USAID | DELIVER PROJECT

LOGISTICS OF HEALTH CARE WASTE MANAGEMENT

INFORMATION AND APPROACHES FOR DEVELOPING COUNTRY SETTINGS

MARCH 2009

This publication was produced for review by the U.S. Agency for International Development. It was prepared by the USAID | DELIVER PROJECT, Task Order 1.

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The USAID | DELIVER PROJECT, Task Order 1, is funded by the U.S. Agency for International Development under contract no. GPO-I-01-06-00007-00, beginning September 29, 2006. Task Order 1 is implemented by John Snow, Inc., in collaboration with PATH; Crown Agents Consultancy, Inc.; Abt Associates; Fuel Logistics Group (Pty) Ltd.; UPS Supply Chain Solutions; Family Health International; The Manoff Group; and 3i Infotech. The project improves essential health commodity supply chains by strengthening logistics management information systems, streamlining distribution systems, identifying financial resources for procurement and supply chain operation, and enhancing forecasting and procurement planning. The project also encourages policymakers and donors to support logistics as a critical factor in the overall success of their health care mandates.

Recommended Citation
Eberle, Jim, Linda Allain, and Paula Nersesian. 2009. *Logistics of Health Care Waste Management*: *Information and Approaches for Developing Country Settings***.** Arlington, Va.: USAID | DELIVER PROJECT, Task Order 1.

Abstract
Medical or health care waste (HCW) refers to all waste generated by health care facilities, research facilities, and laboratories. Health care waste management (HCWM) is a major health and environmental concern. Hazardous waste, including sharps and other infectious waste, pose a serious risk to human health and the general environment. In many developing countries, disposing of this waste is complicated by limited financial and human resources. This document considers the reality of HCWM practices in resource-limited settings. Solutions offered within this text are based on actual experience in developing countries and are presented as practical solutions to vexing logistics problems in HCWM.

Cover photo: Health supplies and safety boxes at a health facility in East Timor. JSI staff photo. 1999.

USAID | DELIVER PROJECT
John Snow, Inc.
1616 Fort Myer Drive, 11th Floor
Arlington, VA 22209 USA
Phone: 703-528-7474
Fax: 703-528-7480
Email: askdeliver@jsi.com
Internet: deliver.jsi.com

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ACRONYMS

HCW	health care waste
HCWM	health care waste management
JSI	John Snow, Inc.
MMIS	Making Medical Injections Safer (project)
MOH	Ministry of Health
PPE	personal protective equipment
PVC	polyvinylchloride
RDT	rapid diagnostic test
SCMS	supply chain management system
USAID	U.S. Agency for International Development
WDU	waste disposal unit
WHO	World Health Organization

ACKNOWLEDGMENTS

The authors wish to thank the USAID | DELIVER PROJECT staff members and colleagues from John Snow, Inc. (JSI) and other organizations, particularly the World Health Organization (WHO) and PATH, for their valuable work in the area of health care waste management and their contributions to this document. In addition, the authors thank everyone who reviewed the manuscript, particularly Marcia Rock and John Durgavich. Also, thanks to Kelly Hamblin and all those who supported the process of making this resource possible.

As always, the authors are grateful to the USAID | DELIVER PROJECT communications team and other staff members for their contributions in publishing this document.

EXECUTIVE SUMMARY

Health care waste (HCW) refers to products generated by health care facilities during a variety of activities—diagnosis, treatment, immunization, and research. HCW has two main categories: hazardous waste and general (non-hazardous) waste. Hazardous waste, which represents between 10 and 25 percent of all HCW, can be sub-divided into ten categories. It includes sharps and other infectious waste that pose a serious risk to human health and the general environment. When hazardous waste is combined with non-hazardous waste, which is 75–80 percent of the health care waste, the combined waste is considered to be contaminated and, therefore, hazardous. It is important to segregate hazardous waste from other general, non-hazardous waste, and to dispose of it correctly. The correct logistics disposal of HCW is often difficult in resource-limited settings. This document offers solutions based on actual experience in developing countries.

The type and amount of waste generated by any health facility depends on the services provided at the facility and the number of patients seen. The most common hazardous waste generated in small health care facilities is sharps, infectious waste, some pharmaceuticals, and some chemicals, such as expired cleaning solvents. All health service delivery points generate waste. To collect and store this waste in preparation for treatment and disposal requires a variety of equipment and supplies, including—

- *Waste bins.* Ideally, waste bins should have color-coded liners to ensure that waste is correctly segregated. The liners should be made of plastic thick enough to prevent rupture, thereby preventing possible injury or contamination to the waste handlers.
- *Sharps containers.* Sharps containers, also called safety boxes, provide safe temporary storage for sharp objects.
- *Needle removers.* Staff sometimes use needle removers at the point of injection to immediately segregate and contain the sharp and mitigate the possibility of needle stick injuries.
- *Sharps barrels.* Sharps barrels, also called permanent disposal devices, are sometimes used by small- to mid-size health care facilities that cannot adequately collect and dispose of sharps on-site or offsite.
- *Personal protective equipment.* PPE protects health care workers, including waste handlers, from sustaining injuries or contracting a disease.

Forecasting for health care waste management (HCWM) equipment—for example, bins and consumable supplies, such as liners—should be based on a consumption/usage model if possible. The type and number of each product is based on three variables: points of waste generation, amount of each type of waste generated at each location in a given period, and frequency of the waste removal. Each waste handler is given their own PPE. The type of PPE for waste handlers can be determined, initially, by defining each handler's tasks and their related risk to exposure and by estimating the frequency of replacement of the items of PPE that the handlers require.

In most ways, procuring HCWM commodities is not significantly different from procuring other health care commodities. When purchasing items such as bin liners and PPE, either internationally

or locally, their quality specification requirements must be ensured. Deciding whether or not to procure locally often depends on the ability of the host country manufacturers to produce products to specification.

Moving HCW can be dangerous, even for only a few feet. To minimize exposure, waste handlers should (if possible) completely close and tie off garbage bin liners; they should also empty the contents of smaller size bin liners into larger bins before moving the waste to its final, central on-site destination. Prior to disposal, infectious waste should be stored for a maximum of 48 hours at the central storage area. The storage area should be secure, and if it is outside, it should also be fenced-in and covered.

Management of HCW is often subject to national regulations developed by government ministries, including ministries of health, the environment, and labor. Treatment and disposal of HCW must follow such laws and regulations already in place in the country. Where specific regulations or laws do not exist, international standards and guidelines developed by the World Health Organization (WHO) or other institutions that can be applied to ensure the safety of health workers, the population at large, and the environment.

1. INTRODUCTION

What Is Health Care Waste Management?

Medical or health care waste (HCW) refers to all waste generated by health care facilities, research facilities, and laboratories. HCW is generated in many ways—in the diagnosis, treatment, or immunization of human beings or animals; as part of research; or in the production or testing of biological products. HCW is divided into two categories: hazardous (posing a risk) waste and general (non-hazardous) waste. Paper and packaging; food; and bottles, cans, and glass for general use are examples of general HCW. Between 10 and 25 percent of HCW is hazardous. The World Health Organization (WHO) defines ten waste groups: infectious, pathological and anatomical, hazardous pharmaceutical, hazardous chemical, heavy metal content, pressurized containers, sharps, highly infectious, genotoxic/cytotoxic, and radioactive (WHO 2005c).

For this document, we collapsed the ten waste groups into the following clusters, based on the types of hazardous waste generated at different levels of a health system:

- infectious (includes pathological, anatomical, and sharps)
- chemical and pharmaceutical
- radioactive materials, genotoxic/cytotoxic and high metal content compounds, and pressurized containers.

