World Health Organization
Western Pacific Region

Responding to Outbreaks of Antimicrobial-resistant Pathogens in Health-care Facilities: Guidance for the Western Pacific Region

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CONTENTS

ABBREVIATIONS

ABHR	alcohol-based handrub
AMR	antimicrobial resistance/resistant
AMS	antimicrobial stewardship
AWaRe	Access, Watch, Reserve
AST	antimicrobial susceptibility testing
CPE	carbapenemase-producing Enterobacterales
CPO	carbapenemase-producing organisms
EML	Essential Medicines List
FETP	Field Epidemiology Training Programme
GLASS-EAR	Global Antimicrobial Resistance Surveillance System – Emerging Antimicrobial Resistance Reporting
GOARN	Global Outbreak Alert and Response Network
HAI	health-care-associated infection
HCF	health-care facility
HCW	health-care worker
ICC	infection control committee
ICU	intensive care unit
IPC	infection prevention and control
IPCAF	Infection Prevention and Control Assessment Framework
LMIC	low- and middle-income country
MRGN	multidrug-resistant Gram-negative
MRSA	methicillin-resistant *Staphylococcus aureus*
NCC	national cordination centre
NICU	neonatal intensive care unit
NRL	national reference laboratory
OMP	outbreak management plan
OMT	outbreak management team
PPE	personal protective equipment
SOPs	standard operating procedures
TBPs	transmission-based precautions
VRE	vancomycin-resistant *Enterococcus*
WASH	water, sanitation and hygiene
WASH FIT	Water and Sanitation for Health Facility Improvement Tool
WGS	whole genome sequencing
WHO	World Health Organization

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GLOSSARY

AMR	antimicrobial resistance/resistant
Antimicrobial-resistant pathogens	Organisms that are resistant to one or more classes of antimicrobial agents and are commonly resistant to all but one or two commercially available antimicrobial agents. Terms used to express the level or degree of drug resistance are: **MDR (multidrug-resistant) pathogen:** a pathogen that is non-susceptible to at least one agent in three or more antimicrobial categories indicated for that bacterial species. **XDR (extensively drug-resistant) pathogen:** a pathogen that is non-susceptible to at least one agent in all but two or fewer antimicrobial categories indicated for that bacterial species. **PDR (pandrug-resistant) pathogen:** a pathogen that is non-susceptible to all agents in all antimicrobial categories indicated for that bacterial species.
Contact	An individual who is exposed to a person colonized or infected with an AMR pathogen in a manner that might allow transmission to occur, or an AMR pathogen-contaminated environment where there is an increased risk of acquisition of the organism. There are two categories of contact – a room or close contact, and a ward or casual contact. **Room/close contact** Any person who has shared a room/cubicle or bathroom/toilet facilities with the index case or any person whose bed is next to the index case for more than 24 hours during the period of transmission risk. **Ward/casual contact** Any person (other than room/close contact) who was on the ward or in the area for more than 24 hours where transmission occurred during the period of transmission risk.
IPC focal point	Person primarily responsible for coordination of a facility's infection prevention and control (IPC) programme. Ideally, they would be supported by an IPC team with delegated responsibilities and advised by a multidisciplinary committee.
Outbreak	An occurrence of more cases of disease, or pathogen, than expected in a given area (for example, ward or hospital) or among a specific group of people (for example, receiving a given procedure) over a particular period of time.
National coordination centre (NCC)	The NCC coordinates and oversees the national AMR surveillance programme; collates, analyses and disseminates national AMR data; and ensures that the system is functional. The NCC function is usually undertaken by a public health institute or health authority.

National reference laboratory (NRL)	The NRL promotes and facilitates good laboratory practice and harmonization within the country. Note that some countries may have several national reference laboratories specializing in specific diseases or pathogens.
Standard precautions	The minimum or first tier of IPC practices that apply to all patient care, regardless of confirmed or suspected infectious status of the patient.
Transmission-based precautions (TBPs)	The second tier of IPC practices used when standard precautions alone are not sufficient to prevent transmission of an infectious disease or organism of significance. TBPs are tailored according to the mode of transmission of the disease or microorganism (contact, droplet or airborne), and are used **in addition** to standard precautions.
Transmission risk area	A distinct geographical area or ward in which local transmission has occurred. Transmission risk areas should be defined by considering whether: • there are two or more confirmed cases of the same antimicrobial-resistant pathogen; **and** • at least one case is locally acquired; **and** • there is a plausible epidemiological connection between the cases through proximity, shared room or equipment or other exposures in the health-care setting; **or** • acquisition from an environmental source is hypothesized, with clustering in time and place without a direct patient-to-patient epidemiological link.

