation system is convenient for storage of small containers or parcels as well as for floor pallets but not practical for pallet racking as rearranging pallets on the racks would be too time consuming.

Since the storage place of individual items will change over time, storage equipment should not be labelled with item descriptions of health care goods since after some time the labels will not correspond to the stocked items.

In a split storage place allocation system (figure 30.11) part of the stock of each item is kept in a dedicated place, called the picking face while the remaining stock ("reserve stock") is kept in another place. For the remaining stock a random, fixed or semi-fixed storage allocation system may be used.

The split storage place allocation system reduces the space needed for the picking face and therefore reduces travelling distances during order picking.

It also allows to place batches for picking at an easily accessible height of shelves while the reserve stock can be stored on top of shelves or on the lowest shelf which are less easily accessible. Another advantage is that no materials handling equipment is needed during order picking although it may be needed for replenishing the picking face (for example if a pallet is taken off a pallet rack).

Figure 30.11 Split storage place allocation system

One of the disadvantages is that it is more difficult to keep track of the storage place of items as each item has at least two storage places. Moreover the picking face has a small capacity and therefore requires regular replenishment from the reserve stock. Strict FEFO/FIFO management is also made more difficult as newly arriving batches of items may have an earlier expiry date than the picking stock and some of the current picking stock may have to be returned to the reserve stock before the newly arrived batches can be put away. If a large quantity needs to be picked there may be a temptation to pick larger packages from the reserve stock rather than from the picking face.

30.4.3 Order of items

Except for the random storage place allocation system, criteria for arranging the items systematically in a certain order need to be chosen. This ensures that, except for the split storage place allocation system, the correct storage place for put-away can be determined, every item is stored in only one storage place and every batch of a product can be found easily and quickly.

If a single storekeeper is in charge of store s/he may know where each item is located. However in stores and warehouses where several staff are working each storekeeper must apply the same logic and system to ensure that all other staff members can find any item independently and quickly.

In any case, the chosen order of items must correspond to the order of items in the stock list and must also be used consistently throughout the entire medical storage facility. Nonproprietary names rather than proprietary names must be used regardless of the applied system.

Except for the alphabetical order, all other systems will require a combination of different systems. For example if items are arranged by therapeutic category the items within each therapeutic category must be arranged in alphabetical order.

Order of items	Advantages	Disadvantages
Alphabetical	• Requires no knowledge about nature and use of items. • Applicable to any item.	• Mixes very different goods. • Does not consider appropriate zone (temperature, safety, security etc.).
Pharmaceutical category	• Unambiguous.	• Applicable only to drug products. • Requires highly skilled staff.
Therapeutic category / clinical indication	•	• Applicable only to drugs products. • Ambiguous.
Dosage form	• Does not require much skill.	• Applicable only to drug products.
Item code	• Same logical order inherent in the coding. • No pharmaceutical knowledge needed. • Groups often correspond to required storage conditions. • Applicable to all items.	• Codes must be known or looked up. • Order may not be entirely consistent.
Level of use	• Reduces time required for put-away and order picking	• Level of use needs to be determined for each item. • Turnover changes.
Combination: Alphabetical within groups / sub-groups	• Applicable to all health care goods. • Corresponds to required storage conditions for most items. • Does not require any knowledge of items.	• Requires precise coding of all items. • Requires indicating item codes on items or in stores.

Table 30.16 Advantages and disadvantages of systems of arranging items

Health care goods can be stored in alphabetical order by their nonproprietary name. The advantage is that this system does not require any knowledge of the nature or use of the health care goods and any staff can locate any item quickly.

The alphabetical order cannot be applied to the entire stock as it would not be practical to mix, for example, drug products, dressing material and catheters. Therefore the alphabetical order system is only practical for application within a certain type or group of health care goods as a second criteria.

Drug products can be stored by pharmaceutical category, for example benzodiazepines, corticosteroids or sulfonamides. Compared to the therapeutic category it has the advantage of being unambiguous. However this system can only be applied to drug products and requires excellent pharmacological knowledge.

The therapeutic category (antimalarial analgesic) which often corresponds to the clinical indication (malaria, pain) and is related to the pharmaceutical category can be used as a system for arranging items in a small store. The WHO Model List of Essential Medicines (WHO 2007n) can be used as a reference.

Again this system can be applied only to drug products and some drug products have several clinical indications. For example Lidocaine is a local anaesthetic as well as an antiarrhythmic drug product.

Drug products can also be stored by dosage form where tablets, ampoules, creams etc. are stored separately. This system has the advantage that dosage forms are obvious from their packaging and distinguishing different dosage forms does not require any pharmaceutical knowledge. A disadvantage is that this system can be applied only to drug products.

All health care goods can be arranged in alphabetical or numerical order of their item codes. The item coding may consider different classes of health care goods such as drug products or surgical instruments as well as different dosage forms or other categories of health care goods.

This system has the advantage that health care goods are arranged in the same logical order as the standard item catalogue. For example a coding system can be designed in a way that all drug products are indicated by a "D" as the first letter of their item code. Any storekeeper can quickly determine the nature of any item by looking at the first letter of the item code, even without knowing the item description.

If the item coding already includes information on different types of health care goods, the arrangement of stock is obvious even to less skilled warehouse staff. In many cases different types of health care goods such as dressing material, catheters or health care equipment can be distinguished even with little experience.

A further advantage is that different groups of health care goods often require similar storage conditions. For example most oral drug products must be stored at room temperature and most vaccines require refrigeration.

If the entire item code is used as a system for arranging items, one disadvantage is that in principle all codes have to be known to staff or have to be looked up. Depending on the coding system, health care goods may not necessarily be arranged in alphabetical order.

Another problem is that item codes use letters or numbers to restrict the length of the code. If health care goods are then placed in alphabetical order of their item codes, they may not be arranged in any logical order.

Health care goods can be stored according to their level of use or turnover and be separated into slow and fast moving items. In this system goods with a high turnover are stored in a

location which minimizes the total travelling distance for put-away and order picking. In a U-flow store items with a high turnover are stored near the receipt and dispatch area while other items are stored further away. In a through-flow store items with a high turnover are stored near to the centre aisle.

The main, and perhaps only advantage, is that the distances which have to be travelled for put-away and order picking are minimized. However this advantage is really only significant in very large stores or warehouses with a high throughput. Disadvantages are that the turnover of each item, which may change has to be calculated and must be known to storekeepers. The level of use itself is not a practical criteria. Rather more global categories such as "fast", "medium" and "slow" would have to be used which have no strict definition. However this system nevertheless has some justification in very large stores.

None of the above systems alone covers the full range of health care goods and is therefore sufficient, at least for larger medical storage facilities.

A practical approach is combining elements of different systems.

Items are first stored according to their type such as drug products, dressing material, catheters etc. Within these groups items might be further distinguished by sub-groups for example by their dosage form. Finally, within these groups and sub-groups, all items are stored in alphabetical order.

The group and sub-group of item codes correspond to similar items (oral drugs, dressing material, catheters etc.) which usually require similar storage conditions. Even without good knowledge of health care goods most items can be attributed to the correct group and sub-group with a little experience.

All items should be coded and their codes should be indicated in all documents such as packing lists, bin cards and stock cards. By identifying the group and sub-group of an item from the first few letters or digits of the item code as well as from the item description, any storekeeper can immediately determine the correct storage place.

For example if a storekeeper should put away or pick Penicillin tablets, s/he will simply need to look for the storage place of the group "drug products", sub-group "oral dosage forms" and search the stored items alphabetically for Penicillin. Within the Penicillin tablets different strengths of dosage unit may be stored in numerical order.

30.4.4 Order of batches

Except for the random storage allocation system, regardless of the system for arranging items, all different batches of the same item must be arranged according to their expiry dates. This system is called "FEFO" for first-expiry-first-out and helps to ensure that batches of items are issued according to the remaining shelf-life.

All batches of items must be stored according to FEFO or FIFO.

All other items, for example non-sterile dressing material or catheters, which are not marked with an expiry date must be placed in order of their date of entry into stock. This system is called "FIFO" for first-in-first-out. This system minimizes the stocking time of each batch and ensures that all batches are turned over. Even if such items do not expiry, all health care goods eventually deteriorate if stored for very long periods of time.

Several batches with the same expiry date or same entry date should be stored in alphanumeric order of their batch numbers.

- Zone (according to required temperature, safety and security).
- Floor pallets or shelving according to volume of batches.
- Semi-fixed storage place allocation system.
- Order by group (and sub-group) according to item coding.
- Alphabetical order (nonproprietary name).
- First-expiry-first-out or first-in-first-out.
- Batch number.

Table 30.17 Recommended system for arranging items and batches

In summary, the following system for arranging all batches of items is the most convenient and practical. Items are first of all stored in the zone that corresponds to the required storage conditions in terms of temperature, safety and security. Depending on the overall volume as well as the volume of individual batches items are stored on floor pallets or on shelves.

Within the pallet storage as well as the shelving, the items are stored according to a semi-fixed storage place allocation system and according to the groups and sub-groups of their item codes. Within each group and sub-group each item is then stored in alphabetical order of their nonproprietary names. Several batches of the same item are finally stored in order of their expiry date or entry date and in alphanumeric order of their batch numbers.

30.4.5 Placement of batches

According to the selected system, each floor pallet is placed in the selected and allocated put-away location, which may require re-arranging other floor pallets to make space and ensure the correct overall order of all floor pallets. Likewise small containers or original manufacturer packagings are placed next to each on shelves in the correct storage place. On the shelves, each batch must be clearly separated from other batches and different batches of health care goods must not be stacked on top of or behind each other.

The floor pallets are arranged according to the selected system from left to right and then in the nearest storage place in the next aisle. Therefore all batches are stored along a continuous path, even if this patch may have several bends. Usually batches are stored successively from left to right. However storekeepers may instead prefer to arrange stock from right to left if this direction corresponds to their writing.

The storage places of each shelving bay are successively from the top left to the bottom right. As mentioned earlier, some storage places at the bottom of each shelving bay can be left empty to accommodate future batches. Once the last storage place on the bottom and right of a shelving bay has been reached, placement of batches is continued on the top left corner of the next shelving bay. This system of arranging batches has the advantage that all items of the same group or sub-group are kept in the same place and can therefore be found more quickly. Locating individual batches of items would be more difficult if the upper most shelf would be filled entirely from one end of the storage facility until the other end before starting to fill the second shelf.

As far as possible, loads should be spread evenly across shelving panels and very heavy loads should preferably be placed on the sides of shelves rather than in the middle.

Figure 30.12 Storage of batches on floor pallets along an aisle

Even heavier parcels should be stored in their systematic storage place. Placing heavy parcels on lower shelves and lighter parcels on higher shelves will lead to confusion or mix-up of batches and items. Instead, suppliers must be requested to limit the weight of individual parcels and very heavy parcels should be split and repacked before put-away.

If shelves are higher than about 180 cm, ladders or steps are required for put-away and order picking. Otherwise there is a danger that staff will be injured by pulling down boxes from above their head which may then fall on them. Warehouse staff must never climb on shelves since they may topple the entire shelf which will cause injury. A person can also bend or break the shelf or slip off and fall.

Floor pallets must be placed with sufficient lateral space between adjacent floor pallet to allow future movement of all floor pallets.

Loads placed on adjustable pallet racking must be spread evenly across each pallet rack bay and the total load must not exceed the permissible load. If the horizontal bearer beams are overloaded they will bend and pallets will fall off. However there is little risk that the whole pallet rack will collapse.

30.5 Storage

All health care goods remain in their storage place until they are picked for filling customer orders or removed because of expiry or damage. The main objective of storage is preventing any damage to health care goods.

The storage of health care goods is covered extensively in the previous chapter and mentioned here only for completeness of warehouse operation processes.

30.6 Order picking

Order picking is the process of selecting and physically extracting goods from storage equipment to collect items ordered by customers.

Order picking is a time consuming process which uses significant resources. It should be therefore organized and managed in an efficient way.

If several customer orders arrive at the same time, order picking must be planned and priorities must be set. Interrupting preparation of one order for treating another order wastes time, distracts and can lead to confusion. On the other hand warehouse management must be flexible enough to immediately treat urgent orders if necessary.

Order picking must be organized on a daily basis to coordinate with receipt of goods as well as other routine tasks carried out by warehouse staff. In small stores receiving and issuing goods at the same time may cause problems due to lack of staff as well as congestion in the storage area.

Order picking as well as receipt must be organized in a way that avoids peak loads of work which unnecessarily stress staff and lead to lulls during other times. Even if receipt and issue of goods are managed well, the workload will vary. However when the workload for receipt and issue of health care goods decreases, warehouse staff can attend to other responsibilities such as updating records, cycle counting, housekeeping as well as training. Staff may also take the opportunity of consuming their annual leave when workload decreases.

Different teams can be assigned to different tasks which are carried out simultaneously. In any case sufficient staff should be available to carry out all assignments swiftly. Order picking should not be delayed because of receipt of goods and receipt should not be delayed because of order picking. In any case the importance of providing excellent services must be kept in mind. Therefore, as far as possible order picking should be the priority. Delaying order picking will increase order lead time while delaying inspection and put-away will not, unless a stockout has occurred.

Generally, order picking should commence as soon as pickling lists are received. Immediate treatment reduces lead times and also avoids building up queues of untreated picking lists. Any backlog increases lead time and reduces the flexibility to treat urgent orders quickly.

If already several picking lists are awaiting treatment and suddenly several emergency orders arrive, treatment of the routine customers orders is delayed even further and lead times may become unreasonably long. Backlogs of picking lists also bear the danger of frequently changing prioritization and suspending order picking for one customer order for treating another. Any interruption reduces overall warehouse efficiency and increases the risk of mistakes.

Appropriate materials handling equipment for order picking must be available to storekeepers. In no case storekeepers should have to carry the loads around the store by hand. This increases the risk of occupational injury, is laborious, time consuming and inefficient.

Under no circumstances must storekeepers (have to) clamber on storage equipment. In case health care goods on shelves cannot be comfortably reached from the ground, steps and ladders must be provided. When health care goods stored on adjustable pallet racking are picked, the respective pallet must first be removed and placed on the ground before individual items are picked.

30.6.1 Order picking methods and regimes

Among the picking methods, "Picker to goods", "Goods to picker" and automated systems can be distinguished (Rushton, A., J. Oxley, and Ph. Croucher 2000, 291).

The "Picker to goods" is the traditional method where the order picker walks around the store or rides on motorized picking trucks. The "Goods to picker" method requires mechanized storage equipment such as carousels. As this type of storage equipment is very expensive it is not practical in the context in which humanitarian organizations work. Likewise automated systems are only economical in very large warehouses which are operated for many years and where throughputs are very high.

Different order picking regimes (see table 30.18) can be applied (Rushton, A., J. Oxley, and Ph. Croucher 2000, 289).

- Consignee order picking.
- Batch picking (summary picking).
- Zone picking.
- Dynamic picking.
- Combination of picking regimes.

Table 30.18 Order picking methods

In consignee order picking, one customer order is picked at a time and all batches of line items of a single picking list are picked at a time. After order picking is completed, the next picking list from the next customer is processed.

This system reduces the risk of errors as only one picking list is treated at a time. The disadvantage is that comparatively long distances have to be travelled for picking batches from several picking lists as different picking lists may require repeatedly travelling along the same or a similar path.

In batch picking several picking lists are treated at the same time and order picking is carried out in two steps. First all batches of line items for all of the picking lists are picked during the same picking circuit. During the following secondary pick the batches of line items are then separated according to the different picking lists.

Especially when the line items on the different packing lists are similar, batch picking can reduce the overall distance travelled for order picking of several picking lists. However there is a danger that batches, line items and quantities from different picking lists may be confused. Therefore batch picking is, if at all, only practical for picking lists with a small number of line items and preferably for picking lists with similar line items.

Zone picking can be applied to medical storage facilities with high throughputs and when the picking lists contains a wide range of health care goods. For the same customer order, separate picking lists are issued for the line items stored in the respective warehouse zones. The picking lists are treated separately and the later collated in the packing area.

In dynamic picking, all line items for several picking lists are picked and moved to a picking area where the individual picking lists are picked one by one. Any residual stock is then returned to their original storage places.

Dynamic picking can be used when several picking lists contain the same line items. However when several different batches of line items are held in stock, picking the exact batch indicated in the picking list can be difficult and there is a danger that different batches will be mixed.

Different picking regimes can also be combined. For example, dynamic picking may be used for picking large quantities of a few bulky line items, such as infusions or dressing material, while consignee picking is applied to all other line items.

In order to avoid the mix-up and ensure stock rotation of possibly many different batches of line items, consignee picking should be the preferred picking regime. In exceptional cases, for example if several different clinics are receiving identical rations or for manufacturing medical kits, batch picking may be applied.

Consignee picking is the preferred picking regime.

30.6.2 Picking lists

The picking list is the document which authorizes the storekeeper to remove any stock from the medical storage facility. Warehouse managers are accountable for any health care goods leaving the warehouse and donors may eventually require detailed reports on distribution of all health care goods. If stock is issued without any requirement for formal authorization, staff may be tempted to commit fraud.

The picking list should indicate the batches and expiry dates of line items in the order they will be picked from the store in order to minimize the distance storekeepers have to travel during order picking. The picking list must never indicate any expired batches or batches which will expiry very shortly. Rather, if such batches were overlooked during the monthly review of stocks and expiry dates, they must be immediately removed from the stocking area and be placed in quarantine.

The picking list contains all the details of all batches of line items which need to be collected for filling a specific customer order. The picking list is used by the storekeeper to identify the correct line item, correct batch (according to FEFO or FIFO) as well as the correct quantity. If a random storage place allocation system is used, the picking list will also indicate the exact storage place.

The individual storekeeper should not be allowed to or have to select among the different available batches of a line item since there is a great danger that the stock will not be rotated properly and that discrepancies between stock records and physical stock will occur.

30.6.3 Order picking process

The order picker moves through the medical storage facility and picks the batches of line items indicated in the picking lists in the exact sequence indicated in the picking lists.

All picked health care goods are placed on a picking trolley in an orderly way in order to reduce the workload of sorting batches before packing. If the batch or the full quantity indicated in the picking list is not found, the order picker must clarify the discrepancy immediately. If the order picker simply picks another available batch, which may have been reserved for another picking list, eventually the discrepancies will be more difficult to reconcile. Moreover another order picker who cannot find the batch for picking, might also pick another batch and compound the discrepancies.

The primary packaging of health care goods must never be opened. In particular, it must be strictly prohibited to open any primary packaging of drug products and remove individual tablets. Instead at least one primary packaging must be picked at all times. Dispensing, that is

the removal of individual tablets or capsules from primary packaging, must be carried out only by a qualified pharmacist. Therefore dispensing by a storekeeper will usually violate national drug legislation and regulations.

Wherever primary packaging contains individual units of products such as syringes, sutures or compresses, only full secondary packaging should be picked.

Wherever possible, full cases which contain several primary packages (of loose units) or several secondary packaging (containing individually packaged units) should be picked.

When items are removed from primary or secondary supplier packaging and repacked in unmarked parcels, the detailed information on packaging is lost for the user at the receiving health care facility and can therefore compromise patient safety. While individual ampoules must be marked with some essential information, the product information on the secondary packaging is more comprehensive and secondary packaging also contains the package insert. Some packaging provides special protection, for example light sensitive drug products must be kept in their packaging to prevent deterioration.

Another reasons for supplying only entire secondary packaging is the unreasonable workload that would be caused by having to count the contents of each secondary package during physical stock counts. As individual items may have been picked from any packaging, the contents of every packaging would have to be counted. For example the number of syringes, tubes or sterile compresses would have to be counted, an impossible task.

In case the quantities of secondary supplier packaging greatly exceed the needs of the assisted health care facility, recipients can transfer unused products together with their packaging to another health care facility with higher demand for this line item.

If providing large manufacturer packaging repeatedly causes problems, products with smaller packaging quantities should be purchased. However these may be far more expensive than larger (hospital) packaging.

Immediately after picking items, the storekeeper must record the transaction on the bin card. Recording order picking at a later stage will increase the likelihood of errors and cause confusion especially if another storekeepers picks an item from the same batch in the meantime.

The remaining balance of each batch should also be indicated in the picking list. This allows to later crosscheck the remaining balance of the stock with the stock records and immediately detect any discrepancy. As discussed earlier this residual balance counting can be seen as a kind of continuous cycle count.

After completing the order picking, the storekeeper must sign the picking list. S/he must be held accountable for any discrepancies in the stock or the picked goods. In case of discrepancies the storekeeper must be identifiable in order to help determine the reason for any discrepancy.

Never remove any items from primary or secondary

supplier packaging during order picking.

Whenever the last item of any batch is picked, the respective small container or manufacturer packaging is removed from the shelf or the empty floor pallet is moved to the pallet storage. The respective bin card is updated and placed in the archives for future reference. Where applicable, master cartons containing the next batch of a line item according

to FEFO/FIFO is opened to transfer the secondary manufacturer packaging to the small containers for future order picking.

30.6.4 Stock rotation

Systematic rotation of stock is essential to avoid expiry and therefore loss of stock in the medical storage facility.

All drug products, sterile single use medical devices and many other health care goods have only a limited shelf-life. In order to prevent goods from expiring in stock, the batch with the nearest expiry date must always be picked from stock first according to FEFO (first-expiry-first-out).

Any products without expiry dates must be rotated according to FIFO (first-in-first-out).

If more than one batch of line items are indicated on a picking list, order pickers might be temped to cut corners and pick the entire quantity from a single batch instead. Consequently small quantities of batches will remain in stock until they expire and will have to be disposed of. Therefore it is essential to ensure that order pickers always pick batches exactly according to their picking lists.

30.7 Packing

Packing of picked health care goods in master cartons is the first step in a wider consolidation process of loads for transport.

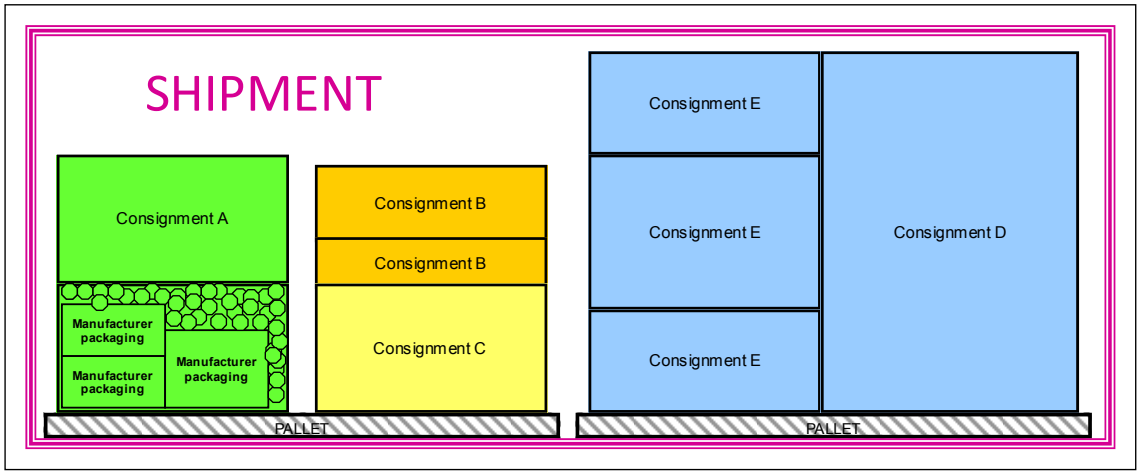

Figure 30.13 Levels of load consolidation for transport

30.7.1 Functions of transport packaging

Transport packaging of health care goods fulfils several functions (see table 30.19). The consolidation of several smaller packagings reduces the number of parcels which need to be counted and handled. Transport packaging greatly facilitates handling and greatly increases handling efficiency. Likewise intermediate storage before loading, storage during transportation as well as during receipt is greatly facilitated. The possibility to stack transport packaging greatly increases the space utilization of means of transportation.

Transport packaging is important for protecting health care goods from mechanical, environmental and other influences which may damage the contents. Parcels are likely to be

loaded and unloaded several times, may be dropped and may require transportation on poor quality roads. Transport packaging helps protect its contents from mechanical forces such as abrasion during handling, shocks caused by dropping, other impacts, compression and crushing by other goods stacked on them as well as vibration during transport.

Transport packaging protects its contents from exposure to light and solar radiation, odour as well as condensation, spray water and, if packed specially, from rain water. Moreover health care goods are protected from dust, dirtying and contamination. Special cold boxes can also protect health care goods from high and low temperatures.

Properly closed transport packaging can deter pilfering of its contents although it can of course not prevent theft of its contents or entire parcels.

Transport packaging is also important for identification of consignments which are marked with their destination, origin, parcel number, packing list reference etc.

Each parcel must also be marked with information for handlers such as indicating breakable contents or parcels which must not be turned upside down. Cold chain consignments and hazardous goods must be marked accordingly to inform the carrier on possible dangers (hazardous goods) and prioritization (cold boxes).

Transport packaging discourages theft as opening requires time and increases the risk of being detected. Moreover, opening or otherwise tampering with transport packaging is likely to be detected (at a later stage) and, compared to removing a loose package from a stack, increases the risk for thieves.

Transport packaging may also protect handlers from injury by sharp or pointed items or parts as well as prevent or limit spills of dangerous goods (especially liquids).

- Consolidation.
- Containment.
- Facilitation of handling.
- Increase of handling efficiency.
- Facilitation of storage.
- Increase of space utilization of means of transportation.
- Mechanical protection (breaking, bending, crushing, deformation etc.).
- Environmental protection.
- Identification (of contents).
- Information (for handlers and carriers, cold chain, dangerous goods, breakable etc.).
- Discourage theft.
- Protection of handlers (mechanical injury, containment of dangerous goods).

Table 30.19 Functions of transport packaging

30.7.2 Selection of packaging materials and fillers

Packaging materials should be light (transportation costs), easily available and fairly inexpensive as it is usually not returned by the customer. Except for metal all packaging materials are more or less flammable.

Some manufacturers and suppliers use bags made of various materials such as plastic or woven fabric made from strips of plastic, especially for dressing material. Bags are cheap and

allow consolidating health care goods but provide almost no mechanical protection. They also cannot be stacked properly and tend to collect dust.

Corrugated cardboard boxes are light weight, inexpensive, available in a large variety of sizes, sturdy, allow packaging of fairly heavy goods and can be stacked. They usually can be reused several times. However the quality of domestically available corrugated cardboard boxes can be poor and offer little protection against humidity and water. Nevertheless corrugated cardboard boxes are the packaging of choice for the great majority of health care goods. Only health care equipment requires more sturdy protective packaging. The sizes of master cartons should be standardized (UNDP 2000, 241) in order to maximize space utilization during transportation and storage as well as facilitate materials handling and transportation (Bowersox, D.J., and D.J. Closs 1996, 437).

Plywood is fairly lightweight, inexpensive but nevertheless very sturdy. Some standard dangerous goods packaging is made from plywood.

Timber boards for making boxes are usually readily available locally although timber may be very expensive. Timber crates and boxes are fairly easy to make, are very sturdy and reusable. The main disadvantages of timber are its cost as well as its weight and therefore high transportation costs. Sturdy timber boxes are the packaging of choice for sensitive health care equipment such as microscopes, autoclaves or oxygen concentrators.

Metal boxes or trunks are very sturdy and protect goods against spray water. They provide good protection against theft and are not flammable.

Packaging material	Advantages	Disadvantages
Bag	• Inexpensive.	• Offer little mechanical protection. • Cannot be stacked.
Corrugated cardboard box	• Light weight. • Inexpensive. • Readily available. • Sturdy. • Can hold fairly heavy goods. • Stackable.	• Little protection against humidity and water. • Quality of domestically available corrugated cardboard boxes can be poor.
Plywood	• Fairly lightweight. • Fairly inexpensive. • Sturdy.	• Heavy. • Expensive.
Timber	• Readily available. • Very sturdy. • Reusable. • Quite tamper resistant.	• Heavy. • Expensive.
Metal	• Very sturdy. • Protect against water. • Tamper resistant. • Not flammable.	• Heavy. • Expensive.

Table 30.20 Advantages and disadvantages of different types of packaging materials

Any empty space in master cartons should be filled with fillers. Fillers protect health care goods from shocks, prevent contents from shifting to and fro during transportation but also makes cartons more rigid and increases the stability of cartons for stacking.

Crumpled up scrap (news) paper and scraps of corrugated cardboard is readily available, inexpensive and can be disposed of without harming the environment.

Shredded paper is often available from offices and free of charge. However during shredding small pieces of paper as well as dust are produced which requires cleaning in the medical storage facility after packing as well as unpacking.

Filler material	Advantages	Disadvantages
Scrap paper and corrugated cardboard	• Readily available. • Inexpensive. • Reusable. • Environmentally friendly.	• Absorbs humidity and water. • Reduction of volume if dampened (and therefore loss of protective function).
Shredded paper	• Readily available. • Inexpensive. • Reusable. • Environmentally friendly. • Reusable.	• Can contain dust. • Absorbs humidity and water. • Reduction of volume if dampened (and therefore loss of protective function).
Polystyrene chips	• Fairly inexpensive. • Offer great mechanical protection. • No dust. • Resistant to humidity and water. • Long lifetime. • Reusable.	• Not environmentally friendly.
Bubble wrap	• Offers good mechanical protection.	• Not readily available. • Not environmentally friendly.
Air pillows	• Good mechanical protection. • Allow filling large spaces. • Prevent goods from shifting. • Reusable.	• Requires special machines for production. • Not environmentally friendly.
Foam rubber	• Good mechanical protection. • Reusable. • Can easily be cut.	• Not environmentally friendly.
Polystyrene	• Very good mechanical protection. • Can easily be cut. • Reusable.	• Not readily available. • Not environmentally friendly.

Table 30.21 Advantages and disadvantages of different filler materials

Polystyrene chips are fairly inexpensive, do not make dust, are resistant to humidity and water, have a long lifetime and can be reused many times. As plastic chips are soft but nevertheless sturdy they offer excellent protection against mechanical shocks and vibration. However the plastic material is difficult to dispose of in an environmentally friendly way.

Bubble wrap offers good protection against mechanical shocks and can be reused many times. However it is not readily available and difficult to dispose of.

Air pillows offer good mechanical protection, allow to fill large spaces, effectively prevent goods from shifting inside master cartons and can be reused many times. However they require special machines for production, are very bulky and are not environmentally friendly.

Foam rubber mats provide good mechanical protection and can easily be cut to the required sizes.

Sheets or blocks of polystyrene offer very good mechanical protection against impacts and shocks, can be easily cut and are reusable. However, polystyrene is not readily available everywhere and not environmentally friendly.

30.7.3 Packing process

In the packing area of the warehouse the picked goods are checked again the picking list and then packed. The parcel number is noted on the picking list during packing. This information is later transferred to the final packing list. Any packing requirements indicated on customer orders such as maximum weight or the need for special protective packaging should be considered.

Small packagings of health care goods are conveniently packed in master cartons made from corrugated cardboard. As far as possible the individual batches should be packed in the same order of the picking list in order to facilitate receipt, inspection and put-away at the receiving storage facility. Master cartons must never be stuffed as this will damage packaging of health care goods or health care goods themselves while only marginally reducing the total number of master cartons needed.

The Bin Packing Problem (BPP) seeks to find a way of maximizing space utilization of master cartons and minimizing the overall number of required master cartons (Bramel, J., and D. Simchi-Levi 1997, 5). As line items should be packed in the order in which they have been picked and in which they appear on the respective packing list, the problem is limited to optimizing the use of space of each individual master carton. The optimal packing of several packagings of different sizes into a single carton can be achieved by sorting them in a non-increasing order (according to their size) and starting the packing with the largest item.

All health care goods should be packed separately and should not be mixed with other types of goods, especially not with any kind of food.

Any empty space is filled with available fillers. Depending on the manufacturer and supplier packaging, health care equipment may require additional protective packaging.

Health care goods which were received in good quality manufacturer packaging of a convenient size for handling, for example boxes of infusions or dressing material, may not require consolidation in master cartons.

The weight of individual parcels should be limited to 25 kilograms which allows manual handling by one person (PAHO 1983, 67 and UNDP 2000, 240).

After closing, every parcel should be at least secured with strong adhesive packing tape (approximately 5 cm wide). Tape dispensers should be used for closing to increase packing

efficiency. However, if possible, parcels should in addition be secured with plastic straps to increase deterrence from theft as well as increase the rigidity of the parcel.

Special packing tape with the name or insignia of the humanitarian organization may increase protection from unauthorized opening. Ordinary packing tape can easily be replaced after opening boxes and pilfering its contents. However specially marked tape will only provide better protection from theft if the special packing tape itself is protected from theft and kept locked.

Heavy and breakable health care equipment may require repacking in rigid timber boxes filled with protective material. Even high quality manufacturer packaging is not designed to withstand the stress of transport on poor roads. Any sharp edges or pointed parts protruding from health care equipment must be covered with or surrounded by rigid materials to prevent injury of staff during handling.

For shipment with small aircraft the maximum permissible dimensions and weights of crates and boxes have to be considered. In some cases bulky and heavy health care equipment might have to be separated into several packages.

30.7.4 Marking and labelling

Marking and labelling is essential for ensuring that parcels arrive at the correct destination and that the parcels are handled and stored correctly during transport. Every parcel (master carton, box etc.) or stretch wrapped pallet must be marked individually.

Markings and labels must be written in a language understood by staff along the transportation route and must be clearly visible.

Wherever possible, markings should be made with dark ink on light backgrounds. Labels should be firmly glued to parcels and self-adhesive labels must be of high quality to avoid detachment during transportation.

Various information must be indicated on each parcel (see table 30.22).

- Name and address of consignor.
- Name and address of consignee.
- Order reference number.
- Packing list reference (number).
- Parcel number / total number of parcels.
- Weight (and possibly volume) of parcel.

Table 30.22 Information indicated on each parcel

Ideally the warehouse information system will allow printing labels for each parcel.

Cold chain consignments and dangerous must be clearly marked with standard stickers. Dangerous goods shipped by air may be marked and labelled only by authorized carriers and such markings must not be altered. However dangerous goods shipped by road may be repacked and may require additional labelling.

Package orientation (This Way Up)

Package orientation (This Way Up)

Caution! Lithium batteries

Cargo Aircraft Only (Forbidden in passenger aircraft)

Magnetized Material

Fragile

Keep away from heat

Do not stack

Handle with care

Keep Dry

Environmentally hazardous

Time and Temperature

Figure 30.14 Handling labels

- Fragile.
- "This side up".
- "Do not use hooks".
- Protect from water.
- Do not expose to direct sunlight.
- Do not freeze.

Table 30.23 Examples of handling information indicated on parcels

In addition parcels may need to be marked with storage and handling instructions.

Pictograms with this information may be preferable as some staff handling parcels may not be literate.

Parcels containing dangerous goods require additional marking and labelling (see chapter 23.7.4).

30.7.5 Weighing

After sealing, marking and labelling, each parcel is weighed and the weight is recorded on the picking list for including in the packing list. The weight should also be written on every parcel.

Weighing parcels allows confirming that the maximum weight does not exceed 25 kilograms and allows determining the total weight of consignments.

Carefully weighing parcels is of particular importance when transporting consignments with (small) aircraft, especially for heavy parcels.

30.7.6 Packing list

A detailed packing list must be issued for every packed consignment. Regardless of their layout packing lists must contain certain information on the consignor (sender), consignee (receiver) and consignment (see table 30.24).

A complete packing list must be attached with the other shipping documents. In addition a copy of the packing list should be attached to each parcel in a protective plastic cover or must be included in the first parcel of every consignment. The parcels containing the copy of the packing list must be clearly marked with a coloured sticker indicating "Packing list inside". In case shipping documents are lost the receiving medical storage facility can still carry out the required inspection.

Copies of packing lists must be provided to the transport department for planning transportation or contracting transportation capacities.

A) Consignor (sender)

- Name of humanitarian organization.
- Address of medical storage facility.
- Date of issuing packing lists.
- Name of storekeeper responsible for packing.