Sharps and other infectious waste are the most common hazardous waste generated in a small health care facility. Infectious waste can include used gauze/dressing, blood/IV lines, gloves, anatomical waste, and body fluids from patients with highly infectious diseases. Sharps waste include used needles, infusion sets, scalpels, blades, and broken glass.

Other common hazardous waste includes pharmaceuticals and chemicals, such as expired drugs, laboratory reagents, and cleaning solvents. Some types of chemical and pharmaceutical waste—radioactive materials, genotoxic/cytotoxic and high metal content compounds, and pressurized containers are more commonly found at higher levels of the health system. For additional descriptions and examples of the ten categories, see WHO document cited earlier.

Health care waste management (HCWM) represents a major health and environmental concern. Sharps waste, in particular, is highly infectious and poses a serious threat to both service providers and the general public if it is not handled and disposed of properly. Other hazardous wastes also pose serious risks to human health and the environment. It is, therefore, important to segregate hazardous waste from other general, non-hazardous waste and to dispose of it properly. Although laws and regulations are usually in place in industrialized countries to address issues related to HCWM, they are often missing or not applied or enforced in middle- and low-income countries.

WHO has defined eight steps in health care waste management (WHO 2005a):

1. *Waste minimization:* Practices employed to reduce waste.
2. *Waste generation:* Activities in a health care setting that generate waste.
3. *Waste segregation:* Practice of separating the waste by category, at the point of generation, based on the type of risk posed. Infectious, non-infectious but hazardous, and general waste are collected in separate containers. Sharps are usually placed in sharps boxes.
4. *Intermediate storage:* Temporary storage of waste in large containers close to the clinic or ward but not accessible to unauthorized personnel.
5. *Internal transport:* Usually is moving waste to a central storage area, either from the point of generation, to the intermediate storage area, or to an on-site treatment facility. To avoid cross-contamination, manage the internal transport of hazardous waste separately from the internal transport of general waste. In addition, plan routes for the high-risk waste to avoid or reduce the possibility of loaded carts passing into the patient wards and other clean areas.
6. *Centralized storage:* Where waste is stored prior to pickup for external transport to the final treatment or disposal area. To avoid cross-contamination, keep the central storage area clean, free of vermin, and separated from the general waste area. Do not keep hazardous waste in storage for longer than 24–48 hours.
7. *External transport:* The transport of waste from the health care facility pickup area to a place of treatment or disposal.
8. *Treatment and disposal:* The final step in the HCWM process is done using various treatment methods specific to the type of waste to be treated. Some waste requires autoclaving; other waste may be incinerated. Waste or its residue after treatment can be buried in a protected pit or sent offsite for disposal in a municipal landfill.

By segregating waste, health facilities reduce the amount of hazardous waste that requires special treatment and safe disposal.

Focus of This Document

This paper addresses health care waste management that is generated mainly at the clinic and health facility level. For this reason, the focus will be on three categories of HCW that are more commonly generated at this level: general waste, infectious and chemical/pharmaceutical, although reference to other waste categories will be made when appropriate. In many developing countries, the HCWM procedures are not ideal because of the lack of financial and human resources. In addition—

- guidelines are not in place in many settings
- supplies and equipment to effectively manage HCW are not available
- data is often not available to estimate need
- HCW is not always segregated using WHO standards
- sharps are not always collected and disposed of properly
- waste handlers are not ideally protected

- waste is not collected and/or disposed of on time or correctly.

This document considers the realities of HCWM practices in resource-limited settings. The solutions offered are based on actual experience in developing countries and are put forth as practical solutions to challenging logistics problems in HCWM.

This document assumes that the reader knows the fundamentals of HCWM, as well as logistics management. The analysis in this document is limited to a discussion of issues likely to be encountered by logisticians who may be asked to provide technical assistance in HCWM. The document offers advice on quantifying HCWM product needs; procuring HCWM products; establishing on-site storage of HCW; and collecting and transporting HCW to a disposal location. It also provides limited discussion of treatment and disposal options. The document focuses on the primary health care setting; therefore, minimal information is provided on radioactive agents and other hazardous material that are encountered at tertiary health care facilities.

View this document as an extension of the informative guide for logisticians, *Safe Injection and Waste Management* (Nersesian et al. 2004), where logistics advisors will find a useful introduction to the logistics of HCWM. The document includes references to articles about specific issues related to HCWM.

Other Related Reference Documents

To obtain additional information on HCWM, many documents are readily available. Following is a sample of the literature on HCWM. See appendix B for a list of agencies to contact for additional information.

An excellent overall reference is WHO's *Safe Management of Wastes from Health Care Activities* (Pruess, Girouit, and Rushbrook 1999).

A complement to the text above is *Better Health Care Waste Management* (Rushbrook and Zghondi 2005). This publication, written for managers and health care providers in developing countries, starts with an easy-to-read introduction and includes a reference guide to HCWM.

For advice on selecting the most appropriate options for managing waste generated by health care facilities, see *Management of Solid Health Care Waste at Primary Health-Care Centers: A Decision-making Guide* (WHO 2005b).

For training materials on HCWM, the Making Medical Injections Safer (MMIS) Project[1] developed a complete set—*Do No Harm: Injection Safety in the Context of Infection Prevention and Control, Facilitator's Guide* (WHO/AFRO/JSI/MMIS 2005a).

Guidelines for the Storage of Essential Medicines and Other Health Commodities, a joint USAID; John Snow, Inc./DELIVER; WHO; and UNICEF publication, includes a chapter on waste management in health care facilities. (John Snow, Inc./DELIVER 2003).

The *Transporting, Storing, and Handling Malaria Rapid Diagnostic Tests in Health Clinics* (World Health Organization et al. 2009) and *Transporting, Storing, and Handling Malaria Rapid Diagnostic Tests at the Central and Peripheral Storage Facilities* (World Health Organization et al. 2009), both forthcoming, describe the processes for disposing of rapid diagnostic tests (RDTs).

[1] MMIS is a multi-country project implemented by John Snow, Inc., and its partners with funding provided by USAID and the Centers for Disease Control and Prevention (CDC).

The Supply Chain Management System (SCMS) project has produced a detailed standard operating procedure for destroying unusable goods, including pharmaceuticals (Smith 2007).

Additional resources are available on the JSI/MMIS website (mmis.jsi.com), WHO's health care waste management website (healthcarewaste.org), and PATH's website (path.org).

2. PRODUCTS

The products required for correctly managing HCW vary depending on the type of waste generated and how the waste will be managed. The products can be categorized according to type next to the eight steps of waste management described by WHO and listed earlier in this document. The HCWM commodities should ensure the safety of health care providers, waste handlers, and the general population, as well as the environment.

Products Used at Point of Generation

Every health care facility, in nearly every part of a facility, generates HCW. The type and amount of waste are a function of the services provided to clients or patients and the number of patients receiving service at the point of waste generation. Community-based workers that work out of their homes and/or deliver basic services in a client's or patient's home are not likely to generate a large amount of hazardous waste and, unless they provide injections, little or no sharps waste. On the other hand, a general outpatient clinic that analyzes patient specimens and treats common ailments probably generates infectious waste, including blood, secretions, and contaminated materials and sharps—including used syringes/needles, lancets, vials/ampoules, and broken laboratory slides. Hospitals, of course, probably generate all types of waste in the largest quantities.

At every site where HCW is generated, commodities are needed to temporarily collect and store waste, including the following products:

Bins or containers: Bins should be made of a non-corrosive material (e.g., plastic) and have a lid that fits tightly and is easily opened and closed. They should be leak-proof and washable, and must have handles that enable waste handlers to safely transport them.