EXECUTIVE SUMMARY

The World Health Organization (WHO) has declared that antimicrobial resistance (AMR) is one of the top 10 global public health threats facing humanity. AMR threatens to return modern medicine to a pre-antibiotic era, when procedures that are considered routine today were not able to be undertaken due to the risk of infection. Overall, AMR can lead to increases in morbidity and mortality, prolonged illnesses and hospital stays and an increase in costs to already overburdened health-care systems. As a consequence, AMR is a concern for low-, middle- and high-income countries. If left unchecked, it jeopardizes attaining many of the Sustainable Development Goals *(2)*.

For the Future: Towards the Healthiest and Safest Region, the shared vision of WHO work with Member States and partners in the Western Pacific Region, identifies health security, including AMR, as one of its thematic priorities. The *Asia Pacific Strategy for Emerging Diseases and Public Health Emergencies* (APSED III) has been guiding countries and WHO in the Region to build and develop public health capacities to prepare for and respond to public health emergencies, including AMR. The *Framework for Accelerating Action to Fight Antimicrobial Resistance in the Western Pacific Region (3)* was endorsed by the WHO Regional Committee for the Western Pacific in October 2019 to accelerate priority actions, including further implementation of national action plans and strengthening health systems to contain AMR, improving surveillance of AMR and monitoring antimicrobial use.

Responding to Outbreaks of Antimicrobial-resistant Pathogens in Health-care Facilities: Guidance for the Western Pacific Region has been developed following requests from Member States in the Western Pacific Region for additional information and support in managing AMR outbreaks. It aims to provide:

- a step-by-step guide for health-care facilities (HCFs) to respond to AMR outbreaks;
- a practical resource for health-care workers to support AMR outbreak response in low- and middle-income countries; and
- practical guidance to implement effective AMR outbreak response policies and procedures in clinical settings.

This document is divided into a number of sections that can be utilized separately or worked through as a whole, depending on the situation in your facility. For facilities suspecting that they may have an outbreak, the following sections are the best place to start:

- Section 2: How to respond to the identification of a suspected or confirmed case of an antimicrobial-resistant (AMR) pathogen – includes risk assessment, management of a single case of an AMR pathogen, and management of contacts.
- Section 3: Investigation and response to AMR pathogens in a HCF – includes all the steps and tools that you will need to identify whether you have an outbreak, then to respond. Although guidance in this section is primarily designed for use by HCFs, also included is a brief section on how to respond to an AMR pathogen outbreak in the community.

For infection prevention and control (IPC) focal points who want to build or strengthen existing IPC programmes to incorporate AMR prevention, Section 4 (Preparedness and prevention of AMR) is the best place to start.

If you require additional support to manage an AMR outbreak, Section 5 outlines some potentially available human resources you may be able to access.

1. Introduction

PURPOSE OF THE GUIDANCE

The key objectives of this document, *Responding to Outbreaks of Antimicrobial-resistant Pathogens in Health-care Facilities: Guidance for the Western Pacific Region,* are to provide:

- a step-by-step guide for health-care facilities (HCFs) to respond to outbreaks of antimicrobial resistance (AMR);
- a practical resource for health-care workers (HCWs) or public health officers to utilize to support AMR outbreak response in low- and middle-income countries (LMICs); and
- practical support to implement effective AMR outbreak response policies and procedures in clinical settings.

The recommendations included in this guidance build upon and align with the overarching infection prevention and control (IPC) standards set by the World Health Organization (WHO) *Guidelines on Core Components of Infection Prevention and Control Programmes at the National and Acute Health Care Facility Level (4).*

WHO SHOULD USE THE GUIDANCE

This document is intended for HCF staff who have responsibility for the management of outbreaks of antimicrobial-resistant (AMR) pathogens. It provides guidance for the local hospital management team and IPC focal point/team responsible for outbreak preparedness, response and planning, development and implementation of the IPC programme, plus staff in hospital or public health laboratories. Intended primary and secondary audiences for the guidance are shown in Boxes 1 and 2.

Box 1. Primary audience

- HCWs and health professionals, including clinicians, IPC focal point/team, laboratory scientists, microbiologists, hospital epidemiologists
- Hospital management teams

Box 2. Secondary audience

- National or subnational AMR coordinating centres, national reference laboratories and public health personnel or policy-makers responsible for outbreak response and national AMR action plans within ministries of health

Although this guidance primarily focuses on acute HCFs, the core principles and practices recommended as control measures against outbreaks with AMR pathogens can be applied to any facility where health care is provided. Therefore, this guidance can be implemented with some adaptations by primary and long-term-care facilities.