B) Consignee (receiver)

- Name.
- Address.

C) Consignment

- Order reference number.
- Packing list number.
- Total number of parcels.
- Total weight.
- Total volume.
- Total value.

D) Parcels

- Parcel number.
- Weight.
- Volume.

E) Health care goods

- Item code.
- item description.
- Unit of measure.
- Manufacturer.
- Country of manufacture.
- Quantity (per batch).
- Batch number.
- Expiry date.
- Price.
- Parcel number (in which each batch is packed).

Table 30.24 Information required in packing lists

30.8 Cold chain equipment

Cold chain products such as vaccines, certain drug products and single use medical devices (for example diagnostic tests) require special cold chain equipment in order to maintain temperatures between + 2° to + 8° C throughout transportation and storage. In most cases maintaining this range of temperatures will require cooling but in very cold climate cold chain equipment may mainly be used for preventing freezing.

By selecting and purchasing only cold chain equipment from the list of equipment prequalified by the World Health Organization, humanitarian organizations can ensure that the equipment is of high quality, safe and reliable, has been thoroughly and rigorously tested, complies with WHO standards and is re-evaluated annually (WHO 2006b, 4).

All used cold chain equipment should be prequalified by the World Health Organization (WHO) and used according to the instructions given by the respective manufacturers. Disposable (one-way) insulated shipping containers which are used for (long-distance) international shipping should be disposed of after unloading and should not be reused in the country of arrival.

30.8.1 Cold boxes

Cold boxes (or vaccine cold boxes) are specially designed insulated containers which are lined with conditioned ice-packs in order to maintain internal temperatures of + 2° to + 8° C for up to 134 hours (at ambient temperatures of + 43° C) and are intended for transportation or temporary storage of cold chain loads.

The cold life is measured by stabilizing the temperature of empty containers at + 43° C, loading them with the type and number as well as in the configuration of frozen ice-packs recommended by the manufacturer, loading the maximum volume of cold chain goods which are pre-conditioned at + 5° C and maintaining a constant ambient temperature of + 43° C throughout the test. After closing the lid, the cold life is measured as the time from when the coldest (measured) point in the load passes - 3° C until the warmest (measured) point inside the cold box first reaches a temperature of + 10° C without opened the lid at any time (WHO 2008d, 7).

Short range cold boxes must have a minimum of 48 hours of cold life, a maximum of empty weight of 12.5 kg and a maximum loaded weight (including the recommended number of filled packs) of 35 kg.

Long range cold boxes must have a cold life of at least 96 hours, a maximum empty weight of 25 kg and a maximum loaded weight (including the recommended number of filled packs) of 50 kg.

The internal and external lining of most cold boxes is made from different types of polyethylene, must not be susceptible to degradation by ultraviolet light, and must be easy to clean as well as resistant to chemicals used for disinfection. A layer of 5 to 10 cm of insulating material, usually polyurethane, is sandwiched between the internal external lining of the entire casing, including the lid. Cold boxes must be designed to operate at ambient temperatures ranging from - 30° to + 55° C and at a relative humidity up to 95%.

Cold boxes must be able to accommodate a payload with a volume of 5 - 25 litres and must be square or rectangular in plan and (cross) section in order to minimize their surface and maximize their cold life. The internal dimensions should be compatible with any of the three standard sizes of packs but must achieve their full specified performance only with one standard size of pack. The overall design of the cold box as well as the placement of packs must allow the free circulation of air inside the cold box to minimize temperature stratification.

The lid of the cold box must be fitted with a captive labyrinth seal which engages with the container walls when the lid is closed in order to minimize cold bridging and maximize structural strength (WHO 2008d, 4).

The lid must be fitted to the body of the cold box with robust hinges which must be recessed for protection against damage during transportation and storage. The lid must open at least 90° in order to give full access to the interior of the cold box but complete opening with possible damage of the hinge must be prevented by a lid stay device.

When closed, the lid must be secured in the closed position by one or more catches which must not be able to open accidentally and which must be recessed to prevent damage during transportation and storage.

The outside of the lid and/or the front face of the body must be furnished with a non-removable, 10 cm wide square label reading: "STOP Do you need to open it!". The inside of the lid must be marked with the rated cold as well as cool life at + 43° C and indicate the number

as well as volume of required ice-packs and depict a loading diagram showing the recommended placement of packs.

The body of the cold box must be fitted with at least two hinged carrying handles which should be recessed and must automatically drop back into a vertical position when they are released. The carrying handles must allow lifting as well as comfortably carrying the fully loaded cold box. All metallic components must be corrosion resistant.

Short range cold boxes must be designed in a way that allows carrying in light vehicles, strapping to a luggage rack of a small motorcycle or carrying by a single porter or a pack animal. Long range cold boxes must be designed to allow transportation in vehicles or boats or carrying by two porters or pack animals.

The upper and bottom surface of cold boxes should be designed in a way which allows stable stacking of several units of the same model on top of each other in a safe way.

Cold boxes must withstand a one metre drop onto each face, edge and corner at its rated fully-loaded weight. The lid must still close and latch correctly and any damage which may have been caused must not affect performance of the cold box.

Cold boxes must achieve a maintenance-free life of at least five years, must be covered by a two year warranty and must be supplied with user and maintenance instructions.

Figure 30.15 Cold box

The selection of cold boxes depends on the required transportation (or storage) capacity, the required cold life and possibly depends on weight and volume limitations, for example for carrying or transporting on bicycles.

Ideally the cold life should be sufficient to cover the expected total time from loading the cold box or vaccine carrier until unloading at the destination as well as the time for return if transportation is interrupted, for example if an aircraft cannot land and has to return.

Type	Range	Model	External and internal lining	Insulation	Insulation thickness (mm)	Internal dimensions (cm)	External dimensions (cm)	Vaccine storage capacity (l)	Ice-packs (pcs / l)	Weight, empty (kg)	Weight, loaded (kg)	Cold life at + 43° C (h)
Large cold box	short	ACB-246LS	LLDPE	Polyurethane	65	19 x 48 x 48	37 x 65 x 65	16.0	24 x 0.6	14.8	36.0	83
Large vaccine cold box	long	ACB-316L	LLDPE	Polyurethane	100	28 x 37 x 52	52 x 62 x 77	22.0	31 x 0.6	21.9	49.5	174
Large vaccine cold box	long	ACB-503L	LLDPE	Polyurethane	100	28 x 37 x 52	52 x 62 x 77	23.3	50 x 0.3	22.2	47.5	141
Large vaccine cold box	short	LSR 50	HDPE / ABS plastic	Polyurethane	50	24 x 39 x 52	39 x 52 x 64	21.6	43 x 0.5*	10.3	37.3	100
Large vaccine cold box	short	TM35	Polyester / Polyethylene	Polyurethane	50	24 x 38 x 39	37 x 51 x 52	18.8	22 x 0.5*	4.3	16.6	63
Large vaccine cold box	short	TM52	Polyester / Polyethylene	Polyurethane	70	34 x 36 x 38	52 x 53 x 54	28.4	24 x 0.5*	5.9	20.5	76
Small cold box	long	ACB-264SL	LLDPE	Polyurethane	100	21 x 28 x 40	45 x 51 x 63	6.0	26 x 0.4	14.2	26.6	134
Small cold box	short	SLR 100	HDPE / ABS plastic	Polyurethane	95	17 x 32 x 45	39 x 52 x 64	9.0	22 x 0.5*	11.2	24.0	112

Table 30.25 Specifications of different types of cold boxes

Cold boxes are typically used to transport larger volumes of cold chain loads between medical distributions centres or from medical distribution centres to health care facilities. They can also be used as temporary storage in case of failure of ice-lined refrigerators.

The actual cold life of a cold box depends on its specifications, the thermal mass of its payload as well as the ambient temperature (profile) during transport and/or storage.

- Type and design of cold box or vaccine carrier.
- Type of insulation and foaming agent.
- Thickness of insulation.
- Gasket and whether lid is properly closed and secured.
- Number, type and thermal mass of ice-packs.
- Temperature of ice-packs at the time of loading.
- Extent of conditioning of ice-packs before loading.
- Thermal capacity of pay load.
- Ambient temperature during transportation or storage.
- Exposure to (sun)light during transportation or storage.
- Number and duration of openings (if any) during transportation or storage.

Table 30.26 Determinants of cold life of cold boxes and vaccine carriers

Dropping and knocks during handling, loading and transportation must be avoided as they can cause cold boxes to crack or break.

After use cold boxes and vaccine carriers must be thoroughly cleaned, wiped dry and stored with an open lid since otherwise they can become mouldy.

30.8.2 Vaccine carriers

Vaccine carriers are smaller, thermally insulated containers which are used for transporting smaller amounts of vaccines for a few hours or up to one day during out-reach immunization sessions, house-to-house immunization activities or transportation of cold chain loads over short distances.

Short range vaccine carriers have vaccine storage capacities of 0.5 to 3 litres, a cold life of at least 15 hours and must have a maximum empty weight of 2 kg and a maximum loaded weight of 2.5 kg. Long range vaccine carriers can hold between 1 and 5 litres of vaccines, have a cold

life of at least 30 hours (WHO 2008c, 4) and maximum empty weight of 4 kg and a maximum loaded weight of 7 kg.

Vaccine carriers should be square or rectangular in plan and (cross) section and must be fitted with an insulated lid. The internal dimensions must be compatible with at least one of the three standard types of packs and the design of the container must promote the free circulation of air within the container to minimize temperature stratification.

If lids are fastened to the body of the vaccine carrier with hinges, they must be recessed for protection during transportation and storage and it must be possible to open the lid beyond 90° for giving full access to the interior. However, hinges are not mandatory and in any case lids must fit securely to the body of the vaccine carrier to minimize cold bridges and maximize structural strength.

The lid must be secured in place with a magnetic or recessed mechanical catch or other closure devices which prevent accidental opening during transportation as well as opening when the vaccine carrier is dropped on its side or its lid. Vaccine carriers should be designed in a way which allows stacking them on top of each other safely and in a stable way. The outside of the lid and/or the front face of the vaccine carrier must be furnished with an (at least) ten by ten centimetre large non-removable label with the text "STOP Do you need to open it!". The inside of the lid must be furnished with a label indicating the number of packs and the respective rated cold life and cool life as well as vaccine transport advice.

Vaccine carriers may be fitted with a soft foam pad of at least 30 mm thickness which fits tightly into the neck of the respective vaccine carrier. The foam pad can serve as a temporary lid during immunization sessions and may have a maximum of 5 incisions for holding vaccine vials during immunization sessions. This avoids having to open the vaccine carrier every time a dose of vaccine is needed and keeps vaccines inside the vaccine carrier cool.

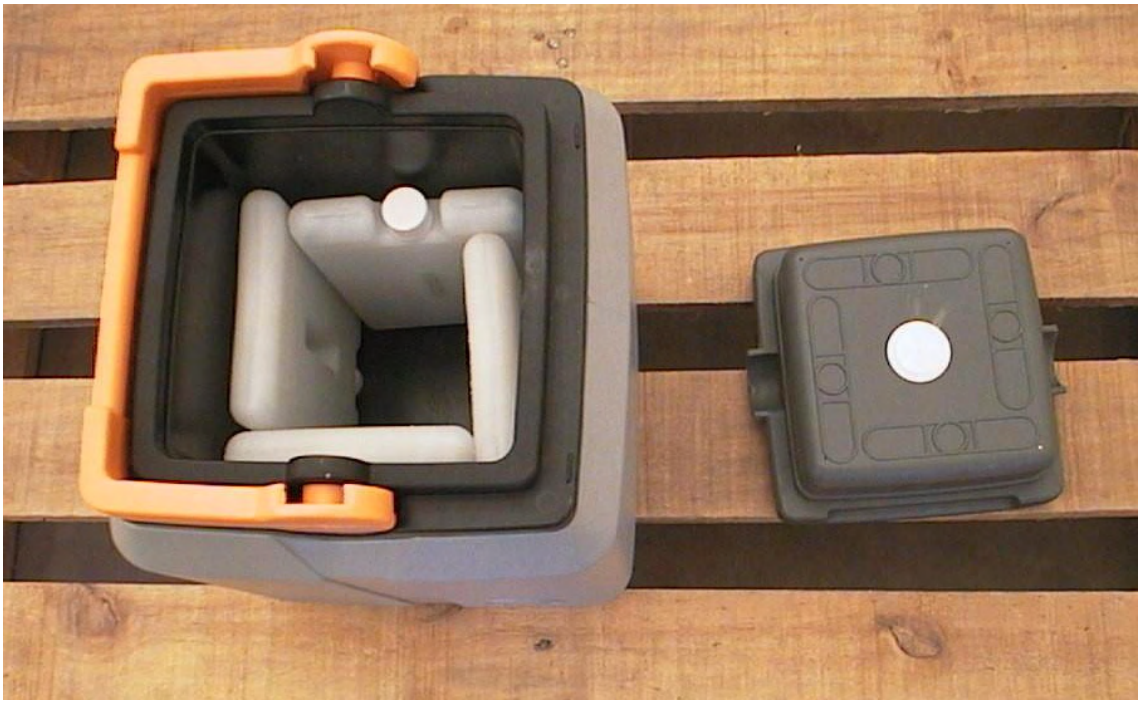

Figure 30.16 Vaccine carrier

Vaccine carriers must be fitted with a carrying device such as flexible or rigid handles attached to the container body, shoulder straps or adjustable padded straps for carrying as a

backpack. The design must allow fully loaded vaccine carriers to be carried comfortably and in an upright position for several hours.

Vaccine carriers must be designed for use at temperatures between - 30 and + 55° C as well as at a relative humidity of up to 95%. All external and internal surfaces must be resistant to degradation by ultraviolet radiation, be easy to clean and be resistant to chemicals used for disinfection. Any metallic components must be resistant to corrosion. Fully loaded vaccine carriers must withstand a one meter drop onto any face, edge or corner without causing any damage that affects performance and without opening the lid or latches. All products should be designed for a lifetime of at least 5 years, must be covered by a two year replacement warranty and must be supplied with written instructions.

The specifications of some standard vaccine carriers are given in table 30.27.

Type	Model	External and internal lining	Insulation	Insulation thickness (mm)	Internal dimensions (cm)	External dimensions (cm)	Vaccine storage capacity (l)	Ice-packs (pcs / l)	Weight, empty (kg)	Weight, loaded (kg)	Cold life at + 43° C (h)
Large vaccine carrier	Antifreeze backpack 7ltA	Honeycomb PP / aluminium bag	Airliner	34	19 x 20 x 34	27 x 29 x 40	3.0	8 x 0.6 + 2 x 0.4	1.4	7.9	37
Large vaccine carrier	Antifreeze backpack 7ltD	Polyester / aluminium bag	Airliner	34	19 x 20 x 34	26 x 27 x 38	3.0	8 x 0.6 + 2 x 0.4	1.2	7.7	31
Large vaccine carrier	AVC-44	HDPE / HIPS	Polyurethane	35/40	16.5 x 16.5 x 22	25 x 25 x 30	1.6	4 x 0.4	2.2	4.2	41
Large vaccine carrier	RCW4	Polyethylene	Polyurethane	25	16 x 19 x 26	29 x 30 x 37	3.0	1 x 0.6 + 6 x 0.3	3.3	7.6	26
Small vaccine carrier	ADVC-24	HDPE / HIPS	Polyurethane	32/36	10 x 12 x 17	18.5 x 21.5 x 25	0.9	2 x 0.4	1.4	2.4	20
Small vaccine carrier	AVC-24	HDPE / HIPS	Polyurethane	20/25	9.8 x 12 x 16	14.5 x 18.5 x 21	0.9	2 x 0.4	1.0	2.0	14
Vaccine carrier	Antifreeze backpack 4ltA	Honeycomb PP / aluminium bag	Airliner	34	15 x 15 x 15	24 x 25 x 25	1.0	5 x 0.4	0.9	3.3	35

Table 30.27 Specifications of different types of vaccine carriers

30.8.3 Packs

Packs are robust, flat, leak proof and rectangular plastic containers which can be warmed to room temperature (warm-pack), be cooled in a refrigerator to between + 2° to + 8° C (cool-pack) or be frozen to temperatures between - 20° to - 5° C (ice-packs).

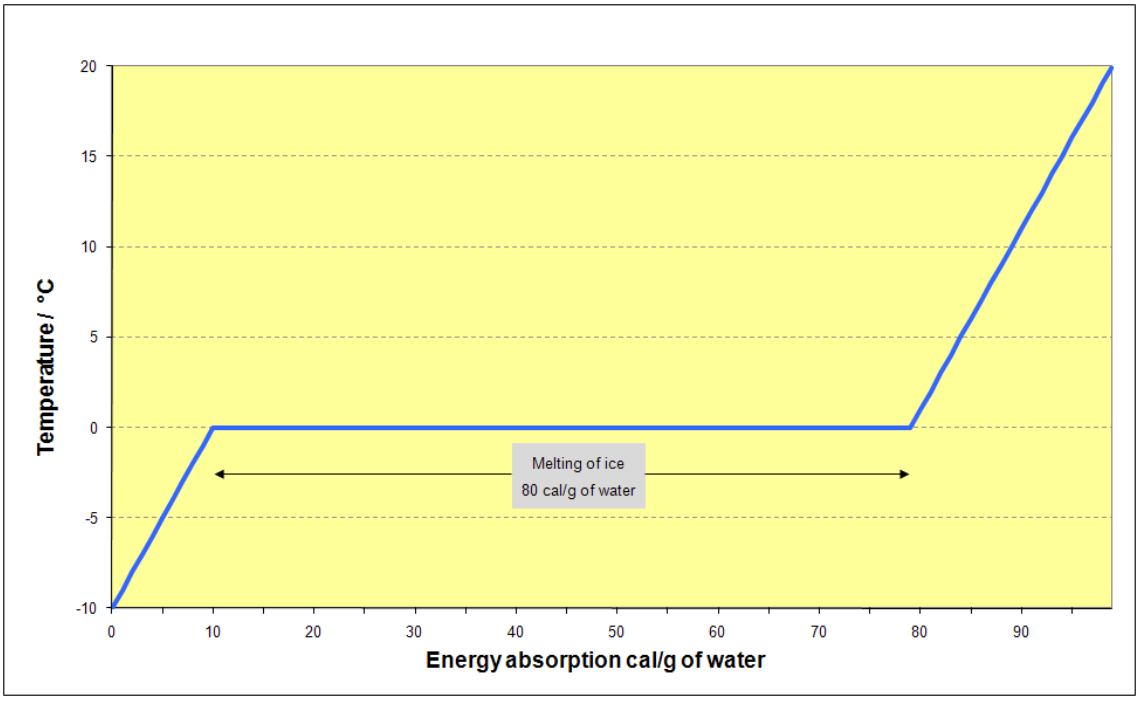

Figure 30.17 Latent heat of freezing

The thermal energy which is absorbed by ice during warming (1 calorie per gram per gram of water per degree Celsius) and especially the latent heat of fusion (see figure 30.17) absorbed

during melting (80 calories per gram of water) allow keeping loads cool in vaccine carriers and cold boxes.

The standard sizes for packs have volumes of 0.3, 0.4 and 0.6 litres (see table 30.28) and must be delivered empty by the supplier. In any case only the number and type of ice-packs specified by the manufacturer for the specific type of vaccine carrier or cold box must be used since otherwise the rated cold life is not ensured.

For every cold box or vaccine carrier at least two sets of ice-packs should be available to allow use of one set for cooling cold boxes or vaccine carriers while the second set is being frozen.

Type	Nominal size / L	Water contents within range / l	Dimensions (external)/ mm	Maximum weight (empty)/ g	Maximum weight (filled) / g
Type 1	0.3	0.25 to 0.30	33 x 90 x 162	80	380
Type 2	0.4	0.35 to 0.40	33 x 95 x 165	100	500
Type 3	0.6	0.55 to 0.60	33 x 120 x 190	120	720

Table 30.28 Specifications of standard ice-packs (WHO 2007d, 4)

Packs must be made from uncoloured, translucent plastic and must be resistant to degradation which can be caused by ultraviolet light. They must be easy to clean, have a lifetime of at least five years and allow environmentally safe disposal. A clearly visible fill line must be permanently marked on the face of every pack and it must be possible to check the water level inside the pack with the filling cap in place. The water level will reach the fill line when the pack is filled with the "rated water content" (WHO 2007d, 2) which is the volume of water at + 21° C in litres which the pack is designed to hold.

Packs must be filled with plain (but clean) tap water and be tightly closed with a removable filling cap. In order to reduce freezing time, cool rather than warm water should be used for filling.

Figure 30.18 Pack

Ice-packs should be filled exactly up to the fill line indicated by the manufacturer and in any case some air space at the top of the ice-pack must be left for allowing the water to expand during freezing. Filling with less water will reduce the thermal capacity of the ice-pack and

therefore reduce the cold life of the insulated containers in to which they are loaded while over-filling will inevitably cause bulging and possibly rupturing of ice-packs during freezing.

The original filling cap must be fit tightly on the ice-pack to prevent leaking of the water. After filling the ice-pack should be held upside down and squeezed to make sure it does not leak.

Ice-packs take a lot of time for freezing solid, approximately 24 hours (WHO 2004a, 89). The number of melted ice-packs which can be frozen at the same time should be limited to the quantity specified in the operating instructions of the ice-pack freezer. For freezing, ice-packs should be spaced apart in order to allow free circulation of cold air, if possible around all six surfaces.

In order to ensure proper rotation of ice-packs as well as preventing freezing to the wall, ice-packs should be placed loosely into (plastic) baskets with handles which fit into the freezer economically. This allows to separate melted ice-packs which are being frozen from solidly frozen ice-packs which will be used for loading. Ice-packs should be spaced 10 mm apart in the baskets in order to allow expansion. Moreover several ice-packs can be placed in or retrieved from the freezer quickly and without having to touch freezing cold ice-packs.

During freezing the thickness of packs laid flat on a flat surface must not increase by more than 25%, the (inevitable) expansion must be reversible when ice-packs are thawed and must not cause any lasting deformation.

Packs must be designed for use in ambient temperatures ranging from - 30° to + 55° C. They must withstand a drop from the height of one meter onto every face, edge and corner when frozen to - 20° C as well as at + 5° C with their contents being liquid.

Unfrozen ice-packs must withstand a lateral force equivalent to the force a weight of 80 kg exerts on either of the two main faces without leaking.

30.8.4 Temperature monitoring devices

Temperature monitoring devices (see table 30.29) are used for monitoring cold chain loads during transportation, storage as well as for monitoring the function of cold chain equipment.

Vaccine vial monitors are colour patches on labels attached to each vaccine vial, tube or neck of an ampoule by the manufacturer which contain heat-sensitive materials. Cumulative temperature exposure over time gradually and irreversibly darkens the colour patch, changing their shade from light to dark but changes in hue are not permitted (WHO 2006p, 3).

The label consists of a light coloured square (active surface) of at least 2 by 2 millimetres in the centre of a darker circle (static or reference surface) of at least 7 millimetres diameter. The time-temperature sensitivity of the active surface closely matches the stability profile of the respective vaccine to which the vaccine vial monitor is attached. Therefore vaccine vial monitors are generally more reliable and more indicative than cold chain monitor (CCM) which do not differentiate between different stability profiles.

The active surfaces of the four vaccine vial monitors (see table 30.30) differ in their reaction rates and are categorized by the number of days it takes to reach the end point when exposed to a constant temperature of + 37° C.

Type of temperature monitoring device	Monitoring range	Purpose	Cumulative	Recording interval	analogue/digital
Vaccine vial monitor	Different stability ranges depending on vaccine	Monitoring individual vials	Yes	continuous	analogue
Cold chain monitor	above + 10° C and + 34° C	Monitoring cold chain consignments	Yes	Continuous	analogue
Irreversible freeze indicator	below - 0.5° C	Detecting freezing	No	Continuous	digital/analogue
Electronic shipping indicator	- 30 to + 50° C	Monitoring cold chain consignments	No	less than 10 minutes	digital
User-programmable temperature data logger	- 30 to + 55° C	Cold chain studies	No	1 - 60 minutes	digital

Table 30.29 Temperature monitoring devices

At the "start point" the active surface has the colour at the time of manufacturing and being attached to the vial. The higher the temperature the faster the active surface darkens and vice versa. However, continuous exposure even to a constant temperature above the recommended storage temperature will also darken the active surface The "end point" (or "discard point") is reached when the colour of the active surface has darkened so much that it exactly matches the shade of the outer circle (reference surface). At this point the cumulative heat exposure has reached a level which is known to have degraded the vaccine beyond acceptable limits, vials must not be administered anymore and must be discarded. Additional exposure (exceeding the end point) will lead to further darkening and therefore VVMs with an active surface darker than the reference surface must also never be used.

Category of heat stability	Number of days to end point at + 37° C	Number of days to end point at + 25° C	Time to end point at + 5° C
VVM 30: High stability	• 30	• 193	• more than 4 years
VVM 14: Medium stability	14	• 90	• more than 3 years
VVM 7: Moderate stability	7	• 45	• more than 2 years
VVM 2: Least stable	2	• not applicable	• 225 days

Table 30.30 Stability ranges of vaccine vial monitors (WHO 2006p , 5)

The principal purpose of VVMs is to clearly indicate to logisticians and health workers when a vial has been exposed to a cumulative and predetermined amount of heat which no longer ensures an effective immunization and must therefore not be administered. Moreover among

vaccine vials with different levels of cumulative exposure to higher than the recommended storage temperature, the vial with the darkest active surface must be selected provided that it has not reached the end point yet (most exposed, first out).

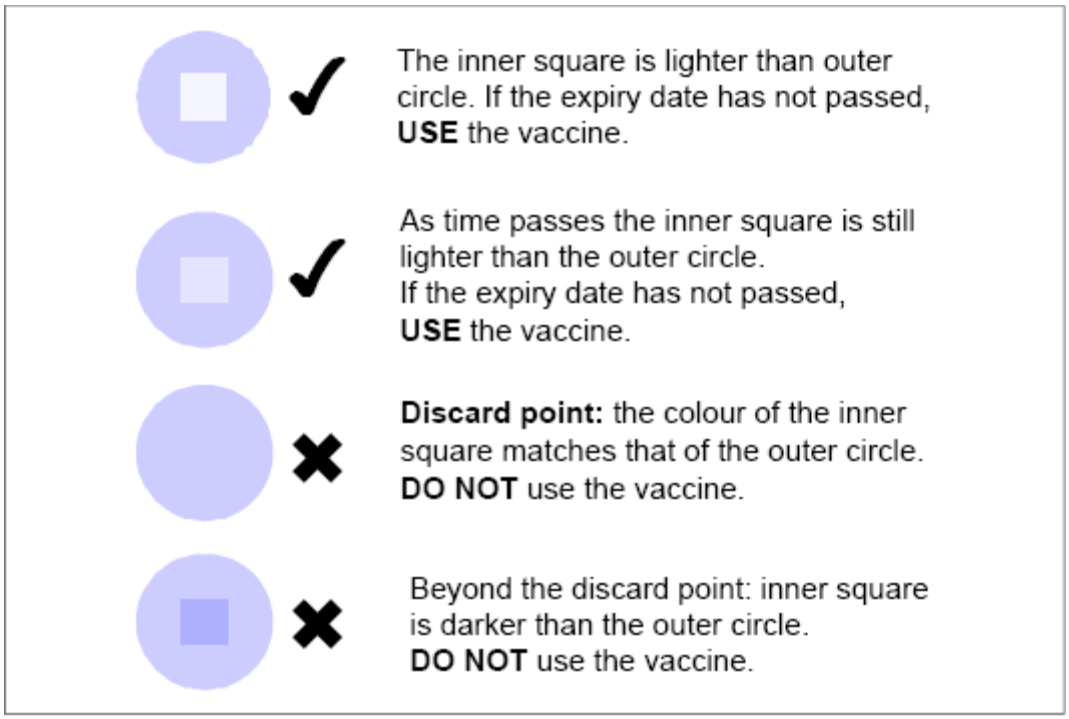

Figure 30.19 Stages of vaccine vial monitors (WHO 2002a, 3), *reproduced with the permission of WHO*

However, vaccine vial indicators do not at all indicate whether a vaccine has been frozen at any time in the supply network and therefore vaccines with VVMs before the "end point" do not guarantee that the vaccine has maintained its efficacy. Moreover, even if the vaccine vial monitor has not reached its end point, expired vaccines must never be administered.

Cold chain monitors (CCMs) are designed to, ideally, register cumulative exposure to temperatures above + 10° C monitors (WHO 2006d, 2) from the time of dispatch from the manufacturer until administration. However they may also be attached to each consignment of vaccines during intermediate stages of (international) transport or in-country transport lasting several days.

A time-temperature indicator which must be activated before use is attached to a card with printed instructions as well as a small table which allows recording the type of vaccine, dates and locations of receipt and dispatch as well as indicator readings. As glue as well as staples can damage indicator strips, detached indicators must be fastened only with adhesive tape.

As soon as activated, the first temperature-sensitive indicator strip gradually and irreversibly changes its colour from white to blue when exposed to temperatures above + 10° C. The colour change will stop as soon as the temperature drops below + 10° C again. In order to allow users to clearly distinguish three different stages the indicator is visible only through three equally sized and spaced windows labelled "A", "B" and "C". When exposed to a constant temperature above + 10° C the colour change spreads from left to right at a constant rate, eventually changing the colour of each window one by one from left to right. At a constant

temperature of + 12° C the colour change will take 14 days, while the colour change will take less time the higher the temperature is (see table 30.31).

The second temperature-sensitive indicator mounted behind the fourth window is labelled "D" and changes its colour irreversibly and gradually from white to blue when exposed to temperatures above + 34° C. Three hours exposure to + 37° C will change the colour of the whole window from white to blue.

Constant temperature	Window "A"	Window "A" and "B"	Window "A", "B" and "C*
+ 12° C	• 3 days	• 8 days	• 14 days
+ 21° C	2 days	• 6 days	• 11 days

Table 30.31 Temperature exposure and colour changes of cold chain monitors (WHO 2006d, 4)

The cold-chain monitor is entirely heat-stable as long as it has not been activated and no colour change must occur, regardless of the temperature to which it was exposed. In order to prevent the residual warmth of cold chain monitors from causing inadvertent but irreversible colour change after activation, cold chain monitors must be cooled to between + 2° and + 8° C in a refrigerator for at least 30 minutes before use. Before use the information indicated on the card must be filled in with a ball-point pen rather than a pencil or felt tip pen. Immediately before use the cold chain monitor must be activated, usually by pulling the tag and physically removing the trigger strip.

One cold chain monitor is then placed inside each cold box or vaccine carrier and remains together with the cold chain load until their final destination is reached. Upon receipt the four windows are checked and any colour changes must be immediately marked and recorded individually for each of the four windows. The cold chain monitor is then returned and remains with the consignment throughout storage in the ice-lined refrigerator as well as any further legs of transport until the last dose of vaccine is administered. However, the cold chain monitor should be kept in the refrigerator or cold box during immunization sessions and not be taken out.

It is important that the cumulative exposure to temperatures exceeding + 10° C is registered only for the time the cold chain monitor was kept with the consignment of vaccines. If the cold chain monitor is activated at the time of dispatch from the manufacturer, the temperature exposure is registered until administration of the vaccine and the readings are within acceptable limits, the cold chain was maintained and the vaccine can be used safely. However, if the cold chain monitor is used only during part of the life time of the vaccine, it might be spoilt even if the registered temperature exposure was acceptable as the temperature exposure before and after using the cold chain monitor are not considered.

Depending on the temperature stability of the different vaccines, the attached interpretation guide, which must include the start and end colour, informs users whether the vaccines can still be used or can only be used after testing. Consignments exposed to unacceptable temperatures must be withdrawn at any medical store and placed in quarantine until destruction or testing confirms the consignment can be safely administered.

Regardless of whether the colour of any of the windows has changed or not, expired vaccines must never be administered. The cold chain monitor also does not indicate or record any freezing which may destroy vaccines.

Once the cold chain monitor is removed from the consignment and kept in the medical store for documentation, the colour change will continue and the state of colour changes upon receipt will irreversibly be lost.

Irreversible freeze indicators detect and register exposure to temperatures of less than - 0.5° C lasting for at least 60 minutes during transportation or storage (WHO 2006j,). The electronic devices must have a battery life of at least 3 years and they must withstand five drops from a height of one metre onto a concrete floor.

The device can be supplied in an activated state or may be activated by the user. However, in any case the activation must be irreversible and it must be impossible to re-set devices. A steady or flashing light must indicate the activation and confirm that the battery is functioning. The LCD (liquid crystal display) must clearly indicate whether the freeze indicator has been exposed to freezing or not.

Indicators with phase change materials must irreversible change from a light to a dark colour rapidly and completely.

Electronic shipping indicators are used for measuring and registering temperatures of cold chain loads during transport in insulated containers (WHO 2006g, 3). They must have an operating temperature range between - 30° and + 55° C, an accuracy of at least ± 1° C and a resolution of at least ± 0.2° C. Devices must be pre-programmed with alarm settings at - 0.5° or + 10° C, + 30° C as well as + 45° C.

Logging start should be delayed for 60 minutes after activation by pressing the "start" button for allowing the temperature of the device to equilibrate with the temperature inside the ISO shipping container before recording starts. Logging intervals must not exceed 10 minutes, the devices must record temperatures for a minimum of 10 days and must retain data for at least six months after being stopped. The receiver must de-active the device by pressing the "stop" button which must be protected from inadvertent de-activation for example by a shifting load.

A LCD display screen must indicate activation status, overall alarm status, total elapsed transportation time and allow displaying a history of any registered alarms.

User-programmable temperature data loggers, with or without external sensors, are intended for carrying out cold chain studies (WHO 2006o, 3). Devices must have an accuracy of at least ± 0.5° C and a resolution of at least ± 0.2° C

Devices must be programmable with logging intervals between one minute and one hour and allow a logging start delay between 0 seconds and 30 days and are activated by a button. Users must be able to programme an upper and lower alarm temperature as well as alarm time delays for any temperatures within the operating temperature range. Devices must not be inadvertently de-activate and able to operate on replaceable or non-replaceable batteries for at least one year.

Devices with LCD displays must indicate that the device is activated, the battery is functioning, display the most recently recorded temperature and indicate whether the measured temperatures have exceeded set alarm limits. A LED (light-emitting diode) may indicate that the device is activated, the battery is functioning and whether an alarm condition has been met.

The accompanying software must, among others, at least allow to record the user name, set a logging start delay, set logging intervals, set upper and lower alarm limits as well as determine whether the device starts logging when the memory is full or continues logging by overwriting the oldest data.

Data downloaded from the device as temperature graphs as well as data tables must indicate time periods in seconds, minutes, hours or days according to the logging interval, indicate programmed alarm settings, data logger serial number as well as some basic statistics (minimum, maximum, average temperatures etc.).

30.8.5 Loading cold boxes and vaccine carriers

Loads must be packed only in cold boxes or vaccine carriers which comply with the WHO (World Health Organization) PQS (Performance, Quality, Safety) product performance specifications, have been inspected by accredited testing laboratories and are pre-validated (WHO 2004b, 13).

Cold boxes must clean and must be packed according to the manufacturer's instructions. Only the type and number of packs recommended by the manufacturer and fitting the respective cold box must be used.

The ice-pack freezer should be opened only as long as necessary for removing the basket(s) with the required amount of ice-packs. The removal of packs which were recently placed in the ice-pack freezer for (re)freezing or which are not thoroughly frozen yet must be avoided by ensuring rotation of packs.

In order to prevent freezing loads, frozen ice-packs must be thoroughly conditioned before being loaded in cold boxes. The ice-packs must be laid out in a single layer on a flat surface spaced 5 centimetres apart. The ice-packs are exposed to the room temperature until water droplets of condensate form on their surface and a coat of water surrounding the frozen inside of the ice-pack can be seen. The proper conditioning of each ice-pack must be checked by shaking it and listening for a gurgling sound.