Bin size usually depends on the amount of waste generated at their location and the frequency with which they are emptied (i.e., should be large enough to prevent overflow). WHO recommends emptying bins when they are 75 percent full to avoid contamination (WHO 2005a). A large bin is usually 36 inches (ins.) or 91 centimeters (cm) tall, with a diameter of 30 inches or 76 cm. A small bin is usually 24 ins. or 61 cm tall, with a diameter of 16 ins. or 40 cm. Bins used to move HCW from one point to another point on-site should have wheels.

To color-code segregated waste according to its type of contamination, use color-coded bins and/or liners.

Bin or container liners: Bin liners are usually made of plastic sufficiently thick to prevent rupture and protect waste handlers from possible contamination or injury during collection, transport, and waste treatment (see figure 1).

Because the three most common types of HCW found in most health facilities in developing countries are general; infectious, including sharps; and pharmaceutical and chemical waste, it is easy to use a classification or color scheme:

Figure 1. Bin Liner

- infectious—yellow or red
- general (non-hazardous)—black
- pharmaceutical and chemical—brown.

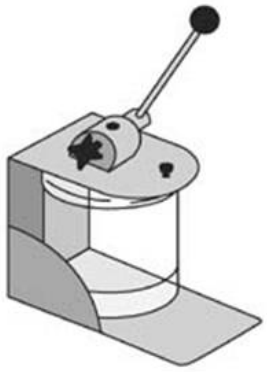
Infectious and pathological waste is often collected in bins with yellow or red bin liners (see figure 1). General or non-hazardous waste is often collected in bins with black bin liners. Sometimes, the bin liners are called *biohazard bags;* they may have a pre-printed label or integrated markings. Pharmaceutical and chemical waste should be collected in a bin with a brown bin liner. Radioactive waste should be disposed of in a lead container or other appropriate receptacle. Different categories of hazardous waste often have specific methods of safe disposal. As noted earlier, see the WHO classification of hazardous waste for details (WHO 2005c).

The overall size of a bin liner depends on the size of the bin. Liners should fit securely and comfortably inside the bin. The thickness of the liner should be at least 1.5 mils.

Sharps boxes or containers: Sharps containers (or safety boxes) safely contain items that could injure a service provider or waste handler before final disposal (e.g., used needles, syringe/needle combinations, and scalpel blades, or broken vials/ampoules). Sharps boxes, made of plastic or cardboard, are coated with a plastic film strong enough to protect waste handlers from injury (i.e., puncture and leak resistant). They typically have an opening large enough to insert sharps but small enough to prevent those already in the container from accidentally falling out. Most sharps boxes have sealable tops. After they are full and sealed, the box cannot be opened (see figure 2).

Figure 2. Sharps Box

The boxes come in a variety of sizes—small one-liter boxes to boxes that can hold many liters worth of sharps waste. The size is usually determined by the amount of sharps waste at the point of generation and the frequency with which it is replaced.



Other related commodities—needle removers: Needle removers are sometimes used in the area where injections are given so the used needles can be immediately segregated and contained, which reduces the possibility of needle-stick injuries. Health care providers insert the needle from a used syringe into a hole located on the device and press a lever to separate the needle from the syringe. The used needles collect inside a small container either attached to or part of the cutter. In some models, the needle collection container is removable so the used needles can be safely transported for final disposal. In other models, the entire needle cutter is disposable. See figure 3, which has a removable collection container (see table 1).

Figure 3. Needle Remover

Table 1. Summary of HCWM Products and Equipment Used at Point of Generation

Product/Equipment	*Type of Waste*	*Examples of Waste*
Bin	Segregate and dispose of waste	
Bin liner—black	General	• Pharmaceutical packaging • Discarded food
Bin liner—yellow/red	Infectious	Used gloves, gauze and other dressing material
Bin liner—brown	Chemical	Expired pharmaceuticals
Sharps box/container	Sharps	• Used needles, needle/syringe combinations, and scalpel blades • Broken vials/ampoules
Needle remover	Sharps	Only needles separated from syringes

Products Used during On-Site Transport and for Intermediate and Central Storage

HCW that accumulates in waste bins at the point of generation should be routinely emptied and moved to an intermediate secure storage location that is inaccessible to unauthorized people. At clinics, HCW is usually moved to large bins located outside the facility until it can be transported for treatment and/or disposal. At hospitals or larger facilities, HCW is usually transported on a trolley or similar device to a temporary intermediate area until it can be moved to the central storage area; from there it will be transported for treatment and/or disposal. In all cases, intermediate and central areas should be designed to ensure that the HCW remains segregated during storage. As mentioned earlier, WHO recommends regular daily removal of HCW from the point of generation; they also suggest that waste in central areas should not be left for more than two days. However, if national HCWM policies and/or guidelines exist, those standards should be followed.

In addition to containers used at the intermediate storage areas, trolleys used for internal transport and containers used at the central storage areas are also needed. Because hazardous HCW must be segregated from general HCW, containers and trolleys are needed for each type of waste.

Personal protective equipment (PPE): All waste handlers must be protected from injury and exposure to diseases or contaminants associated with HCWM. PPE protects health care workers from injuries or exposure to infectious agents or contaminants.

PPE could include any or all of the following:

- heavy duty gloves
- face shield
- safety glasses/goggles
- hard hat
- safety shoes/boots

- clothing including coveralls and aprons
- ear plugs
- respirators.

The exact type of PPE required depends on the hazards at the time. Waste handlers should protect themselves from the potential risks. As stated before, for HCW in developing countries, the main hazard is injury from sharps. Secondary hazards include contracting disease from exposure to infectious agents within the waste, burns, and inhaling smoke or ash from burning waste.

The MMIS project, funded by PEPFAR through USAID and the Centers for Disease Control and Prevention (CDC), have developed detailed specifications for gloves, eyewear, respirators, and footwear, as well as bin liners (MMIS/JSI/PATH 2008).

3. Quantifying Product Needs

Effective forecasting for HCWM commodities depends on the availability of accurate information about the usage or consumption of HCWM products. If this information is not available, either because the data on usage is unreliable or the situation is new, then the need is estimated according to the expected usage of the commodities. This is usually based on observation or information obtained through interviews with relevant health facility staff regarding the number of staff involved in waste handling activities and the volumes of waste.

If possible, future quantifications should be based on a consumption model that dictates the data on actual consumption or usage collected by the health care system. This is used to determine how much, and when, to reorder supplies so that a constant and adequate supply of HCWM commodities is ensured. Because this publication does not include information on how to develop a reorder system for collecting and analyzing this information, see the resource from the DELIVER project, *Logistics Handbook: A Practical Guide for Supply Chain Managers in Family Planning and Health Programs*, (USAID |DELIVER PROJECT 2007).

Quantifying Products Used at Point of Generation

The products used for HCWM at the point of generation include waste bins, bin liners, and sharps boxes. Waste bins are durable goods that a health care facility orders when needed; bin liners and sharps boxes are consumable items that require regular resupply.

In all cases, the type and quantity of each product required by a health care facility depends on three variables—

1. number of points (or locations) of waste generation
2. amount of each type or category of waste generated at these locations in a given period (e.g., one bin per day for infectious waste)
3. how often waste is removed from the points of generation.

In general, the countries' Ministry of Health (MOH) or a health care facility should identify two sizes of waste bins (see chapter 2 for suggested sizes) that will be used at the points of generation and also identify one or two (no more than two) sizes for sharps boxes.

After the container sizes are determined, the points of generation for the following waste categories must be identified: general (non-hazardous), hazardous/infectious, hazardous/non-infectious, and sharps. Typical points of waste generation at a primary health care facility for both hazardous—including infectious—and general waste include the following:

- family planning clinic
- immunization clinic
- antenatal clinic
- outpatient clinic.