HOW TO USE THIS GUIDANCE

For HCFs (and other relevant stakeholders) that suspect they may have an outbreak, the following sections are the best place to start:

- Section 2 – How to respond to the identification of a suspected or confirmed case of an AMR pathogen – includes risk assessment, management of a single case of an AMR pathogen, and management of contacts.
- Section 3 – Investigation and response to AMR in a HCF – this section is divided into three main subsections:
  - Section 3.1 – Ten steps to investigate and respond to an AMR pathogen outbreak – this section details the *steps* involved in investigating and responding to an outbreak.
  - Section 3.2 – Essential components of outbreak response – this section outlines all the *tools* that you will need to identify whether you have an outbreak, and then to respond.
  - Section 3.3 – Responding to an outbreak of AMR pathogens in the community.
- At the same time, the IPC focal point should also review Section 4 to ensure all IPC systems are meeting the minimum requirements, which will assist with the response to any AMR pathogen outbreak.
- Section 5 contains information on potentially available human resources to support an AMR outbreak response.

This document can also be used to build on or strengthen existing IPC programmes to incorporate AMR prevention, with the key components of IPC precautions, administrative support, AMR surveillance, antimicrobial stewardship (AMS), environmental cleaning and education (Section 4). These are the components that should be addressed when a facility is not currently experiencing an outbreak.

Note: there are several key WHO guidance documents and guidelines on IPC programmes, management of specific AMR pathogens, laboratory systems and testing, which are referenced here. This guidance document is not meant to be a replacement for these documents, but rather to bring the key information together in a format that is easy to understand and use for HCFs (and other key stakeholders) in LMICs. Always refer to the source references for more details, particularly when building or strengthening programmes.

WHY AMR OUTBREAK RESPONSE IS IMPORTANT

Outbreaks of AMR pathogens should be detected and controlled as early as possible; the emergence and spread of AMR pathogens threatens the ability to treat common infectious diseases. It results in prolonged illness, disability and death, and also increases the cost of health care, with lengthier stays in hospital and the requirement for more intensive care. Without effective antimicrobials for the prevention and treatment of infections, medical procedures such as organ transplantation, cancer chemotherapy and major surgery (for example, caesarean sections or hip replacements) become very high risk.

AMR OUTBREAKS IN THE WESTERN PACIFIC REGION

AMR outbreaks have been reported in Member States in the Western Pacific Region and, as focus and capacity increase, will continue to be reported. Each of the outbreaks reported have resulted in significant morbidity and mortality. Such outbreaks are likely to be either first notified through established routine surveillance systems of the Member States or detected through an event-based surveillance system.

WHO is able to provide and coordinate technical support to respond to such outbreaks. Three case studies (case studies 1, 2 and 4) are presented in this document as examples of AMR outbreaks in the Region in which WHO supported the response. Support included deployment of technical staff and access to additional laboratory capacity. This highlights the complex nature of AMR outbreaks and the importance of further capacity strengthening to identify and respond to outbreaks. Box 3 presents Case Study 1.

Box 3. Case Study 1: WHO deployment of an epidemiologist for investigation of methicillin-resistant *Staphylococcus aureus* (MRSA) cases

An outbreak of MRSA was reported to WHO by the Ministry of Health of a country in the Western Pacific Region. Fifteen cases of MRSA had been identified in a hospital over a one-and-a-half-month period, compared to seven cases for the whole of the previous year. Verification of cases and a risk assessment were conducted by the hospital and the Ministry of Health with the support of WHO. The risk assessment did not identify any clear evidence of possible sources. Hence it was thought that further cases would probably occur if associated risk factors were not identified and addressed. WHO deployed an epidemiologist to conduct further investigations and provided financial and logistical support for further laboratory testing. Investigation showed that three cases had died, but it was difficult to assess whether the deaths were due to MRSA infection. At least five cases were likely to have been hospital acquired. Different MRSA susceptibility patterns were found among the 15 isolates tested, which indicated multiple MRSA strains circulating locally, rather than an outbreak caused by a single strain within the community or hospital.

2. How to respond to the identification of a suspected or confirmed case of an AMR pathogen in a health-care facility

2.1 RISK ASSESSMENT

When an AMR pathogen is first identified (suspected or confirmed) an initial assessment of risk should be undertaken. The IPC focal point or team at the affected hospital is usually best placed to make an initial assessment of the risk. Should they decide that there is an AMR pathogen outbreak, they will need to coordinate a multidisciplinary assessment to determine the need for and type of escalation response that may be required. For example, this could involve the setting up of an outbreak management team (OMT) (see Section 3.2 Administrative controls). Where an IPC team does not exist or requires assistance, support could be sought from a nearby supporting hospital or from local/national government level.