Figure 30.20 Conditioning of ice packs

Cold boxes must be loaded and packed only immediately before their shipment in order to maximize the cold life of cold boxes. The type and number of conditioned ice-packs recommended by the manufacturer must be loaded into the cold box or vaccine carrier according to the manufacturer's instruction.

Finally, the load is placed inside the vaccine carrier or cold box. Whenever vaccines are packed, vaccine cold chain monitors must be activated and included in each cold box.

Cold boxes must not be overloaded or stuffed since otherwise they will not close properly. The gasket must be checked for its correct position before tightly closing the lid of cold boxes and securing them with catches. For vaccine carriers (without hinges), the lid must be tightly placed on the top and be locked into place by turning down the handle.

Cold boxes must be cleaned and wiped dry after every use as otherwise they well become mouldy, especially if the empty cold boxes are kept closed during storage.

30.8.6 Packing of specimen

Specimen of body liquids (for example blood or components), liquor cerebrospinalis, excreta or secreta which are collected for microbiological or other examinations at national laboratories must always be considered as infectious. In order to safely prevent accidental contamination of staff or means of transportation during transportation, such specimen must only be transported in specially designed, shock resistant specimen carriers. As some specimen require a cold chain, these portable containers together with the number of ice-packs recommended by the manufacturer must allow maintaining a temperature below + 4° C for at least 72 hours at an ambient temperature of + 43° C.

Specimen carriers must allow accommodating between 0.5 and 1.5 litres of specimen and 5 - 9 specimen kits (see table 30.32).

Type	Length / mm	Width / mm	Height / mm	Maximum weight (loaded)/ kg	Specimen storage capacity / l	Number of specimen kits (pots)
Medium	300	250	250	4	0.5 - 1.0	at least 5
Large	370	250	250	6	1 - 1.5	at least 9

Table 30.32 Specifications of specimen carriers (WHO 2005, 2)

Instructions for placement of the recommended number of standard ice-packs as well as the specimen pots must be attached to the specimen carrier.

Devices must be fitted with external lids which can be safely closed and remain closed during transportation even when subjected to accidental knocks and drops. All outer and inner surfaces must withstand chemicals used for disinfecting, "Disinfect thoroughly before re-use" should be printed on the internal side of the lid and the manufacturer must provide instructions for disinfection.

The external body should have a yellow colour and be marked (preferably embossed) with the international sign designating infectious material (see figure 30.21).

Specimen carriers should be fitted with handles and/or shoulder straps and permit stacking several containers easily in a stable stack. They must be robust enough to withstand a one

meter drop on every face, edge and corner and be designed for use at ambient temperatures between - 10° to + 45° C.

Specimen must be collected and packed by health professionals. Specimen carriers which are transported by air must be packed in compliance with the respective dangerous goods regulations.

Figure 30.21 International sign for infectious substances

Specimen must be placed in a water-tight receptacle, specifically designed for this purpose. The receptacle must be wrapped and surrounded with absorbent material (such as cotton wool) which can absorb the entire quantity of liquid in case the receptacle leaks, cracks or breaks. Where necessary, the specimen carrier is lined with the number of ice-packs recommended by the manufacturer before closing.

30.9 Staging of consignments

After completing packing, marking, labelling and weighing, all parcels belonging to the same consignment (same packing list number) are assembled in the dispatch area. It is important to clearly separate all parcels or pallets belonging to different consignments.

The efficiency of handling consignments during loading, transportation, transhipment as well as unloading at the recipient can be increased by grouping many parcels together on roll cage pallets, pallets or in ISO shipping containers. These unit loads can then be moved as an entity manually, with mechanical or powered materials handling equipment.

- Consolidation of parcels.
- Prevents parcels from falling off pallets during handling and transportation.
- Allows consolidation of parcels of odd sizes and shapes.
- Increased stability of stacks.
- Protection against humidity, dirtying and spray water.
- Discourages tampering with parcels.
- Tampering is more easily visible.

Table 30.33 Advantages of stretch wrapping pallets

Roll cage pallets are very convenient but unfortunately expensive and can be used only if their return to the medical storage facility shipping goods can be ensured.

The simplest and most convenient method is stacking master cartons on pallets and then stretch wrapping the loads on the pallets.

Stretch wrapping is inexpensive, can be carried out quickly with simple equipment and has many advantages (see table 30.33).

Advantages

- Efficient handling, movement, loading and unloading of a large number of parcels.
- Great reduction in loading and unloading time.
- Reduces number of staff needed for loading and unloading.
- Facilitates inspection (counting of pallets rather than parcels).
- Facilitates calculation and planning of required transportation capacities.

Disadvantages

- Requires materials handling equipment throughout the supply network.
- May reduce space utilization of means of transportation.
- Cost for returning pallets to sender.
- Cost for replacing pallets which are not returned to the sender.
- Pallets may not be returned to sender.

Table 30.34 Advantages and disadvantages of shipping entire pallets

Shipment of entire pallets rather than of individual parcels has many advantages but also some disadvantages (see table 30.34).

Where applicable, all consignments designated for the same consignee or destination are collected and stored together in the dispatch area.

30.10 Loading and dispatch

The warehouse manager or a storekeeper must supervise the loading of vehicles and first of all ensure that the right consignments are loaded on the right vehicle. The driver should also be present to count the number of parcels or pallets being loaded.

The order of loading must consider that the parcels loaded first will be unloaded last (first-in last-out). If several vehicles are loaded at the same time, the volume and weight should be balanced to avoid that one vehicle is overloaded with heavy goods while the other vehicle is loaded only with low density goods.

Consignments may be loaded as individual parcels or pallets. Individual parcels must be stacked crosswise in order to avoid the bottom parcels from being crushed. Heavy parcels should be loaded on the bottom and light parcels should be stacked on top. Inserting horizontal layers of plywood can reduce the risk of crushing significantly. Metal or timber beams can be placed at intervals from one side to the truck to the other to prevent goods from moving and slipping. Parcels can also be secured by straps or nets.

As far as possible, loads should be evenly distributed over the entire surface of the vehicle. The maximum loads of the entire vehicle as well as of the individual axles must be respected. Goods must not protrude over the sides or back end of the vehicle.

A) Consignor (sender)

- Name of humanitarian organization.
- Address of medical storage facility.
- Waybill number.
- Date of issuing waybill.
- Name of storekeeper responsible for loading.

B) Consignee (receiver)

- Name.
- Address.

C) Shipment

- Total number of parcels.
- Total weight.
- Total volume.
- Total value.
- Information on dangerous goods.

D) Consignments

- Order reference number.
- Packing list number(s).
- General description of consignment.
- Number of parcels.
- Weight.
- Volume.
- Value.

E) Transportation

- Name of driver.
- Name of carrier (transporting organization).
- Vehicle registration number.

Table 30.35 Information contained in a waybill

Crates and boxes with health care equipment should be strapped to the truck to prevent movement during breaking as well as damage caused by moving to and fro, rocking or toppling.

The vehicle doors must be firmly closed, locked and if possible sealed. Consignments loaded on trucks without rigid roofs, must be well protected from the dust, sun, rain and snow by appropriate fabric covers.

After completion of loading a detail waybill is issued for each shipment (see table 30.35).

From the time of loading, the driver is responsible for the entire shipment. With his signature on the waybill s/he confirms having loaded the number of parcels or pallets indicated on the waybill.

In case consignments are shipped across international borders, drivers must be provided with the respective customs documents.

All dispatched consignments must be carefully recorded in the goods outward register (see table 30.36).

After loading and completion of documentation, vehicles can be dispatched.

- Consecutive number.
- Date of dispatch.
- Carrier.
- Mode of transportation.
- Vehicle registration number.
- Name of driver(s).
- Name and address of consignee.
- Number of parcels.
- Total weight.
- Brief description of consignments.
- Signature of the storekeeper.

Table 30.36 Contents of goods outward records

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31 STOCK REPLENISHMENT

The importance of replenishing medical stocks correctly and timely cannot be overestimated.

A regular, rational and structured system for calculating safety stocks, order-up-to-levels and replenishment order quantities is needed at the level of health care facilities as well as at each distribution centre operated by humanitarian organizations.

Correct stock replenishment calculations are the single most important task of health care logisticians.

Irregular, delayed or erroneous stock replenishment calculations can lead to shortages and stockouts with subsequent urgent orders which require expensive premium transportation. Moreover patients may be treated inappropriately, suffer or even die because of the lack of essential health care goods. On the other hand incorrect calculations can lead to overstocks with the danger of expiry and waste of donor funding.

The calculations for replenishing stocks of health care goods are either carried out at regular intervals according to the review period or, in continuous review systems, whenever the inventory position drops below the reorder level. In particular contingency stocks should be replenished immediately whenever stock has been issued.

Calculating replenishment orders requires following a number of steps which are outlined in table 31.1.

A) Updating customer demand data

- Determining (updating) stock list.
- Updating customer demand data.
- Correcting customer demand data.
- Demand aggregation.

B) Collaborative planning and forecasting

- Updating customer demand data for demand forecast.
- Forecasting customer demand.

C) Updating elements of inventory control system

- Determining stock on hand by a complete physical stock count.
- Analysing remaining shelf-life of stock on hand.
- Updating stock on order.
- Updating backorders.
- Analysing replenishment lead time.

D) Preparing replenishment order

- Calculating order quantities.
- Adjusting order quantities.
- Prioritizing replenishment of items (stockouts and shortages).
- Managing items with excess stock.

Table 31.1 Steps in calculating stock replenishment orders

31.1 Updating customer demand data

Between subsequent stock replenishment orders usually customer orders will have been received and therefore customer demand data needs to be updated. Ideally all customer orders, their line items and ordered quantities will be recorded and updated in an information system and therefore updated customer demand would be available at any time.

The decision which items to permanently hold in stock and replenish regularly is critical and must not be overlooked. Existing stock lists need to be reviewed regularly to ensure that all essential health care goods but also only health care goods with regular demand are held in stock. However, frequent changes will cause demand distortion and lead to stockouts and overstocking.

Items of contingency stocks must be included in the stock list in order to ensure regular replenishment. The safety stocks of items used for regular assistance may cover stock levels required for contingency stocks which use the same items. Alternatively the items needed for contingency stocks are added to the stock list and replenished according to the imprest system.

Demand data should be collected from as far downstream in the supply network as possible. However, if demand data from assisted health care facilities is not available, at least the quantities from customer orders rather than stock issues must be used for demand forecasting and inventory control.

Ideally all assisted health care facilities provide a data sheet with the items and the total demand in the past, usually as monthly aggregates.

Customer demand data should always be collected and recorded as multiple of the smallest usable unit for example tablets, syringes or tubes etc. Packaging units must not be used as they are not relevant for forecasting and packaging quantities, even from the same supplier, may differ. Using (different) packaging sizes is a frequent cause of errors, miscalculations and large errors in calculating and forecasting values of donated health care goods.

The accuracy and reliability of customer demand data must be checked during collection. Data might be inaccurate because staff have not been trained and a certain error rate is inevitable where only manual records are being used. If donations by humanitarian organizations depend only on provided customer demand data, assisted health care facilities might feel encouraged to inflate numbers.

After collection, customer demand data needs to be reviewed and corrected if necessary (see table 31.2).

Although not recommended, if it is inevitable to use stock issues instead of end-user demand data, the respective corrections will have to be made for the medical storage facility itself.

Mistakes made during recording or calculations need be corrected. These may be difficult to detect if no further records or documents are available to crosscheck customer orders. However, often mistakes are made by adding or omitting a zero and sometimes such mistakes are obvious just by reviewing order quantities.

Customers may mistakenly order health care goods in packaging units rather than number of items. If an x-ray department orders three x-ray films it is obvious that they are actually ordering 3 boxes of 100 films.

Outliers are unusually high or low customer demands which are not indicative of future demand and must therefore be removed. Outliers, whether unusually high or low customer demand, will distort demand and therefore cause inaccurate forecasts, causing shortages or

overstocking. Outliers cannot be defined precisely but observations can be considered as outliers if they lie more than three standard deviations below or above the mean.

For example high demand could be caused by a clinic at a displaced camp distributing drug products for de-worming or by a vaccination campaign. Unusual low demand may be caused by assisted health care facilities receiving irregular donations from third parties. Outliers, high or low customer demand, can be caused by mistakenly using packaging quantities instead of the number of units.

Outliers, even if they are caused by genuine demand, should be removed from the time series if they are not expected to be indicative of future demand.

Expired, damaged, lost or stolen health care goods should not be recorded as demand in the first place, neither in assisted health care facilities nor in medical distribution centres. However, should such quantities (mistakenly) have been included, they should be removed from data.

- Mistakes in recording or calculations.
- Errors in converting packaging quantities and units.
- Outliers.
- Expired or damaged health care goods.
- Lost or stolen health care goods.

Table 31.2 Reasons for correcting customer demand data

End-user demand data received from health care facilities will usually already be aggregated over a week or a month. However, for example, weekly demand data may have to be aggregated for monthly unit time periods.

31.2 Preparing a demand forecast

Forecasting methods should not be changed frequently and must be changed only if there is a good reason.

However, wherever customer demand data is used for forecasting, data must be updated before generating and updating forecasts based on quantitative forecasting methods.

Ideally forecasts will be generated automatically by an information system. However these can use only more or less rigid algorithms while forecasting customer demand in humanitarian assistance usually also requires some judgemental forecasting.

Forecasts need to be corrected for expected changes in demand caused by changes of standard treatment protocols, increases or decreases of assistance to health care facilities or expected increases or decreases of demand caused by changing levels of conflict intensity.

Customer demand forecasts must be generated separately for each item of the stock list. Any parameters for quantitative forecasting methods should be changed only infrequently and only if really justified.

31.3 Updating elements of inventory control system

While the selection of appropriate inventory control systems and their parameters is a tactical decision which should not be changed frequently, the various elements need to be

updated before every replenishment order. Any errors in the stock on hand, stock on order or backorders will inevitably lead to false calculations and incorrect stock replenishment.

Determining the exact stock on hand of all stock list items by carrying out a complete physical stock count just before calculating stock replenishment orders is essential.

The expiry dates and remaining shelf-life of all items must also be checked at least once a month. This not only to avoid distribution of expired or very shortly expiring health care goods but also to ensure that shortly expiring health care goods are re-ordered on time. This analysis can be seen as a "forecast" for the stock on hand where batches of items expiring in the future are subtracted.

The quantities of any batches which expire in a time period of less than the desired remaining shelf-life upon distribution plus the review period and replenishment lead time, must be reordered. For example, 50,000 tablets of Penicillin, 500 mg with a remaining shelf-life of 6 months must be (re)ordered for stock replenishment if the desired remaining shelf-life upon distribution is 3 months, the review period is 1 month and the expected replenishment lead time is 2 months. From the time the expiry date falls to 6 months, it will take 1 month (in the worst case) to notice and 2 months to receive the replenishment order and the stock will just arrive at the time where the 50,000 tablets (now with a remaining shelf-life of only 3 months) have to be distributed.

The stock on order must be updated by comparing all past stock replenishment orders with packing lists of arrived consignments. Ideally these calculations are carried out automatically by the information system.

The stock on order records at any medical distribution centre should be compared with the backorder records of upstream medical distribution centres to detect any discrepancies.

Likewise the backorder record needs to be updated by cancelling any filled items from customer orders.

Depending on the inventory control system which is being applied, the replenishment (supplier) lead times may have to be updated for every item.

31.4 Preparing replenishment orders

After updating customer demand data, preparing a demand forecast and updating the elements of the selected inventory control system, the actual replenishment order can be prepared.

Regardless of the selected forecasting method, selected inventory control system and calculation of the order-up-to-level, the principle for calculating order quantities is the same for all line items (see equation 26.1). The order quantity is calculated by subtracting the inventory position from the order-up-to-level. As discussed earlier, the inventory position is calculated by adding the stock on hand to the stock on order and subtracting backorders.

$$Q_O = S - IP \qquad \text{Eq. 31.1 a}$$

$$Q_O = S - (SoH + SoO - BO) \qquad \text{Eq. 31.1 b}$$

$$\mathbf{Q_O = S - SoH - SoO + BO} \qquad \text{Eq. 31.1 c}$$

Of course an order is only placed if the order quantity is greater than zero. A negative order quantity means that inventory position is greater than the order-up-to-level and stock would need to be returned to the upstream medical distribution centre.

The calculation in equation 31.1 in principle also applies to fixed order quantity inventory control systems. If all transactions are unit sized the order-up-to-level is by definition s + Q and therefore the order quantity (Q_o) is always equal to the fixed order quantity Q. However, if the transactions are not (all) unit sized than the equation 31.1 does not apply and the order quantity does not require calculation but is Q by default.

In the special case of the imprest system, stock on hand as well as backorders are disregarded and can be considered as zero for the purpose of calculating replenishment orders. Therefore only the stock on hand needs to be subtracted from the imprest level, which is in fact the order-up-to-level.

Even where information systems are used to automatically generate replenishment orders, users must always have the possibility of a manual override (Silver, E.A., Pyke, D.F., and Peterson, R. 1998, 256).

The results of calculating order quantities are likely to be odd numbers. Although upstream distribution centres would anyway round odd numbers up according to multiples of minimum supplier packagings, calculated order quantities are usually rounded after calculation for different reasons (see table 31.3).

It should be noted that this rounding of order quantities will not cause any demand distortion as long as actual end-user demand is used for forecasting at all stages of the supply network. Even if end-user demand cannot be used for good reasons, the adjustment of order quantities is usually very small.

Although order quantities should not be reduced in order to decrease the value of the order, humanitarian organizations may have no choice if they lack sufficient funding.

In some cases the order quantities may be increased in order to benefit from quantity discounts. However, in these cases programme managers must still be able to make good use of the larger quantity which they will have at their disposal for assisting health care programmes.

The calculated order quantity of some line items may be increased in order to benefit from transportation economies and avoid wasting transportation capacities by filling up full truck loads or air cargo containers. Such capacities can usually be easily filled by ordering fast moving and bulky line items such as infusions or dressing material. In case of long distance road transportation, order quantities may be increased significantly in order to use larger vehicles in order to reduce transportation costs.

Shortages and stockouts must not lead to inflating calculated order quantities (Silver, E.A., Pyke, D.F., and Peterson, R. 1998, 276) as this can lead to demand distortion if the upstream medical distribution centre is not using end-user demand. Instead stock on order should be expedited

- Rounding of odd order quantities.
- Lack of funding.
- Opportunity of benefiting from quantity discounts.
- Benefiting from transportation economies and avoid wasting transportation capacities.

Table 31.3 Reasons for adjusting calculated order quantities

Before placing replenishment orders to upstream medical distribution centres, any backorders of non-stock items from customers, such as health care equipment or health care goods for special programmes should be added in order to consolidate orders.

Any stockouts and shortages of line items should be clearly indicated in the replenishment order in order to allow the upstream medical distribution centre to prioritize order treatment and shipment.

During review of the stock on hand any excess stock such as non-stock line items or overstock of stock list items should be identified. Health programme managers should be regularly provided with an updated list in order to decide on how to make best use of these stocks.

31.5 First order for establishing stocks

The calculations explained in the previous chapter equally apply for ordering for establishing new stocks or ordering a new item for the first time. However, as there is neither stock on hand nor stock on order, the order quantities will be large.

In principle there are two possible methods for establishing the required stocks. First, a single order with an order quantity corresponding to the order-up-to-level can be placed which will arrive after the lead time (see figure 31.1). Note that during the time between the initial order until after stock is issued, no replenishment orders are made and, except for the initial order, no stock is on order.

The advantage of a single order is the efficiency of purchasing or picking and packing and transporting a single consignment. The main disadvantage is that the time horizon for forecasting is long and no adjustments to the single order can be made even if forecasts change before distribution of health care goods begin.

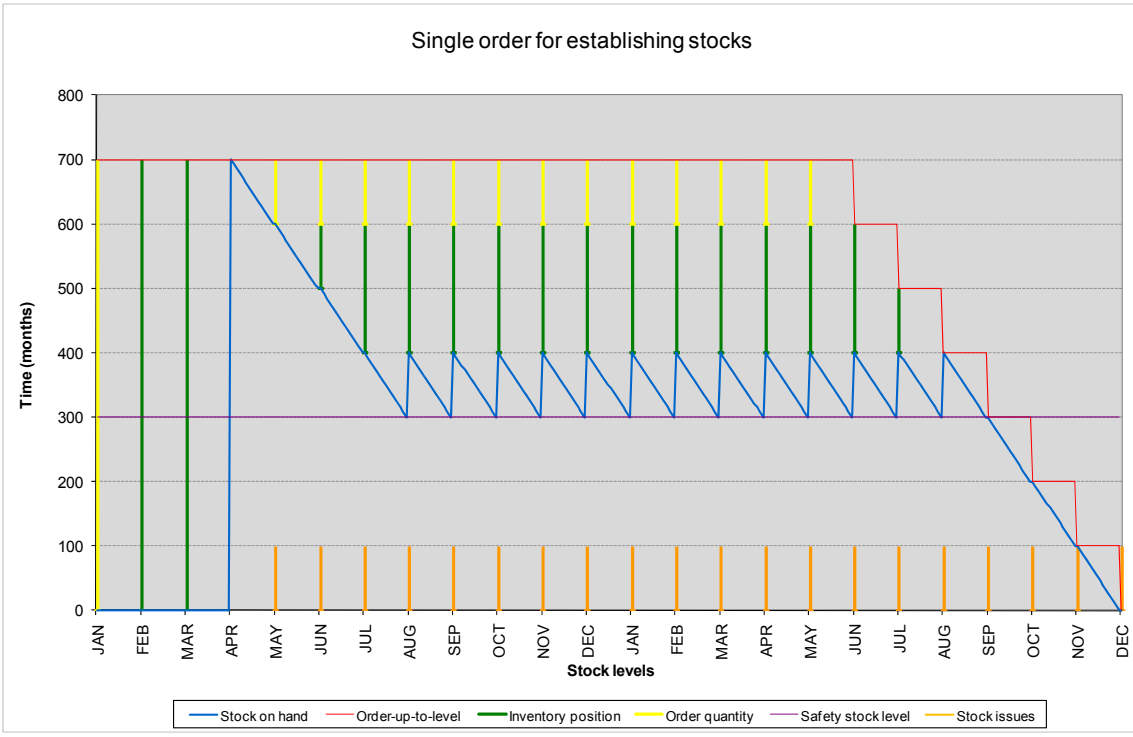

Figure 31.1 Single order for establishing stocks

Once the initial order arrives at the distribution centre, the stock on hand will rise far above the required safety and cycle stock. However, these higher stock levels are required to provide stock during the subsequent months when stock is issued but no stock is on order for monthly replenishment. In the example in below, the initial order will correspond to 7 months worth of

stock issues. Therefore health programme managers and donors must spend more than half of their annual budget upfront. This investment will not be returned until the programmes are closed which could be only years later.

The second possibility is starting placement of regular (monthly) orders in advance of the planned start of health programmes (see. figure 31.2). A small advantage could be that the order quantities can be adjusted every month in case forecasts of future demand change and that needs for funding are spaced out evenly.

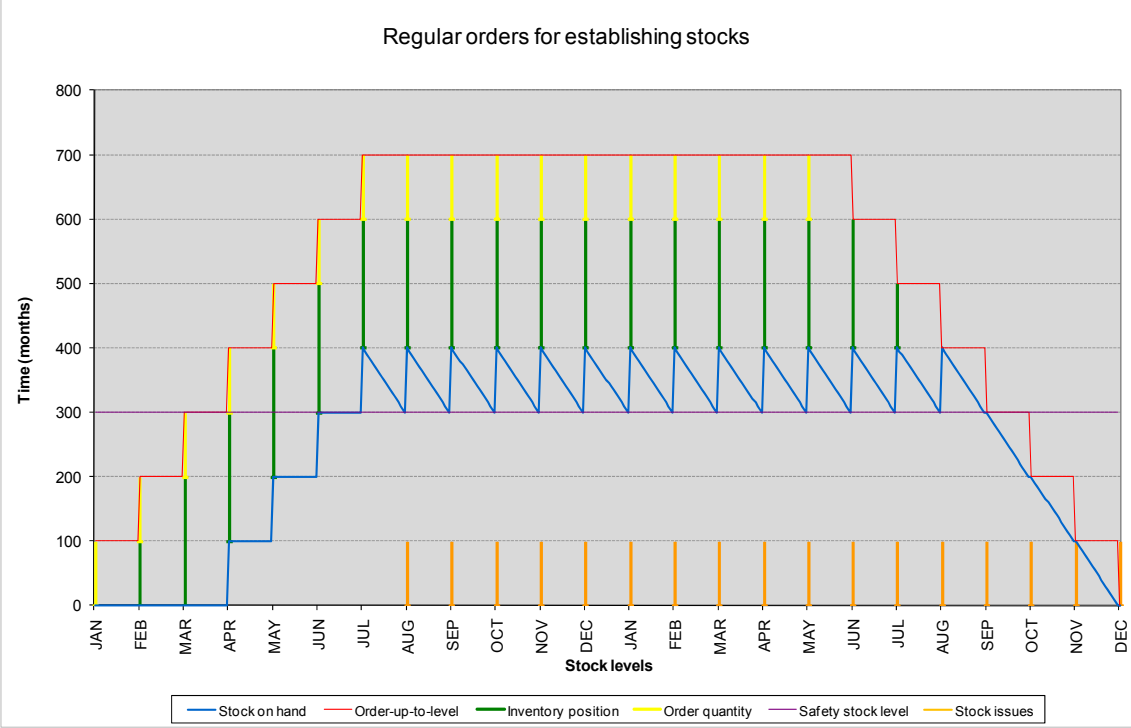

Figure 31.2 Regular orders for establishing stocks

However the need to place orders far in advance are a significant disadvantage. Ordering needs to start the number of months in advance which correspond to the order-up-to-level. While the previous method required considering only the expected replenishment lead time, the second method requires consideration of safety and cycle stocks. Moreover a large number of separate orders for the same items is highly inefficient.

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32 TRANSPORTATION AND DISTRIBUTION TO CUSTOMERS

Transportation of health care goods as well as materials for operational use are indispensable for establishing and sustaining humanitarian assistance programmes. International transportation is usually carried out by commercial service providers in a secure environment while transportation within crisis areas is subject to security and safety constraints.

Transportation costs can be very considerable, sometimes reaching or even exceeding the purchasing price of health care goods with low value densities such as infusion solutions. The overall of objective of transportation and distribution to final customers is minimizing security and safety risks as well as transportation costs while delivering health care goods by the due delivery date.

32.1 International transportation

Since high quality health care goods are not available in all countries where humanitarian organizations assist health care facilities, international transportation is needed in many cases to ensure supply of all essential health care goods.

32.1.1 Phases of international transportation

The process of international transportation can be separated into the three phases pre-carriage, main carriage and on-carriage (CIDA 2000, 3).

aPre-carriage covers packing and marking, issuing of packing lists, loading of consignments on vehicles at the supplier, international or regional distribution centre, (domestic) transport to the port of loading as well as unloading vehicles at the seaport or airport. Depending on the purchase contract and the applicable Incoterms, pre-carriage may be the responsibility of the supplier.

Main-carriage covers transportation from the port of loading to the final airport or seaport. The main-carriage, which is often outsourced to freight forwarders, concerns selection of freight forwarders, selection of carriers, possibly chartering vessels or aircraft, contracting marine surveyors, transportation from the port of loading to the final airport or seaport and unloading.

Humanitarian organizations may demand that their consignments are not transported together with military equipment in the same means of transportation (Lewis, Ch. 1999, 17).

On-carriage, or downstream carriage, covers inland transportation in the recipient country from the airport or seaport to the medical distribution centre or possibly directly to assisted health care facilities. This third phase concerns port operations (docking and unloading), customs clearance, storage at ports, assessment of damages and claims as well as inland transportation to the final destination.

Because of the often poor quality of port and transportation infrastructure as well as possibly inefficient customs clearance in the destination country, on-carriage is often the most critical phase in terms of security of consignments, effectiveness of transportation as well as cost.

32.1.2 Transportation in ISO shipping containers

ISO freight containers are steel framed metal boxes with two doors at one end which can fit and stack together to make up modular loads. They are mainly used for international and intermodal shipment of large consignments and eliminate the need for (multiple) handling of a large number of parcels or pallets. Containers can be transported on ships, barges, railway cars or trucks and the mode of transportation can be changed without the need for repacking consignments.

ISO shipping containers are sturdy, robust, provide excellent protection from possible mechanical damage and protect consignments from the environment (rain, dust etc.). ISO shipping containers also provide good protection against theft as their walls are made from corrugated iron sheets and their doors can be secured with padlocks and seals.

ISO Containers	Foot	Metre	Foot	Metre	Foot	Metre	Foot	Metre	Foot	Metre	Foot	Metre
Container type	40 foot		30 foot		20 foot		10 foot		6.5 foot		5 foot	
Outer length	40	12.19	30	9.14	20	6.10	10	3.05	6.5	1.98	5	1.52
Outer width	8	2.44	8	2.44	8	2.44	8	2.44	8	2.44	8	2.44
Outer height	8	2.44	8	2.44	8	2.44	8	2.44	8	2.44	8	2.44
Capacity/cube	2'260	64.00	1920	54.37	1130	32.00	565	16.00	367	10.39	282.5	8.00
Max. metric tonnes	30		25		20		10		7		5	

Table 32.1 Dimensions of ISO shipping containers

Figure 32.1 40 foot ISO Shipping container

In hot climates special refrigerated containers ("refer" containers) keep consignments cool throughout transportation on ships as well as trucks. Refrigeration units must be connected to an electric power supply on the vessel as well as trucks throughout transportation.

The main disadvantage of ISO shipping containers is that they require cranes or heavy duty counterbalanced forklift trucks for loading and unloading. These are usually available at ports but may not be available at the receiving warehouse for unloading.

The 20 foot and 40 foot ISO shipping containers are the most frequently used. A 20 foot container is equivalent to 1 twenty-foot equivalent unit (TEU) while one 40 foot container is equivalent 2 TEUs. The dimensions of the different sizes of ISO shipping containers is given in table 32.1.

The loading of ISO shipping containers is called "stuffing" while the unloading is called "stripping".

32.1.3 Parties involved in international transport

International transportation often involves a number of different parties and specialists, each with their own responsibilities.

The shipper is the person or organization sending consignments which may be the supplier or the humanitarian organization. The shipper may carry out transportation with his own means but usually outsources transportation to commercial carriers.

The shipper must make consignments ready for shipment and must give the consignee sufficient notice when the consignments will be ready shipment, when the consignments will be loaded and when they are expected to arrive at the airport or seaport in the destination country.

International freight forwarders may offer a wide range of services (see table 32.2).

- Receiving and inspecting consignments (before shipment).
- Packing and marking of consignments.
- Consolidation of consignments into a single shipment.
- Preparation of export declarations.
- Preparation of shipping documents (air waybills and bills of lading).
- Supervision of pre-carriage.
- Reservation of main-carriage space.
- Inspection of ships.
- Inspection of consignments at ports of loading and unloading.
- Customs clearance at the destination seaport.
- Inspection of consignments at the delivery point.
- Contracting on-carriage in the recipient country.
- Payment of carriers.
- Buying insurance coverage.
- Handling of transport claims.
- Submitting reports.

Table 32.2 Services provided by international freight forwarders (CIDA 2000, 19)

International freight forwarders may specialize in air or sea transportation and may offer their services only for transportation to certain countries.

When contracting international freight forwarders, their exact responsibilities such as the beginning and end of their mandate, date of taking charge of consignments, expected delivery

dates and proof of transfer of ownership must be clearly defined (CIDA 2000, 20). Freight forwarders must be provided with the exact destination, delivery address and contact person, the Incoterms of the purchase contract as well as shipping and export documents for the consignment.

Alternatively humanitarian organizations may directly charter aircraft through international brokers and organize pre-carriage as well as on-carriage themselves.

Transport companies are commercial organizations which either transport consignments with their own means of transportation or contract out transport to other commercial carriers.

The carriers are commercial organizations which carry out the actual, physical movement of consignments (transportation) with their own vehicles, aircraft, railway wagons or ships.

Marine surveyors may be contracted to act as an independent party for monitoring and supervising the transportation process (CIDA 2000, 30). They can certify that vessels are suitable for carriage, goods and consignments are correctly packed, supervise loading and unloading, inspect consignments at ports of loading and unloading, inspect consignments at the final destination as well as issue reports in case goods are damaged during transportation.

Insurance companies may be contracted for insuring consignments against damage or loss throughout the transportation process.

The consignee is the designated recipient of consignments, usually the medical distribution centre of the humanitarian organization in the recipient country or in some cases the assisted health care facility.

32.1.4 Shipping documents

Documents for international shipping are usually far more complex than domestic documentation and requirements differ according to the country where goods are exported to.

Providing freight forwarders, carriers as well as offices in charge of importation with complete and accurate shipping documents is essential in order to avoid unnecessary delays and possibly penalties during crossing international borders.

Often original shipping documents or copies must be sent to the receiving medical distribution centre for customs clearance and obtaining import permits as well as possibly exemption from taxes and duties prior to the arrival of goods.

- Packing list.
- Shipper's export declaration.
- Waybill.
- Air waybill.
- Ocean bill of lading.
- Commercial invoice.
- Certificate of origin.
- Insurance certificate.

Table 32.3 Commonly required shipping documents

In addition to customs clearance, in some countries detailed documents must be submitted to the national drug regulatory authorities of the Ministry of Health for obtaining an importation permit prior to arrival of health care goods.

A detailed packing list with the description, quantity, country of manufacture, manufacturer, expiry date (where applicable) and batch number of each line item is the basis of all documents. In addition the value of consignments is essential for insurance purposes, for calculating taxes and fees as well as for filing claims.

The shipper's export declaration may be a legal requirement for any consignment above a certain value.

Waybills indicate the type of goods, number of parcels, weight, volume as well as value and are used for road transportation.

Although the format and numbering system of air waybills have been standardized, each airline has its own air waybill which serves as a contract of carriage between shipper and carrier. The air waybill is prepared by the shipper and indicates details of the consignment, route, carrier as well as transportation charges.

Each carrier has its own bill of lading (B/L) form which serves as a contract of carriage between carrier and shipper and spells out legal responsibilities and liabilities of all parties to the shipment (Lambert, R.S., and J.R. Stock 1993, 700). The bill of lading, which indicates the details of the consignment as well as the consignee, can also be used to transfer title to the goods. This means that any person holding the bill of lading effectively owns the consignments and can claim them upon arrival of the vessel. Therefore the transfer of the bill of lading effectively transfers ownership.

Commercial invoices may be needed for clearing goods through customs at the destination.

The certificate of origin may be required by some countries for assessing duties and sometimes for statistical purposes.

The insurance certificate indicates the type and coverage of insurance for consignments.

32.1.5 Transportation insurance

Any internationally shipped consignments should be insured up to the final point of delivery for damage, loss or theft. Insurance is by no means automatic and depending on the purchase contract and the Incoterms, insurance may be the responsibility of the supplier, the carrier or the shipper.

Insurance companies may not be liable for losses or damages resulting from insufficient packaging of consignments.

32.1.6 Transportation claims

All consignments arriving at medical distribution centres must be inspected within reasonable time periods, depending on the size of consignments within hours or a few days. Depending on the insurance policy, insurers are only liable to compensate for any damage if claims are submitted within certain periods of time after arrival at the final point of delivery.

Submitting claims to carriers or insurance companies may require a detailed report from an independent surveyor which assesses, documents and certifies damages.

32.2 Customs clearance

Humanitarian organizations are subject to national laws and regulations and must therefore clear goods for exportation and importation like any other (commercial) organization. National customs authorities may grant temporary or even permanent exemption from duties, taxes and fees for importation of humanitarian assistance goods but humanitarian organizations are by no means entitled to this preferential treatment.

Effective and efficient customs clearance is absolutely critical for any humanitarian organization as any delays or even failure can stop entire humanitarian assistance programmes or even prevent them from starting altogether.