The points of waste generation for hospitals vary and usually include any or all of the following:

- family planning clinic
- immunization clinic
- antenatal clinic
- outpatient clinic
- male and female in-patient wards
- laboratory
- pharmacy
- x-ray
- operating theater.

It may also include a variety of specialty clinics—pediatrics, gynecology, ophthalmology, and dentistry.

Waste bins: At each point where hazardous waste, most likely infectious waste, is generated, there should be a minimum of two bins—one for infectious waste and one for general waste. The MOH may have specific procedures for disposing of other hazardous material, including expired pharmaceuticals and chemicals. Expired pharmaceuticals may either be placed in bins with brown liners or kept in their original packaging for transport to the intermediate storage or final disposal area. Other material, such as expired cleaning solvents, should not be placed in waste bins but should be disposed of using the specifications described on their containers. Bins should ideally be emptied at least once a day. The size of the bin at the point of generation will depend on the amount of waste that accumulates during a typical day. Areas where large amounts of waste are generated should have large size bins. Areas that generate small amounts of waste during a day should have small size bins.

Bin liners: When quantifying the need for waste bin liners at health care facilities for the first time at each point of generation, the types of waste generated, the size of the proposed bins, how quickly the bin fills up, and the number of times the bins are likely to be emptied during a typical day must be determined. With this information for all points of generation, the average daily requirement for the facility can be determined. The following steps should be followed to estimate the quantities needed for each color bin liner (i.e., black, red/yellow, or brown).

1. Identify all points of generation.
2. Determine what color bin liners are needed at each point of generation.
3. For each color bin liner required at a point of generation, determine what size is required and the number per day that are required.
4. If only black and yellow or red bin liners of sizes small and large are required for the facility, complete table 2.

Table 2. Estimating Number of Bin Liners per Waste Generation Point per Day

Point of Generation	# Small Yellow or Red	# Large Yellow or Red	# Small Black	# Large Black
Point 1				
Point 2				
Point 3				
Point 4				
Total				

To obtain the most reliable data needed to estimate the initial need for bin liners is to observe the waste generation practices at the various points of generation. Because these practices cannot always be observed, individuals who work in each area should be interviewed to gather an estimate of the need for each type of bin liner. Future estimates of need can be obtained by routinely monitoring daily consumption or usage.

Sharps boxes: Quantifying the initial need for sharps boxes can be complicated. First, the points where sharps are generated must be determined; these are not always the same as the points of other waste generation. In general, sharps waste is generated where injections are given to patients, surgeries are performed, and laboratory procedures are undertaken.

The size of the box and number of boxes required per day at a point of generation depends on the type and amount of sharps generated. To ensure a sufficient supply and to ensure that the way the safety boxes are filled is consistent with the delivery of health care services, it is highly recommended that the supply of safety boxes correspond in volume and size to the supply of sharps. While safety boxes that meet high-quality standards are durable by design, any safety box that is weakened by age or weather should be immediately discarded.

Different health care facilities follow different rules for using sharps boxes. Small- to mid-sized health centers generally use the boxes to hold only syringes and/or needles. Some use the boxes to hold syringes with the accompanying needle (e.g., for immunization programs). Others that do have access to needle removers may use the boxes to hold only needles; and others may use the boxes to store only syringes. Larger health care facilities, especially those that perform laboratory and surgical procedures, may use sharps boxes to hold syringes, needles, lancets, broken laboratory supplies, and used consumable surgical instruments (e.g., scalpel blades and trocars).

Because the rules for what should be placed in sharps boxes are not the same in every case, it is important to understand how the boxes are being used at a health care facility before quantifying the initial need. Noting the number of sharps boxes used each day at each type of facility may be a good way to make projections for future sharps box needs. When this is not possible, table 3 can be used to make an initial estimate of the number of 5-liter boxes needed at various types of health facilities. The table lists an estimated number of injections performed at different facilities, if an average size 5cc syringe is used for each injection. The number of injections is a variable that can be determined with some degree of accuracy.

Table 3. Estimating Number of Injections per 5-Liter Sharps Box

Facility Type	Needles and Other Sharps in Box (no syringes)	Syringes and Other Sharps in Box (no needles)	Needles, Other Sharps, and Syringe in Box
Health Post	3,000 injections	125 injections	75 injections
Health Center	3,000 injections	125 injections	75 injections
District Hospital	2,000 injections	115 injections	65 injections
Regional Hospital	1,000 injections	110 injections	55 injections

Note: Table 3 is based on research in Guyana by the Guyana Safer Injection Project.

If 10-liter sharps boxes are required, the number of injections in the table 3 is doubled. The numbers in the table can be multiplied proportionately for even larger size sharps boxes.

As mentioned above, all future estimates of need should be determined using consumption data. Of course, care should be taken in the case of health posts and health centers where boxes fill at a very slow pace. In these cases, it is probably best to keep an additional one or two boxes on-site.

Without the actual number of injections administered at a health facility, the WHO recommendations can also be used as a guide: 100 syringes per safety box when the box is use solely for immunization services, and 75 syringes or fewer for curative health care settings where the box is used for a variety of services.

Quantifying Products Used during Intermediate and Central Storage and On-Site Transport

Larger containers and trolleys: Depending on how HCW is stored at intermediate and central sites, estimates for the number of large bins and trolleys needed for on-site transport will depend on the quantity of waste generated and the frequency of disposal. This type of equipment is usually procured as needed because it is long-lasting. Additional containers and trolleys may need to be procured proportionately to the increase in the quantity of HCW generated and as they break and become unusable. Transport is discussed further in chapter 5.

PPE: The products used during on-site transport and intermediate storage are mainly PPE. This equipment is usually quantified and ordered depending on the number of people who require PPE and how often specific items need to be replaced. As mentioned earlier, waste handlers, including cleaners and launderers, require equipment that will protect them against the possibility of contamination. Incinerator operators require a full set of PPE, including a respirator.
The first quantification for PPE is a relatively easy exercise. Through interviews with health care administrators, it can be determined which categories of personnel deposit waste into bins, which categories remove waste from bins, and which categories wash the linen; the number of personnel can also be determined. It is important to remember that each waste handler receives their own PPE that is not to be shared. Consequently, the only time that PPE needs to be reordered is when it is damaged or lost or when a new waste handler is employed. It is also important to understand how often personnel are required to replace items of PPE. By speaking with employees, it may be possible to estimate the need to replace PPE and, therefore, to determine the amount to maintain as a buffer stock.

4. Procuring HCWM Products

An effective procurement process ensures that HCWM commodities are available to health care workers anytime they are needed. The ability to procure HCWM commodities that meet international standards is an important component of the logistics of HCWM. This chapter explains the guidelines for effective procurement of quality HCWM products, including guidance on potential suppliers of these products. Procurement of equipment for treatment and disposal of HCW is not considered here; it is discussed briefly in chapter 6.

Procurement Guidelines

The guidelines for procuring HCWM products are basically the same as those used to procure other health care commodities, including—

1. selection of products
2. estimation of product needs
3. procurement preparation
4. tender processing
5. evaluation and selection of supplier.

Step 1 is discussed in chapter 2; step 2 is discussed in chapter 3. Procurement preparation mainly includes choosing a procurement method (e.g., restricted, competitive, sole source) and, if necessary, locating suppliers. Guidance on some international sources for HCWM commodities is discussed later in this chapter.

Like any commodity, cost will influence the procurement process. However, special attention must be given to meeting specifications to avoid risk or injury to health care workers. Consequently, one important question about HCWM products is whether to buy products produced locally or internationally. Although bin liners are usually available in developing countries, it is often difficult to find liners that meet the 1.5 mils thickness specification mentioned previously. Experience has shown that bin liners often have to be specially ordered or imported. Waste bins, however, are readily available in a variety of sizes in most developing countries.