Factors to consider in a risk assessment include the following:

Pathogen components

- The organism and resistance phenotype/gene(s): has the organism been identified as being of international, national or local significance? (see Section 2.2)
- Is this a clinically and epidemiologically important AMR pathogen?
- Spread of infection: are significant numbers of patients affected?
- Number of antibiotic classes the organism is resistant to: what treatment options are available?
- Ratio of infections to colonizations: how pathogenic is the organism?

Patient components

- What type(s) of infections is/are occurring – for example, catheter-related infection, ventilator-associated infection, urinary tract infections?
- Severity of infection (morbidity and mortality): are infections severe and are patients dying from infection?
- Which patient population is affected – for example, are they from a higher-risk patient group such as haematology or intensive care unit (ICU)?

Hospital components

- Is there potential for or evidence of health-care-associated infections (HAIs)?
- Is there a particular ward or facilities where the infections have occurred?
- Is the capacity of the IPC team sufficient to conduct an outbreak investigation or will external support be needed?
- Does the hospital management/leadership have the capacity to manage the outbreak successfully or will external support be needed?

- Are there sufficient resources at the HCF to treat infections with the AMR pathogen – for example, are last-line antibiotics available or easily accessible at a reasonable cost?
- Are there sufficient resources at the HCF to implement appropriate IPC practice including PPE and WASH infrastructure?

Local components

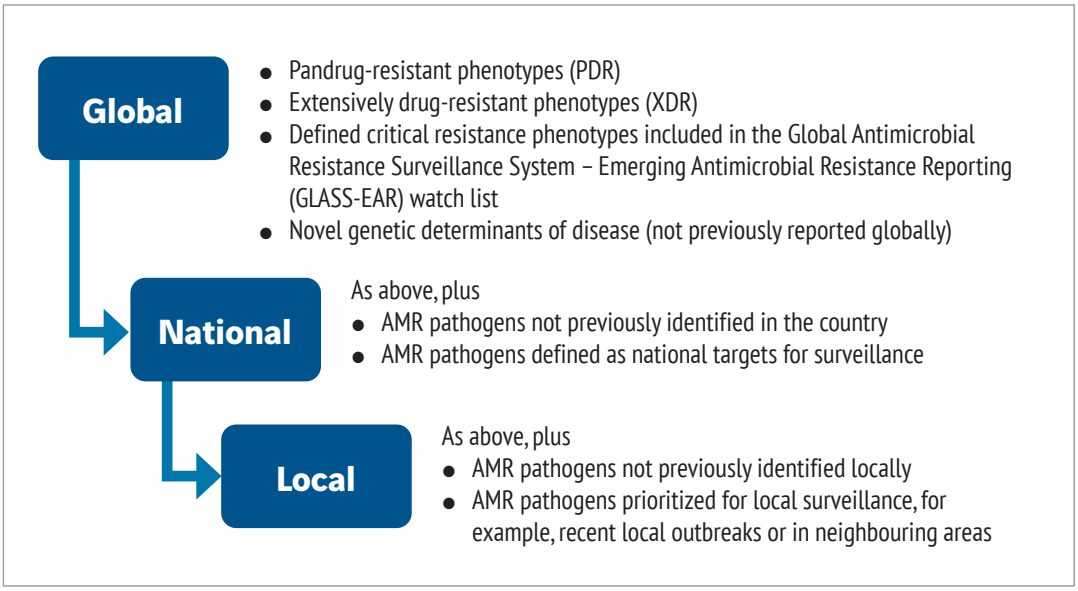
- Is there a need for support from local/prefectural/national public health authorities?
- Does the local/prefectural public health authority have the capacity to respond to the outbreak or will support be needed?
- Has the same outbreak been observed in neighbouring hospitals/areas?
- Is there a risk of spread to neighbouring hospitals/areas?

If the detection of an AMR pathogen is suspected to be part of a transmission event or outbreak, it is also important to consider the epidemiology of the identified cases, including the number of cases over time and location.

2.2 ASSESSING THE SIGNIFICANCE OF AN AMR PATHOGEN

Assessing the risk of a particular AMR pathogen in a specific location requires multiple factors to be taken into account. The potential "risk" of an AMR pathogen can be defined on several levels: global, national and local. It includes factors related to the AMR pathogen (for example, resistance patterns and mechanisms) and the local epidemiology (for example, is it already endemic in the local area?). The local significance of an AMR pathogen can only be assessed by taking all relevant factors into account, and a multidisciplinary team should be involved in the assessment. Fig. 1 provides a guide to this assessment, but additional factors may also be included.

Fig. 1. Assessing the local significance of an AMR pathogen in a risk assessment



Note: GLASS-EAR (emerging antimicrobial resistance) watch list: refer to Annex 1 and https://www.who.int/initiatives/glass/glass-focused-surveillance.