Cold chain consignments should always be given priority and should, wherever possible, be pre-cleared with customs.

32.2.1 Exportation

Exportation of humanitarian assistance goods must comply with national legislation and regulations in the country from where consignments are shipped.

In case of sanctions humanitarian organizations may have to apply for exemption and obtain permission for exportation.

32.2.2 Importation

Especially in acute emergencies staff and procedures must be in place before shipments arrive to ensure that they can be cleared from border crossing points, airports and seaports without delay.

In order to avoid possible damage during storage as well as accrual of fees and charges for consignments stored at ports awaiting clearance, consignments may be customs pre-cleared at the destination port. All necessary documents are sent to the importer by the exporter and consignments are cleared in the country of importation with customs authorities in advance. Only once permission for importation by customs authorities as well as national drug regulatory authorities have been granted, consignments are shipped by the exporter and can be released from customs immediately after arrival. Especially cold chain consignments should be customs pre-cleared to allow release from customs immediately after arrival. If cold boxes are not repacked on arrival or consignments are stored in refrigerators or cold rooms, cold chain loads may be damaged or destroyed.

Humanitarian organizations can either hire staff with good knowledge of importation procedures as well as experience in importation who clear goods or hire clearing agents who process documents and clear goods. In order to ensure safe and appropriate storage at ports during customs clearance, clearing agents must be reliable and competent in handling of health care goods as well as have appropriate storage facilities for health care goods.

At seaports various dues and charges may be levied. Stevedoring is the movement of goods from the ships hold to the first resting point on the quay. Wharfage charges are collected by the port authorities as fees for using the port infrastructure and facilities. Other charges may be accrued for handling and movement of goods, heavy lifting equipment for handling of ISO shipping containers as well as temporary storage at customs warehouses

Customs verification charges may be levied by the customs authorities for stripping and re-stuffing containers in order to verify their contents.

Demurrage which can be very considerable is charged for covering the cost of storage at ports and is due if goods are not collected within a defined period of time.

Consignments should be picked up from ports and transported directly to medical distribution centres by dedicated staff members as soon as customs clearance has been completed. Staff must be authorized to enter the respective premises of sea and airports and vehicles may also require special permits.

Humanitarian organizations must maintain complete and detailed files on every importation in case questions arise with the customs authorities.

32.3 Means of transportation

Apart from the use of small and heavy vehicles other means of transportation such as carrying, bicycles and motorcycles or small boats need to be considered as possibilities for distribution of health care goods.

32.3.1 Non-motorized transport

At least for short distances, human portage (see table 32.4) can be considered (Quick, J.D. (ed.) 1997, 396 and Starkey, P., et al. 2002, 56).

Means of transportation	Maximum payload (kg)	Maximum volume (m^3)	Maximum speed (km/h)	Maximum range per day (km)
Porter (carrying)	• 25 - 35	• 0.25	• 5	• 20
Wheelbarrow	• 100	•	• 4	• 1
Handcart	• 100	•	• 4	• 5
Standard bicycle	• 20 - 60	• 0.25	• 10 - 20	• 20 - 60
Load-carrying bicycle	• 25 - 100	• 0.35	• 10 - 15	• 30 - 40
Bicycle with trailer	• 150	• 0.5	• 10 - 15	• 30 - 40
Tricycle	• 150	• 0.5	• 10 - 15	• 30 - 40

Table 32.4 Transportation capacities of non-motorized transport

If vehicles are not available or the terrain does not permit the use of motorized vehicles, animal portage (see table 32.5) can be considered (Starkey, P., et al. 2002, 56 and Leonard, A.G. 1894).

1,500 donkeys trek aid to Darra Souf

In 2000 the United Nations used a convoy of 1,500 donkeys to deliver humanitarian assistance goods such as tents, blankets and food to 5,000 families who had fled conflict in a remote and snowed-in area in Northern Afghanistan which was inaccessible by road vehicles (UNOCHA 2000).

Parcels may require special packaging such as wrapping with plastic foil to protect health care goods from dust and rain. Two parcels carried on either side of a pole or a beast of burden must be balanced to even out their weight. Large consignments may need splitting into a large number of smaller parcels with defined maximum weights.

Means of transportation	Maximum payload (kg)	Maximum speed (km/h)	Maximum range per day (km)
Donkey	• 80	• 5 - 7	• 20
Donkey cart	• 400	• 6	• 15
Horse cart	• 1,000	• 7	• 15
Ox cart	• 1,000	• 5	• 10
Camel	• 100 - 250	• 4 - 13	• 30 - 100
Elephant	• 200 - 400	• 3 - 6	•
Animal-drawn cart	• 500 - 3,000	• 5	• 20

Table 32.5 Transportation capacities of animal portage

32.3.2 Road vehicles

For domestic transportation, road vehicles of various capacities (Quick, J.D. (ed.) 1997, 396 and Starkey, P., et al. 2002, 56) are the most common means of transportation in humanitarian assistance (see table 32.6). Depending on the criteria pointed out in chapter 11 and chapter 20 transportation can be carried out with own vehicles or be outsourced to commercial carriers.

Among different available vehicles the most appropriate and the most cost efficient should be selected for each delivery according to various criteria (see table 32.7). Vehicles must have sufficient capacities but should not be too large to avoid wasting fuel.

Selection of suitable road vehicles will first of all depend on the total weight and volume of shipments. Some health care goods such as infusions or other liquids are very heavy while others such as cotton wool or syringes are light but bulky. Some countries limit the maximum weight which can be loaded on vehicles as well as maximum axle weights as high axle loads lead to disproportional damage of roads.

Especially for health care equipment the dimensions of the largest parcels must be taken into consideration.

Wherever possible, complete stretch wrapped pallets of palletized consignments should be loaded rather than loading them manually parcel by parcel. However vehicles must allow loading of entire pallets either from the side or from the back.

The required conditions during transportation are an important criteria especially for long distance transportation. Shipments which require protection from high or low temperatures should be transported in rigid vehicle bodies which allow cooling or heating.

Means of transportation	Maximum weight (kg)
Motorcycle	• 50 - 100
Motorcycle and sidecar or tricycle	• 200 - 300
Single-axle tractor and trailer	• 1,000 - 1,500
Four-wheel drive vehicle	• 700 - 1,000
Pickup	• 500 - 1,200
Light duty truck (2 axles)	• 5,000 - 8,000
Medium duty truck (3 axles)	• 10,000 - 14,000
Heavy duty truck / semi-trailer	• 30,000
Truck with trailer	• 30,000 - 40,000

Table 32.6 Transportation capacities of road vehicles

Poor road conditions may make use of all-terrain vehicles (four wheel drive) compulsory and limit the size of vehicles which can be used. Roads are often not paved or asphalted or the asphalt concrete ("tarmac") is damaged resulting in worse roads than without any road surfacing. Only dirt or gravel roads or sometimes no proper roads at all may be available.

Finally availability of suitable fuel along the transportation route, especially for long distance transportation, must be considered.

- Total weight of shipment.
- Total volume of shipment.
- Dimensions of large parcels.
- Load unitization and means of loading.
- Protection of goods during transport (cooling and heating).
- Distance of transportation.
- Road conditions.
- Type of fuel available on the transportation route.

Table 32.7 Criteria for selecting types of road vehicles

32.3.3 Watercraft

In remote areas with dense forests, absence of road infrastructure but rivers and lakes or in coastal areas the use of boats, ships, ferries, rafts or barges may be the only feasible means of transportation.

Type of water craft	Maximum capacity / tonnes
Canoe (rigid)	• 0.100 - 0.8
Rowing boat (rigid)	0.500 - 1.2
Sailing boat / Dhows	0. 1 - 100
Motorboat	0.1 - 1
Barge	up to 1.500
Boat (inland and coastal waters)	500 - 15,000
Ship (ocean going)	up to 200,000

Table 32.8 Transportation capacities of watercraft

32.3.4 Railway

Reliable rail networks and services are rarely available in less developed countries but, due to their high transportation capacities (see table 32.9) can be a very cost efficient means of transportation.

Means of transportation	Maximum volume / m^3	Maximum capacity / tonnes
Railway car for cargo	• 50 - 100	• 30 - 70
Train (with up to 30 railway cars)	2,000 - 4,000	1,000 - 3,000

Table 32.9 Transportation capacities of rail transport

A covered goods wagon must be used in order to protect consignments from the environment.

32.3.5 Aircraft

Managing aircraft requires professional training, expertise and experience. The following sub-chapter will only discuss some operational issues and constraints which are important for general logisticians to understand.

All logisticians and other staff involved in managing or using aircraft must above all consider security and safety of crew, passengers, any staff handling aircraft as well as of the aircraft itself as their first priority.

Aircraft must be properly maintained by their operators, must be registered with the authorities in the country or countries of operation and hold a valid certification of airworthiness.

The security of crew, passengers, aircraft and cargo must be ensured by the operator together with the humanitarian organization. Even on remote airfields and airstrips basic fire fighting and first aid equipment must be available.

Aircraft are usually chartered for a specific flight or contracted for a certain number of flying hours per month.

If the number of pilots available to fly a specific aircraft is limited, two important limitations need to be considered. According to international regulations, crew can only spend a limited number of hours per day as well as per week physically flying an aircraft. Sometimes certain activities before and after flights are also counted.

The crew duty time which includes time for flying an aircraft or standing by for a flight, for example during a stopover between two legs of a flight, is also limited.

For planning weekly or monthly available flying hours of an aircraft, downtime due to maintenance, days off for crew as well as the possibility of poor weather conditions must be considered. Moreover aircraft might be restricted to flying during daylight only or restrictions on the earliest time of take-off and the latest time of landing might be imposed by the authorities.

Each flight must be manifested and detailed statistics on aircraft movements, legs, number of transported passengers, weight and volume of transported cargo, flight time and fuel consumption must be maintained.

Aircraft type	Required runway length / m	Cruising speed / km/h	Maximum payload / kg	Maximum payload volume / m3
Cessna 185	2,593	241	408	
Cessna 206	2,778	241	499	
Helio Courier	1,130	241	544	4
Turbo Porter	1,148	263	635	3
Cessna 207	3,519	241	1,134	10
Caravan	3,519	315	1,134	10
DHC-6 Otter	3,519	296	1,588	14
Skyvan	2,778	241	1,588	22
Casa C-212	4,630	361	1,814	

Beach 99	3,241	417	2,268	
F-27 (Foker)	11,112	444	3,402	56
Dash 8	5,000	463	3,856	40
Dash 7	4,074	417	5,126	59
F-28 (Foker)	9,630	704	6,804	96
C-130	5,556	519	11,340	57
L-100 Hercules	7,964	541	23,156	127
L-188 Electra (Lockheed)	11,112	574	14,515	105
B-727-100	12,964	917	15,876	229
DC-9	12,964	833	15,876	127
Transall C-160	6,112	833	16,783	139
L-100-20 Hercules	8,334	509	16,783	150
C-141B Starlifter	11,668	759	41,222	170
L-100-30 Hercules	7,964	519	18,144	172
B-727-200	15,372	917	24,948	229
DC-8-51F	14,816	889	27,669	
Ilyushin IL-76	5,186	796	34,019	235
B707-320C	14,816	833	36,287	170
DC-8 61F	14,816	889	37,648	
DC-8 70F	14,816	889	38,555	
C-17 Globemaster	8,334	759	40,823	592
DC-8 63F	14,816	889	42,638	
DC-8 54F	14,816	889	43,454	
DC-8 55F	14,816	889	43,998	
DC-8 73F	14,816	889	46,266	

C-5 Galaxy	14,260	783	58,967	368
B747-100	17,409	907	101,151	588
B747-200	19,816	907	103,873	628
Antonov 124	18,520	833	136,078	850

Table 32.10 Transportation capacities of fixed wing aircraft (modified USAID 1998, VI-17 ff.).

Helicopter type	Cruising speed / km/h	Maximum internal payload / kg	Maximum external payload / kg
Hughes 500C	232	318	408
Hughes 500D	232	318	408
Hiller FH 1100	194	318	408
B-206B (Jet Ranger)	204	345	413
Bell G-47	139	363	454
Allouette II SA 318C	176	408	590
B206L (Long Ranger)	204	440	440
A-STAR	232	499	635
Allouette III	204	635	726
Lama SA 315B	185	635	635
B-204 (Huey)	185	1,179	1,406
B-205 (Huey)	185	1,179	1,406
B-212	185	1,179	1,406
B-214	185	1,361	3,175
BV-107 ("Vertol")	232	3,175	4,082
BV-234 (Chinook)	241	10,206	10,206

Table 32.11 Transportation capacities of helicopters (modified USAID 1998, VI-20).

In case of a choice, the selection of aircraft will depend on the weight and volume of consignments, the size of individual parcels as well as the distance to the destination. Some indicative data on aircraft are given in tables 32.10 and 32.11.

The maximum permissible pay load must be determined by the pilots in advance in order to prepare the cargo accordingly. Pilots must be provided with detailed packing lists indicating the exact weight and volume of cargo.

Permission for flights might have to be obtained from the authorities, possibly the military as well as conflict parties in due time. In any case a detailed flight plan must be filed with air traffic service units. Flight plans must, among others, indicate the aircraft's identity, type of aircraft, point and time of departure, flight route and altitude, destination, estimated time of arrival as well as the alternate airport in case landing at the destination is not possible (ICAO 2006, Annex 2).

The maximum pay load an aircraft can carry on a specific flight depends on a variety of factors (see table 32.12).

The maximum total take-off weight as well as the maximum pay load of an aircraft rated by the manufacturer is an absolute limit that cannot be exceeding under any conditions or circumstances.

The maximum weight of the aircraft and therefore the maximum pay load will be reduced if the available length of the runway at either the place of departure or destination is shorter than required for take-off with the maximum rated weight of the respective aircraft. Likewise poor conditions of runways will reduce the maximum pay load.

The flight distance as well as the estimated length of the flight will determine the fuel requirements which in turn will determine the maximum pay load. As the total weight of the aircraft is limited, the more fuel is required the less pay load can be lifted.

The amount of fuel loaded at the place of departure will also depend on whether refuelling is possible along the planned flight route, either during scheduled stops or during planned landings for refuelling. In the worst case the aircraft will have to carry fuel for the entire flight route which will in turn reduce the maximum pay load.

Pilots must always load sufficient fuel for reaching an alternative airport or airstrip or even returning to the place of departure in case of an emergency or if landing at the destination airport is, unexpectedly, not possible for example because of poor security or poor visibility.

The maximum pay load depends on the altitude (elevation above sea level) of the place of departure and destination. The density of air decreases with increasing elevation and less dense air provides less aerodynamic lift to aircraft.

The maximum pay load also depends on the ambient air temperature at the places of departure and destination. Cooler air is denser provides more aerodynamic lift to aircraft than warmer air. For this reason some aircraft may only be able to take-off during the night.

The maximum pay load also depends on the direction and speed of winds.

The number of passengers booked on the same aircraft will also determine the maximum pay load. The possibility of last minute changes of passengers should be taken into consideration.

For the overall planning all requests for transporting cargo between the various destinations of the aircraft along the entire route must be considered. In the worst case, the aircraft will have to depart without any cargo in order to have enough fuel and cargo capacity to carry cargo between two other legs of the same route.

- Maximum rated total take-off weight of aircraft.
- Maximum rated pay load of aircraft.
- Length of runway or airstrip.
- Condition of runway or airstrip.
- Distance between places of departure and destination.
- Estimated flight time.
- Availability of fuel along the route.
- Distance of alternative airport in case of emergency or impossibility to land at destination airport.
- Altitude at departure and destination location.
- Air temperature at departure and destination location.
- Direction and speed of wind.
- Number of passengers.
- Cargo scheduled between stops along the flight route.

Table 32.12 Factors influencing maximum pay load of aircraft

Loading and unloading of aircraft must be carefully planned. A sufficient number of vehicles of sufficient capacity as well as enough handlers must be available for quickly and efficiently loading and unloading aircraft.

All cargo with the necessary documentation must be ready at the airport or airstrip before the aircraft arrives or is ready for loading. Any delays in loading will reduce available flight time and are therefore expensive.

All cargo must be consolidated and packed in medium-sized and handy master cartons which allow rapid loading and unloading. Each parcel must be small enough to fit through the (cargo) door otherwise repackaging will cause unnecessary delays.

Each parcel must be marked individually with its exact weight to allow re-calculation of the weight of loaded in cargo in case cargo has to be left behind or has to be unloaded at another than its final destination. The weight of each parcel should be limited to 25 kilograms to allow handling by a single person, especially when parcels have to be moved and stacked inside the aircraft.

Each parcel must be marked individually with its final destination, especially when cargo is loaded and unloaded at several destinations on the flight route.

The pilot takes the final decision on all matters concerning the aircraft. On large cargo aircraft load masters may be responsible for loading and unloading. Therefore any instructions concerning loading or leaving behind cargo or passengers must be followed.

During loading safety of staff as well as the aircraft must be the main concern. Fixed wing aircraft must not be approached while propellers are rotating. Helicopters with still rotating blades must be approached only after receiving permission from the pilot.

Aircraft must not be accidentally damaged by goods, staff or (reversing) vehicles. It is prohibited to place any goods or equipment on aircraft wings or any other parts. Staff must refrain from sitting, or even leaning, on any aircraft parts.

Aircraft must be loaded quickly and efficiently to avoid unnecessary delays of departure. The time aircraft spend on the ground for loading and unloading must be paid for and missing allocated slots for take-off can lead to long and costly delays.

Parcels containing dangerous goods must be clearly marked individually. Pilots must be explicitly informed of any dangerous goods which are being loaded and must be handed the respective documentation.

Pilots or other crew members are responsible for opening and closing aircraft doors which may be damaged by incorrect operation.

Aircraft must never be overloaded under any circumstances. There is no "emergency" which justifies risking the safety of crew, passengers and aircraft.

Never, under any circumstances, overload an aircraft.

Fixed wing aircraft can be loaded in bulk, with aircraft pallets or containers and helicopters can be loaded in bulk or externally.

In bulk loading parcels are placed on the floor of the aircraft or stacked on other parcels one by one manually and secured with ropes, straps or nets in order to preventing shifting of loads (and therefore the centre of gravity) during take off, manoeuvring of the aircraft and landing.

Bulk loading has the advantage that the aircraft space can be filled in order to make full use of available cargo capacity and that no materials handling equipment is required. However loading and unloading is very slow. Moreover mixing of parcels from different consignments is inevitable and consignments have to be re-sorted after unloading.

Alternatively cargo can be arranged on special aluminium aircraft pallets and secured with ropes, nets or straps before loading. Standard (stretch wrapped) EURO pallets can be arranged efficiently on some aircraft pallets and therefore eliminate the need for re-palletizing cargo. The height of the load must limited according to the respective aircraft. However, provided the total cargo weight does not exceed the maximum pay load, pallets should be stacked to the maximum height allowed to maximize space utilization of the aircraft.

Subsequently entire aircraft pallets can be quickly loaded and unloaded with counterbalanced forklift trucks. The availability and functioning of materials handling equipment at the destination airport must be ensured. The equipment must be low enough to fit under open cargo doors but allow lifting loads high enough to reach cargo doors. Counterbalanced forklift trucks must have a sufficient capacity to lift entire aircraft pallets and the forks must be long enough to handle the respective aircraft pallets. Otherwise suitable materials handling equipment must be loaded in the back of the first aircraft.

Cargo can also be stacked on aircraft pallets in the aircraft but loading times will far longer than for pre-loaded aircraft pallets. Aircraft pallets must eventually be returned to the owner.

The use of aircraft pallets does not allow maximizing utilization of the available cargo volume. However loading of the aircraft is likely to be limited by the weight and not by the volume.

Cargo can also be pre-loaded in special aircraft cargo containers which can be directly loaded onto commercial aircraft. Cargo containers come in a large variety of different sizes and shapes and require special materials handling equipment or at least a counterbalanced forklift truck for loading and unloading.

Loading cargo into containers is difficult and time-consuming and materials handling equipment for unloading containers at the destination airport may not be available.

Some helicopters allow carrying loads externally in nets suspended below the aircraft, called "slinging". Pre-loaded nets which may be suspended on cables (lead lines) can be quickly attached or detached to a belly hook on the underside of the helicopter.

The use of nets allows loading and unloading cargo much faster than manually loading individual parcels and nets can be unloaded and loaded without the need for the helicopter to land. For manual loading turnaround times are not only increased by the time needed for loading and unloading individual parcels but also for landing, stopping engines and rotors as well as starting up engines and rotors again before take-off.

Nets and ropes which are specially designed for the respective helicopter must be returned to the owner after use.

For receiving aircraft sufficient ramp space for parking the aircraft during unloading and loading must be planned. Aircraft being loaded or unloaded on the active runway will block the runway for any other aircraft.

The ramp must support the loaded aircraft and provide sufficient space for loading and unloading.

Unless shipments are delivered to medical storage facilities immediately after unloading, sufficient and suitable storage space inside a sound building must be reserved for temporary storage at the airport.

Suitable and sufficient materials handling equipment, fuel and operators or labourers for unloading and loading must be ready at the time the aircraft arrives.

32.4 Protection of health care goods during transportation

During transportation goods need to be protected from damage, deterioration as well as theft. Damage of goods not only incurs cost for their replacement but also costs for urgent purchases and expediting of critical goods.

32.4.1 Prevention of theft

Any consignment may be exposed to the risk of theft during transportation, during loading and unloading as well as during intermediate storage, for example at borders.

- Working with trustworthy carriers.
- Employing trustworthy staff.
- Use of road vehicles with closed, rigid bodies.
- Sealing of vehicles or ISO shipping containers.
- Alarm systems on road vehicles.
- Omitting value of line items and consignments on documents.

Table 32.13 Measures to reduce the risk of theft during transport

The risk of theft can be reduced (see table 32.13) by employing trustworthy staff and working together with trustworthy carriers. A long-term cooperation is an incentive for the carrier to deliver complete shipments and prevent losses.

Wherever possible, box vans or ISO shipping containers attached to flat bed vehicles rather than tarpaulin covers should be used which also provide far better protection against theft as well as the elements.

Box vans and ISO shipping containers should be sealed by the warehouse manager immediately after loading and broken only by the warehouse manager at the receiving store.

Alarm systems may be fitted to trucks.

Although indicating the value of health care goods and consignments on customs documents is mandatory, these values can be omitted on packing lists and other documents when delivering consignments to customers. This may reduce the temptation of targeting certain types of health care goods or items with high values.

All transported goods should be insured against damage as well as theft during transportation. Although insurance does not decrease the risk of theft, it reduces the financial losses incurred by the humanitarian organization.

32.4.2 Maintaining the quality of health care goods

In principle the same adverse influences which can lead to damage or deterioration of health care goods during storage (see figure 32.2) apply equally to transportation. However the risk of mechanical damage through pressure, crushing, falling, shocks and vibration as well as from sun, rain, high as well as low temperatures are greater during transportation than during storage.

The risk of damage can be greatly reduced by proper packaging as well as careful loading of health care goods as discussed earlier.

The mode of transportation should be carefully considered especially for health care equipment which may be very sensitive to mechanical damage. The often high value of health care equipment warrants the use of expensive air transportation especially if the alternative is long transportation on poor quality roads.

On road vehicles loaded consignments must be safely protected from exposure to direct sunlight, dust, rain and snow and vehicle bodies or covers must be checked before loading. The floor of trucks must be checked for their integrity as consignments can also be damaged from dust, water and mud kicked up from the road surface by the wheels and penetrating inside the vehicle from the under side.

Careful driving will also reduce the risk of mechanical damage.

The second main concern is the possible damage from high or low temperatures during transportation. Rigid vans provide better protection from high temperatures than trucks covered with tarpaulins. In tropical climates and for long duration of transportation air-conditioned vehicles might have to be used. For international transport refrigerated ISO shipping containers can be used which maintain constant temperatures.

Conversely in cold climates heating of vehicles may be needed to prevent freezing of health care goods during transportation.

32.4.3 Transportation of cold chain loads

Cold chain loads are particularly susceptible to damage and require guarding against deviation of the required temperature even during a very short period of time.

Most commonly specially designed insulated containers in which cold chain loads are surrounded by frozen ice-packs are used which maintain the required temperatures for several days even in a tropical environment. This method is reliable, fairly cheap, can be used on any means of transportation and does not rely on any power supply during transportation.

For large consignments refrigerated containers or refrigeration devices which are installed in the vehicle can be used. The advantage of unlimited transportation time has to be balanced against the fairly high cost of devices as well as the risk of breakdowns and the need for maintenance.

Cold chain loads must be packed immediately before shipment and must be transported by the means of transportation which ensure the overall shortest total transportation time. Cold chain consignments must always be given the priority and if necessary require separate shipment with smaller vehicles to ensure fast delivery. Cold boxes must also be shipped as directly as possible and, wherever possible, delivered without intermediate storage.

During transportation cold boxes must not be opened (except if inevitable by customs officials), must not be exposed to direct sunlight and be protected from mechanical damage. At airstrips cold boxes must not be left exposed but rather should be kept in vehicles before loading, loaded on the aircraft immediately or at least placed in the shade from the aircraft.

32.4.4 Transportation of blood

Blood is a biological substances which must be kept at + 4° Celsius from the time of collection until transfusion in order to prolong the life of the living cells it contains as well as in order to reduce bacterial contamination.

Whole blood as well as components such as plasma or blood cells must only be stored at specially equipped blood banks. However, humanitarian organizations may be requested to transfer units of blood for example from central blood banks to blood banks in hospitals.

Blood is a living organ and especially susceptible to damage through high temperatures or freezing. Therefore units of blood must never come into direct contact with ice-packs as freezing of blood will cause irreversible damage.

Units of blood must be transported only in special cold boxes and suitable ice-packs which meet defined performance standards defined by the World Health Organization. Small blood carriers as well as short and long range small and large cold boxes insulated with up to 10 cm polyurethane and with a capacity of up to 26 blood units of 450 ml and a cold life of up to 145 hours are available.

32.4.5 Transportation of specimen

The transportation of infectious substances must be strictly limited to the rare cases where microbiological or (histo)pathological examination of specimen of human tissue is not possible in the country where they originated. Clinical and other health care wastes must be disposed of at or at least near health care facilities and must not be handled by health care logisticians.

Body liquids such as blood (components), liquor cerebrospinalis, excreta or secreta may be collected for carrying out microbiological examinations for diagnosis or research. While routine examinations can be carried out in many health care facilities, specialized examinations such as to confirm cases of cholera or various forms of haemorrhagic fever may not be possible in the country where the samples originated.

Samples of human soft tissue such as intestines or skin as well as hard tissue such as bones may be collected during a biopsy or operation for various (histo)pathological examinations for example for confirming osteomyelitis or identifying cancer.

While body tissue intended for (histo)pathological examinations can be treated with and transported in disinfecting agents, the infective agent (and therefore potential) of samples intended for microbiological examination must be maintained and therefore must always be considered as infective.

All biological samples must be considered infective even if the patient has not been positively diagnosed for any infectious disease. Biological samples which are known to be infective, for example from a patient diagnosed with cholera, may contain a range of other infective agents for which the same patient has not been tested, for example HIV.

The volumes of biological specimen are usually small and in the range of tens or a few hundreds of millilitres.

Biological samples which are transported by air are subject to UN hazard class 6 (toxic and infectious substances), division 6.2 (infectious substances) and therefore require special packaging and labelling as well as precautions during handling and transportation.

Infectious substances and materials must be transported in special and purpose made containers. The inner packaging must be made of a watertight primary receptacle of metal or plastic with a leak-proof seal and also watertight secondary packaging. Absorbent material which is sufficient to absorb the entire liquid of the primary packaging must be placed between the inner and the outer packaging.

The outer packaging must be clearly labelled as infectious material and contain a document indicating the exact nature of the specimen.

Depending on the type of specimen as well as well as the type of intended examination, the entire sample may additionally require transportation in a cold chain.

32.5 Transportation of dangerous goods

For domestic transportation of dangerous goods by air, the same principles and regulations as for international transportation (see chapter 23.7) apply.

Compressed medical gas cylinders must be furnished with protective caps and must be secured in an upright position in metal racks which are attached to the back of trucks. Vehicles should be ventilated to avoid the build-up of gases in case medical gas cylinders leak during transportation.

The driver must be instructed on the proper handling of medical gas cylinders as well as suitable measures in case of an emergency. Drivers should carry the Data Safety Sheets for all dangerous goods they are transporting.

32.6 Routing and scheduling

Routing and scheduling is the most important operational transportation decision.

As the primary concern of logistics managers is the security of staff, assets and goods, the trade-off between delivery frequency and risk must be considered.

Vehicles are easily identifiable targets and nearly half of all security incidents occur during travelling (Bickley, S. 2003, 60). The "economies of risk" requires using larger vehicles,

consolidating consignments into full car or truck loads and reducing delivery frequency and flexibility if necessary. For the driver and the assets, the risk of travelling through a dangerous area is the same whether the vehicle is empty or full. Consequently two deliveries with a half full vehicle will double the risk for the driver. Likewise two deliveries of full car loads incur twice the risk of a single delivery with a truck which can carry the same load as two cars.

The risk and frequency of transportation must be balanced against the urgency of health care goods as well as the importance of (more) frequent deliveries. Health programme managers need to determine priorities depending on the needs for health care goods at individual health care facilities as well as available stocks and transport managers then need to try to minimize risks in their routing and scheduling.

The majority of injuries and fatalities of humanitarian workers are caused by traffic and vehicle related accidents (Bickley, S. 2003, 60) rather than by conflict related risks. In order to maximize safety for drivers and vehicles, vehicles must be well maintained and in good condition. However breakdowns of vehicles also pose significant security risks as vehicles which have to stop are easier to target and the lengthening of the journey also increases the overall security risk especially if safe places cannot be reached before dark. Among alternatives the safest route should be selected to minimize the risk of road accidents.

Every vehicle travelling along a dangerous route must be accompanied by at least another vehicle (Bickley, S. 2003, 69). This allows drivers to assist each other in case of accidents or security incidents, and all staff can continue their journey in case a broken down vehicle has to be left behind. Drivers must be familiar with the area and road network in order to avoid unintentionally deviating into more insecure areas and losing their way. Local drivers are familiar with road conditions and impassable sections as well as more knowledgeable about mined areas and roads and other potential threats (Bickley, S. 2003, 64). Roads used by the local population and commercial transport can be considered as safer as deserted roads.

Vehicles and convoys should not drive at night (PAHO 2001a, 122) and if journeys last more than one day, safe places must be planned along the route for drivers to spend the night, preferably in closed and guarded compounds.

Before every journey, approval must be obtained from all concerned authorities as well as conflict parties (Roberts, D.L. 2005, 90), especially when checkpoints and front lines have to be crossed (Mayhew, B. 2004, 36). When national borders or borders between areas with different ethnicity, religious or cultural beliefs or political convictions are crossed, drivers must be carefully selected in order to avoid putting them at risk (PAHO 2001a, 123). In case of doubt "neutral" staff from countries considered as impartial must be employed.

If permissions are not granted, alternative routes must be used or transportation must be postponed until further negotiations are successful. Warnings on dangers along routes given by authorities or conflict parties, which may be genuine or simply an attempt to obstruct humanitarian assistance, must be followed in any case (Roberts, D.L. 2005, 95).

In order to avoid mined roads and sniper areas, as much information on the security situation along the planned route should be gathered from local staff members, local authorities, security forces and other humanitarian organizations (Roberts, D.L. 2005, 45).

Before any further planning, national legislation and transportation regulations (Lambert, R.S., and J.R. Stock 1993, 15) such as safety regulations, maximum vehicle loads or maximum daily driving hours need to be considered.

Weather conditions, and their possible changes, need to be carefully considered for planning transportation routes as well as for planning alternatives in case routes are blocked by deteriorating road conditions (mud), flooding or snow.

For supplying health care facilities a choice between collection systems and distribution systems (Quick, J.D. (ed.) 1997, 325) must be made, both of which have advantages and disadvantages (see table 32.14).

In a collection system the assisted health care facilities send their own or contracted vehicles to the medical storage facility of the humanitarian organization to collect consignments of health care goods.

A collection system has the advantage that staff of assisted health care facilities may collect consignments at a day and time of their convenience which also allows them to coordinate receipt of health care goods with other activities. Depending on the security situation, it may be safer for staff than for humanitarian organizations to transport health care goods. Especially where humanitarian organizations are using commercial transportation, collection of consignments is an opportunity for staff of assisted health care facilities to meet with staff of medical distribution centres and discuss various issues face to face.

For the medical distribution centre the collection system has the disadvantage that it must meet deadlines for preparing consignments since otherwise vehicles and staff will have to wait. If many health care facilities are being supported, coordination may be difficult. If every health care facility sends their own vehicle, these may be poorly utilized and they may not be able to take advantage of transportation economies by supplying several health care facilities with the same vehicle.

The collection system requires all health care facilities to regularly ensure reliable transportation and may use scarce time of staff. Transportation may also be used as a pretext for utilizing transportation for private purposes.

Depending on the security situation, delivery of consignments by humanitarian organizations may be less risky than for staff from assisted health care facilities. The possibility of using vehicles for delivery to several health care facilities may reduce overall transportation costs.

	Advantages	**Disadvantages**
Collection system	• Customers collect at their convenience. • Arranging transportation by health care facility may be more secure. • Opportunity for pharmacy staff to meet medical warehouse staff.	• Deadline for preparing consignments must be met. • Possibly poor utilization of means of transportation. • No advantage of transportation economies. • Requires reliable transportation means by all assisted health care facilities. • Takes up time of health care facility staff. • Transportation may be used as a pretext for utilizing transport for other purposes.
Delivery system	• Arranging transportation by humanitarian organization may be more secure. • Lower overall transportation costs.	• Health care facilities may be closed upon arrival of vehicles. • Delivering vehicle in a hurry to unload and return.

Table 32.14 Advantages and disadvantages of collection and delivery systems

A delivery system can have the disadvantage that pharmacy staff may not be present at the time vehicles arrive. Moreover, drivers will be eager to unload and depart as quickly as possible, reducing the time available for checking consignments upon arrival.

The trade-off between transportation economies as well as transportation frequency and responsiveness is a key consideration for transportation planning (Chopra, S., and P. Meindl 2007, 410). Consolidation of consignments into single shipments increases vehicle utilization and decreases transportation costs. However, especially when order volumes are small, transportation consolidation results in less frequent deliveries which in turn increases demand distortion (Thonemann, U., et al. 2003, 118) and requires the increase of stock levels. Infrequent deliveries also decrease the ability to respond quickly to changes in demand or delivery of urgently required health care goods.

Transportation efficiency as well as transportation frequency can be increased by consolidation of health care goods with other humanitarian assistance goods such as food or shelter material, requested by the same destination. Another possibility is consolidation of health care goods from different humanitarian organizations but for the same destination into one shipment. Commercial carriers, provided they are available, can consolidate consignments from several customers in a single shipment and improve efficiency. Planning transportation capacities and selection of means of transportation requires considering whether the overall weight or volume is the primary constraint of the respective means of transportation.

Overall transportation planning should be flexible (Chopra, S., and P. Meindl 2007, 411) and allow to be changed quickly in case the delivery of a routine consignment becomes urgent and requires expediting. This might require changing the planned mode of transportation or cancelling planned transportation to one customer in order to serve another customer first. Transportation planning should also allow the flexibility of serving a customer from another distribution centre in case the intended source faces a stockout (Bowersox, D.J., and D.J. Closs 1996, 485). Alternative transportation routes should be planned for in case the original route is impassable or no longer considered safe enough (Ockwell, R. A. 1994, 118).

Another means of filling urgent orders is diverting and re-consigning shipments which are already en route to another customer (Bowersox, D.J., and D.J. Closs 1996, 313). Even though transportation needs to be planned in advance, it must also remain flexible to allow considering unexpected changes of customer orders.

Some degree of redundancy should be included in the overall transportation planning so that transportation schedules do not have to be disrupted in case unexpected customer demands need to be filled urgently.