Sharps containers are often imported into developing countries; they must be designed so they can be permanently sealed when full. It is important that they cannot be opened without substantial difficulty (i.e., must use a saw or other cutting device to open). Anecdotal stories abound of people collecting sharps boxes from open landfills, then injuring themselves after they opened the boxes and handled the contents.

Because WHO has adopted a strategy of coordinated procurement for purchasing safety boxes, (WHO 2003), they should be procured with syringes and, at least initially, in amounts that correspond to the number of syringes being purchased. It is not easy to determine the number of boxes that correspond to syringes (see chapter 3); after consumption data is available, it should be used as a guide to determine the number of boxes to procure.

Many needle remover manufacturers produce devices with either fixed or removable needle containers. The type of device procured will depend on existing relationships with manufacturers and the final disposal solutions available.

Like bin liners, the decision to purchase PPE locally or to import often depends on the ability of host country manufacturers to produce products to specification. At a minimum, waste handlers' gloves must be puncture-resistant yet flexible enough to be functional.

Procurement Sources

Finding reliable suppliers for HCWM commodities is not always easy. By actual experience, PATH has identified a list of sources for safety boxes, syringes, and needle removers (PATH n.d.). PATH's list includes information about the manufacturer; product specifications; current cost; minimum packaging requirements; expected lead time; country of origin; and any pre-qualifications, registrations, or certifications for the product. While PATH provides this information, they do not necessarily endorse any manufacturer.

MMIS also produced a resource on specifications for PPE and bin liners that includes a list of sources (MMIS/JSI/PATH 2006b). In addition to a detailed list of specifications, it includes a list of illustrative products and the websites for the manufacturers of those products. This information is provided by MMIS as a resource; however, the manufacturers are not endorsed by JSI, PATH, or USAID.

The preceding information pertains to national-level procurement. However, health facility managers are also customers in the HCWM supply chain and they need sources to obtain appropriate HCWM supplies. One way to ensure that health facilities down the supply chain procure products with the correct specifications is for national-level procurement agents to acquire PPE and HCWM supplies and include them on standardized medical stores supply lists for lower levels to requisition. This will provide two-fold benefits by ensuring quality and reducing cost through bulk buying. By providing the commodities through existing requisition and issue structures, facilities avoid buying from local stores on their own. However, the cost of storing and transporting bulky supplies must also be considered when developing a supply strategy for these items.

5. Transport of HCW

Most of us understand the importance of waste collection. However, very few of us are aware of the processes involved in the collection and transport of waste to its final destination and disposal.

On-Site Transport and Storage

HCW must be moved from its point of generation to a storage area or a treatment/disposal device or facility. Usually, two options are available for transporting waste:

- Move waste to an on-site treatment and/or disposal area (e.g., at a low-level health center, waste is collected at the point of generation and dumped directly into a protected pit; or used needles are dumped directly into a sharps barrel or sharps pit).
- Move waste to an intermediate, secured storage area pending on-site treatment and disposal (e.g., at an inpatient facility waste is collected at the point of generation and taken to a restricted access waste collection area pending on-site incineration). In larger institutions, waste collected at intermediate areas can be moved to a central holding area where it will either be disposed of on-site or transported to an offsite treatment/disposal facility.

In all cases, waste handlers must avoid contact with hazardous materials when transporting or storing HCW.

Strategies and Approaches

Moving HCW can be dangerous even if the distance is only a few feet. To minimize exposure, waste handlers should (where possible) completely close bin liners by tying them off; they should also empty the contents of smaller size bins into larger bins before transporting the waste to its final on-site destination. Where available (e.g., at larger hospitals), waste should be transported on wheeled bins or trolleys; the size of a trolley depends on the ability of the waste handler to move it.

Transport to on-site treatment: In smaller health facilities, waste is sometimes transported directly from the point of generation to a final disposal area on-site. Facilities using needle removers and sharps barrels or sharps pits are in this category because the used needles are deposited directly into the device.

Temporary on-site storage: HCW often requires temporary on-site storage. Either it is held in an intermediate storage area until it can be treated on-site or until it is transported to an offsite treatment facility.

Non-hazardous waste (accounting for 75–90 percent of all health care waste) is normally kept on-site only for as long as necessary (e.g., until it is collected and/or delivered to a landfill for final disposal). This type of waste requires no unusual measures for temporary storage; it can usually be placed at a location where it can be easily collected.

Hazardous and infectious waste (including sharps waste) is a different matter. If the hazardous waste will be collected and transported to another facility for final disposal, it should be temporarily stored

in a secure area suitable to hold whatever volume might accumulate between the intervals of pickup and delivery of the waste. The hazardous waste should be segregated from general non-hazardous waste, and should not be kept longer than 48 hours. The storage area should be locked, and if it is outside, it should also be covered and fenced.

Collection and Transport for Offsite Disposal

HCW that is not disposed of on-site (either through incineration or in protected pits) must ultimately be collected and transported offsite for disposal. Waste removal to an offsite facility has important supply chain implications because the amounts of waste to collect must be quantified, the way to move it must be arranged or procured, the intermediate storage arrangements may be required, and the transportation must be coordinated to achieve efficiency and cost savings. Above all, personnel involved in transporting waste must have the necessary training, equipment, and supplies so they can conform to the required safety standards and to protect their health.

In this section we explore some basic approaches to the collection and transport of HCW, which is pertinent to developing countries. We will discuss some basic strategies for quantifying the waste, selecting appropriate transport to move the waste, providing intermediate storage for the waste, and, ultimately, transporting the waste to its site of disposal. We include some basic approaches to optimize transport.

This is by no means a comprehensive survey of the procedures and methods available to logisticians to manage the collection and transport of HCW, but it is a review of the most commonly known and implemented approaches.

Strategies and Approaches

Quantification

Quantification in waste collection begins with estimating the amount of waste generated by the health care facilities that require waste collection. Care must be taken to select the proper units for estimating the waste. If the disposal method (e.g., landfill) uses volume (usually cubic meters) to measure waste, the waste to be collected must be measured by volume. Likewise, if the disposal method (e.g., some incinerators) uses weight (usually kilograms) to measure waste, the waste to be collected must be measured by weight. In all cases, waste flow should be defined as occurring over some time period (usually amount generated per day).

However, the process does not end there. It is important to consider the disposal constraints of the logistics system. For example, if government policy calls for the collection and proper incineration of HCW, but the logistics system is constrained by the number of incinerators available and their capacity to incinerate, the constraints will determine the upper limit of the amount of waste that can be collected. Otherwise, the waste may accumulate at the disposal site.

The availability of transport can also constrain the ability of an organization to collect waste. Care must be taken to avoid cross-contamination of hazardous and general waste during transport. WHO recommends that dedicated vehicles that are free of sharp edges, are easy to load and unload, and are easy to clean and disinfect should be used for hazardous material. The transport should also be fully enclosed to prevent any spillage. In cases where an organization is limited to a certain size or number of vehicles, the size of the container(s) on these vehicles will dictate the amount of waste that can be collected. There are ways to ease this problem. One method is discussed later in this chapter.

Procurement

What to procure, to collect, and to transport HCW depends on a number of variables. First, and foremost, it depends on the mode or modes of transportation available (i.e., how will the waste be transported from generation point to disposal site). In developing countries, many possibilities exist, including manual labor (e.g., porters in high altitudes), handcarts (to navigate narrow city alleyways), bicycles, boats or other watercraft, trains, automobiles, trucks, and even airplanes. The mode of transportation and how many of each are required depends on the terrain and available resources.