2.3 MANAGEMENT OF A SINGLE CASE OF AN AMR PATHOGEN

Whether a single case of an AMR pathogen is determined to require notification/reporting to the public health authority (see Section 2.6) or an outbreak may be occurring, appropriate management of each case will need to be determined and implemented. This will include such measures as room placement (for example, single versus shared room) and the need for additional or enhanced IPC measures (for example, standard precautions only versus standard and contact precautions).

Actions required to manage a single case of an AMR pathogen may differ according to the risk assessment (see Section 2.1). For some AMR pathogens, for example MRSA or vancomycin-resistant *Enterococcus* (VRE) – in areas where these pathogens are endemic – little or no further action may be required, particularly if the isolate cannot be linked to an active infection requiring antimicrobial treatment. However, even a single detection of a pandrug-resistant *Klebsiella pneumoniae*, *Pseudomonas* spp. or *Acinetobacter* spp. will require urgent and enhanced actions, regardless of whether the organism is causing an active infection.

Local epidemiology may indicate that colonization with a particular AMR pathogen does not represent an increased risk of transmission (for example, colonization of the nares with MRSA without the presence of an actively infected open wound). Alternatively, the current rate of colonization does not represent an increase in transmission incidence (for example, the colonization rates for VRE have remained stable in a ward over an extended period). As such, an enhanced response may not be required. In these instances, at a minimum, an alert or note should be placed in the medical record of the patient colonized with the AMR pathogen. Further information about screening strategies that could be implemented can be found in Section 3.2.

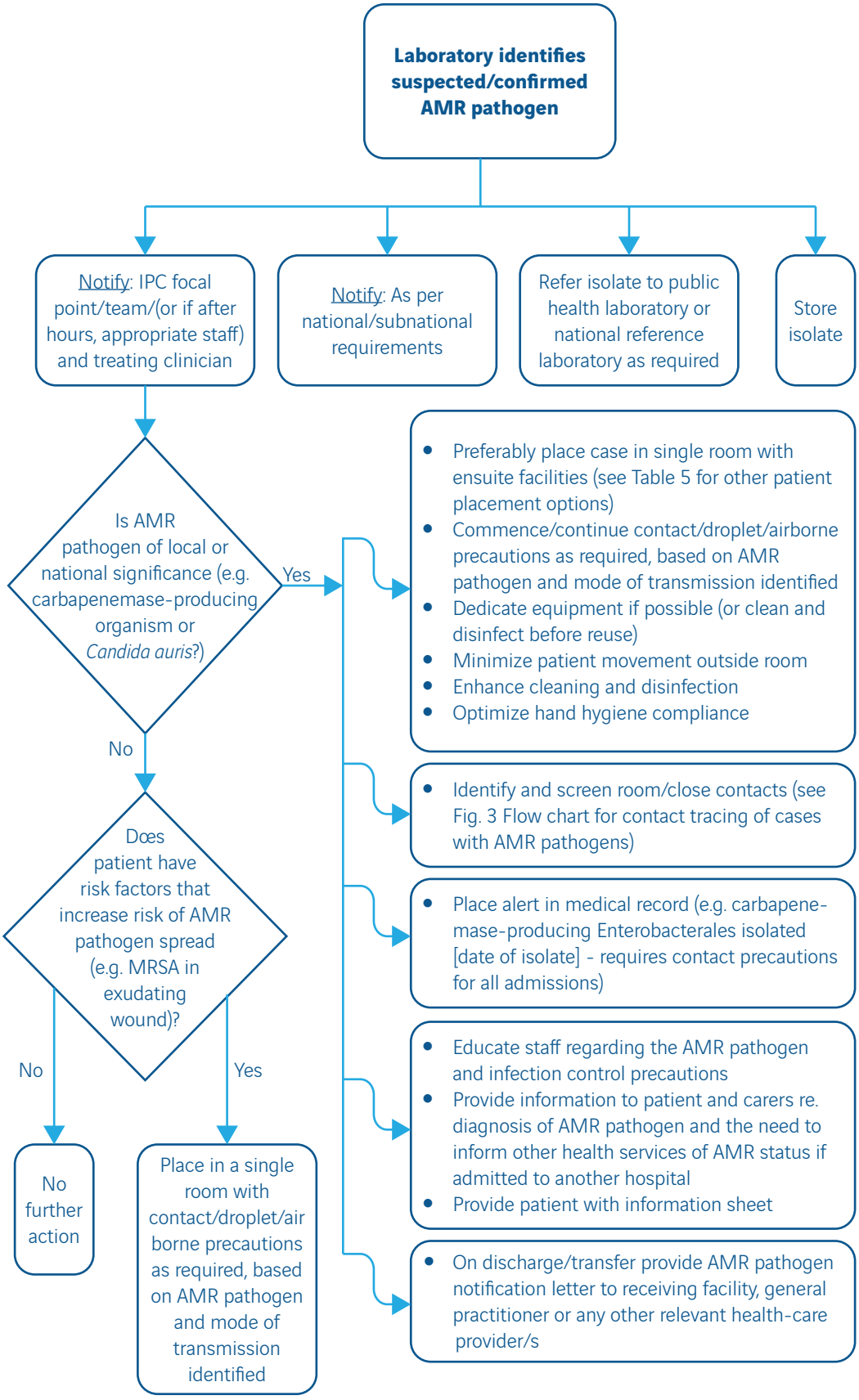
In some circumstances, there may be other risk factors that dictate the need for enhanced or additional actions. For example, isolation in a single room with contact precautions is required even for some less significant AMR pathogens (according to local risk assessment) if there is an increased risk of transmission to other patients. This could include MRSA isolated from a wound with exudate that is difficult to contain.