Among available alternatives, first of all the safest and most reliable route must be selected (PAHO 2001a, 124) even if it is much longer and adds several days to the journey. Load limitations of bridges along transportation routes must be considered. For long journeys, availability of services such as fuel stations and workshops must be considered along the entire route. Routines should be avoided and where possible alternative routes chosen at random (Bickley, S. 2003, 67).

When calculating travelling time, some reserve time should be planned to allow for delays (Bickley, S. 2003, 67) and contingencies such as vehicle breakdowns, unplanned detours and longer than expected waiting times at borders or checkpoints. Planning of transportation legs should be realistic to avoid the higher safety as well as higher security risk of driving during dawn or in the night.

In order to avoid pilfering and diversion, wherever possible consignments should be delivered directly to the pharmacy of the assisted health care facility and handed over

personally to the person in charge rather than delivering to intermediaries who forward consignments to the recipients.

Routing of aircraft requires specialists as a multitude of factors such as type of aircraft, altitude of the destination, condition and length of runways and airstrips, availability of fuel at the destination, weather conditions as well as national and international regulations have to be considered (PAHO 2001a, 125).

Accountability of humanitarian organizations towards recipients as well as donors implies that all shipments of health care goods must be accurately tracked and accounted for.

32.7 Transportation

Reliability and on-time delivery are essential for sustaining humanitarian assistance programmes as health care goods are useful only if they are actually at the right place on time. Health care facilities may have to reduce their services or even close them if they are not supplied regularly.

Transportation management may be hampered by poor infrastructure and lack of resources in the country where humanitarian assistance is being provided. Transportation may be particularly difficult in emergencies, where humanitarian assistance goods are required quickly.

Transportation in countries or areas suffering from armed conflicts is dangerous and requires special considerations for preventing staff from injuries and goods from being misappropriated.

Several preparations are necessary before departure of one or several vehicles (see table 32.15).

Whatever the level of risk for a specific transport operation may be, it can be decreased by taking precautions and will be increased further by carelessness, negligence and poor preparation.

The security situation must be followed before the day of departure and be assessed again the morning of departure. Information on the general security situation and development of the conflict in general as well as location of check-points and front-lines must be collected. Drivers and other local people may be able to provide valuable information on routes, condition of roads and possible security problems along the route.

The transportation route which minimizes overall security risks must be selected. The planning must include possible places for refuelling vehicles.

If necessary, safe places for staying overnight must be determined.

Accurate maps of the entire transportation route and if necessary navigation equipment need to be provided.

Obtaining clearances from all conflict parties along the entire route as well as their notification needs to be confirmed before departure and any curfews during (early) morning as well as evenings and nights must be respected.

A plan of locations or intervals for radio contacts needs to be established and provided to the radio operator in writing. This allows determining the approximate vehicle location in case no radio or telephone contact is made in order to be able to send help if needed.

A contingency plan with alternative routes and measures in case of breakdowns or injury of staff needs to be established.

All vehicles must be ready for departure on time. Delays for loading or checking vehicles and late departure can encourage speeding and may force vehicles to stay overnight in unsafe places.

Drivers must ensure that only authorized consignments are loaded and especially no weapons, explosives, drugs, alcohols or goods intended for private business of participants are loaded.

All necessary documents, especially packing lists and waybills must be checked for completeness. Missing or incorrect documents may cause suspicion and lead to delays at checkpoints or borders.

A sufficient number of vehicles, at least two for insecure areas, which are appropriate for transporting the consignments as well as suitable for the prevailing road and weather conditions must be selected. One vehicle should allow transportation of an injured person on a stretcher.

Depending on and according to the policy of the respective humanitarian organization, all vehicles and trailers must be clearly marked with stickers (emblems) on all sides (including the roof) as well as flags.

Drivers must have driving licences which are valid along the entire route, possibly including neighbouring countries and must have valid travel documents and if needed visas.

Drivers should be selected for their reliability and experience and have good knowledge of the route and area.

The origin, ethnicity, nationality and religion of drivers must not put them at any foreseeable risk.

Drivers should be rested, healthy and must not be under the influence of alcohol, drugs or any medication which may impair their concentration or ability to drive.

Before departure of vehicles or convoys, drivers and other participants should be briefed. One experienced driver or convoy leader should be in charge of planning as well as for security and safety throughout the trip.

All participants should be aware of the final destination, the travel route and schedule, planned rests as well as of alternative routes in case the security situation does not allow using the planned route.

All drivers must be briefed on the number and order of vehicles, spacing of vehicles as well as the maximum speed which depends on national regulations as well as on the slowest vehicle.

All participants should be briefed on previous security incidents and the general security situation in the area, along the planned route as well as at the destination. Drivers must be aware of (invisible) frontlines and other unsafe areas to avoid accidentally entering combat areas.

The contingency plan in case of the breakdown of a vehicle as well as injury of any participant should be explained.

The security rules, including the behaviour at checkpoints and borders, must be known to all participants. Everyone must be aware of the measures in case of shelling, shooting or other attacks as well as the location of first aid equipment and stretchers. Any health professionals or trained first aiders participating in the journey should be identified.

A) Security

- Assessment of the security situation.
- Planning and selection of route.
- Planning of places for refuelling vehicles.
- Determine safe locations for overnight stays.
- Planning of alternative routes.
- Provision of accurate maps.
- Provision of navigation equipment.
- Obtaining clearances from all parties to the conflict.
- Notification of all parties to the conflict.
- Establish contact plan (with radio operators) at pre-arranged locations.
- Prepare contingency plan (injury of staff, unplanned need to detour etc.).
- Ensure that convoy is ready to depart on time.

B) Vehicle selection

- Determine number of vehicles.
- Select appropriate vehicles.

C) Driver selection

- Valid driving licence for entire route.
- Valid travel documents.
- Reliability.
- Experience.
- Knowledge of route and area.
- No security risk caused by origin, ethnicity, nationality or religion.
- Health.
- No consumption of alcohol, drugs or medication which could impair driving.

D) Briefing

- Name of person responsible for transportation or convoy.
- Destination.
- Route.
- Alternative routes in case of security problems.
- Time schedule and planned rests.
- Number of vehicles.
- Order of vehicles.
- Spacing of vehicles.
- Maximum speed.
- Names of drivers and passengers.
- Security situation in the area, along the route and at the destination.
- Review of previous security incidents on the same route and in the same area.
- Contingency plan in case of breakdowns or injury of people.
- Security rules.
- Behaviour at borders and checkpoints.
- Emergency procedures in case of shelling, shooting etc.
- Location of first aid equipment and trained medical staff.
- Radio channels used of telecommunications between vehicles.

Table 32.15 General preparations before departure of vehicles

All participants must be able to use telecommunication equipment and must be familiar with the VHF and HF channels used for communicating with radio rooms as well as between vehicles.

Finally the leader of the convoy should be available for answering any other questions participants may have.

Every driver is personally responsible for fuelling and checking the vehicle, equipment, loaded consignments as well as their respective documentation before departure (see table 32.16).

The good technical condition of vehicles in itself is an important safety measure as it will reduce the probability of accidents. Reducing the likelihood of breakdowns is also an important security measure as it will reduce the risk of having to stop in insecure places or even be forced to stay or drive during the night.

Testing of telecommunication equipment by making contact with transceivers or mobile or satellite telephones is essential and all vehicles must be tuned to the same transceiver frequency.

A) Vehicle

- Vehicle registration documents and logbook.
- Fuel and spare fuel.
- Engine oil.
- Coolant.
- Battery (liquid level and connections).
- Fan belt.
- Breaks.
- Tire condition.
- Tire pressure.
- Lights.
- Spare tire.
- Snow chains.
- Towrope and/or tow bar.
- Tool box.

B) Safety equipment

- First aid box.
- Fire extinguisher.

C) Security

- Telecommunication equipment (radio transceivers, mobile/satellite telephone).
- Tuning to the same agreed frequency.
- Markings of vehicles (stickers and/or flags).

C) Others

- Water.
- Food.

Table 32.16 Checking of vehicles before departure

On the road the driver or convoy leader is in charge of security, safety, telecommunications as well as making regular contacts according to the submitted schedule for reporting the

position of the convoy. Windows should be kept half open in order to hear any conflict related noises (shooting, shelling etc.) better and earlier. Doors should be kept unlocked to allow escaping quickly if necessary but should be kept locked when driving through (aggressive) crowds.

Drivers and team leaders need to monitor the security situation, exchange any relevant information with other vehicles and make decisions on changing the route or returning to a safe place for security reasons. They are also responsible for negotiating clearance at checkpoints as well as managing security incidents, accidents or illness of drivers.

The convoy leader is in charge of announcing departure of convoys, making regular contacts with the radio room according to the documented contact schedule and informing the radio room of any changes to the route or the time schedule. In case of any security concerns or incidents the radio room must be update on the exact location of vehicles.

Slower trucks and trucks with trailers should lead the convoy to avoid being left behind. For security reasons all vehicles in the convoy must stay together and vehicles should not change the position they were allocated before departure. Especially before checkpoints, borders or places with potential security problems all vehicles must keep together closely.

Convoy leaders are responsible for ensuring that the vehicles maintain the agreed distance to each other and should ideally have visibility of all vehicles at all times. Vehicles should stay together and scattering should be avoided. As far as possible no vehicles not belonging to the convoy should be allowed between convoy vehicles and convoys should always keep a distance from any vehicles or convoys belonging to any of the conflict parties.

Drivers must inform the convoy leader of any technical problems who in turn must ensure appropriate measures are taken.

The convoy leaders must also ensure that drivers rest if necessary. During resting drivers should also take the opportunity to check their vehicles. Vehicles must be locked and guarded at all times during any stops and must never be left unattended.

After arrival, the driver or convoy leader are responsible for announcing the safe arrival at the destination and parking vehicles in a safe place.

All vehicles should be checked for defects and if necessary be cleaned. Vehicles should also be refuelled and be made ready for immediate departure in case of an emergency.

If necessary drivers should be debriefed on any difficulties they encountered and be accommodated.

33 REVERSE LOGISTICS

Logisticians usually manage downstream flows of goods from manufacturers to end-users but sometimes the physical flow of goods needs to be reversed. This process is also called reverse (physical) distribution, backward distribution or reverse supply chain management.

Reverse logistics can be defined as "An organization's management of material resources obtained from customers" (Giuntini, R., and T. Andel 1995). These material resources may encompass materials, products as well as packaging materials. In this case the customer becomes the supplier and vice versa.

Two reverse logistics systems, closed loop and open loop can be distinguished which may be used separately or in conjunction. In a closed-loop system goods and materials are returned to the manufacturer. The manufacturer may reuse, recycle or dispose of the goods or materials. A typical example would by oxygen cylinders which are refilled by a commercial supplier.

In an open-loop system materials and products such as recyclable materials are processed by other parties than the commercial suppliers.

While the great majority of health care goods flow downstream throughout the supply network, the small quantity of health care goods flowing in reverse must also be managed efficiently and sometimes very quickly. Supply networks are usually conceived of and designed for downstream flows but must always consider the possible need for reverse flows, possibly through several stages of the supply network.

Because the usually small volumes of reverse flows may not allow transportation consolidation and the possible need for immediate recalls the cost of moving health care goods through the supply network in reverse may be several times as high as for downstream flows.

Reverse flows of goods may be even more unpredictable and therefore more difficult to forecast than downstream flows of goods. Uncertainties concern the kind of goods, the quantities as well as the time of return. For example a large batch of a product with poor quality or stocks returned from assisted health care facilities which are being closed may lead to a sudden and possibly unpredicted surge of returns.

The value of reversely distributed goods can vary from expensive medical equipment to packaging material of very low value to expired pharmaceuticals without any value.

33.1 Reasons for reverse flows

There are numerous reasons for reverse (or upstream) flows in supply networks (see table 33.1). In terms of medical waste this chapter is limited to disposal of unused but expired or damaged health care goods but does not cover the disposal of (contaminated) medical waste from health care facilities. Under no circumstances should medical distribution centres accept any contaminated waste from health care facilities for disposal as this poses a risk for staff and can contaminate medical stores and stocks.

Some health care goods require regular or repeated returns to suppliers.

For example medical gas cylinders need to be returned to suppliers for refilling as well as servicing and maintenance. Health care equipment such as x-ray dosimeters require (monthly) return to suppliers or (government) laboratories for analysis.

A) Operational returns

- Replenishment or refilling.
- Analysis (for example x-ray dosimeters).
- Maintenance and servicing.
- Calibration (for example vaporizers for anaesthetics).
- Loaned health care equipment.

B) Customer returns

- Customer claims.
- Repair of equipment.
- Return of health care goods for replacement .

C) Product recalls by suppliers

- Detection of quality problems (or suspicion therefore) after selling.

D) Redistribution of health care goods

- Upstream return of overstocks.
- Closure of health care facilities or medical distribution centres.
- Redistribution between medical distribution centres or customers (lateral transhipment).

E) Reuse or recycling

- Return of packaging material and unit loads (e.g. cold boxes, pallets, containers).

F) Disposal of unusable health care goods

- Disposal requiring special facilities according to national legislation and regulations.
- Disposal of unwanted health care goods (despite absence of legislation or its enforcement).
- Safe disposal of toxic compounds and materials.

Table 33.1 Possible reasons for reverse flows in supply networks

Routine servicing, maintenance as well as calibration of some health care equipment such as diagnostic imaging equipment or vaporizers for anaesthetics cannot be carried out by maintenance staff or engineers at health care facilities. If the supplier's technicians are not available in the country or cannot travel to the health care facilities for security reasons, the respective health care equipment may have to be transported to the supplier, possibly even abroad.

Health care equipment which humanitarian organizations may temporarily loan to health care facilities for replacing equipment which is under repair or being replaced eventually has to be returned.

Customers may return health care goods because the wrong quantity or wrong item was delivered or because of quality complaints.

Health care facilities may also return health care equipment for repairs which cannot be carried out on site because of the lack of qualified technicians.

Likewise customers may return health care goods to the supplier for replacement, for example health care equipment under warranty.

Manufacturers or suppliers of health care goods may recall all items belonging to a certain batch or model because a quality problem was detected by them or one of their customers which poses a risk for patients.

Medical distribution centres may return overstocks to upstream medical distribution centres for stocking or immediate redistribution to other medical distribution centres or assisted health care facilities.

The closure of health care facilities managed by humanitarian organizations may require returning health care goods. While single use medical devices can usually be donated to other health care facilities, health care equipment may not be needed.

Packaging materials as well as unit loads may be returned to upstream distribution centres for environmental as well as financial reasons.

33.2 Management of reverse flows

Reverse logistics management must consider not only transportation but also information management and storage.

The effective and efficient flow of information is equally important for reverse flows of health care goods, in particular for customer returns.

In order to maintain transportation efficiency throughout the entire supply network, reverse distribution must be co-ordinated carefully with the predominant downstream flow of goods. In principle reverse flows can take any network path available in the supply network and should be preferably transported as backloads.

Suitable modes of transportation must be selected, especially for goods sensitive to damage such as health care equipment for servicing or repair.

In order to avoid unnecessary transportation legs, the final destination such as the final place of disposal of unusable health care goods, should be decided in advance.

For goods crossing international borders the need for customs clearance should not be forgotten. Health care goods for temporary exportation for repair or servicing should be carefully declared in order to possibly benefit from exemption from duties and taxes upon re-importation. The need for insurance coverage especially for valuable health care equipment should also be considered.

In principle upstream flowing consignments are received and inspected like any other consignment. However, afterwards the flows inside the medical storage facility must be carefully separated to prevent confusion.

Consignments requiring storage under quarantine must be put-away immediately to avoid accidental picking and shipping.

33.2.1 Operational returns

Medical devices such as medical gas cylinders for refilling, x-ray dosimeters for analysis or vaporizers for volatile anaesthetics requiring calibration need to stored separately and furnished with a packing list indicating their serial number before return to suppliers.

Health care equipment returned from customers for routine maintenance or service may require repacking.

Loaned health care equipment, for example a small autoclave or oxygen concentrator, returned from customers must not be contaminated and must be carefully checked for its completeness and operational efficiency by a qualified professional.

33.2.2 Customer returns

Customers may return any type of health care goods with a claim or return health care equipment for repair or replacement.

Claims may be issued because of errors in order fulfilment, damages (see chapter 33.2.4) or production defects by the manufacturer.

Qualified staff such as technicians or health professionals must provide a written report and clearly specify the problems they encountered with the product in as much detail as possible. Very general, inaccurate or incomplete claim reports (for example "poor quality") will require further inquiries which will delay treatment by commercial suppliers. Moreover commercial suppliers replacing returned health care goods free of charge will demand a justification from customers. Detailed claim reports will also help manufacturers to improve the design and quality of their products.

All claims must also be carefully recorded and filed for future reference as well as for rating suppliers. Some claims may require immediately changing the preferred supplier of the respective product.

Customers may return health care equipment which cannot be repaired on the spot, which requires a certified technician or which must be repaired by commercial suppliers in order not to lose the warranty. In some cases it may be easier and cheaper to transport health care equipment to commercial suppliers than to arrange for qualified technicians to travel to the respective health care facility. Qualified technicians may also be unable or unwilling to travel for security reasons. Commercial suppliers will usually only replace health care equipment or parts therefore under warranty if the faulty pieces are returned to them.

Recording the exact type, model as well as serial number of health care equipment returned by customers may be essential for documentation provided to commercial suppliers, especially if health care equipment is still under warranty.

Customers should consider the total costs of repairing health care equipment as well as compare the expected lifetime of new and repaired equipment.

33.2.3 Product recalls by suppliers

Manufacturers of health care goods may have to recall the entire batch of a given product because they detected a quality problem or have a serious doubt about the product quality after selling (some of) the product. Typically a health care facility or a health professional will report a problem, or the suspicion of a problem, to the manufacturer. If the quality problem is confirmed by testing, the manufacturer will recall the respective batch.

The ability of humanitarian organizations to effectively and quickly carry out a recall is essential in order to prevent patients and possibly health professionals from being harmed or at least reduce the number of (potentially) affected people.

Drug products may contain the wrong active pharmaceutical ingredient or the wrong quantity, health care goods may not have been sterilized properly and health care equipment may be faulty.

In countries or areas affected by complex political emergencies there may be no legal framework to hold manufacturers, distributors or humanitarian organizations liable for any injuries or disabilities caused by distributed health care products. However, even if national legislation and regulations concerning product recalls do not exist or are not enforced,

humanitarian organizations have at least a moral obligation to minimize any harm caused by faulty health care goods as far as possible.

Drug products may be recalled because contamination with solids, active pharmaceutical ingredients or excipients which are not part of the formulation or by micro-organisms and pyrogens. Another reasons could be a faulty process such as mixing, drying or compression during manufacturing.

Adverse effects may appear which were not detected during development and clinical testing of drug products.

Single use medical devices my be faulty, for example leaking syringes and the sterilization process may be found to have been faulty.

Manufacturers may find design faults in health care equipment or initiate a product recall because of a manufacturing defect.

A) Drug products
• Contamination (e.g. solids, wrong ingredients, micro-organisms).
• Faulty manufacturing process.
• Adverse effects unknown to the manufacturer.
B) Single use medical devices
• Manufacturing defect.
• Faulty sterilization process.
C) Health care equipment
• Faulty design.
• Manufacturing defect.

Table 33.2 Possible reasons for product recalls

The difficulty and complexity of recalling products as well as the resources required by any of the involved actors is affected by a number of different of factors (see table 33.3).

The level of difficulty also increases with the overall complexity of the supply network. The more stages, the more nodes and the more end users, in this case the assisted health care facilities, the more difficult the product recall becomes. In the worst case, drug products distributed in dispensaries would have to be retrieved from the homes of individual patients. For example health care equipment delivered directly from the manufacturer to assisted health care facilities is easier to recall than drug products which are distributed through several stages of the supply network and stored at several medical storage facilities at each stage.

The difficulty of the recall process also depends on the number of different organizations which manage the total supply network. As long as the entire quantity of the product is under the control of the manufacturer, recalling is fairly simple. The difficulty of locating the product grows with every intermediary (wholesaler, distributor) and humanitarian organization as each organization has to communicate with each organization to which they have distributed the product.

The longer the time span between the first sale of a product by the manufacturer and the time the recall is announced, the larger the distributed quantity and the larger the penetration in the supply network is, there more difficult the recall is likely to be. However large quantities may have been distributed over a short period of time, for example single use medical devices,

or a small quantity over a very long period of time, for example specialized health care equipment.

The shorter the shelf life of a product, the larger the probability will be that stocks will be disposed of because they are expired in stock.

The difficulty of the recall process depends on the number of distributed consignments (packing lists), the number of recipients and the total quantity of the distributed product.

The type of health care goods may also affect the difficulty of the recall process. Manufacturers or at least commercial suppliers maintain detail records of assisted health care facilities which have installed health care equipment under warranty, regardless of how many organizations were involved in the distribution.

- Number of stages in the supply network.
- Number of nodes in the supply network.
- Number of health care facilities (or patients) having received the product.
- Number of affected organizations.
- Time span between dispatch and recall of product.
- Penetration of the product in the supply network.
- Remaining shelf life.
- Number of distributed consignments (packing lists).
- Total distributed quantity.
- Type of health care goods.

Table 33.3 Factors affecting the difficulty of product recalls

A number of different actors can be involved in the recall process and each organization must ensure their capacity to carry out the recall process effectively and quickly.

In any case manufacturers or national drug regulatory authorities will have to initiate the recall and end users, either assisted health care facilities or patients, are involved. In addition any commercial intermediaries such as sales agents, importers, distributors, wholesalers or retailers as well as humanitarian organizations and possibly governmental organizations (Ministry of Health) which have received donations may be involved.

Humanitarian organizations must comply with any national legislation or regulations concerning product recalls which may, for example, require notification of the national drug regulatory authorities.

After the manufacturer or the national drug regulatory authorities have confirmed the need to initiate a recall, the process comprises several steps or phases.

The entire recall process relies on the ability of all involved organizations to locate any quantity of any batch of a product they have distributed. Humanitarian organizations must ensure that every batch of every product can be traced throughout their entire supply network. This requires the accurate recording of the names of health care goods, batch and serial numbers as well as the name of manufacturers and customers on all packing lists. Manual or electronic information systems must allow to quickly identify all customers to which the respective batch of a product has been sent. In any case every medical storage facility must at least record the quantities, customers and date of distribution for each batch of a product on the respective bin card.

The manufacturer must locate the product or a batch of the product in the supply network under his control, retrieve the product and place it under quarantine. In addition the manufacturer must check his records and immediately notify all customers to which the respective product or batch of a product has been distributed in writing. The manufacturer must give clear instructions whether the (batch of a) product must be disposed of, kept in quarantine until further notice or be returned to the manufacturer. In some cases the manufacturer might have to carry out or complete testing on a suspected quality problem and afterwards confirm or possibly revoke the recall.

Alternatively, the national drug regulatory authorities of a country may notify the public by media (radio, television, newspaper) about the need to recall a (batch of a) product, especially in case of imported health care goods.

The customers notified by the manufacturer, which may be commercial intermediaries or humanitarian organizations, must in turn locate the respective (batch of a) product and inform their customers. This process must be repeated by every organization and at every stage of the supply network until the assisted health care facilities are informed. These in turn may have to inform patients to which they have distributed the respective (batch of a) product and which have in the meantime left the health care facility. In addition any sets manufactured by the humanitarian organization which contain a recalled product must also be located.

Any quantity of the recalled product which has been successfully located must immediately be clearly marked and locked in a quarantine area in order to ensure that the product is not inadvertently distributed. Depending on the instructions by the organizations which initiated the recall, the product must either be disposed of properly, kept in quarantine until further notice or be returned to the manufacturer.

In addition humanitarian organizations should make every effort to physically retrieve and recover the recalled products from all customers. Even if customers are properly informed there is a danger that the products may be used anyway or be diverted. Patients and health professionals may not share the same concern for the quality problem and, especially in countries with chronic lack of health care goods, disposal of products without any apparent fault may be considered as a waste. However humanitarian organizations can encourage retrieval of the recalled batch by providing a substitute of good quality.

Ideally the humanitarian organization should retrieve the entire quantity they have distributed and place it in quarantine.

Depending on the consequences, recalled products which have already been used or administered to patients, the respective health care facilities may have to notify all treated patients for treatment or examination.

In some cases further analysis may not confirm the quality concerns and the manufacturer will inform customers that the previously recalled product can be safely used.

If the recall requests returning products to the manufacturer, each packaging as well as each parcel of the consignment must be clearly marked in order to avoid that the product is inadvertently put away and later distributed to a customer at any upstream medical distribution centre.

If returning recalled products to the manufacturer or commercial supplier is not possible, safe disposal of the entire recalled quantity must be ensured by the humanitarian organization.

33.2.4 Redistribution of health care goods

Health care goods may be redistributed in the supply network for different reasons. Assisted health care facilities or downstream medical distribution centres may return overstocks or all of their stock because assisted health care facilities or medical distribution centres are being closed.

Medical distribution centres may also receive consignments for facilitating distribution between two medical distribution centres at the same stage of the supply network or between two assisted health care facilities (lateral transhipment):

Health care goods from assisted health care facilities should not be accepted unless proper storage conditions, especially appropriate storage temperatures of drug products as well as cold chain loads, throughout the entire period of storage can be ascertained.

Health care goods received for put-away should undergo the same process as consignments received from upstream distribution centres. The remaining shelf-life must be checked for compliance with the minimum requirements at the respective medical distribution centre.

Returned health care equipment must not be contaminated and must be carefully checked for its completeness and operational efficiency by a qualified professional.

33.2.5 Reuse or recycling

Unit loads such as reusable pallets are often expensive, not easily available in countries and should therefore be retrieved after delivery of health care goods to customers.

Cold chain equipment such as cold boxes, ice-packs and thermometers are expensive and need to be returned in order to recover the assets.

Packaging material such as corrugated cardboard boxes or various fillers which cannot be reused by recipients may be returned for reuse in order to reduce the volume of waste or for collection for recycling or proper disposal.

33.3 Management of unusable health care goods

In this chapter only unused and uncontaminated health care goods are considered. Health care goods become unusable because no recipient can be identified or because they do not (any longer) comply with required quality standards. They may be manufactured with a poor quality, have expired or been damaged during transport, storage and handling.

Proper management of unusable health care goods has several objectives (see table 33.4). The main objective is to prevent harm to people from the reuse or resale of expired, damaged or recalled health care goods as well as harm from sharps, regardless of whether national legislation and regulations are enacted or enforced.

- Preventing ham to people.
- Preventing diversion for reuse or sale.
- Environmental protection.
- Compliance with legislation and regulations.

Table 33.4 Objectives of managing unusable health care goods

A further objective is protecting the environment which can be harmed by inappropriate disposal of drug products or substances contained in certain health care equipment.

In any case humanitarian organizations must comply with international legislation (Basel convention) as well as any national legislation or regulations.

While disposal of unusable health care goods must be carried out in complete transparency towards the health authorities, public information must be handled carefully as it may be politicized and sensationalized" (WHO 1999d, 8).

33.3.1 Legislation and regulations

Less developed countries may not have enacted national legislation or regulations concerning disposal of health care goods or their provisions may not be enforced because of the absence of government authorities.

National pharmaceutical legislation regulates the obligations concerning disposal of unusable drug products and possibly other health care goods while environmental protection laws govern management and disposal of potentially harmful substances such as refrigerants, batteries or heavy metals.

In some countries environmental protection laws may require recycling certain materials such as paper or plastics or oblige suppliers to take back equipment (for example refrigerators) for disposal at the end of its lifetime.

The Basel convention (see chapter 23.2.1) prohibits exportation of hazardous wastes from states party to the convention unless facilities and expertise for safe disposal are unavailable in the country.

33.3.2 Sources of unusable health care goods

Products can be or become unusable health care goods for various reasons (see table 33.5). In general health care goods become unusable if their quality does not comply with the quality assurance policy of the humanitarian organization. For example drug products which are not marked with batch numbers and expiry dates or sterile single use medical devices which are not marked with an expiry date.

Where donations contain a large number of small quantities of miscellaneous products, sorting and identification may not be worthwhile. Donations received from other organizations may be inappropriate for the recipient country or for the context (of complex political emergencies).

The quantities of health care goods used and needed in the assisted health programmes may exceed the needs because of miscalculations or unsolicited donations.

The national drug regulatory authorities may reject products after inspection because they are not registered in the recipient country or because their quality does not comply with national standards and regulations.

Health care goods may have been damaged by water, humidity or mechanical forces anywhere along the upstream supply network or in the current medical storage facility during transportation, materials handling or storage.

Other organizations may have donated already expired products or have donated products with very short remaining shelf life. Upstream medical distribution centres may have accidentally shipped expired products, or health care goods may have expired during

transportation for example because of very long transportation times or long delays during customs clearance. Finally products can expire in stock.

Products which do not comply with treatment protocols may have mistakenly been ordered and delivered, for example a wrong antimalarial drug product or the health authorities or humanitarian organizations may have changed treatment protocols.

Drug products, especially vaccines and diagnostic tests requiring a cold chain, may have been damaged by too high temperatures during transportation or storage. Any unsealed tubes, syrups or eye drops are unusable, even if they are not expired. Moreover any drug products which have been removed from their secondary manufacturer packaging must not be used.

The packaging of sterile single use medical devices may have been damaged by accidental opening, tearing, cutting or puncturing, the contents been contaminated or sterile paper packaging material may have been soiled.

A) All health care goods

- Non-compliance with requirements of quality assurance policy.
- Product recalls by suppliers.
- Unidentifiable products (missing or incomplete labelling).
- Product information in a language not understood in the recipient country.
- Donation of small quantities of miscellaneous products.
- (Unsolicited) donations of unneeded health care goods.
- Quantities of donated products which exceed needs.
- Products rejected during inspection by the national drug regulatory authorities.
- Damage during transportation, handling or storage (for example mechanical, humidity, water).
- Expired (or with very short remaining shelf life) upon donation by other organization.
- Expiry during transportation.
- Expiry in stock.

B) Drug products

- Mistaken delivery of drug products which do not comply with treatment protocols.
- Change of (national) treatment protocols.
- Damaged during (inappropriate) transportation (physical, heat, freezing).
- Damage during storage (chemical, biological, environmental, mechanical).

C) Sterile single use medical devices

- Damaged packaging (torn, cut, opened, punctured).
- Soiled paper packaging (even if dried later).
- Biological contamination.

D) Health care equipment

- Incompatible with existing equipment or accessories.
- Incompatible power supply (for example wrong voltage).
- Unavailability of operating materials and replacement parts.
- Equipment returned because it cannot be repaired (anymore).
- Equipment (returned) at the end of its lifetime.

Table 33.5 Possible sources of and causes for becoming unusable health care goods

33.3.3 Avoiding unusable health care goods

Various measures can be taken to prevent, or at least reduce, the generation and accumulation of unusable health care goods (see table 33.6).

The receipt of unusable health care goods must be avoided. Whenever purchasing or receiving health care goods from abroad, the language understood in the recipient country must be clearly specified.

Health care goods must be purchased only from reliable commercial suppliers in order to avoid receiving health care goods of poor quality which cannot be used. When purchasing or ordering health care goods the minimum remaining shelf life required upon receipt must be defined or specified.

Every humanitarian organization should establish a clear policy on the quality requirements of health care goods received as donation in kind from donors. Potential donors should submit a detailed packing list indicating the multisource name of health care goods, the country of manufacture, manufacturing, language of labelling as well as expiry date which can carefully analysed before accepting any donation. Any donations in kind, or part of donations, which do not comply with the policy on receiving donations, must be refused and must not enter the supply network of the respective humanitarian organization.

A) All health care goods

- Specify language required for product information in purchase contracts and donor information.
- Purchase health care goods from reliable sources.
- Purchase of health care goods with a defined minimum remaining shelf life.
- Establish clear policy on receiving donations in kind from other organizations.
- Request detailed documentation before accepting any donations.
- Refuse unsolicited donations.
- Avoid overstocks by careful inventory control.
- Strict FEFO management.
- Monthly analysis of the remaining shelf life of all batches in stock.
- Import only health care goods registered with national drug regulatory authorities.
- Protect health care goods from damage during transportation, storage and handling.

B) Drug products

- Order and stock only drug products which comply with national treatment protocols.
- Carefully manage the cold chain.

C) Sterile single use medical devices

- Prevent damage to secondary and especially primary supplier packaging.

D) Health care equipment

- Carefully assess health care equipment standards in the country before ordering or purchasing.
- Confirm type of available power supply in the country before ordering or purchasing.
- Assess availability of operating materials and replacement parts.

Table 33.6 Measures to avoid and prevent unusable health care goods

Overstocking with subsequent expiry should be avoided by careful inventory control and all order picking must strictly follow FEFO management. At least once a month the remaining shelf life of all batches must be checked and compared with their respective coverage times. Any batches which cannot be used for ongoing health care programmes should be donated to

other health care facilities with a sufficiently long remaining shelf life to ensure appropriate utilization.

Only health care goods registered with the national drug regulatory authority of the recipient country or with the required exemption from national regulations should be imported to avoid that their distribution is prohibited.

Only drug products complying with national treatment protocols should be purchased or ordered and the cold chain must be managed carefully.

Great care should be taken to protect health care goods from damage during transportation, storage and handling.

Sterile single use medical devices must be handled and stored with particular care in order to avoid mechanical damage or damage by water and humidity.

The compatibility of voltage as well as with other health care equipment at the recipient health care facility should be confirmed before ordering or purchasing any health care equipment. The domestic availability of suitable power sources as well as operating materials and replacement parts must be ensured.

33.3.4 Types of wastes requiring special disposal

Since medical storage facilities must never accept and receive any kind of contaminated goods, many materials such as paper, various plastics, cotton or gauze can be disposed of in the same way as domestic or industrial waste.

However, some health care goods or components can pose environmental hazards and require special disposal methods.

- All drug products.
- Laboratory chemicals and reagents.
- Photographic (waste) chemicals.
- Refrigerator coolants.
- Heavy metals (mercury, lead).
- Sharps.

Table 33.7 Types of waste requiring special disposal

All drug products can potentially be harmful to the environment and must be disposed of in a special way.

Health care wastes may contain oxidizing, toxic or corrosive substances. Some laboratory chemicals and reagents such as xylene or acetone as well as photographic chemicals (developing and fixing solutions) are toxic.

The heavy metals mercury which thermometers and sphygmomanometers may contain as well as lead used in protective radiation shielding or batteries are toxic to the environment and refrigerators and freezers contain coolants.

Sharps such as hypodermic needles, cannulas, single use scalpels, surgical blades, giving sets (for infusions) are not an environmental hazard but if disposed of in open landfills may injure the feet or hands of scavengers and livestock.

33.3.5 Dangers of inappropriate handling of unusable health care goods

As a consequence of inappropriate handling, unusable health care goods may be diverted for personal use, abuse or sale which in turn can cause harm to people. Expired or damaged drug products and single use medical devices may be repackaged and sold for a profit. Expired sterile single use medical devices may simply be relabelled with false expiry dates or repackaged (without subsequent sterilization) and sold.

The secondary packaging as well as the patient information may be diverted and used for packaging counterfeit drug products with original manufacturer packaging. Broken or damaged health care equipment may be "repaired" or refurbished and sold as a new piece of equipment.

The accidental distribution of damaged or expired drug products or single use medical devices can harm patients. People can be harmed by the explosion of accidentally incinerated aerosol cans or be injured by sharps. The disposal of health care goods without making them unusable may encourage scavenging of landfills with all its secondary health risks such as injury and infection.

In general expired drug products become less efficacious and do not pose a serious risk to public health or the environment (WHO 1999d, 7) if they are handled correctly. However, incorrect disposal of drug products can contaminate water sources or release toxic pollutants into the air. Antibiotics and disinfectants can disrupt sewage treatment plants by killing the micro-organisms which break down organic matter.

A) Diversion for

- Private use and abuse.
- Sale.
- Repackaging and sale.
- Re-labelling of expired sterile single use medical devices.
- Repackaging of expired sterile single use medical devices.
- Reuse of packaging materials for counterfeiting.
- "Repair" and sale of not properly functioning health care equipment.