If no financial, human, or regulatory constraints govern the selection of a mode of transportation, then the decision about what to procure can be based solely on the location of clients and their accessibility. The size of a mode or modes of transport will then depend on how much waste the client generates and the client's capacity to temporarily store HCW. For hospitals, daily pickup is usually required. In general, hazardous waste must not remain on-site for more than 48 hours.

After the mode or modes are established and the waste collection needs of clients are determined, a strategy for waste collection can be devised. The strategy selected will ultimately determine the equipment needs and will help drive the procurement. Some of these strategies are discussed below.

Temporary storage for unusual circumstances

In some cases (especially in developing countries), non-hazardous HCW must be stored temporarily (more than 48 hours) before it is collected and destroyed. Medical campaigns that call for the treatment of large numbers of clients throughout the country often require the temporary storage of used medicine containers and non-contaminated medical consumables at a service delivery point or district store until arrangements can be made to collect and dispose of the HCW. One of the greatest challenges in these circumstances is establishing sufficient space to temporarily store the unusable items. Examples abound of used medicine containers being confused for usable medicines because they were temporarily stored in the same location. It is, therefore, very important to separate returned (and unusable) commodities from usable commodities and to keep a careful record of both (e.g., maintain a stock ledger for both).

It is also typical in developing countries for expired or unusable drugs to be stored for excessive periods of time while the facility or organization awaits approval for disposal. As mentioned earlier, it is important to keep these items separate from usable medicines and record their movement (in and out of quarantine) in a stock ledger or other record-keeping instrument.

Basic approaches to defining a waste collection/transport strategy

After HCW has been quantified, the modes of transportation defined and the constraints (if any) established, a strategy for waste collection can be devised. Transportation management is a broad and complex field of logistics and, as such, the approaches discussed here merely scratch the surface of the possible strategies for managing waste collection. Below we provide some basic approaches to collecting and transporting HCW to an offsite facility.

The simplest and most obvious strategy for HCW collection is to collect the waste according to the needs of the client without regard to system optimization or cost reduction. In this case, the logistician should collect the requirements of the clients, specify the most obvious route or routes for collecting the HCW, and allocate transport accordingly (e.g., if trucks are to be used, collect HCW until truck is full, return HCW to disposal site and continue the process until all HCW generated by clients is processed).

If a more precise solution that optimizes resources and reduces cost is required, but the logistician has neither the time nor a complete understanding of the field of transport management, several transport management software tools are available that can help determine the best routes, frequency, etc. The best strategies optimize resources by reducing costs while addressing constraints, such as physical geography, road networks, or other geo-political or policy limitations.

Other resources for establishing transport routes are logistics and supply chain handbooks. One of these, *Supply Chain Strategy* by Edward Frazelle (2002), presents transportation options in great detail. Frazelle provides a step-by-step approach to selecting an optimized transportation system. He also provides some basic guidance on how to choose a software tool to analyze different strategies. The WHO resource referenced earlier, *Management of Solid Health Care Waste at Primary Health-Care Centers: A Decision-making Guide,* also explores options for transport of HCW.

As various solutions are explored, it is important to consider national regulations that might limit transport options. For example, some countries collect filled safety boxes during resupply visits to health facilities if there is no possibility of cross-contamination. However, policies in some countries prevent transporting hazardous waste and medical supplies in the same vehicles, so this solution would not work everywhere. Other solutions are also being explored, such as in Botswana where trailers for HCW are attached to the back of medical supply vehicles. Other countries have explored the use of secure bins on the back of trucks for the transport of full safety boxes.

6. TREATMENT AND DISPOSAL

HCW must ultimately be treated and disposed of in a way that is regulated by whatever law exists within the country. When laws exist, they may include the following provisions:

- *Non-hazardous waste* must be disposed of either through incineration or by disposal in a landfill. Usually, special arrangements are not made to treat this type of waste.
- *Hazardous/infectious waste* must be disinfected and buried, incinerated, or disposed of by following specific procedures, such as in the case of chemicals. Carcinogenic materials should be disposed of following established procedures or WHO recommendations.
- *Sharps waste* must be immediately contained, then incinerated (if the temperature achieved through incineration is 900°C or high enough to disfigure and melt the sharps), buried, preferably in a sharps pit, or isolated in a sharps barrel.

Evaluating Options

In the WHO document *Safe Management of Wastes from Health-care Activities,* a decision tree lists paths of disposal or treatment for a variety of types of waste at the hospital level (see appendix A).

The DELIVER project's *Safe Injection and Waste Management* (described in chapter 1) has useful information for evaluating treatment and disposal options for immunization waste. It describes the strengths and weaknesses of burial, incineration, needle removal/destruction, and autoclaving.

As also mentioned in chapter 1, WHO's *Management of Solid Health Care Waste at Primary Health-Care Centers: A Decision-making Guide,* offers guidance on selecting the most appropriate option for safely managing solid waste generated in developing countries. It contains a number of decision trees that can be used to identify appropriate waste management methods. It outlines the basic elements of HCWM and lists options for disposal. The guide then provides a list of parameters used to assess different disposal methods. Finally, it gives guidance on estimating costs.

In a more extensive study on the health effects of landfills and incinerators, WHO published *Population Health and Waste Management: Scientific Data and Policy Options,* a report from a WHO workshop held in Rome on March 29-30, 2007. It examines the long-term health effects of landfills and incinerators and provides some guidance on the selection and placement of both.

Methods and Approaches to Treatment and Disposal

The type of equipment used at a health care facility to treat and dispose of HCW usually depends on the method and type of facility. Health care facilities, such as health posts or health centers, do not usually have the financial means to support the use of protected pits and/or incineration that meet WHO standards. They will often burn infectious waste at low temperatures and use a disinfectant to treat hazardous waste that cannot be burned. Safe disposal of sharps waste is a challenge in these

circumstances because they require incineration for complete destruction; low temperature burning will not completely destroy the sharps waste, plus it exposes personnel and the surrounding community to toxic gasses from the burning plastic. Low-temperature burning of expired medicines may release toxic or carcinogenic compounds into the air.

Burial

On-site burial is a common practice in many lower-level health facilities. Practices to increase the safety of burial include placing a layer of soil or dirt on top of each load of HCW, constructing a fence around the designated burial area, and training health workers on safe disposal practices.

Sharps Pit

In facilities where burning devices cannot reach high temperatures, or where transport of the safety boxes to a treatment facility is not an option, needle removers and sharps pits may be an option to safely dispose of used needles. Protected sharps pits are constructed on-site, set in the ground, and designated for disposal of sharps only (i.e., no injection devices such as used syringes). They should be located away from ground water sources and the bottom of the pit should be above the water table, and usually lined with concrete or brick. An approximately 1 meter long chute should extend from the top of the pit and include a lid that will prevent water from entering. The entire structure should be fenced to prevent unauthorized entry. PATH has developed instructions for constructing a sharps pit (PATH 2005); see figure 4 for two designs currently in use.