The detection of colonization or infection with AMR pathogens designated as significant (locally or nationally) should always be investigated and actions implemented to prevent transmission.

Enhanced IPC precautions or actions that may be implemented are discussed in further detail in Section 3.2 Essential components of outbreak response.

A process flow chart for the management of a suspected or confirmed case of an AMR pathogen is provided in Fig. 2.

Fig. 2. Suspected or confirmed AMR pathogen case management flow chart



2.4 ROLE OF DECOLONIZATION FOR PATIENTS AND STAFF

Decolonization means treatment of a person with antibiotics or topical antiseptics to eradicate carriage of an organism. Attempts to eradicate multidrug-resistant Gram negatives or VRE have not been widely successful and are not recommended.

MRSA decolonization is potentially useful for specific situations, but not effective enough to recommend routinely. It may be considered in *(5)*:

- outbreak situations, to reduce the potential sources of ongoing transmission;
- some high-risk situations or populations, such as ICUs; or
- patients going for high-risk surgeries – for example, implantation of prosthetic materials, cardiac surgery.

This requires identification of MRSA carriers by culture of nasal swabs (and/or throat and axilla), administration of decolonization therapy (see Annex 2) and follow-up cultures (to ensure eradication) to be performed. Note that patients may become recolonized despite decolonization therapy.

2.5 MANAGEMENT OF CONTACTS

The purpose of contact tracing is to identify potentially infected or colonized patients and to manage the risk of possible further transmission from these patients.

The period of time for which contacts should be identified will need to be determined. This will usually be from when the index case is determined to have first acquired the AMR pathogen, which will be dependent on a number of epidemiological factors, until they are placed into appropriate transmission-based precautions (TBPs) or are discharged, whichever comes first.

Contacts can be divided into room or close contacts, and ward or casual contacts. Those with the closest contact – for example, those who have shared a room and/or bathroom facilities – will be most at risk for transmission and should be identified and screened first. If there is evidence of transmission to these contacts, consideration should be given to widening screening to include ward/casual contacts.

HCWs are not usually classified as close contacts and, as such, screening is not recommended. Instead, reinforce or provide further education about standard precautions and TBPs. Screening of HCWs may be considered as part of further outbreak investigations (see Table 1). Further information about this can be found in Section 3.2 Staff screening.