B) Harm to people

- Accidental distribution of health care goods of inappropriate quality.
- Explosion of accidentally incinerated aerosol cans.
- Injury by sharps.
- Incentive to scavenge landfills.

C) Environmental risks

- Contamination of water sources.
- Disruption of sewage treatment plants.
- Release of toxic pollutants into the air.

Table 33.8 Possible dangers of inappropriate handling of unusable health care goods

33.4 Processing unusable health care goods

Pilfering, theft as well as loss of unusable health care goods must be prevented at all stages of processing (see table 33.9).

- Collection.
- Packing and labelling.
- Transportation from downstream medical distribution centre and receipt.
- Recording.
- Storage (and collection) in quarantine.
- Treatment.
- Selecting disposal method.
- Obtaining authorization for disposal.
- Witnessing disposal.

Table 33.9 Processing unusable health care goods

Health care goods need to be picked or collected at the medical storage facility immediately after becoming unusable, for example after being damaged or having expired. Their removal from stock must be recorded in the respective bin card and stock card like any other stock issue and a claim report needs to be issued.

Damaged packaging (for example broken, torn, punctured) of liquid drug products or chemicals must be placed in waterproof containers to avoid leakage especially if they must be transported to another facility. Sharps of which the packaging has been damaged must be collected in special sharps containers.

They must be packed, for example into cartons, and clearly labelled as unusable in order to avoid accidental order picking and shipping.

In case the unusable health care goods cannot be treated appropriately at the medical storage facility from where they originate, they may have to be transported to upstream medical distribution centres within the same country. However unusable health care goods must not be transported across international borders.

The type of products as well as their quantities collected in the medical storage facility or received from another medical storage facility should be registered. Maintaining a detailed and accurate record is an essential measure to prevent or at least detect theft and usually required for obtaining an authorization for disposal.

Unusable health care goods often need to be temporarily stored in order to allow consolidation and more efficient disposal, waiting for the availability of facilities for disposal (such as an incinerator) as well as for waiting for the authorization for disposal by the relevant authorities.

In order to avoid confusion with usable stocks, all unusable health care goods must be placed in clearly marked and labelled containers and stored in a dedicated and lockable quarantine area, ideally a separate room but at least a dedicated and lockable cupboard. Such storage may be needed before as well as after sorting and treatment.

Generally, unusable drug products do not pose any risk provided they are securely stored in dry conditions (WHO 1999d, 8).

Internationally controlled drug products must be separated as their disposal may require a special notification of the national drug regulatory authorities and a special disposal procedure.

If different disposal methods are envisaged, unusable drug products should be sorted according to their final disposal method, for example into solids, liquids and aerosols.

Different chemicals must never be mixed but be kept separate in their respective containers.

Unusable health care goods should be treated before disposal in order to reduce the overall volume, the required storage space as well as the disposal cost. Moreover, for example, capsules removed from their blister packaging are made unsalable.

Depending on the disposal method, either all or all but the primary packaging is removed from solid dosage forms while powders and liquids are left in their (primary) packaging. Any packaging material that could be abused for counterfeiting must be later shredded and burned while any other packaging material can be disposed of with other warehouse waste.

Capsules or tablets should be removed from their primary packaging as late in the process as possible (WHO 1999d, 17) and all staff must wear masks in order to prevent inhaling particles.

Single use medical devices can be removed from their primary packaging and can usually be made unusable by cutting or breaking.

Health care equipment must be made unusable by crushing (hydraulic press), smashing or cutting in order to prevent "repair" and resale or reuse.

The weight and volume of unusable health care goods might need to be determined for deciding on the disposal method as well as for planning capacities, for example for transport and incineration.

Depending on national legislation and regulations, disposal of unusable health care goods usually requires applying for a permission from or notification of the national drug regulatory authorities. The application should contain a detailed record of the types, quantities, weights and volumes of health care goods designated for destruction and indicated the proposed disposal method.

The national drug regulatory authorities, ministry of health, local and regional health authorities as well as governmental environmental protection agencies may be involved in issuing the authorization for disposal. In addition the governmental agencies responsible for administering narcotic and psychotropic substances may be involved.

The disposal can only be carried out once a formal authorization has been granted and national legislation and regulations my require the presence of representatives of the national drug regulatory authorities during actual disposal or destruction for witnessing in order to prevent diversion and sale.

33.5 Methods for the disposal of unusable health care goods

The objectives of safe disposal of unusable health care goods are minimizing the risk to public health of the local population and the environment at reasonable disposal costs.

The optimal disposal method may not be possible because of lack of resources or lack of access to disposal facilities because of the poor security situation. Therefore the objective is to find the simplest, safest and most practical alternative with the smallest possible risk.

Non-disposal is the worst way of treating unusable health care goods.

Even if the best and safest method of disposal is not possible, any other alternative will be less harmful to public health and the environment than non-disposal.

The criteria for selecting the most suitable disposal method(s) (see table 33.10) depends on the type of unusable health care goods, their quantities as well as national pharmaceutical and environmental legislation and regulations.

- Return to manufacturer or commercial supplier.
- Return to donor.
- Landfill.
- Waste immobilization by encapsulation.
- Waste immobilization by inertization.
- Sewer.
- Low temperature incineration (< + 800° C), open burning.
- Medium temperature incineration.
- High temperature incineration (> + 1,200° C).
- Chemical decomposition.

Table 33.10 Disposal methods for unusable health care goods

Especially the disposal of large quantities of unusable health care goods requires supervision by a pharmacist and careful planning of human resources (expertise), equipment, facilities, required time as well as funding.

Depending on the type and volume of unusable health care goods, available facilities as well as national legislation and regulations disposal may be carried out by the humanitarian organization, by a health care facility, the health authorities or a contracted commercial company.

33.5.1 Return to manufacturer

Return of drug products and health care goods should be considered whenever the quality of products is not satisfactory and the quality problem was not caused by storage or transportation. Usually the manufacturer (or commercial supplier) will be obliged to replace the purchased goods.

However where the value of health care goods is low compared to the transportation costs, return to the manufacturer may not be economical.

For the disposal of unusable health care equipment or chemicals which require special expertise, specialized treatment and disposal facilities, an agreement with the manufacturer can be made. For example lead used for radiation shielding in x-ray equipment requires special disposal. Silver contained in photographic waste from processing x-ray films contains silver is toxic to the environment and should be returned to commercial suppliers for processing and recovery.

33.5.2 Return to donor

The possibility of returning unsolicited donations to donors should be considered when donated health care goods are inappropriate for the situation and context, especially when expired health care goods are received. Such returns will contribute to reducing the number of inappropriate donations.

The Basel convention, which most countries from which donations of health care goods usually originate will be signatories to, considers exportation of expired drug products as

"illegal traffic". The exporter, generator or, if necessary, the state itself must take the waste back or, if impractical, at least dispose of the waste in accordance with the provisions of the convention.

33.5.3 Landfill

Like most of the waste in less developed countries, unusable health care goods can be disposed of in different types of landfills (see table 33.11).

- Open, uncontrolled and non-engineered dump.
- Engineered landfill.
- Highly engineered sanitary landfill.

Table 33.11 Types of landfills

Before sending unusable health care goods for disposal the landfill should be visited and inspected to ensure the landfill is properly designed and managed.

The open, uncontrolled and non-engineered dump where untreated waste is simply discharged and scattered in an open space, is probably the most common land disposal method in less developed countries

The disposal of unusable health care goods in such landfills can cause harm to public health as well as the environment and should not be used. Leakage from the landfill can contaminate and pollute aquifers and other sources of water. If waste is set on fire, toxic pollutants from drug products, their packaging and other health care goods are released into the air.

Scavengers and livestock may be injured by sharps and unusable drug products, packaging material and other health care goods may be collected for private use, sale or counterfeiting.

If there is no possibility of disposing health care goods more safely, as an absolute minimum the deposited waste must be covered with a thick layer of other (municipal) waste to safely prevent scavenging.

Engineered landfills are designed to retain the waste and prevent leakage of hazardous substances into the aquifer, water courses, surface water or the drinking water system. In order to prevent scavenging and possibly injuries, deposited unusable health care goods should be covered with a fresh layer of municipal waste.

Highly engineered sanitary landfills are purpose built on impermeable grounds above the water table in order to protect the aquifer, water courses, surface water or the drinking water system from any contamination. The landfill must be properly operated and any deposited unusable health care goods must be covered with a layer of soil.

33.5.4 Waste immobilization by encapsulation

Large quantities of unusable health care goods should not be disposed of in landfills without prior treatment such as encapsulation. In order to reduce the volume of goods all outer packaging is removed from drug products which must remain in their primary manufacturer packaging. High-density polyethylene or metal drums which have previously not contained explosives or hazardous materials are cleaned and filled to three-quarters of their capacity with unusable solid and semi-solid health care goods.

The remaining space is filled up with plastic foam, bituminous sand, cement, mortar or clay material. A mixture of 3 parts lime, 3 parts cement and 1 part water (in terms of weight) can also be used (WHO 1999d, 12). After drying then the containers are sealed by tightly fitting or welding a lid and disposed of in a landfill.

Encapsulation makes scavenging very difficult, prevents release of unusable health care goods or components into the environment or at least delays the release until the container is damaged or degraded.

Encapsulation is inexpensive, simple to carry out and does not require specialized equipment.

33.5.5 Waste immobilization by inertization

Waste immobilization by inertization can be applied only to solid dosage forms and powders or to other wastes in form of powder such as ashes with high metal content.

Compared to immobilization by encapsulation, the waste volume is greatly reduced by removing all packaging from tablets, capsules, granules etc. before grinding them to a powder with a grinder or road roller. During this process all workers must wear gloves, boots, overalls and dust masks to prevent inhalation of aerosols and particles.

The ground drug products (65% by weight) are mixed with lime (15%), cement (15%) and water (5%) and mixed to form a homogenous paste. The paste is formed into cubes or transported in liquid form and decanted into a landfill where it sets and solidifies. By bonding the ground drug products form a solid mass and their release into the environment is greatly delayed.

33.5.6 Sewer

Some liquid drug products such as syrups and intravenous fluids can be diluted and disposed of into public sewer systems in small quantities or fast flowing watercourses over a period of time (WHO 1999d, 22). However liquid wastes must never be disposed of in stagnant waters and antibiotic or antineoplastic substances must never be disposed of into sewers or watercourses.

33.5.7 Low temperature incineration

Burning waste or unusable health care goods at temperatures below + 800° C, either by open-air burning or in single-chamber incinerators, is considered as low temperature incineration.

In the absence of any proper incineration facilities or because the environmental disadvantages are not considered, unusable health care goods are sometimes burnt in metal drums or open pits.

Compared to landfilling, open-air burning has the advantage of certainly making the health care goods unusable and preventing reuse, greatly reducing the volume of waste as well as destroying sharps by melting them, provided that the incineration is complete.

However, open-air burning can lead to incomplete and non-uniform incineration. Because the temperature of less than + 800° C is not high enough to decompose chemical compounds, the burning of drug products can release toxic pollutants into the air. Moreover the burning of

halogenated plastics (such as PVC) at low temperatures also releases toxic compounds such as dioxins and hydrochloric acid (Prüss, A., E. Giroult, and P. Rushbrook 1999, 81).

The open-air burning should be carried out away and downwind from facilities and communities and the ashes can be buried in a landfill.

A "drum" or "field" incinerator is the simplest form of single-chamber incinerator and can be made from a 200 litre steel drum, a sheet of metal or from clay (Prüss, A., E. Giroult, and P. Rushbrook 1999, 87). The drum incinerator should be designed to allow the intake of sufficient air as well as adding fuel in order to keep the incineration temperature as high as possible. Both ends of a 200 litre steel drum are removed, a fine grate is fitted at the bottom and a screen or fine grate on the top to prevent ashes or light material from blowing out of the drum. In addition a chimney may be fitted. Instead of a steel drum, a wall of bricks or concrete can be erected.

A brick incinerator is built by laying a base of brick and cement, setting walls around the perimeter, placing a horizontal grill across the entire surface just above the front door and closing the cavity with a roof of bricks supported by horizontal steel strips. A metal cover in the ceiling allows loading the refrigerator, a door at the bottom allows removing ashes as well as

reside allows and a vertical pipe evacuates fumes.

Figure 33.1 Drum incinerator and brick incinerator

Drum and brick incinerators are inexpensive to built and operate and, like open-air burning, have the advantage of greatly reducing the weight and volume of unusable health care goods.

However, the temperature will not exceed + 200° C which will not destroy many chemicals and pharmaceuticals, burning will emit a lot of black smoke, fly ash as well as potentially toxic gases and the burning may be incomplete.

For operating a fire is started at the bottom of the incinerator and a bag of unusable health care goods is placed inside. Kerosene may be added and manual ventilation may be used to kindle the fire. After burning, the ashes are removed and buried in a landfill.

Depending on the size and the type of waste, approximately 100 - 200 kilograms of waste can be incinerated per day.

Static-grate, single-chamber incinerators operate at a temperature of only about + 300° C and have a burning efficiency of about 90-95%, meaning that 5-10% of the material is not burnt.

This type of incinerators are inexpensive to built and operate. While the incineration will reduce the weight and volume of waste by about 80%, the incineration temperature is not high enough to decompose pharmaceuticals and some chemicals.

The incineration at low temperatures and without any cleaning of the exhaust gases generates significant emissions of atmospheric pollutants such as sulfur dioxide, hydrogen chloride, hydrogen fluoride, black smoke, fly ash (particulates), carbon monoxide, nitrogen oxide and heavy metals (Prüss, A., E. Giroult, and P. Rushbrook 1999, 86).

The incinerators are operated manually and do not require qualified operators. Unusable health care goods and other wastes are placed on the grate at the bottom of the incineration chamber. Depending on the type of waste, lighting the fire may be aided by adding some kerosene. Hot air escapes through the chimney and air is drawn in through the oven mouth by natural ventilation. However, ventilation may be assisted by mechanical means. In order to ensure proper functioning of the incinerator, soot and slags need to be removed regularly from the incineration chamber with a shovel and can be landfilled.

During removal of ashes and slags from any incinerator workers should wear protective dust masks.

33.5.8 Medium temperature incineration

The double-chamber pyrolytic incinerator consists of two chambers both made from steel lined with refractory bricks which retain their strength at high temperatures and are resistant to corrosion as well as thermal shocks.

In the pyrolytic chamber the medium-temperature combustion process at + 800° to + 900° C is started with a fuel burner which thermally decomposes the waste but produces potentially toxic flue (exhaust) gases. Therefore gases are led to the post-combustion chamber where they are burned for at least 2 seconds with a fuel burner at a temperature of + 900° to + 1,200° C with a 100% excess of oxygen and high turbulence to minimize the smoke. Properly maintained and operated small pyrolytic incinerators do not require exhaust-gas cleaning while large incinerators require treatment of the flue gases to remove fly ash and toxic compounds.

The capacity of pyrolytic incineration, also called controlled air incineration or double-chamber incineration, at hospitals is usually around 200 - 1,000 kg/day.

The incinerators are relatively expensive to built and require trained operators in order to monitor the combustion process and minimize the environmental impact of emissions.

33.5.9 High temperature incineration

Incineration at high temperatures requires purpose built incinerators which are equipped with facilities to remove pollutants from emissions (flue gas cleaning). Such facilities are expensive and unlikely to be found in less developed countries.

Rotary kiln incinerators consist of a combustion chamber rotating 2 to 5 times per minute and a post-combustion chamber where gases are heated and burned at high temperatures with a residence time of at least 2 seconds (Prüss, A., E. Giroult, and P. Rushbrook 1999, 84). Rotary kiln incinerators which are inclined at an angle of 3-5% are operated continuously by charging waste at the top and evacuating ashes at the bottom end.

Rotary kiln incinerators operate at temperatures of + 1,200° to 1,600° C and allow decomposition of several tonnes of toxic waste, chemicals and waste drug products per day.

The equipment as well as operations are expensive and require specially trained staff.

While purpose built rotary kiln incinerators are unlikely to be available in less developed countries, temperatures well in excess of + 850° C are reached in cement kilns, coal fired thermal power stations or foundries. Long combustion retention times are reached and exhaust gases are dispersed by high chimneys. These are therefore good alternatives to medium temperature incineration.

Cement kilns reach temperatures of up to + 1,450° C, combustion gas temperatures of up + 2,000° C with combustion retention times of several seconds and are therefore particularly suited for disposal of unusable drug products and chemicals (WHO 1999d, 14).

The incineration in existing facilities does not require any investment and as a general guideline, 5% of the total fuel can consist of unusable drug products. As cement kilns consume large quantities of fuel they allow to incinerate large quantities of unusable drug products.

33.5.10 Chemical decomposition

This method should be carried out only by experts. According to the manufacturer's instructions, unusable drug products are treated with specific chemicals and the remaining waste is then disposed of in a landfill.

Chemical decomposition is time consuming, requires special chemicals as well as an expert. Moreover different drug products require different treatment.

33.5.11 Selecting disposal methods

The following chapter will discuss the appropriate disposal methods for different types of health care goods (see table 33.12).

Again this chapter considers only unusable health care goods which have accumulated in medical distribution centres or were damaged upon receipt but does not consider any kind of contaminated health care waste from health care facilities. In terms of contamination only the damaging of packaging of sterile single use medical devices is considered which will lead to immediate exposure to micro-organisms ubiquitous in the environment.

Radioactive waste is not considered as the use of radionuclides for diagnostic or therapeutic purposes is unlikely in the context of less developed countries in complex political emergencies.

The option of returning health care goods to the donor is purposely not considered in table 33.12 as this will depend on the circumstances. Returning any health care goods which are (nearly) expired, damaged or unsuitable for the context at the time of shipment by the donor should be considered. However, health care goods which expire in medical distribution centres of humanitarian organizations because of poor stock management can of course not be returned.

	Return to manufacturer /supplier	Engineered or highly engineered landfill	Waste immobilization by encapsulation	Waste immobilization by inertization	Sewer	Medium temperature incineration	High temperature incineration
Drug products (except categories below)	•	SQ	•	•		SQ	•
Anti-infective drug products	•		•	•		SQ	•
Antineoplastics drug products	•		•				•
Antiseptics and disinfectants	•		•		SQ		
Chemicals (in general)	•		•			SQ	•
Chemicals, halogenated compounds	•						•
Chemicals, photographic waste	•						
Glass ampoules, sealed	•		•				
Internationally controlled drug products	•		•	•		•	•
Liquids, water-soluble (except anti-infective, -neoplastic)	•	•	•		•		•
Liquids, volatile	•						
Pressurized containers	•	•					
Single use medical devices (in general)		•				•	•
Containing chlorinated compounds		•					
Sharps			•			•	•
Health care equipment (in general)	•	•	•				
High heavy-metal content	•		•				

Table 33.12 Selection of disposal methods by type of unusable health care goods

The dumping on open, uncontrolled and non-engineered sites (landfills) is not considered as an option as humanitarian organizations should at least be able to treat unusable health care goods by encapsulation or inertization.

Disposal into "fast flowing water courses" is also not considered as an option as there is no clear definition and water courses are often not available. Moreover, knowing that in many countries untreated surface water will be used as drinking water and for personal hygiene,

disposal of any type of waste might be difficult to explain to the public as well as to the authorities.

Low temperature incineration should never be used for the disposal of unusable health care goods and is therefore not considered. Again, humanitarian organizations should at least be able to treat unusable health care goods by encapsulation or inertization.

Chemical decomposition is also not considered as it is not recommended unless special chemical expertise and materials are available (WHO 1999d, 16).

The option "Return to manufacturer" includes return to any intermediary such as a commercial distributor, wholesaler, importer etc.

The category "Engineered or highly engineered landfill" refers only to untreated unusable health care goods and not immobilized waste.

Disposal by waste immobilization by encapsulation or inertization by definition requires subsequent landfilling which is therefore not mentioned in the table.

The abbreviation "SQ" means "small quantities" which are defined in the respective section.

The overall criteria for selecting suitable disposal methods are the type of unusable health care goods, the total quantity as well as national legislation and regulations.

The objective of sorting unusable health care goods discussed in chapter 33.4 is to separate health care goods by disposal methods in order to possibly reduce the overall cost of disposal.

Under no circumstances should drug products be disposed of by open-air burning or other methods of low temperature incineration (WHO 1999d, 13) as toxic pollutants may be released into the air.

Returning unusable drug products to the manufacturer or supplier can always be considered but may not be practical.

The following considerations apply to drug products in general but excluding anti-infective and antineoplastic drug products, antiseptics and disinfectants, chemicals, sealed glass ampoules, internationally controlled drug products, liquids as well as pressurized containers.

Provided that no other suitable method is available, disposal together with municipal waste is acceptable provided that the unusable solid and semi-solid dosage forms constitutes less than 1% of the total volume of waste which is being disposed of at the same time (WHO 1999d, 21). The unusable drug products must be disposed of at the base of the working face of the landfill, be covered immediately with fresh municipal waste and security measures to prevent scavenging must be in place.

In general drug products can be disposed of by waste immobilization by encapsulation or inertization.

In emergencies and in the absence of high temperature incinerators, disposal in a double-chamber pyrolytic incinerator at a minimum of + 850° C and a two second retention time is acceptable (WHO 1999d, 13) whereby the unusable drug products should not constitute more than 5% of the total waste load (Prüss, A., E. Giroult, and P. Rushbrook 1999, 81).

The ideal method for disposal of drug products is high temperature incineration at temperatures above + 1,200° C in purpose built incinerators such as rotary kiln incinerators, cement kilns (Prüss, A., E. Giroult, and P. Rushbrook 1999, 115) or foundries.

Unusable anti-infective drug products, even in small quantities, must not be landfilled in order to ensure that they do not contaminate the environment. Ideally anti-infective drug

products should be incinerated at high temperatures but waste immobilization by encapsulation or inertization can also be applied.

Unusable antineoplastic (genotoxic, cytotoxic, cytostatic, anti-cancer) drug products should be returned to the manufacturer as they can stop growth or kill living cells, can have mutagenic, teratogenic or carcinogenic properties (Prüss, A., E. Giroult, and P. Rushbrook 1999, 4). They can interfere with the reproductive processes in various life forms (WHO 1999d, 23) and are highly hazardous to the health of individuals and to the environment.

Ideally they are returned to the manufacturer or supplier for disposal. Unusable antineoplastic drug products must not be removed from their primary packaging and can be immobilized by encapsulation but drums must be filled only to 50% capacity before adding the mixture of lime, cement and water. The sealed drums must be disposed of only in landfills which have been lined with an impermeable layer of clay or a membrane (WHO 1999d, 25).

As medium temperature incineration can result in the release of hazardous cytotoxic vapours (Prüss, A., E. Giroult, and P. Rushbrook 1999, 116), unusable antineoplastic drug products must be incinerated only at high temperatures.

The disposal of small quantities of up to 50 litres of antiseptics and disinfectants into sewers must be spread over the whole working day (WHO 1999d, 24). Larger quantities must not be disposed of in sewers as they will damage aquatic life and may kill the bacteria needed for the biological treatment of the sewage.

A wide range of chemicals such disinfectants, solvents, diagnostic reagents (xylene, methanol, acetic acid hydrochloric acid, acetone, various stains), preservatives (formaldehyde) as well as photographic chemicals are used in health care facilities.

As different chemicals are likely to react with each other, they should be stored separately and must never be mixed. Chemicals must never be disposed of in sewer systems and must not be landfilled as they may contaminate water sources.

Ideally unusable chemicals should be returned to the manufacturer or supplier who will have the expertise, equipment and facilities for their safe disposal and provisions should be included in the respective purchase contracts. Alternatively companies specializing in disposal of chemicals may be contracted.

Small quantities of chemicals such as residues in their packaging may be encapsulated or incinerated at medium temperatures.. However large amounts of chemicals must not be encapsulated as they may be corrosive or flammable.

Disposal in rotary kiln incinerators is ideal as the high temperatures will cause decomposition of the chemicals.

Halogenated chemicals (for example containing chlorine or fluorine), x-ray contrast media and povidone iodine should only be incinerated at high temperatures (WHO 1999d, 14) and in facilities with adequate gas-cleaning equipment.

Photographic waste from unusable or used x-ray film developing and fixing solutions should ideally be returned to the manufacturer or supplier but must be incinerated in any case.

The glass ampoules can either be encapsulated but must under no circumstances be incinerated as they can explode, injure workers, damage equipment and melted glass can clog up the grate of the incinerator.

Except for antineoplastic and anti-infective drugs, alternatively glass ampoules can be crushed, the glass disposed of as sharps and the liquid disposed of in sewers (WHO 1999d, 23).

According to national legislation and regulations, the disposal of internationally controlled drug products by medium or high temperature incineration, waste immobilization by encapsulation or inertization must be supervised by a pharmacist, the national drug regulatory authorities or other competent authorities.

Water-soluble and relatively mild drug products, such as vitamin solutions, syrups, intravenous solutions (salts, amino acids, lipids, glucose etc.) or eye drops, but not anti-infective, antineoplastic or internationally controlled drug products can be diluted with large amounts of water and discharged into sewers (Prüss, A., E. Giroult, and P. Rushbrook 1999, 114). Alternatively they can be incinerated at high temperatures or be disposed of in landfills with or without prior waste immobilization by encapsulation.

Small quantities of volatile liquids can be allowed to evaporate in the open air.

Pressurized containers such as, aerosols, inhalers, sprays or cartridges must never be incinerated as they may explode and can harm operators as well as damage incinerators.

Pressurized containers may be returned to the supplier or can be landfilled, provided they do not contain any poisonous substances (WHO 1999d, 25).

Containers which are de-pressurized, for example after being damaged, can be disposed of in a landfill.

Generally single use medical devices which do not contain any hazardous substances can be disposed of with municipal waste after they have been removed from their primary packaging and been made unusable by breaking, crushing, cutting or shredding. Single use medical devices and packaging materials which do not contain halogenated plastics such as PVC can be incinerated like health care waste.

Halogenated plastics such as polyvinyl chloride (PVC) must not be incinerated as the exhaust gases may contain hydrochloric acid and dioxins.

Damaged sharps such as hypodermic needles, cannulas, syringes, trocars, scalpel blades, single use scalpels, razors, razor blades, infusion and blood giving sets, broken glass or (sterile) sharps with damaged packaging must be collected in puncture-proof safety containers to avoid injury of staff during collection, storage and transportation.

Safely closed sharps containers can be either encapsulated or incinerated at medium or high temperatures. Safety containers containing the sharps as well as needles, razors or various blades may be attractive for scavengers and must therefore not be disposed of in landfills without encapsulation.

Unusable health care equipment may be returned to the manufacturer or supplier. Provided that health care equipment does not contain any toxic substances and has been rendered unusable without any possibility of repair, can be landfilled. Reuse or repair of small devices can also be prevented by encapsulation.

Health care equipment containing heavy metals such as lead (batteries), mercury (thermometers, sphygmomanometers) or cadmium must not be incinerated, not even in high temperature incinerators, as the heavy metals will generate toxic vapours. They must also not be disposed of in landfills as the heavy metals can contaminate water sources.

Medical devices containing heavy metals may be returned to the manufacturer or supplier for recycling or disposal by waste immobilization of encapsulation and subsequent landfilling at an impermeable site.

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34 ORDER FULFILMENT

Recipients of humanitarian assistance usually do not have a choice between different suppliers and may be reluctant to complain about poor services. Humanitarian logisticians may also be tempted to use the constraints humanitarian organizations encounter as well as the difficult environment in which they work as a pretext for providing mediocre services such as poor stock availability and long lead times.

Nevertheless health care logisticians must make every effort to continuously improve their services and strive for excellence.

Filling customer orders is the ultimate objective of all logistics activities.

The process of order fulfilment (see table 34.1) starts when customer orders are received and is completed when the full quantities of all ordered line items are delivered.

A Order processing

- Receipt of order.
- Registration.
- Review and validation.
- Prioritization.
- Order entry.
- Allocation of stock.
- Substitution (if necessary).
- Acknowledgment.

B Preparation of ordered goods

- Issuing picking list.
- Order picking.
- Packing.
- Issuing of documentation.
- Issuing of an advance shipping notice.
- Loading.

C Delivery

- Shipment.
- Handing-over of consignments.
- Acknowledgment of receipt by customers.

D Follow-up

- Receipt and follow up of claims (if applicable).
- Updating backorder record.
- Updating order status information.
- Closing order.
- Filing documents.
- Analysis of quality of service provide to customers (performance measurement).

Table 34.1 Process of order fulfilment

34.1 Processing customer orders

Processing and filling customer orders is the main objective of health care logisticians and must be at the centre of all logistics activities. Logistics procedures can be perceived or seen as bureaucratic or even unnecessary. A written customer service policy and guidelines for ordering can help customers understand the process and procedures which result from these processes and help convince them that formal customer orders are indispensable for providing services effectively and efficiently.

34.1.1 Receipt

All customer orders should be made in writing. Verbal orders, whether in person or by radio or telephone, are less precise and misunderstandings are more likely than with written customer orders. Verbal ordering requires logisticians, who might not know the programme or context and who may not be health professional, to take notes which makes mistakes almost inevitable. Customers may later not recall all the details of their verbal orders which are also more likely to be changed than written customer orders. Moreover accepting verbal orders bears the risk of misappropriation of stocks as they cannot be formally approved and authorised by health programme managers.

Wherever possible, customers orders should be transmitted to logistics services by electronic means such as electronic mail or telefax. Transmission of hardcopies not only cause unnecessary delays but paper documents may be lost or mislaid.

If, exceptionally, verbal customer orders are received and accepted in acute emergencies, also written customer orders should be sent as soon as possible for confirmation and documentation.

In order to avoid unnecessary delays customer orders received by mail or telefax must be forwarded to logisticians in charge of customer service immediately.

Customers serving themselves in medical distribution centres without prior submission of a formal customer order should not be allowed. If health care goods are removed from medical stores without any documentation and recording, monitoring stock issues and stock levels is impossible. Consequently orders for stock replenishment will be incorrect or will be made too late.

No "shopping" by customers in medical distribution centres.

34.1.2 Registration

Customer orders must be registered immediately after receipt in order to prevent them from being mislaid or lost without noticing.

All important details such as the date of receipt, name of the customer, her/his destination, order reference number, the requested delivery date as well as type of ordered health care goods, should be entered chronologically into a central register.

34.1.3 Review and validation

All customer orders must be carefully reviewed as soon as possible in order to determine whether important details are ambiguous or missing as well as for determining any obvious

mistakes. This allows clarifying any missing details or apparent mistakes as quickly as possible in order to avoid any unnecessary delay of filling customer orders. However, careful review of customer orders must be part of providing services rather than be mistaken for part of the validation process in which customers have to "justify" their orders.

As customer orders are issued and validated by health professionals, they must in principle be assumed to be reasonable and correct. Health care logisticians, who are not necessarily health professionals and who may not be familiar with the respective health programme or health care facility, cannot be expected to evaluate customer orders.

All details of customer orders (see table 34.1) should be carefully reviewed. As the name and location of recipients may differ from those of the requester, the exact delivery address must be ascertained.

The specifications of all requested health care goods must be unambiguous and, for example, include the dosage form and strength of dosage unit for all drug products.

The unit of measurement is of particular importance as misunderstandings can lead to significant differences between the quantities customers intended to order and quantities they actually receive.

Order quantities should also be carefully reviewed for obvious mistakes. In case of mistyping, order quantities can easily be mistakenly increased by tens or hundreds by customers.

The requested delivery date should also be carefully checked to ensure that logistics services can realistically delivery within the requested lead time.

Customer orders should be treated immediately after receipt.

34.1.4 Prioritization of order treatment

Ideally all customer orders are treated immediately after receipt according to the "first come, first served" (FCFS) principle and therefore in the same order as they arrive.

However, in case several customer orders are received before treatment of previous customer orders can be completed, customer orders may need to be prioritized. Whenever possible, prioritization should be undertaken in close cooperation with all concerned customers as well as the health programme managers.

There may be little benefit from immediate treatment of customer orders which request delivery only in some weeks time. At the same time treatment of such an order may delay another order by a customer who has requested immediate delivery.

Customer orders can be prioritized by the requested delivery date or earliest due date (EDD). The time required for order picking and packing, which may differ considerably between customer orders, must be taken into consideration. Therefore customer orders must not simply be treated in the order of their due delivery date as this would only be appropriate if all customer orders required the same time for order picking, packing and shipment.

However, customers who plan ahead and allow logistics services time for filling orders, must also be served reliably and on time. Otherwise customers will lose confidence in the logistics services and request immediate delivery for all their orders just to avoid unreasonably long lead times.

The criticality of ordered health care goods as well as the health programme and situation of customers are relevant criteria. For example delivery of life-saving drug products or

replacement parts for essential health care equipment must be given priority. Customer orders from acute emergencies must be given priority over providing health care goods for routine stock replenishment.

Customer orders might also be prioritized according to the next available transportation. For example customer orders arriving the day before weekly flights to their destination might be given priority over customer orders which were received earlier but for which daily transportation is available. In this system the objective is to minimize the total delivery lead time for all customers rather than minimizing delivery lead time for any particular customer.

The overall expected transportation lead time may also be a criteria. Customers for which lead time for transportation and customs clearance are known to be long might be given priority over other customers. In this system the objective is to minimize the longest lead time for any customer.

- First come, first served.
- Due delivery date (earliest due date).
- Criticality of ordered health care goods.
- Health programme and situation of customer (routine replenishment versus emergency).
- Availability of next available means of transportation.
- Expected total transportation lead time.

Table 34.2 Criteria for prioritizing customer orders

Although convenient, merely treating customer orders according to the shortest processing time (SPT) must be avoided as this will eventually lead to longer and longer delays of larger customer orders. Moreover, customers will be tempted to split larger orders into smaller orders if they realize that the later are prioritized.

34.1.5 Order entry and allocation of stock

Ideally customer orders are received electronically and are simply uploaded into the logistics information system.

In case available stocks are not sufficient for filling all unfilled customer orders or stocks are sufficient but further customer orders which will cause a stockout are expected, various policies for sharing available stocks are available (see table 34.3). A decision must be made which order to fill first or which quantity to allocate to each customer order.

A distinction must be made whether stock is allocated to different customer orders subsequently without knowing when and how many customer orders will follow in future or whether stock is allocated to several customer orders at the same time.

In the case of subsequent allocation, customer orders are treated immediately after receipt. As it is usually not know whether further customer orders will arrive in future, the question of allocating stock is limited to the decision whether to issue all available stock.

The simplest allocation policy is to issue any ordered quantity as long as stock is available. The policy is easy, does not require any interventions by health care logisticians, the policy ensures that all available stocks are used and that no unnecessary backorders are accumulated. The disadvantage of this policy is that customers which already have large stocks may receive even more stock while, in case of a stockout, subsequent urgent orders from other customers cannot be filled.

A) Subsequent allocation

- First come, first served.
- Maximum order quantity ("heavy order trap").
- Maintaining defined minimum (safety) stock levels.

B) Simultaneous allocation

- Urgency of orders.
- Pro rata allocation.
- "Fair share allocation" (equalizing coverage time of stocks of all customers).

Table 34.3 Policies for limiting maximum order quantities

An alternative is to limit the maximum quantity which any customer can order for any line item (Mak, K.L., Y.S. Wong, and G.Q. Huang 1999, 276). Any order quantity up to the maximum quantity is filled from stock while any quantity exceeding the defined maximum is backordered. This policy will reduce the probability of stockouts as it prevents a single customer order to "wipe out" the entire stock. On the other hand, despite stock being available, such a policy will lead to backorders which have to be managed and eventually have to be filled.

However, maximum order quantities have to be defined for each line item and will inevitably be arbitrary. Moreover customers may be tempted to place multiple customer orders with smaller order quantities to circumvent the restrictions.