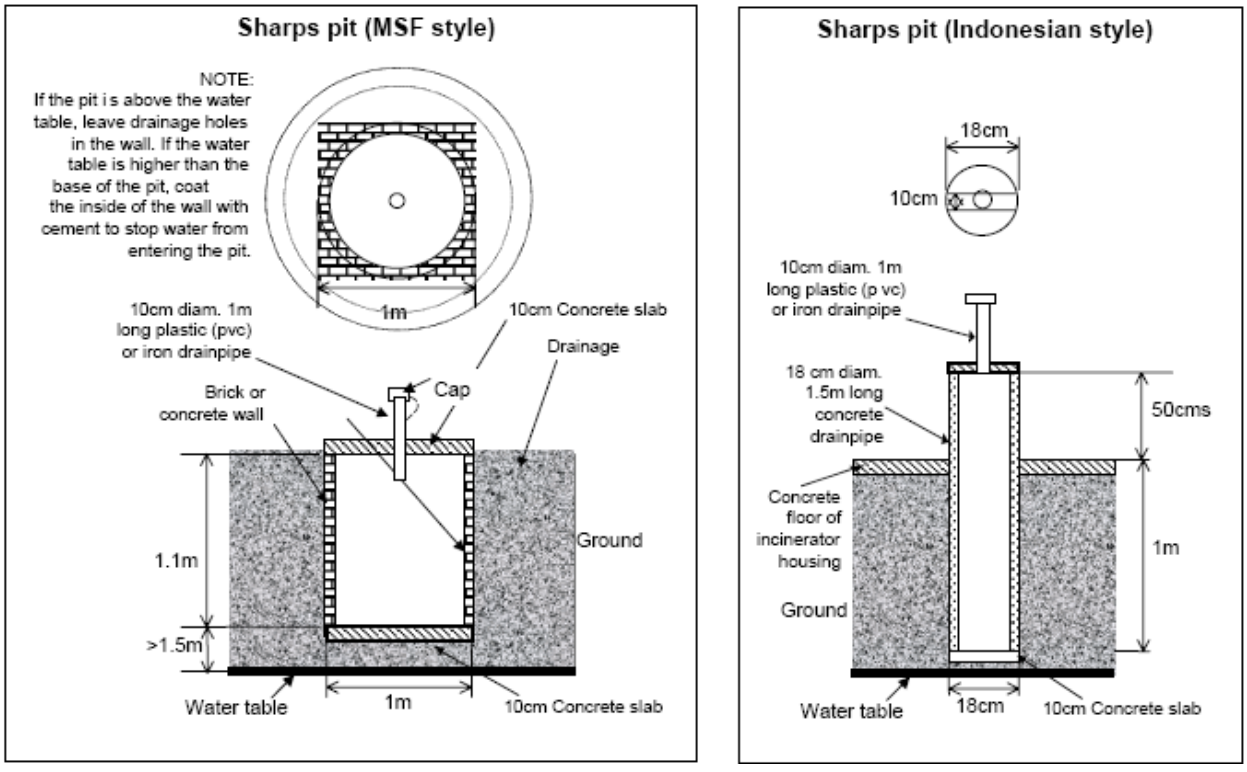
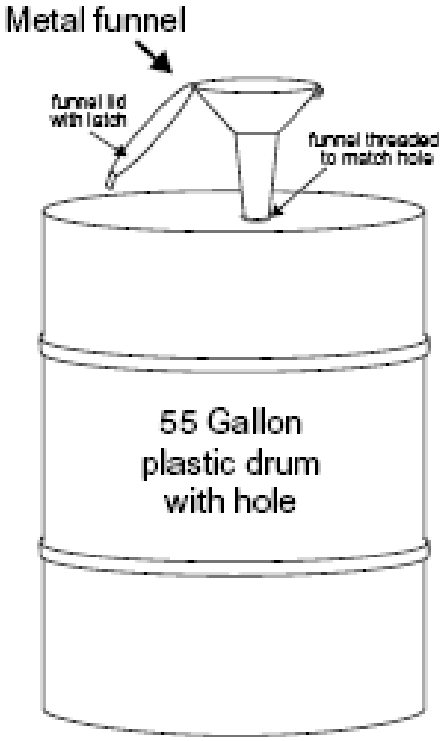


Figure 4. Sharps Pit

Sharps Barrel

In facilities where sharps pits may not be an option because of scarcity of land or high water table, sharps barrels can be used to safely dispose of used needles. Sharps barrels, usually procured and/or fabricated in-country, consist of an approximately 55-gallon plastic barrel, ideally with a funnel fabricated and fixed to a small opening in the top of the barrel to facilitate safe emptying of the sharps into the device. Contaminated sharps should not be handled. PATH can provide specifications for sharps barrel construction. Because the device is large compared to the waste it contains (i.e., only contaminated sharps, not devices such as syringes), it can take a very long time to fill them (i.e., many years or even decades). Because of this, quantifying need is not an issue.



Sharps barrels offer an attractive option for small- to mid-size health care facilities that produce small amounts of sharps waste. A sharps barrel that can hold between 50 and 60 gallons of waste (the recommended size if a larger size is not warranted) could last a decade or longer. When the barrel is full, cement is added to the contents and the barrel is sealed.

Sharps barrels are often made of heavy-duty puncture-proof plastic that is not biodegradable. They usually have a small opening on the top of the barrel where the needles are inserted. A funnel can ensure that the sharps are safely and easily inserted into the receptacle. The small opening and use of a funnel protect the waste handler from touching the contaminated sharps. PATH's specifications and guidelines for building and using a sharps barrel are available on their website.

Figure 5. Sharps Barrel and Funnel

Incineration

Although lower-level facilities are often challenged by incineration (i.e., their burners do not reach sufficiently high temperatures of 900°C) (Pruess, Giroult, and Rushbrook 1999), when properly designed, small-scale incinerators are a reasonable option for treatment and disposal of HCW at health centers and health posts. Sufficiently high temperatures can be reached when the correct design specifications for a double-chamber combustion burner are followed. Furthermore, the double-chamber design helps ensure that toxic emissions are minimized and that incinerator operators and nearby communities have minimal impact from incinerator emissions. The De Montfort incinerator (figure 6) is a classic example of a double-chamber small-scale incinerator that has been constructed in many rural areas around the world.

Figure 6. De Montfort incinerator in Myanmar

Some lower-level health facilities may consider constructing a waste disposal unit (WDU) (see figure 7) to facilitate safe and efficient HCWM using a combination of on-site incineration and burial of HCW. Originally conceived by WHO/AFRO and PATH, then updated by CREATE, the WDU's components include—

- small-scale auto-combustion incinerator
- a combination ash/needle pit for residual ash, glass, and metallic parts, including needles
- a shelter to protect the incinerator, waste and reheating fuel from the elements, and to support the 4 m stack
- a waste store for safety boxes and non-sharp waste bags (referred to as bin liners in this document)
- a fuel store to stock agro-residues or wood required to preheat the incinerator
- a storage box for tools, protective clothing, and records
- an enclosure with a lockable door
- an opening to deposit safety boxes when the door is locked
- an opening to deposit used needles (CREATE 2008).

PPE is required for anyone who operates a WDU. Of particular concern is operation of the incinerator and handling of the toxic ash that results from incineration; incinerator operators need

sufficient protection to ensure they can safely deposit ash into the ash pit. Ash should never be deposited into a well.

Figure 7. Medical Waste Disposal Unit

Source: www.create.org

The construction and implementation of WDUs and other health care waste management approaches are not without challenges. MMIS has documented lesson learned on this topic in *Small-Scale Incinerator Construction: Recommendations from the Rwanda Experience* (available on the MMIS website).

Table 4 summarizes the different methods of HCW treatment and disposal, including the conditions/selection criteria for each method.