Table 1. Screening requirements for contacts

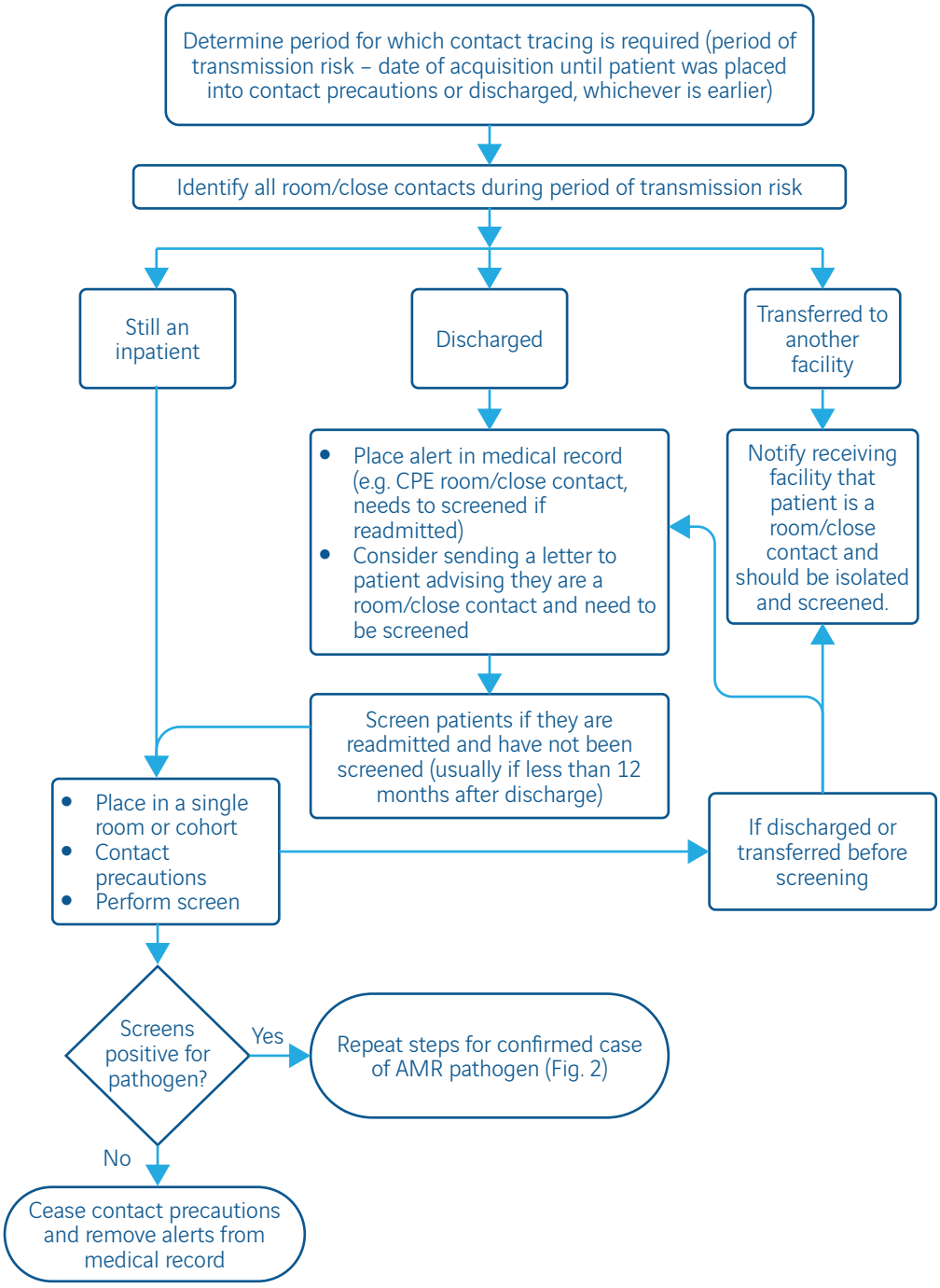
Contact	Definition	Screening recommendations
Room/close contacts	Any person who has shared a room or bathroom/toilet facilities with the index case for more than 24 hours during the period of transmission risk.	• Screen with appropriate specimen(s). • Where possible, pre-emptively isolate until result is known. • If transferred, contact facility and advise screening is recommended. • If discharged, consider contacting and recommend screening. • At minimum, place alert in medical record to screen if readmitted within 12 months following discharge.
Ward/casual contacts	Any person who was in the ward or area for more than 24 hours where transmission occurred during the period of transmission risk.	• Screen if: o there is evidence of transmission to room/close contacts o transmission has occurred in other wards/areas o there is evidence of an environmental source o there is no information available that the outbreak is confined to the initially identified case(s). • Consider conducting point-prevalence screens weekly in the affected ward/unit until there have been no further cases found for 3–4 consecutive weeks.
HCWs	HCW who has provided direct care to the case.	• Not recommended
Household contacts	Person who resides with the case.	• Not recommended

Contacts must be provided with information about why it is recommended that they should be screened. Consent to screening should be sought from the patient or next of kin. They should be advised of the risk of transmission and what the possible consequences or impact on future health-care treatment and access are if they return a positive screen result. Contacts should be informed of the results of screening that is undertaken.

Choice of screening sample(s) should include usual site(s) for colonization by that organism – for example, faeces for carbapenemase-producing Enterobacterales (CPE). Consideration should be given to including other sites such as medical device insertion sites (for example, central venous catheter or percutaneous endoscopic gastrostomy), wounds, sputum or rectum/faeces. Consult with laboratory staff for further information about the type of specimens to collect and best collection methods when screening contacts.

A flow chart provided in Fig. 3 summarizes the process for identification and screening of contacts of an AMR pathogen case.