Another policy is maintaining a defined safety stock for each line item. Customer orders are filled without any limitation until stock on hand reaches the defined minimum (safety) stock level while any subsequent customer orders are backordered. These safety stocks are then reserved for urgent customer orders such as emergencies or impending stockouts at health care facilities. Defining safety stock levels will inevitably be arbitrary to some degree and customers may be tempted to declare all their orders as "urgent" in order to have their orders filled rather than backordered.

All the policies described above have the disadvantage that they are indiscriminate and do not consider how much stock is left at assisted health care facilities.

When several customer orders are received simultaneously stock can be allocated according to different principles. Several customer orders may actually arrive at the same time or a second customer order may arrive while another previous customer order has not been filled yet and stock can still be re-allocated.

Available stock can be allocated according to the urgency of customer orders, for example giving priority to health care facilities facing a sudden influx of a large number of patients. However, while it is tempting to give priority to acute emergencies, every shortage or stockout at a health care facility must be considered as an emergency. Such a policy seems obvious but defining and comparing the urgency of different customer orders may be difficult.

Another policy is to allocate available stock proportionally according to the ordered quantities, for example filling 50% of the order quantity for any line item of all customer orders. This policy may tempt customers to always inflate their customer orders and causing demand distortion. Moreover this policy does not consider stock levels at assisted health care facilities.

The "fair share allocation" policy allocates stock in a way that coverage times of stocks at all customers are raised to same level (Bowersox, D.J., and D.J. Closs 1996, 289) or at least the

differences are minimized. In principles any stock at a customer which is not needed does not provide any value while the same stock could be life saving at another customer facing a stockout.

In this policy customers with large stocks on hand will receive less than customers with low stock levels and customers with low average demand will be allocate less stock than customers with on average higher demand. This policy has the disadvantage that the stock on hand as well as average demand of all customers must be know but minimizes the overall risk of stockouts at all assisted health care facilities.

Wherever possible, the fair share allocation system should be applied as the main objective of health care logisticians must always be to minimize the number of stockouts at all assisted health care facilities.

Allocate available stocks in a way that minimizes the number of customers with stockouts.

While shortages of stocks must be managed as well as possible, at the same the demand forecast, inventory control system and previous stock replenishments must be reviewed to identify any mistakes or potential for improvement.

34.1.6 Substitution

Substitution is the replacement of an ordered line item by another line item which is similar or can serve the same purpose or function.

Substitutes may be offered to customers for several reasons (see table 34.4), especially in emergencies. In case of stockouts or shortages of one line item another similar item may be offered. For example compresses or syringes of similar sizes.

Customers ordering non-standard line items should be offered the corresponding line item included in the standard item catalogue.

Health care logisticians should offer available cheaper substitutes to customers. For example hospital packaging of drug products are usually far cheaper than the same drug product in blister packaging.

Unused excess stock may also be offered to customers which have ordered similar line items.

Finally customers ordering line items which are contained in a standard kit which needs to be turned over in order to ensure stock rotation may be offered the standard kit instead of filling the order with separate line items.

- Stockout of requested line items.
- Shortages of requested line items.
- Orders for non-standard items.
- Availability of cheaper substitutes.
- Available excess stock which can substitute ordered line items.
- Need to turn over kits.

Table 34.4 Reasons for offering substitutes to customers

In any case line items should be substituted only after informing customers and obtaining their approval. In some case the initial order quantities may have to be adjusted to the offered substitute.

34.1.7 Acknowledgment

The order acknowledgment first of all confirms to customers that their orders were not lost, have arrived at the right place and are now being treated. In case orders are forwarded to a higher level customers are informed where the order will be treated.

All received customer orders must be acknowledged in writing.

Ideally the receipt of customer orders should be acknowledged immediately by the medical distribution centre. However, ideally the customer should also be provided with a range of information (see table 34.5) which may not all be available immediately.

If treating customer orders and collecting the information for providing a detailed acknowledgment is expected to take more than one working day, a simple acknowledgment of receipt should be sent immediately and a second order acknowledgment with the missing details should be sent as soon as possible later on.

If customer orders are routinely acknowledged only after several days, customers will not notice in case their orders were actually lost or customer orders were not transmitted by mistake.

The order acknowledgment should indicate the date and time of receipt. This will allow determining any possible delays in validation or transmission of customer orders. The customer should also be informed whether the customer order is being treated at the medical distribution centre where it was received or is backordered to an upstream medical distribution centre.

The health care logistician treating and following up the customer order should be named as a future reference in case customers want to inquire or have further questions.

- Date and time of order receipt.
- Place where order is being treated.
- Person responsible for treating the order.
- Stock availability.
- Proposal for substitutes if necessary.
- Backorders.
- Cost (estimate).
- Weight (estimate).
- Volume (estimate).
- Expected shipment date.
- Planned mode of transportation.
- Partial shipments.
- Expected delivery date.
- Request for clarification of unclear orders.

Table 34.5 Contents of order acknowledgment

Customers should be informed about any line item or any quantity of a line item which is not available and whether they are being backordered to a local supplier or an upstream medical distribution centre while other line items are assumed to be in stock. This information allows the customer to decide whether expected delays for line items which are not in stock are acceptable or an urgent order to the upstream medical distribution centre is necessary.

Wherever possible, a substitute should be offered in case of a stockout or shortage of any line item.

The order acknowledgment should include an estimate of the total value, the total weight as well as the total volume of the consignment. Moreover the expected shipment date, planned mode of transportation as well as expected delivery date should be indicated. Customers should also be informed if several partial shipments will be made for filling the order, for example if the capacity of the means of transportation is not sufficient to ship the entire consignment at the same time.

In order to avoid delays for filling orders, customers should be requested in writing to clarify any ambiguous, incomplete or incorrect orders as quickly as possible.

34.1.8 Issuing picking lists and packing

Picking lists should be generated automatically by the information system. In case customer orders were entered manually the picking list should be crosschecked with the original customer order for detecting possible errors.

The picking list should be signed by the responsible health care logistician before handing over to the medical warehouse staff for processing (see chapter 28).

As soon as the consignment is ready for shipment, the medical warehouse manager should forward the details to the health care logistician for preparing the advanced shipping notice.

34.2 Delivery to customers

When different modes and means of transportation are available, speed and costs need to be compared. Customers tend to favour fast transport such as by air. However if they are made aware of the real costs they may consider more carefully in which situations fast, and expensive, delivery is really justified and adds value to their health programme.

34.2.1 Advance shipping notice

Before any consignments are shipped to another medical distribution centre or an assisted health care facility, the respective customer must be informed in advance (see table 34.6).

The advance shipping notice must clearly identify the customer order reference number as well as the order date. Customers may receive the same line item from different customers orders, possibly even in the same shipment.

Recipients must also receive details on the number of parcels, the total weight, volume and value of consignments as well as the packing list and waybill or air waybill number. The medical distribution centre should also provide information on the mode of transportation.

The inclusion of any cold chain consignments in shipments must be clearly indicated in order to allow recipients to make arrangements for immediate pickup and, if necessary, transfer, for example from an airport to the medical distribution centre.

Finally the expected or actual date of shipment as well as the expected date of arrival as well as transportation schedules in case of shipment of several consignments should be included. The exact destination and delivery address should be added as they may differ from the location of the requester.

Ideally advance shipping notices should include the electronic copies of any shipping documents.

- Order reference (order number, order date).
- Packing list number.
- Number of parcels.
- Total weight.
- Total volume.
- Total value.
- Waybill or air waybill number.
- Mode of transportation.
- Special transportation requirements(if applicable), cold chain etc.
- Expected or actual date of shipment.
- Expected date of arrival.
- Final destination.

Table 34.6 Contents of advance shipping notices

34.2.2 Handing over to recipients

Consignments should be handed over by a staff member responsible for the health programme in general as well as for deciding what types as well as quantities of health care goods should be donated to assisted health care facilities. These staff members are in a better position to discuss all issues concerning assistance with health professionals at assisted health care facilities than health care logisticians.

If vehicles were sealed after loading, a staff member of the humanitarian organization together with staff at the receiving health care facility should open the seal.

Recipients must be handed a detailed waybill as well as a detailed and accurate packing list indicating each batch of each line item in the consignments. Without a detailed packing lists recipients are not able to inspect consignments or acknowledge receipt.

The number of parcels should be counted during unloading and compared with the (air) waybill and packing list(s). During unloading parcels should be also checked for any obvious damage such as crushing or leaking liquids.

In case consignments are shipped to another medical distribution of the humanitarian organization the procedures outlined in chapter 28 apply.

34.2.3 Acknowledgment of receipt

Recipients should acknowledge receipt of consignments of health care goods by signing the respective waybill. After counting the contents of all parcels the name and place of the assisted health care facility, date of receipt and name of person responsible receiving the consignments should be written on the packing list which should also be signed before

returning to the humanitarian organization. Humanitarian organizations require this acknowledgment for their donor reports and accounting for funds they have received.

Any missing line items or quantities of line items as well as any damages should also be indicated on the packing list or in a separate claim.

34.2.4 Issuing claims

Claims and complaints may be raised by customers concerning the quantity, quality or packaging of health care goods as well as concerning the documentation.

Consignments may contain line items which were not ordered, health care goods with the wrong specifications such as the wrong strength of unit dose, size or in the wrong quantity.

Recipients may raise claims because of the poor quality of health care goods or the poor quality of packaging.

Other reasons for claims are damaged packaging or damaged health care goods such as broken health care equipment or drug products exposed to too high temperatures. Drug products or single use medical devices may also be returned because the remaining shelf life upon receipt was too short to allow utilization before expiry.

Finally claims may be raised because of missing or inaccurate packing lists or waybills.

- Wrong line item.
- Wrong quantity (too many or too few).
- Poor quality of health care goods.
- Poor quality of packaging.
- Too short remaining shelf life.
- Damaged packaging.
- Damaged health care goods.
- Missing shipping documents.
- Inaccurate shipping documents (packing list).

Table 34.7 Possible reasons for claims by customers

Quality claims may be raised at the time of receipt or at any time afterwards when problems are noted. Any problems with the quality of health care products need to be documented carefully by a competent health professional.

Customers need to provide as much detail on the problem they encountered as possible. For example simply stating that goods were of "poor quality" will not be sufficient information to take up the issue with a supplier.

34.3 Order follow-up

The ultimate purpose of logistics activities is providing good services to customers and fulfilling customer orders on time.

Health care logisticians must follow up all customer orders in order to ensure that eventually the order quantities of all ordered line items have been delivered. Customers should never have to be concerned that their orders are not being followed up.

34.3.1 Following up claims and complaints

Any complaints or claims must be taken seriously, carefully registered and their receipt acknowledged to customers. Likewise any complaints, for example because of late deliveries should be treated in the same way.

Health care logisticians need to determine whether the cause of claims or complaints lies with the manufacturer, medical distribution centre or the carrier in order to prevent the problem from recurring.

Any health care goods which were found to be damaged upon receipt by the customer must be replaced. Medical distribution centres in turn might raise claims with carriers, manufacturers or suppliers in case of damage or non-compliance of delivered health care products with purchase contracts.

34.3.2 Updating the backorder record

All line items or quantities of line items for which customers have acknowledged receipt must be recorded in and removed from the respective customer order.

Meticulous follow-up is especially important when customer orders are only partially filled and several partial shipments are needed to fill the order.

Ideally the backorder record is maintained and automatically updated by the information system. If backorder records are updated manually, great care must be taken to avoid mistakes as otherwise any mistake will lead to unfilled line items or quantities of line items.

All backordered line items must be added to the orders for stock replenishment to upstream medical distribution centres or be forwarded to the purchasing department.

The backorder record is also essential for identifying line items arriving from a supplier which must be immediately prepared for shipment. Whenever consignments arrive at the warehouse, or shipment advance notices are received, packing lists are compared with the backorder record. Backordered line items expected to arrive are marked so they can be immediately picked and packed after the consignment has been received at the warehouse.

The backorder record is also an important tool for monitoring the quality of provided logistics services. Health care logisticians should make every effort to fill backorders as quickly as possible.

34.3.3 Order status information

Keeping customers and health programme managers updated on the status of their orders is essential for planning health programmes.

The regular provision of order status information starts with acknowledging receipt of customer orders. Further steps are information on order picking and packing as well as stages of shipping and the location of consignments.

For line items which are not in stock, information on progress of purchasing must be provided regularly. Customers should be informed whether suppliers currently have the requested line items in stock, are awaiting backorders, must place an order to their suppliers or are offering a substitute.

In addition to informing customers on the progress of individual customer orders a complete overview of all backordered line items should be compiled regularly, weekly or at least once a month.

This backorder record should indicate the order reference number, order date, ordered quantity, outstanding quantity as well as expected delivery date for every line item.

Detailed backorder records assure customers that all their orders are being treated and have not been forgotten. The expected delivery dates allow health programme managers and assisted health care facilities to consider alternatives such as substitutes, in case the indicated lead times are not acceptable.

The careful review of backorder records by customers is also an important means of detecting mistakes made during treating customer orders, such as mistakes in recording the kind or quantities of ordered health care goods at the time of receipt of customer orders by logistics services.

35 PERFORMANCE MEASUREMENT

Actual performance measurements require identifying suitable data sources and collection of data by staff members or external evaluators. Logistics managers must clearly assign responsibilities for these tasks and determine the measurement frequency and times.

35.1 Data sources

Ideally all required data will be recorded in the (logistics) information system and will be readily available at any time through reports. In addition most records will be available as hard copies.

All records such as customer orders and backorder records, customer claims and complaints, the stock list and stockout list, warehouse records (bin cards, stock cards, goods inward and goods outward register, entry forms, picking lists, packing lists, waybills) as well as purchase contracts and supplier files are potential sources of data.

Other sources are (donor) reports, written communications (electronic mails), organization charts, financial records (budget, expenses), temperature records (stores and refrigerators) as well as vehicle log books (distances, times, fuel consumption).

Data may also be collected through measurements such as time (picking and packing time), distances (size of stores and warehouses), counts (warehouse utilization) as well as physical stock counts (spot checks).

Quantitative as well as qualitative data can also be collected by direct observations.

The most important source of qualitative data are casual and formal meetings with customers, open and structured interviews with programme managers as well as health professionals at assisted health care facilities as well as written questionnaires and surveys.

- Information systems.
- Records.
- Measurements.
- Direct observations.
- Customer interviews and written surveys.

Table 35.1 Possible data sources for performance measurements

35.2 Data collection

Required data may need to be collected by measuring, analysing records, direct observations or require carrying out interviews. However the required (raw) data may also be available from electronic or hard copy records for further processing and calculation of performance measures. Finally, ideally the required performance measurements are readily available from information systems as reports.

If the required data is not readily available, it must be collected systematically by selecting only relevant data items. For quantitative data usually all available data (such as customer orders, contracts etc.) will be analysed. In cases where the required data is not registered, for example for measuring the accuracy of stock records, taking a sample will allow reducing the time required for data collection.

The acquisition of qualitative data should be based on a reasonably large sample. For example a single interview for determining customer satisfaction is unlikely to be representative for the perception of services by all customers.

Instead of taking the collected data at face value, its accuracy should be validated. Wherever possible, information received verbally should be confirmed by direct observations. In case of sampling the probability of discrepancies between the sample mean and the actual mean, for example, will decrease with increasing sample sizes. However the additional resources required for analysing a larger sample should be balanced against the expected increase in accuracy.

The collected data can be converted into usable and interpretable information by selection of data (items), analysis and interpretation as well as by calculation of performance measures by using formulas or algorithms.

35.3 Customer satisfaction surveys

Customers satisfaction surveys using interviews or questionnaires allow measuring intangible attributes such as perceptions and are a specific way of collecting data and information. Survey forms and questions should be standardized in order to avoid bias during recording, allow analysis as well as comparison with other services or across time.

Customer satisfaction surveys should be used by logistics staff in the field regularly as well as at head offices during debriefings.

Written customer satisfaction surveys using rating scales allow quantifying the results as well as calculating averages and distributions.

Unlike quantitative performance measures, customer surveys allow determining levels of customer satisfaction as well as understanding the importance and priorities customers assign to various service elements. Customer surveys also allow identifying services which are less important to customers and therefore help avoid wasting valuable resources.

When interviewing customers or carrying out surveys the possibility of bias in both directions must be considered. Especially staff at assisted health care facilities may be suspicious about the motives for asking many questions and may be reluctant to answer them. Customers may be (very) reluctant to disclose their real opinion on the received services as they may fear that any negative comments may decrease or even jeopardize future assistance.

36 CLOSING LOGISTICS OPERATIONS

Humanitarian organizations provide services to people in need during emergencies and therefore programmes are closed or handed over to local authorities or organizations when the emergency recedes and needs for (international) assistance decrease.

The length of programmes are sometimes limited in time from the beginning because humanitarian organizations have only limited resources.

Closing logistics operations involves management of staff, assets, stocks, facilities and vehicles.

36.1 Reasons

Medical storage facilities may be down-sized or closed entirely for various reasons (see table 36.1) and such closures may be planned or unplanned.

- Evacuation of staff.
- Damage to or destruction of medical storage facilities.
- Closing of programmes.

Table 36.1 Reasons for closing medical storage facilities

36.2 Managing closures

Closing of logistics operations should be planned well in advance.

36.2.1 Staff

The first step is to inform staff, who will perhaps have been working for the humanitarian organization for many years. This allows them to consider the options for their future and find employment elsewhere.

Gradual reduction of staff levels as logistics operations decrease may be easier to manage than a sudden closure.

All staff must be given appraisals and documents certifying their employment. In a country suffering from the consequences of armed conflict and with high rates of unemployment, these documents may be their best asset for seeking employment elsewhere. Staff with experience in humanitarian organizations are often coveted by other humanitarian organizations which continue their programmes or development organizations which are starting their programmes.

36.2.2 Stocks

Stock levels should be gradually decreased as humanitarian assistance programmes decrease in order to avoid having large unwanted stocks at the time of closure. Customer demand must be monitored very closely and replenishment orders decreased accordingly.

Alternatively stocks may be moved to other medical distribution centres or even other countries where the same humanitarian organization maintains other health programmes. However the cost of packing and transportation should be considered.

Remaining stocks can also be donated either to the health care facilities which are currently supported, to other health care facilities, the authorities, the government or other humanitarian organizations.

Most less developed countries suffer from chronic shortages of health care goods and health care equipment and therefore most stocks will be needed in the country. However, donations to local health care facilities may not be in line with the intention of the humanitarian organization as well as the donors.

Donated health care goods must have sufficient long remaining shelf-lives in order to allow utilization by the receiving health care facilities. Expired or unusable health care goods must be disposed of safely to avoid use or resale.

36.2.3 Assets

Various assets (see table 36.2) must also be managed during closures.

- Vehicles.
- Materials handling equipment (forklift trucks, pallet trucks etc.).
- Generator sets.
- Computers.
- Communication equipment (telephones, radios).
- Office equipment (photocopiers).
- Furniture.

Table 36.2 Assets which need to be managed during closures

Because of the high value of assets, they usually are transferred to another programme or returned to national, regional or even international distribution centres. However they may also be donated in the country.

Furniture can be donated to health care facilities as well as schools or various social institutions.

When transferring assets such as vehicles or generator sets abroad, the customs status must be considered. Assets may have been imported for humanitarian assistance programmes and have been exempted from duties and tariffs which may imply restrictions on re-exporting.

36.2.4 Facilities

Various facilities (see table 36.3) also need to be considered during closures.

Management of facilities depends mainly on whether they were originally purchased, leased, rented or built.

Storage equipment may be disassembled and moved to another medical distribution centre if it is needed and transportation costs are reasonable.

In most cases terminating contracts for rent or lease will require giving advance notice and ensue some legal obligations. Facilities may need repair or conversion into their original state and facilities and premises must be cleaned.

- Warehouses.
- Stores.
- Offices.
- Workshops.
- Accommodations for staff.

Table 36.3 Facilities which need to be managed during closures

Any hazardous materials such as waste oil must be removed and be disposed of safely.

Any emblems, signs, flags etc. of the humanitarian organization must be removed to avoid abuse.

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GLOSSARY

Accelerated stability testing Finished drug products are subjected to exaggerated temperature and humidity (for example at 40° C and 75% relative humidity) for prolonged times (3 - 6 months) in order to increase the rate of chemical degradation. This allows predicting (estimating) the degradation at the recommended storage conditions and determining the recommended shelf life without requiring years of real-time studies (WHO 1997a, 53).

Acceptable quality level "The maximum percentage or proportion of nonconforming items or number of non-conformities in a lot or batch that can be considered satisfactory as a process average" (Mitra, A. 1998, 423).

Acceptance sampling Drawing of a sample from a received batch of health care goods for inspection. The inspection result (acceptance or rejection) of the sample is then considered as representative for the entire batch (Mitra, A. 1998, 422).

Active pharmaceutical ingredient (also active substance, drug substance, medicinal substance) Drug molecules (substances) which are intended to have a pharmacological effect, other effect in the diagnosis, cure, mitigation, treatment, or prevention of disease or affect the structure and function of the body (WHO 2007g, 10).

Advance shipping notice Written or electronic notification informing the (future) recipient of the weight, volume etc. of the consignment(s), mode of transportation as well as of the place and time of arrival etc. (Chopra, S., and P. Meindl 2007, 269).

Air waybill Contract of carriage between shipper and carrier for air transportation (Lambert, R.S., and J.R. Stock 1993, 699).

Algorithm "A systematic set of rules for solving a particular problem" (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 589).

Ampoule Single-dose plastic or glass container which is sealed by fusion and is used for packaging liquid drug products (or powders for reconstitution) intended for a single administration (WHO 1999b, 23, Aulton, M.E. 1988, 377).

Armed conflict A dispute involving the use of armed force between two or more parties. International humanitarian law distinguishes between international or non-international armed conflicts (UNOCHA 2003, 7).

Assay Quantitative analysis of finished drug products for determining the concentration of active pharmaceutical ingredients (and possibly degradation products) or its potency (for example for antibiotics).

ATA carnet "Temporary admission papers used for the temporary admission of goods, excluding means of transportation" (Convention on temporary admission, Annex A).

Autocorrelation function Correlation between values of a time series and the same time series with a time lag (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 590).

Auto-disable syringe (mistakenly also called auto-destruct syringe) Single use syringe which irreversibly locks the plunger in the barrel after administration of a vaccine and makes pulling back of the plunger, and therefore any reuse of the syringe, impossible (WHO 2004a, 3).

Backorder Line item (or quantity of a line item) in a confirmed customer order which is not (yet) filled, either because the item has not been picked yet or because it is not in stock.

Batch (lot) "A defined quantity of a starting material, packaging material, or product processed in a single process or series of processes so that it can be expected to be homogeneous" (WHO 1997a, 205).

Batch certificate (certificate of analysis) Document issued by the manufacturer stating and certifying the results of a full laboratory analysis for each individual batch of a drug product carried out (just) before the batch release (WHO 1997a, 192) and certifying compliance of the batch with the manufacturer's stated specifications.

Batch number (lot number) "A distinctive combination of numbers and/or letters which uniquely identifies a batch on the labels, its batch records and corresponding certificates of analysis, etc." (WHO 2007g, 11).

Batch picking Primary picking of the total quantity of a line item on several picking lists, transfer to the packing area and secondary picking for filling several customer orders.

Berth A place where a ship lies at anchor, a ship's place at a wharf.

Bid Formal offer of a supplier (bidder) for supplying specific goods or services at a stated cost and other conditions.

Bidder Supplier submitting a bid in response to an invitation to tender.

Bill of lading Contract of carriage between carrier and shipper, specifying details of the consignment and indicating legal responsibilities and liabilities. The bill of lading can be used to transfer title to the goods to a party named in the document (Lambert, R.S., and J.R. Stock 1993, 700).

Bill of materials Detailed list of required items (components) and quantities as well as the sequence for assembling a product or kit.

Bin card Stock record held for each batch in stock in its storage location which indicates item specifications, stock movement and current stock on hand.

Bioavailability "The rate and extent of availability of an active drug ingredient from a dosage form as determined by its concentration-time curve in the systemic circulation or by its excretion in urine" (WHO 1997a, 9).

Bioequivalence "Two pharmaceutical products are bioequivalent if they are pharmaceutically equivalent and their bioavailability (rate and extent of availability), after administration in the same molar dose, are similar to such a degree that their effects can be expected to be essentially the same" (WHO 1997a, 64).

Blister packaging Multidose container consisting of a plastic tray shaped to hold individual capsules, tablets or ampoules which is permanently sealed with a push-through or peelable sheet of paper, metal-foil, clear or opaque plastic.

Bonded warehouse Storage facility licensed by the government to store goods prior to payment of taxes or duties (Lambert, R.S., and J.R. Stock 1993, 400) or for goods in transit through the country.

Bottle Rigid plastic or glass container with a more or less pronounced neck and usually a flat bottom (WHO 1999b, 23).

Box pallet Pallet fitted with corner posts and sides to contain the products. The bottom ends of the corner posts may be fitted with bell ends to allow stacking (Rushton, A., J. Oxley, and Ph. Croucher 2000, 243).

Breaking bulk Splitting of a large consignment (for example pallets) of a single item received from a supplier into several smaller consignments for shipment to several customers (Bowersox, D.J., and D.J. Closs 1996, 394). Corresponds to cross-docking for a single item.

Bridge plate Steel plate for covering the gap between a lorry and the loading dock which can support materials handling equipment (for example hand pallet trucks or counterbalanced forklift trucks) during loading and unloading.

Caking The undesired sedimentation, agglomeration and consolidation by gravitational settling of dispersed particles (powder) in suspensions which are hard to redisperse by shaking (Beringer, P. et al. 2006, 309).

Capping (of tablets) Horizontal fracturing and separation into two parts (Aulton, M.E. 1988, 294).

Capsule Solid preparation with hard or soft shells of various shapes and capacities, usually containing a single dose of active pharmaceutical ingredient and intended for oral administration (Aulton, M.E. 1988, 322).

Cargo Goods (physical loads) carried by any means of transport.

Carrier (transporter) The person or organization operating the means of transportation and actually carrying out the physical transportation of goods.

Certificate of origin Certificate issued by the competent authorities confirming that the indicated goods were manufactured in the stated country.

Charriere Unit of measure for the internal or external diameter of medical devices such as tubes and catheters. Charriere indicates the length of the circumference in millimetres. A tube with an external diameter of 1 CH (1 mm) has a diameter of $1/\pi$ (1 Charriere corresponds to a diameter of approximately 1/3 of a millimetre).

Civilian Populations "Groups of unarmed people, including women, children, the sick and elderly, refugees and internally displaced persons, who are not directly engaged in the armed conflict" (UNOCHA 2003, 8).

Classical decomposition method Separation of a time series into trend, cyclical, seasonal and random subpatterns (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 593).

Closure Part of the container/closure system such as stoppers, (screw) caps, valves as well as various tamper-evident seals which seal the container, ensure containment of drug products and prevent contamination (WHO 1999b, 15).

Coefficient of variation Calculated by dividing the standard deviation of a set of data by its mean (Cachon, G., and Ch. Terwiesch 2006, 412). While the standard deviation is an absolute measure of variation, the coefficient of variation is a relative measure of variability which allows comparing the variability even if the data sets have different means.

Cold box Insulated container with a tightly fitting insulated lid that is lined with frozen ice-packs to keep cold chain loads at + 2° to + 8° C during transportation and storage (WHO 2004a, 4).

Cold chain A system of freezers, refrigerators, cold boxes, monitoring devices, transportation and people needed to maintain the temperature of cold chain loads at + 2° to + 8° C from the point of manufacture to the point of administration (Quick, J.D. (ed.) 1997, 332 and WHO 2004a, 72).

Cold chain load Consignment of cold chain goods contained and transported in a cold box or stored in an ice-lined refrigerator.

Cold chain products Drug products and in vitro diagnostic tests which require storage and transportation at + 2° to + 8° C without any interruption from the time of production until administration to the patient or use by a health professional.

Cold life Measured in a test chamber at a constant ambient temperature of + 43° C, after tightly closing the container lid of a cold box or vaccine carrier lined with the number and type of ice-packs recommended by the manufacturer and loaded with the maximum volume of cold chain goods, duration of time from when the the coldest (measured) point passes - 3° C until the warmest (measured) point inside the cold box first reaches a temperature of + 10° C without opened the lid at any time (WHO 2008d, 7).

Cold storage Storage of (cold chain) products at temperatures between + 2° to + 8° C.

Combatant "A person who takes an active part in hostilities, who can kill, and who, in turn, is a lawful military target. S/he can be a member of the armed forces, other than medical personnel and chaplains, or of an organized group" (UNOCHA 2003, 9).

Complement Items which are (generally) only accepted by customers together with another item or items (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 27). For example a bottle of infusion solution (usually) requires an infusion set for application.

Complex political emergency "A situation with complex social, political and economic origins which involves the breakdown of state structures, the disputed legitimacy of host authorities, the abuse of human rights and possibly armed conflict, that creates humanitarian needs" (ALNAP 2003, 201).

Consignee "A person to whom goods are consigned" (Shorter Oxford English Dictionary, 5th ed.).

Consignment Goods consigned for delivery to a consignee. Corresponds to the contents of a packing list.

Consignor "A person who dispatches goods to another" (Shorter Oxford English Dictionary, 5th ed.).

Contingency plan "A management tool used to ensure that adequate arrangements are made in anticipation of a crisis" (UNOCHA 2003, 10).

Counterfeits Counterfeits are health care products with a deliberate, fraudulent and false representation of the identity and/or source of the product, any of its components (active pharmaceutical ingredients or excipients) its composition, containers or other packaging as well as labelling (WHO 2008b, 3).

Coverage time (runout time) Stock on hand divided by the average monthly demand (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 368). The coverage time corresponds to the number of months customers can be supplied from the available stock, provided that average demand does not change and no stock is received.

Cross-docking Consignments arriving from suppliers are split by breaking bulk or separating items and regrouped into consignments for customers without any remaining goods and without any stock keeping (Chopra, S., and P. Meindl 2007, 397).

Curve fitting Approach to forecasting by simply fitting some form of curve, for example a polynomial function, to the historical time series data (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 594).

Customer "Customer means anyone or anything whose demand is met by removing units from stock" (Waters, D. 2003, 7).

Customer service level Percentage of line items or quantities delivered to customers up to the due delivery date. Assuming immediate order picking and packing, the customer service level corresponds to the stock availability.

Cycle stock Stocks held for filling customer orders during the review period, assuming that average demand does not increase (Bowersox, D.J., and D.J. Closs 1996, 251).

Dangerous goods Articles or substances which are capable of posing a risk to health, safety, property or the environment and which are listed in or classified according the IATA Dangerous Goods Regulations (IATA Dangerous Goods Regulations, Section 1, 1.0).

Date of manufacture Month and year (or day, month and year) of completion of the manufacture of a drug product (WHO 2007a, 43).

Demand A call for goods (or services) on the part of customers (Shorter Oxford English Dictionary, 5th ed.). Irrespective of needs, demand arises (only once) customers confirm orders.

Demand point Physical location where (end-user) demand arises (Ballou, R.H. 2004).

Demand shaping Actively influencing (changing) demand (Taylor, D.A. 2004, 270) by proposing orders for standard sets, standard items or specific substitutes.

Demurrage Rate or amount which the charterer must pay to the owner (as a penalty) for the failure to load or discharge a chartered ship within the time agreed (Shorter Oxford English Dictionary, 5th ed.).

De-rating (of generator sets) Decrease of performance (in percent) of generator sets at higher altitudes and higher external temperatures (WHO 2002d, VIII).

Desiccant Agent (substance) placed inside a drug container which absorbs (and therefore removes) moisture from the air and reduces the humidity to which drug products are exposed.

Distribution channel (physical distribution channel) Collections of cooperating organizations which organize and manage the flow of goods (and related information) from the manufacturer to the end-user as well as intermediate storage throughout the supply network (Lambert, R.S., and J.R. Stock 1993, 72).

Dosage Definite quantity of a (prescribed) drug product given or taken at any one time or per day. Not to be confused with "strength" of a drug product.

Dosage form (pharmaceutical dosage form) "The form of the completed pharmaceutical product, e.g. tablet, capsule, elixir, injection, suppository" (WHO 1997a, 65).

Drug "Any substance or pharmaceutical product for human or veterinary use that is intended to modify or explore physiological systems or pathological states for the benefit of the recipient" (WHO 1998c, 34).

Drug product "Any substance or mixture of substances that is manufactured for sale or distribution, sold, supplied, offered for sale or presented for use in: (i) the treatment, mitigation, cure, prevention or diagnosis of disease, an abnormal physical state or the symptoms thereof and abnormal physiological conditions in human or animal; or (ii) the restoration, correction or modification of organic functions in human or animal" (WHO 2007g, 307).

Drug molecule ("molecule") Synonym for active (pharmaceutical) ingredient.

Due delivery date Date indicated by a customer on her/his order until which goods should be delivered at the latest.

End user Person who uses or applies a (health care) product.

End-user demand Demand (confirmed orders) caused by an assisted health care facility. In practice end-user demand must be aggregated over a defined period of time.

Essential drug products Drug products that satisfy the health care needs of the majority of the population. Each country may generate its own list of essential drugs (WHO 1998c, 34).

Evaluation "The systematic and objective assessment of an on-going or completed project, programme or policy, its design, implementation and results" (OECD 2002, 21).

Excipient (pharmaceutical excipient) Any substances, other than the active pharmaceutical ingredient, which are (intentionally) included in a drug product (WHO 2007g, 200).

Expendable health care goods Drug products and single use medical devices.

Expiry date "The date given on the individual container (usually on the label) of a drug product up to and including which the product is expected to remain within specifications, if stored correctly [according to storage conditions indicated by the manufacturer]" (WHO 1997a, 48).

Finished drug product "A drug product that has undergone all stages of production, including packaging in its final container and labelling" (WHO 1998c, 34).

First come, first served (FCFS) Processing of customer orders in the order of receipt by the customer service.

First expiry, first out procedure (FEFO) Order picking of batches in the order of their respective expiry dates (and regardless of their date of entry into stock).

First in, first out procedure (FIFO) Order picking of batches in the same order as they were entered into stock (put away).

Forecasting "Prediction of values of a variable based on known past values of that variable or other related variable" (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 599).

Formulation "The composition of a dosage form, including the characteristics of its raw materials and the operations required to process it" (WHO 1998c, 34).

Forrester effect The increase of demand variability as demand information moves upstream through the supply network.

Full case picking Order picking of a complete case (carton, container, several primary or secondary packagings) of products as packed by the manufacturer.

Gas cylinder "Container usually cylindrical suited for compressed, liquefied or dissolved gas, fitted with a device to regulate the spontaneous outflow of gas at atmospheric pressure and room temperature" (WHO 1999b, 23).

Good distribution practices (GDP) "Good distribution practices are that part of quality assurance that ensures that the quality of a pharmaceutical product is maintained by means of adequate control of the numerous activities which occur throughout the distribution process" (WHO 2006r, 183).

Good manufacturing practices "That part of quality assurance which ensures that pharmaceutical products are consistently produced and controlled to the quality standards appropriate to their intended use and as required by the marketing authorization" (WHO 2006r, 183).

Good storage practices (GSP) "Good storage practices are that part of quality assurance that ensures that the quality of pharmaceutical products is maintained by means of adequate control throughout the storage thereof" (WHO 2006r, 183).

Health care facility Any facility such as a health centre, vaccination centre, hospital, orthopaedic centre etc. providing services for the prevention, diagnosis or treatment of human health conditions.

Health care goods Summary term for drug products, single use medical devices and health care equipment regardless of any particular manufacturer and brand name.

Health centre (clinic) Health care facility providing health services such as health promotion, immunization, diagnosis, preventive and curative care to outpatients.

Holdover time Measured in a test chamber at a constant ambient temperature of + 27° C, + 32° C or + 43° C (depending on whether the device is rated for moderate, temperate or hot zones), the refrigerator is fully loaded with cartons of empty glass vials or bottles and the internal temperature is stabilized within the acceptable temperature range. The holdover time is the duration of time from switching off the refrigerator at the start of a compression cycle until the warmest point of the load exceeds + 10° C without opening the refrigerator (WHO 2007i, 7f).