Table 4. Treatment and Disposal Options[2]

Method of Treatment/Disposal	Selection Criteria
Offsite final disposal of infectious waste	• The distance to legally approved treatment facilities to final disposal must be reasonable. • Means of transport and a reliable road infrastructure should be available. • Vehicle should be disinfected after transporting infectious waste material. • Quantity of daily waste generated should be sufficient to justify transport costs.
On-site final disposal of infectious waste	• Only if the conditions above are not met.
Separation of needle from syringe	• Relevant for most health care facilities if a safe needle remover device is selected for the separation process. • A sharps pit or needle barrel must be available on-site. • Inappropriate if sharps are not properly stored afterwards.
Sharps pit to bury sharps/needles	• Relevant for most health care facilities that are out-of-reach of transport to facilities with better options for disposal. • Inappropriate in regions with heavy rains and floods or shallow water table. A sharps barrel can be used in these situations.
Autoclave	• Proper training of staff for operating procedures is necessary. • Device and spare parts should be locally available. • Monitoring equipment is needed.
Construction of an incinerator	• Proper materials, qualified construction, and training for operating procedures are necessary. • Space is needed on premises to allow a minimal distance of 250 m from populated areas and maximal dispersion of gas emissions.
Controlled burial	• Not suitable in case of a shallow water table (bottom of the pit should be 1.5 m higher than the groundwater level) or in seasonally flooded area. • Burial site should be fenced. • Sufficient land should be available.
Encapsulation	• Sufficient land should be available if burying on-site. • Encapsulation material necessary.
Municipal landfill	• If no other option is possible, municipal land fill is better than open dumps. • Encapsulation of sharps, mutilation beyond usability, and disinfection of plastic syringes is necessary.

[2] Adapted from (WHO 2006)

7. CONCLUSION

The supply chain considerations for HCWM are complex, as they are for any supply chain. Many external factors could influence how a health facility handles its HCW. The first step would be to determine whether any national HCWM policies are in place. Then the volume of waste to be managed, transportation limitations, and geographic constraints that may impact how a health facility manages its waste should be considered. Finally, health facility and district HCWM policies should be tailored to both facility needs and HCW categories.

The primary objective of HCWM is to protect health workers and facility staff, the community, and the environment. At a minimum, hazardous waste must be contained and separated from general waste. Anyone handling the waste should have access to the material and equipment that will help them carry out their duties safely. Even facilities in resource-poor settings have the ability (and should make it a priority) to manage their HCW.

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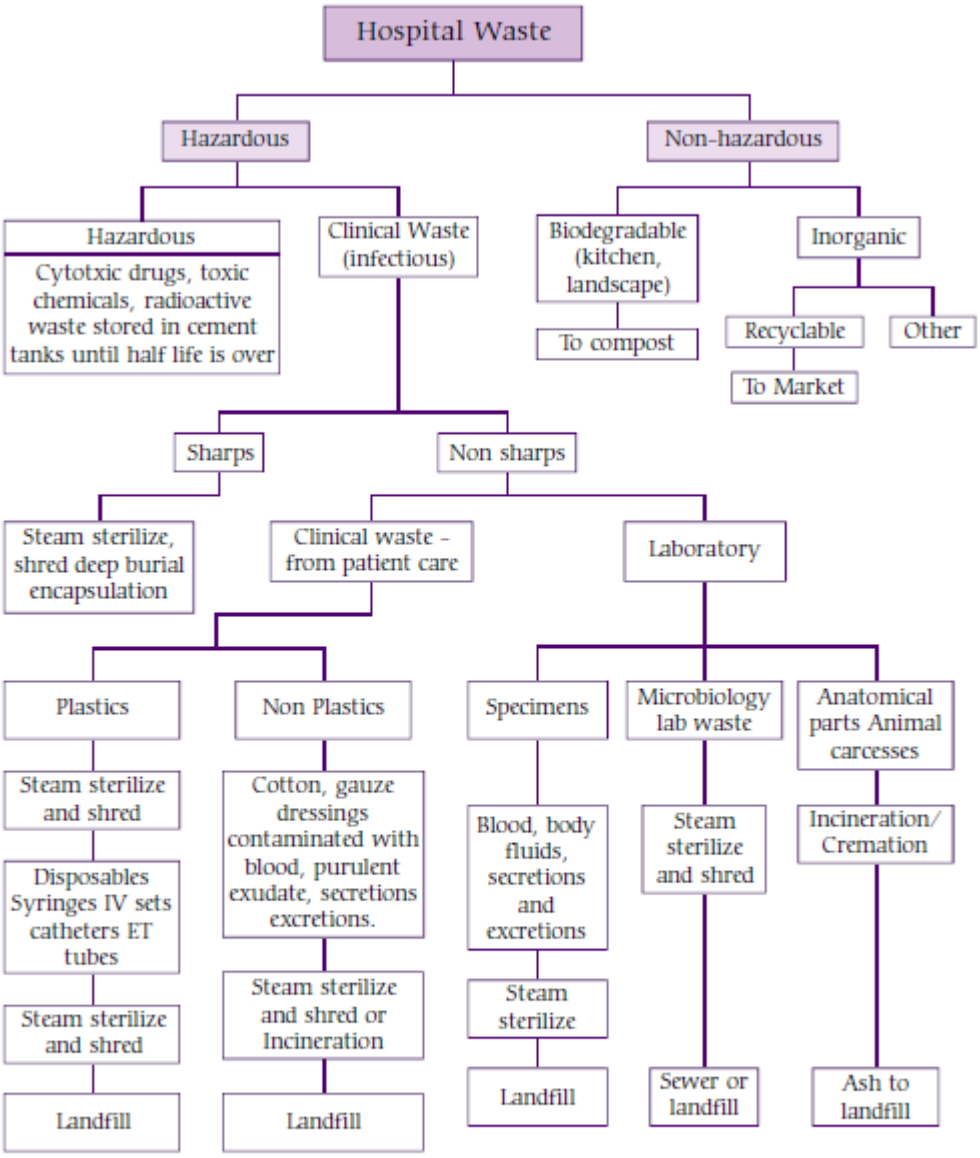
APPENDICIES

A. PRACTICAL CLASSIFICATION OF HOSPITAL WASTE AND METHOD OF TREATMENT



Source: Prüss A, Girault E and Rushbrook P, eds. *Safe Management of Wastes from Health-care Activities*. Geneva, World Health Organization, 1999, page 168. Electronic access: http://whqlibdoc.who.int/publiations/9241545259.pdf

B. ADDITIONAL CONTACT INFORMATION

Centre for Renewable Energy, Appropriate Technology and Environment (CREATE)

G - A, Alsa Glenridge

Ground Floor

32,Langford Road

Bangalore- 560 025

India

Phone: 91 (0) 98947 15168

Fax: 91 (0) 80 5114 2437

De Montfort incinerator specifications

info@mw-incinerator.info

http://www.mw-incinerator.info/en/101_welcome.html

Making Medical Infections Safer (MMIS)

John Snow, Inc.

1616 Fort Myer Drive

11th Floor

Arlington , VA 22209 USA

Phone: 1 703 528 7474

Fax: 1 703 528 7480

mmisinfo@jsi.com

PATH

1455 NW Leary Way

Seattle, WA 98107

Phone: 206 285 3500

Fax: 206 285 6619

publications@path.org

http://www.path.org/projects/health_care_waste_resources.php

Supply Chain Management Systems (SCMS)
1616 Fort Myer Drive
12th Floor
Arlington, VA 22209-3100
USA
Phone: +1 571 227 8600
Fax: +1 571 227 8601

USAID | DELIVER PROJECT
USAID | DELIVER PROJECT
John Snow, Inc.
1616 Fort Myer Drive
11th Floor
Arlington, VA 22209 USA
Phone: 703 528 7474
askdeliver@jsi.com
http://deliver.jsi.com

WHO Health Care Waste Management
Department for Public Health and Environment
20, Avenue Appia
1211 Geneva 27
Switzerland
Phone: 41 22 791 21 11
Fax : 41 22 791 31 11
hcwaste@who.int
www.healthcarewaste.org

For more information, please visit deliver.jsi.com.

USAID | DELIVER PROJECT

John Snow, Inc.

1616 Fort Myer Drive, 11th Floor

Arlington, VA 22209 USA

Phone: 703-528-7474

Fax: 703-528-7480

Email: askdeliver@jsi.com

Internet: deliver.jsi.com