Humanitarian assistance "An intervention to help people who are victims of a natural or man-made disaster meet their basic needs, such as adequate health care, water, sanitation, nutrition, food and shelter" (ECHO 1999, 60). This assistance must be impartial, have strictly humanitarian motives and respect the sovereignty of affected states (UN General Assembly Resolution 45/100, 1990).

Humanitarian organization Organization providing humanitarian assistance.

Ice-pack "A pack frozen to a temperature between - 5° C and - 20° C before use" (WHO 2007d, 2).

Ice-pack freezing capacity "The maximum weight of icepacks which can be frozen, in one batch, during a 24 hour freezing cycle. During this period the temperature of the icepack freezing compartment must not exceed - 5 °C" (WHO 2007e, 2).

Immediate container (primary packaging) Packaging which is in direct contact with drug products (WHO 2002e, 122).

Immunization "The protection of individuals or groups from specific diseases by vaccination or the injection of immune globulins" (Venes, D. 2005, 1159).

Importation "The act of bringing or causing any goods to be brought into a customs territory (national territory, excluding any free zone)" (WHO 1997a, 216).

Importer An individual or company or similar legal entity importing or seeking to import health care goods (WHO 1997a, 216).

Imprest system Periodic review inventory control system with fixed order-up-to-levels (Quick, J.D. (ed.) 1997, 332 and Jessop, D., and A. Morrison 1994, 80).

In stock (on hand) Available in the store and ready for delivery.

Innovator drug product (pharmaceutical product) The drug product which was first authorized for marketing (normally as a patented drug product) on the basis of documentation of efficacy, safety and quality (WHO 1997a, 65).

Intermodal transportation "The movement of goods in one and the same loading unit or vehicle, which uses successively several modes of transport without handling of the goods themselves in changing modes" (Rushton, A., J. Oxley, and Ph. Croucher 2000, 351).

Internally displaced person (IDP) "Person who is forced or obliged to flee from her/his home in particular as a result of or in order to avoid the effects of armed conflicts, situations of generalized violence, violations of human rights or natural or human-made disasters, and who has not crossed an internationally recognized State border" (UNHCR 2006, 365).

International nonproprietary name (INN) The shortened scientific name of active pharmaceutical ingredients assigned by the WHO (WHO 2007a, 11).

Internationally controlled drug product Drug product which is subject to international conventions as well as national legislation and regulations which govern importation, exportation, possession and distribution.

Inventory "List of the items held in stock" (Waters, D. 2003, 4).

Inventory control "Inventory control sets the overall policies for stock, considering the materials to store, investment, customer service, stock levels, order sizes, order timing and so on" (Waters, D. 2003, 32).

Inventory position Stock on hand + stock on order - backorders - committed quantities (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 233).

Invitation to tender Document issued by an organization, containing the details of products they want to purchase as well as their conditions of purchase.

Item Specific article, irrespective of any particular product or manufacturer and irrespective of its quantity. For example any quantity of a 10 millilitre syringe is an "item".

Lamp, fluorescent Type of lamp in which ultraviolet radiation from an electrical gas discharge causes a thin layer of phosphor on a tube's inside surface to fluoresce (Concise Dictionary, Collins, 5th ed., 2001).

Lamp, incandescent Source of light that contains a heated solid, such as an electrically heated filament (Concise Dictionary, Collins, 5th ed., 2001).

Lead time The time between when an order is placed and when goods are delivered to the customer (Cachon, G., and Ch. Terwiesch 2006, 414).

Level of care Range and sophistication of health care services provided at primary (home and in the community), secondary (health centre, dispensary, clinic) and tertiary (hospital) level.

Line item Corresponds to an item in a document such as an order or picking list, irrespective of its quantity.

Manufacture (manufacturing) "All operations of purchase of materials and products, production, quality control, release, storage, shipment of finished products, and related controls" (WHO 1997a, 207).

Manufacturer "A company that carries out at least one step of manufacture" (WHO 1997a, 207).

Marketing authorization (licence, product licence) "A legal document issued by the competent drug regulatory authority for the purpose of marketing or free distribution of a product after evaluation for safety, efficacy and quality" (WHO 2007a, 11).

Master carton Larger, standard sized cartons used by distribution centres after order picking to combine and consolidate primary, secondary and possibly tertiary manufacturer packaging of health care goods for transportation.

Materials handling equipment Manual, mechanized or powered equipment for handling and moving parcels or pallets.

Medical device "“Medical device” means any instrument, apparatus, implement, machine, appliance, implant, *in vitro* reagent or calibrator, software, material or other similar or related article, intended by the manufacturer to be used, alone or in combination, for human beings for one or more of the specific purposes of:

- diagnosis, prevention, monitoring, treatment or alleviation of disease
- diagnosis, monitoring, treatment, alleviation of or compensation for an injury
- investigation, replacement, modification, or support of the anatomy or of a physiological process
- supporting or sustaining life
- control of conception
- disinfection of medical devices
- providing information for medical purposes by means of in vitro examination of specimens derived from the human body and which does not achieve its primary intended action in or on the human body by pharmacological, immunological or metabolic means, but which may be assisted in its function by such means" (GHTF 2005b). A very similar, but not identical definition is given in Council Directive 93/42/EEC of 14 June 1993 concerning medical devices (EC 1993)

Mode of transportation Type of transportation such as by road, rail, water, air or the use of pipelines.

Monitoring "A continuing function that uses systematic collection of data on specified indicators to provide management and the main stakeholders of an ongoing development intervention with indications of the extent of progress and achievement of objectives and progress in the use of allocated funds" (OECD 2002, 27 f.).

Moving average (of order k) The mean value of the last k consecutive observations of a time series (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 606).

Multisource drug products ("generic drug product") Pharmaceutically equivalent drug products, which may or may not be therapeutically equivalent to the innovator drug product (WHO 1997a, 65).

National drug regulatory authority A national body that regulates the manufacture of pharmaceutical products, carries out (GMP) inspections, grants marketing authorizations for drug products, grants licenses for manufacturing and distribution, carries out quality control of drug products in the market, monitors adverse drug reactions and promotes the rational use of drug products (WHO 2007a, 34).

National essential drug list The list of essential drug products for use by all health care facilities has been defined, adopted and published at country level" (WHO 2007a, 12).

Net stock Quantity of stock on hand minus backorders (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 233)

Non-governmental organization (NGO) "An organized entity that is functionally independent of, and does not represent, a government or State" (UNOCHA 2003, 19).

Nonproprietary name Unique and universally applicable name for drug substances which are assigned by the World Health Organization and make no reference to any trade names.

Non-stock item Item which is not automatically replenished (every month) and which is therefore not (permanently) kept in stock.

Observation "The value of a specific event as expressed on some measurement scale by a single data value" (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 608).

Offeree A person to whom something is or has been offered.

Offeror Person who offers something.

Order fulfilment Process from receiving customer orders until delivery of all ordered goods.

Order picking The systematic process of locating products in a store and extracting them from their storage place for packing, delivery and fulfilling customer orders (Jessop, D., and A. Morrison 1994, 84).

Order status The stage and progress of treatment of a customer order, such as order receipt, registration, acknowledgment, picking, packing, dispatch of consignment(s), receipt and order fulfilment.

Out of stock No physical stock on hand.

Outlier Data value that is unusually large or small (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 609) and which may not to be representative for the time series.

Pack Flat, leak proof, plastic container, filled with tap water (WHO 2007d, 2). Depending on the conditioning it may be used as ice-pack, cool-pack or warm-pack.

Package inserts Leaflet containing information for the user which accompanies the drug product (EC 1992, art. 1) or health care devices.

Packaging "All operations, including filling and labelling, that a bulk product has to undergo in order to become a finished [drug] product" (WHO 2007g, 13).

Packaging material "Any material, including printed material, employed in the packaging of a pharmaceutical, but excluding any outer packaging used for transportation or shipment" (WHO 2007g, 13).

Packaging, primary Packaging which is in direct contact with drug products (WHO 2007g, 13) or medical devices.

Packaging, secondary Manufacturer packaging which consolidates several primary packaging units.

Packaging, tertiary Manufacturer transport packaging which consolidates several secondary packagings.

Packing list Document with detailed description of the contents of each parcel of a consignment.

Pallet "A portable, horizontal, rigid platform used as a base for assembling, storing, stacking, handling and transporting goods as a unit load, often equipped with a superstructure" (Obal, Ph. 117).

Pallet truck Mechanized or powered equipment for movement of pallets in stores as well as for loading them onto and unloading them from vehicles.

Pareto principle (Pareto rule, 80-20 rule) Principle that postulates that 20 % of causes account for 80 % of the respective effects.

Party to the conflict "A state or other entity taking part in an armed conflict, whether formally or de facto" (P. Verri 1992, 36).

Pharmaceutical equivalence "Products are pharmaceutical equivalents if they contain the same amount of the same active substance(s) in the same dosage form; if they meet the same or comparable standards; and if they are intended to be administered by the same route. However, pharmaceutical equivalence does not necessarily imply therapeutic equivalence as differences in the excipients and/or the manufacturing process can lead to differences in product performance" (WHO 1997a, 66).

Pharmacopoeia Official and legal document which defines the standards for specifications, quality as well as testing procedures for active pharmaceutical ingredients as well as excipients.

Primary health care Set of principles which addresses the main health problems in the community, provides preventive, curative as well as rehabilitative services and considers nutrition, adequate supply of safe water and basic sanitation, maternal and child health care, family planning, immunization, treatment of common diseases and injuries as well as provision of essential drug products (Declaration of Alma-Ata, 1978).

Product Item with all the specifications of a particular manufacturer.

Product information Printed information for health professionals and patients which must be approved by the national drug regulatory authorities during the process of granting the marketing authorization indicating, among others, dosage and use, adverse effects, overdosage information, contraindications as well as use during pregnancy and lactation (WHO 1998c, 37 and WHO 1997a, 36).

Product licence (registration, authorization) Official and legal document issued by the national drug regulatory authorities granting the permission to market a drug product in the respective country (WHO 1997a, 208).

Product pooling Filling demand from several customer with fewer items by providing substitutes to some customers (Cachon, G., and Ch. Terwiesch 2006, 416).

Product recall Process of withdrawing or removing a drug product from the entire supply network because of defects in the product or complaints of serious adverse reactions to the product. The product recall might be initiated by the manufacturer, a supplier or the national drug regulatory authority (WHO 1997g, 308).

Proprietary name Trade name assigned and used by the manufacturer (Willig, S.H. 2001, 216).

Put-away Physical process of taking goods from the receipt area, moving them to the storage area and physically placing them in the locations where they are to be stored" (Lambert, R.S., and J.R. Stock 1993, 276).

Pyrogen Agent that causes fever. The thermostable pyrogens produced by some moulds, yeasts and bacteria in contaminated solutions are not destroyed by sterilization and can harm patients after injection or infusion.

Pyrolysis The chemical decomposition of organic material by heat (Prüss, A., E. Giroult, and P. Rushbrook 1999, 185). The process can occur in the presence or absence of oxygen and the chemical decomposition is not caused by oxidation.

Quality assurance Totality of arrangements made during the design, development, manufacture, quality control, release and storage of drug products intended to ensure compliance with the stated specifications (WHO 2007g, 16).

Quality control "All measures, including the setting of specifications, sampling and testing, taken, to ensure that starting materials, intermediate products, packaging materials and

finished drug products conform with their specifications for identity, strength, purity and other characteristics" (WHO 2006r, 246).

Quarantine The physical isolation of drug products (or other effective means) while a decision on the acceptance or rejection of drug products is awaited (WHO 2007g, 14).

Quotation The price and terms with a validity period provided by a supplier upon request (Kaur, M., et al. 2005, 91).

Randomness (random noise, white noise) Fluctuations of a time series around a constant mean.

Real-time (long-term) stability studies "Experiments on the physical, chemical, biological, biopharmaceutical and microbiological characteristics of a drug [product], during and beyond the expected shelf-life and storage periods of samples under the storage conditions expected in the intended market. The results are used to establish the shelf-life, to confirm the projected shelf-life, and to recommend storage conditions" (WHO 1997a, 308).

Refugee "Person who, owing to a well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion, is outside the country of his nationality and is unable or, owing to such fear, is unwilling to avail himself of the protection of that country" (Convention Relating to the Status of Refugees Art. 1 A. (2)).

Registered drug product "Pharmaceutical products that have a marketing authorization" (Marketing authorization, 37).

Regulations The second stage of the legislative process which are specifically designed to provide the legal machinery to achieve the administrative and technical goals of legislation (first stage) (WHO 2007a, 13).

Reliability "An expression of the degree to which a measurement performed by different people at different times and under different circumstances produces the same results (see also validity)" (WHO 2007a, 11).

Review period Period after which the elements of on inventory control system are updated and calculations whether a replenishment order is necessary are made.

Room temperature, controlled "A temperature maintained thermostatically that encompasses the usual and customary working environment of + 20° to + 25° C; that results in a mean kinetic temperature calculated to be not more than + 25° C; and that allows for excursions between + 15° and + 30° C that are experienced in pharmacies, hospitals, and warehouses" (United States Pharmacopeia 24, 2000).

Rule-of-five The prices for multisource drug products reach their minimum if five bids are received while additional bids generally do not lower prices. (WHO 1999f, 15).

Safety stock (buffer stock) Stocks kept in addition to cycle stocks in order to hedge against uncertainty (fluctuations) of demand as well as supply.

Sharps Items that could cause cuts or puncture wounds and which may be infected. These include needles, hypodermic needles, scalpel and other blades, knives, infusion sets, saws, broken glass and nails (Prüss, A., E. Giroult, and P. Rushbrook 1999, 3)

Shelf-life, remaining Length of time between today and the expiry date of a health care product. If only the month and year of expiry are indicated, the last day of the indicated month must be considered.

Shelf-life, total "The period of time during which a drug product, if stored correctly [according to storage conditions indicated by the manufacturer], is expected to comply with the specification as determined by stability studies on a number of batches of the product. The shelf-life is used to establish the expiry date of each batch" (WHO 1997a, 48).

Shipment Entirety of goods transported on any (or several) means of transportation, which may consist of one or several consignments.

Shipper Person or organization initiating the transportation of consignments (goods).

Shortage gaming Inflation of orders because customers expect (fear) to receive only a part of the ordered quantity because stocks for filling all customer orders in full are insufficient (Cachon, G., and Ch. Terwiesch 2006, 417).

Short shipment Cargo that was not fully loaded on board of an aircraft or ship but which is listed in the shipping documents.

Shrink-wrap Thin, heat-shrinkable plastic film which is wrapped around packages or pallet loads before applying heat in order to shrink the film firmly around the package or pallet load.

Shrinkage Discrepancy between physical stock and stock records caused by pilferage and theft in a warehouse.

Single-dose container "Container for single doses of solid, semi-solid and liquid preparations". (WHO 1999b, 23). For example sachets, blister packaging or ampoules holding a single dose.

Stability "The ability of a pharmaceutical product to retain its chemical, physical, microbiological and biopharmaceutical properties within specified limits throughout its shelf-life" (WHO 1997a, 49).

Stability tests "A series of tests designed to obtain information on the stability of a pharmaceutical product in order to define its shelf-life and utilization period under specified packaging and storage conditions" (WHO 1997a, 49).

Staging Assembly of all parcels of a consignment and temporary storage in the dispatch area.

Standard deviation The statistical measure of dispersion (spread) for a sample (population) usually denoted by σ (sigma). It is defined as the square root of the average of the squared deviations of the individual data items about their mean (Sanders, D.H. 1995, 79).

Standard operating procedure (SOP) "An authorized written procedure giving instructions for performing operations not necessarily specific to a given product or material (e.g. equipment operation, maintenance and cleaning; validation; cleaning of premises and environmental control; sampling and inspection)" (WHO 2003c, 44).

Starting material "Any substance of a defined quality used in the production of a pharmaceutical product, but excluding packaging materials" (WHO 2007g, 15).

Stationary Customer demand pattern with a constant mean and constant variance (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 615).

Statistic Summary number that captures a property of a sample consisting of n values (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 615). For example the mean, variance or standard deviation.

Sterility The absence of viable micro-organisms.

Sterilization "The process of completely removing or destroying all micro-organisms from an object" (Venes, D. (ed.) 2005, 2204).

Stock The totality of (health care) goods kept in a store or warehouse.

Stock count, physical (stock taking, "inventory") Physically counting the quantities of all items held in stock in a warehouse also for comparison with stock records.

Stock item Line items which are routinely replenished in a store or warehouse.

Stock list List of all line items which are routinely replenished in a store or warehouse.

Stockout Stock list item with no stock on hand, regardless of whether quantities are backordered or not.

Stock on hand Stock which is physically available in a store or warehouse (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 233).

Stock on order Stock which has been ordered (for stock replenishment) by a distribution centre but has not been received yet (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 233).

Stock records Documents such as stock cards and bin cards which provide information on stock movements and stock on hand.

Storage conditions, normal Storage in dry, well-ventilated premises at temperatures of + 15° to + 25° C or, depending on climatic conditions, up to + 30° C, excluding extraneous odours, other indications of contamination and intense light (WHO 1997a, 43).

Strength (of drug products) The quantity or concentration of active pharmaceutical ingredient(s) in the unit dose of a drug product.

Stripping Unloading of ISO shipping containers.

Stuffing Loading of ISO shipping containers.

Supplier Anyone (commercial suppliers or other medical distribution centres of the same or other organization) delivering health care goods.

Tamper-evident container Closed container fitted with a device that reveals irreversibly whether the container has been opened" (The Stationery Office 1999, 14).

Target population "The expected beneficiaries (individuals, groups, etc.) of an intervention" (ECHO 1999, 61).

Temperature, mean kinetic (MKT) "The single calculated temperature at which the total amount of degradation [of a drug product] over a particular period is equal to the sum of the individual degradations that would occur at various temperatures. Thus, MKT may be considered as an isothermal storage temperature that simulates the non-isothermal effects of storage temperature variation" (United States Pharmacopeia and National Formulary 27, 2003).

Tender Formal process of selecting suppliers, inviting them to submit bids for supplying specific goods or services to an organization which would like to acquire these goods and services, receiving, opening, evaluating and comparing bids and finally award the contract.

Therapeutic equivalence "Two pharmaceutical products are therapeutically equivalent if they are pharmaceutically equivalent and after administration in the same molar dose their effects, with respect to both efficacy and safety, will be essentially the same, as determined from appropriate studies (bioequivalence, pharmacodynamic, clinical or in vitro studies)" (WHO 1997a, 65).

Time series An ordered sequence of values of a variable observed at equally spaced time intervals (Makridakis, S., S.C. Wheelwright, and R.J. Hyndmann 1998, 616).

Transaction reporting Quasi continuous review inventory control system where reviews are carried out after each transaction (receipt of customer orders, receipt or issue of stock) (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 237).

Transportation packaging Tertiary manufacturer packaging or master cartons for consolidating several primary and/or secondary packagings of health care goods for transportation.

Transhipment Temporary storage of entire consignments at transhipment depots or distribution centres without physically changing the consignment before onward transport (Rushton, A., J. Oxley, and Ph. Croucher 2000, 234).

Transhipment, lateral Redistribution of stock between distribution centres of the same stage of the supply network (Silver, E.A., D.F. Pyke, and R. Peterson 1998, 517).

Treatment episode A patient contact for which a standard course of drug treatment is required (Griffiths, A. 1988, 6.1).

Treatment protocol "Systematically developed statements designed to help practitioners or prescribers make decisions about appropriate treatments for specific clinical conditions" (Quick, J.D. (ed.) 1997, 138).

Undershoot In a continuous review inventory control system, the difference between the reorder level and the inventory position after the inventory position drops more than one unit below the reorder level by filling a single customer order (of more than one unit).

Unit (of an item) One piece of a solid item such as one tablet, one compress, one syringe or one pair of sterile surgical gloves, one primary packaging for liquids (for example bottle, pouch) or one tube or container of semi-solids (for example cream or ointment) as manufactured.

Unit load A unit load is an assembly of individual items or packages, usually of a like kind, to enable convenient composite movement, whether manual or mechanized" (Rushton, A., J. Oxley, and Ph. Croucher 2000, 238). For example tote bins, pallets or ISO shipping containers.

Unit of measurement (measurement unit) "Real scalar quantity, defined and adopted by convention, with which any other quantity of the same kind can be compared to express the ratio of the two quantities as a number" (BIPM International Vocabulary of Measurement (VIM), 2008, p. 6).

Unitization (load unitization) Consolidation and packing of several parcels in unit loads (Lambert, R.S., and J.R. Stock 1993, 324).

Unloading Removing loads (cargo) from means of transportation.

Utilization period "The period of time during which a reconstituted preparation or the finished dosage form in an opened multidose container can be used" (WHO 1997a, 49).

Vaccination Inoculation with any vaccine or toxoid to establish resistance to a specific infectious disease (Venes, D. 2005, 2424).

Vaccine carrier Smaller, thermally insulated containers, lined with conditioned ice-packs which are used for transporting smaller amounts of vaccines for out-reach immunization sessions or house-to-house immunization activities.

Vaccine storage capacity Net capacity (volume) in a refrigerator (freezer, cold box or vaccine carrier) available for the storage of vaccines (WHO 2007c, 3).

Vaccine vial monitor "A vaccine vial monitor (VVM) is a label that changes colour when the vaccine vial has been exposed to heat over a period of time" (WHO 2004a, 10).

Validation "Action of proving, in accordance with the principles of GMP, that any procedure, process, equipment, material, activity or system actually leads to the expected results" (WHO 2007g, 15).

Validity "An expression of the degree to which a measurement performed actually measures the characteristic which the investigator wishes to measure" (WHO 2007a, 14).

Variability (of customer demand) Fluctuations of customer demand, the extent of which is measured by its coefficient of variation.

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APPENDIX A

Data sources and description of indicators presented in table 2.2.

List of Least developed countries (LLDC)

Reference: UNCTAD 2009, iii

Definition: The list of least developed countries (LLDC) is established by the United Nations Economic and Social Council, reviewed every three years (last time in March 2009) and currently comprises 49 countries. Inclusion in the list is based on three criteria. The "low-income" criterion includes a gross national income (GNI) per capita of less than USD 905, based on a three-year average. The "human assets weakness" considers comprises the percentage of undernourished population, the child mortality rate, rate of school enrolment and adult literacy rate. The "economic vulnerability" criterion considers, among others, the instability of agricultural production, percentage of population displaced by natural disasters, instability of exports of goods and services as well as the share of agriculture, forestry and fisheries in GDP (UNCTAD 2009, iii).

List of less developed countries (LDC)

Reference: UNCTAD 2008, xii - xiv

Definition of less developed country: includes "Developing countries" as well as "Economies in transition". All countries which are not developed countries (Japan, Canada, the United States, Australia, New Zealand and Europe in general) and not least developed countries are considered as less developed countries.

Year of data: 2008

List of countries affected by complex political emergencies

Reference: HIIK 2009, I.

Definition: All conflicts classified by HIIK as category 4 ("Severe crisis") and category 5 ("War") were considered. Severe crisis is defined as "A conflict is considered to be a severe crisis if violent force is used repeatedly in an organized way" (HIIK 2009, 84) while wars are defined as ". . . violent conflict in which violent force is used with a certain continuity in an organized and systematic way. The conflict parties exercise extensive measures, depending on the situation. The extent of destruction is massive and of long duration" (HIIK 2009, 84).

Year of data: 2009

1) Adult literacy rate

Reference: Watkins, K. (ed.). 2010, 285 - 286.

Definition: "Number of literate persons aged 15 and above, expressed as a percentage of the total population in that age group" (Watkins, K. (ed.) 2010, 446) where literacy is defined as a ". . . person who can read and write with understanding a simple statement related to his/her everyday life" (Watkins, K. (ed.) 2010, 446)

Scale: 0 to 100%
Year of data: 2007.

2) Enrolment in secondary education

Reference: Watkins, K. (ed.). 2010, 364 - 371.

Definition: "Total enrolment in secondary education, regardless of age, expressed as a percentage of the population in the official age group corresponding to this level of education . . . The GER can exceed 100% due to early or late entry and/or grade repetition" (Watkins, K. (ed.) 2010, 447).

Scale: 0 to 100%
Year of data: 2007.

3) Enrolment in tertiary education

Reference: Watkins, K. (ed.). 2010, 372 - 379.

Definition: "Total enrolment in tertiary education, regardless of age, expressed as a percentage of the population in the official age group corresponding to this level of education . . . The GER can exceed 100% due to early or late entry and/or grade repetition" (Watkins, K. (ed.) 2010, 447)

Scale: 0 to 100%
Year of data: 2007.

4) Human Development Index

Reference: Klugman, J. (ed.) 2009, 167-170.

Definition: "A composite index measuring average achievement in three basic dimensions of human development - a long and healthy life, access to knowledge and a decent standard of living" (Klugman, J. (ed.) 2009, 210).

Scale: 0 - 1
Year of data: 2007

5) Health expenditure per capita

Reference: Klugman, J. (ed.) 2009, 199-202.

Definition: "Public expenditure on health by all levels of government (in purchasing power parity US dollars), divided by the mid-year population. Health expenditure includes the provision of health services (preventive and curative), family planning activities, nutrition activities and emergency aid designated for health, but excludes the provision of water and sanitation" (Klugman, J. (ed.) 2009, 210).

Scale: indicated in USD
Year of data: 2006

6) Public health expenditure as percentage of total government expenditure

Reference: Klugman, J. (ed.) 2009, 199-202.

Definition: "Public expenditure on health by all levels of government expressed as a percentage of total government spending" (Klugman, J. (ed.) 2009, 210).

Scale: 0 - 100%
Year of data: 2006

7) Number of people per physician

Reference: Evans, T. (ed.) 2006, 191 - 198.

Definition: Average number of people for which one physician is available.

Scale: open ended number
Year of data: 2006

8) Number of people per Nurse

Reference: Evans, T. (ed.) 2006, 191 - 198.

Definition: Average number of people for which one nurse is available.

Scale: open ended number
Year of data: 2006

9) Number of people per health professional

Reference: Evans, T. (ed.) 2006, 191 - 198.

Definition: Average number of people for which one health professional (physician, nurse, midwife, dentists, pharmacists, public and environmental health worker, community health worker, laboratory technician, other kind of health worker and health management and support worker) is available.

Scale: open ended number
Year of data: 2006

10) Annual per capita expenditure for drug products

Reference: Creese, A., N. Gasmann, and M. Mariko 2004, 122 - 129.

Definition: Annual per capita expenditure for drug products in USD (Creese, A., N. Gasmann, and M. Mariko 2004, 112).

Scale: open ended number
Year of data: 2000 (WHO National Health Accounts database)

11) Access to essential drug products (estimate)

Reference: Creese, A., N. Gasmann, and M. Mariko 2004, 130 - 137.

Definition: "WHO's ongoing World Medicines Survey asks a local medicines expert in each country to estimate the percentage of the population who have access to a minimum list of 20 essential medicines, which are continuously available and affordable at a health facility or medicines outlet, within one hour's walk from the patients' home" (Creese, A., N. Gasmann, and M. Mariko 2004, 61). In order to allow averaging across countries, the estimate "<50" was entered as 25%, "50-80" as 65%, "81 - 94" as 88% and ">95" as 97.5%.

Scale: 0 - 100%
Year of data: 1999

12) Hospitals beds per 1,000 people

Reference: World Health Organization, Global Health Observatory.

Definition: The average number of hospital beds available per every 1,000 inhabitants in a population.

Scale: open ended number
Year of data: 2000 - 2008

13) Main (fixed) telephone lines per 100 inhabitants

Reference: ICT Statistics database, International Telecommunication Unit.

Definition: "Main (fixed) telephone lines refer to telephone lines connecting a customer's equipment (e.g., telephone set, facsimile machine) to the Public Switched Telephone Network (PSTN) and which have a dedicated port on a telephone exchange" (ITU 2008, 3).

Scale: open ended number
Year of data: 2008

14) Mobile cellular phone subscribers per 100 inhabitants

Reference: ICT Statistics database, International Telecommunication Unit.

Definition: "Mobile cellular subscribers refers to users of portable telephones subscribing to an automatic public mobile telephone service using cellular technology that provides access to the PSTN. Per 100 inhabitants is obtained by dividing the number of mobile cellular subscribers by the population and multiplying by 100." (ITU 2008, 3). As individuals can own several cellular phones and subscribe to different service providers, the percentage can exceed 100%.

Scale: open ended number

Year of data: 2008

15) Population covered by mobile cellular network

Reference: International Telecommunication Union, World Telecommunication Development Report and database, and World Bank estimates.

Definition: Average percentage of population covered by mobile cellular network

Scale: 0 - 100%

Year of data: 2008

16) Internet subscribers per 100 inhabitants 2008

Reference: ICT Statistics database, International Telecommunication Unit.

Definition: "Internet subscribers refers to the number of dialup, leased line and fixed broadband Internet subscribers. inhabitants is obtained by dividing the number of Internet subscribers by the population and multiplying by 100." (ITU 2008, 4).

Scale: open ended number

Year of data: 2008

17) Internet users per 100 inhabitants 2008

Reference: ICT Statistics database, International Telecommunication Unit.

Definition: "Internet users is based on nationally reported data. . . . The reported figure for Internet users – which may refer to only users above a certain age – is divided by the total population and multiplied by 100 to obtain Internet users per 100 inhabitants. Countries that do not carry out surveys generally base their estimates on derivations from reported Internet Service Provider subscriber counts, calculated by multiplying the number of subscribers by a multiplier." (ITU 2008, 4).

Scale: open ended number

Year of data: 2008

18) Broadband subscribers per 100 inhabitants 2008

Reference: ICT Statistics database, International Telecommunication Unit.

Definition: "Fixed broadband subscribers refers to the sum of DSL, cable modem and other fixed broadband subscribers. Although various definitions of broadband exist, it is here defined as sufficient bandwidth to permit combined provision of voice, data and video. Speed should be greater than 256 kbps, as the sum of capacity in both directions" (ITU 2008, 4).

Scale: open ended number

Year of data: 2008

19) Computers per 100 people

Reference: International Telecommunication Union, World Telecommunication Development Report and database, and World Bank estimates

Definition: Average number of computers per 100 people.

Scale: open ended number

Year of data: 2005 - 2009

20) Percentage of households with computers

Reference: ITU 2010, 103 - 104.

Definition: Percentage of households with computers (ITU 2010, 18).

Scale: 0 - 100%

Year of data: 2008

21) Motor vehicles per 1,000 people

Reference: Laych, K., V. Alexeev, and O. Latipov 2009.

Definition: "Motor vehicles include cars, buses, and freight vehicles but do not include two-wheelers. Population refers to midyear population in the year for which data are available" (Laych, K., V. Alexeev, and O. Latipov 2009, 24).

Scale: open ended number

Year of data: 2005 - 2009

22) Road density (km / km^2)

Reference: Laych, K., V. Alexeev, and O. Latipov 2009.

Definition: "The ratio of the length of the country's total road network to the country's land area. The road network includes all roads in the country: motorways, highways, main or national roads, secondary or regional roads, and other urban and rural roads".

Scale: open ended number

Year of data: 2005 - 2009

23) Percentage of paved roads

Reference: Laych, K., V. Alexeev, and O. Latipov 2009.

Definition: "Percentage of all roads that are surfaced with crushed stone (macadam) and hydrocarbon binder or bituminized agents, with concrete or with cobblestones" (Laych, K., V. Alexeev, and O. Latipov 2009, 8).

Scale: 0 - 100%

Year of data: 2005 - 2009

24) Air passengers carried (millions per year)

Reference: International Civil Aviation Organization, Civil Aviation Statistics of the World and ICAO staff estimates.

Definition: "Air passengers carried include both domestic and international aircraft passengers of air carriers registered in the country".

Scale: open ended number

Year of data: 1991 - 2008

25) Air transportation, cargo (million ton-km)

Reference: International Civil Aviation Organization, Civil Aviation Statistics of the World and ICAO staff estimates.

Definition: "Air cargo is the volume of cargo, express, and diplomatic bags carried on each flight stage (operation of an aircraft from takeoff to its next landing), measured in metric tons times kilometres travelled".

Scale: open ended number

Year of data: 2005 - 2009

26) Trade and transportation infrastructure

Reference: Arvis, J.-F., et al. 2007, 8.

Definition: Quality of trade and transport related infrastructure (e.g. ports, railroads, roads, information technology.

Scale: 1 (worst) to 5 (best)

Year of data: 2010

27) Customs clearance efficiency

Reference: Arvis, J.-F., et al. 2007, 8.

Definition: Efficiency of the clearance process (i.e. speed, simplicity and predictability of formalities) by border control agencies, including Customs.

Scale: 1 (worst) to 5 (best)

Year of data: 2010

28) Timeliness of shipments

Reference: Arvis, J.-F., et al. 2007, 8.

Definition: Timeliness of shipments in reaching destination within the scheduled or expected delivery.

Scale: 1 (worst) to 5 (best)

Year of data: 2010

29) Logistics competence

Reference: Arvis, J.-F., et al. 2007, 8.

Definition: Competence and quality of logistics services (e.g., transport operators, customs brokers).

Scale: 1 (worst) to 5 (best)

Year of data: 2010

30) Logistics Performance Index

Reference: Arvis, J.-F., et al. 2007, 8.

Definition: the weighted average of the country scores on the six key dimensions: efficiency of the clearance process by customs and other border agencies, quality of transport and information technology infrastructure for logistics, ease and affordability of arranging international shipments, competence of the local logistics industry, ability to track and trace international shipments, domestic logistics costs as well as timeliness of shipments in reaching destination.

Scale: 1 (worst) to 5 (best)

Year of data: 2010.

31) GDP

Reference: Klugman, J. (ed.) 2009, 171-174.

Definition: "The sum of value added by all resident producers in the economy plus any product taxes (less subsidies) not included in the valuation of output. It is calculated without making deductions for depreciation of fabricated capital assets or for depletion and degradation of natural resources. 'Value added' is the net output of an industry after adding up all outputs and subtracting intermediate inputs" (Klugman, J. (ed.) 2009, 210).

Scale: indicated in USD

Year of data: 2007

32) Rule of law

Reference: Kaufmann, D. , A. Kraay, and M. Mastruzzi 2009, 92-94.

Definition: ". . . perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence" (Kaufmann, D. , A. Kraay, and M. Mastruzzi 2009, 6).

Scale: - 2.5 to 2.5

Year of data: 2008.

33) Regulatory quality

Reference: Kaufmann, D. , A. Kraay, and M. Mastruzzi 2009, 89-91.

Definition: ". . . perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development" (Kaufmann, D. , A. Kraay, and M. Mastruzzi 2009, 6).

Scale: - 2.5 to 2.5

Year of data: 2008.

34) Government effectiveness

Reference: Kaufmann, D. , A. Kraay, and M. Mastruzzi 2009, 86-88.

Definition: ". . . perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies" (Kaufmann, D. , A. Kraay, and M. Mastruzzi 2009, 6).

Scale: - 2.5 to 2.5

Year of data: 2008.

35) Political stability and absence of violence/terrorism

Reference: Kaufmann, D. , A. Kraay, and M. Mastruzzi 2009, 83-85.

Definition: ". . . perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism" (Kaufmann, D. , A. Kraay, and M. Mastruzzi 2009, 6).

Scale: - 2.5 to 2.5

Year of data: 2008.

36) Corruption Perception Index (CPI)

Reference: Transparency International 2009, 298 - 302.

Definition: ". . . abuse of entrusted power for private gain" (Riano, J. and R. Hodess 2008, 2).

Scale: 0 (very corrupt) to 10 (very clean)

Year of data: 2009

37) Control of corruption

Reference: Kaufmann, D. , A. Kraay, and M. Mastruzzi 2009, 95-97.

Definition: ". . . perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests" (Kaufmann, D. , A. Kraay, and M. Mastruzzi 2009, 6).

Scale: - 2.5 to 2.5

Year of data: 2008.