Fig. 3. Flowchart for contact tracing of cases with AMR pathogens

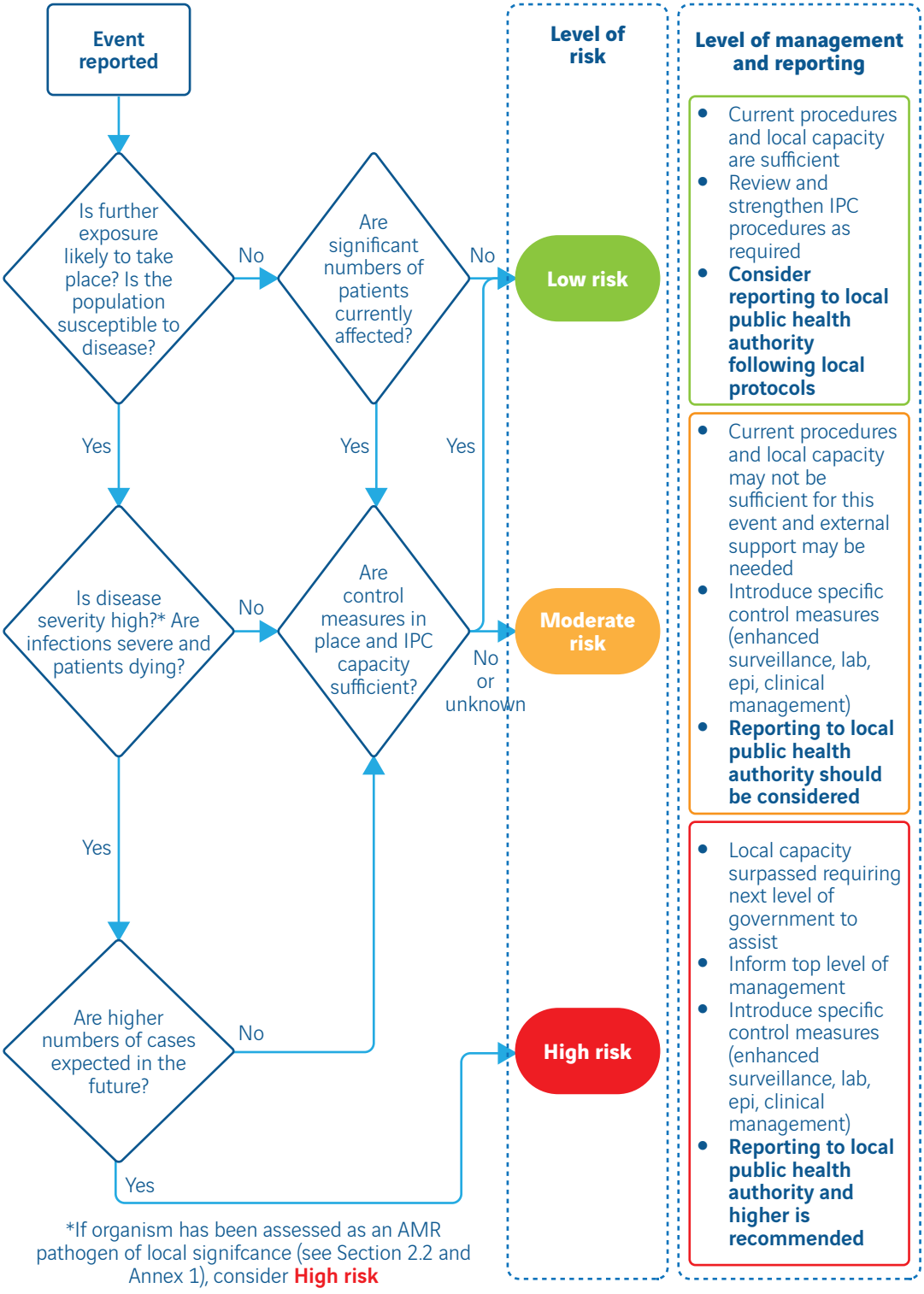


2.6 WHEN TO REPORT TO THE PUBLIC HEALTH AUTHORITY

Reporting to the public health authority should be based on national or subnational requirements. If the pathogen detected is included in the notifiable diseases or reportable diseases surveillance system, it should be notified. The detected pathogen can be reported as part of event-based surveillance (see Section 4.2 Event-based reporting). Reporting to the public health authority is especially important when the HCF does not have the capacity, including human resources and expertise, to respond to the outbreak and needs support from public health authorities or other partners. Fig. 4 shows an example of management and reporting based on risk assessment and level of risk. International Health Regulation (2015) requires countries to report an event which fulfils certain criteria to WHO through National IHR Focal Point.

WHO, as well as other partners, may be able to provide support such as: 1) technical support by either deploying professionals to respond to an outbreak or facilitating access to experts who can provide advice, including epidemiologists, IPC specialists, clinical management specialists and microbiologists; and 2) support access to detailed testing of strains for outbreak investigation, such as whole genome sequencing (WGS). If such support is needed, consider contacting the WHO country office or country liaison office through the government focal point (see Section 5).

Fig. 4. An example of management and reporting based on risk assessment in responding to an outbreak involving an AMR pathogen



Box 4 gives details of Case Study 2 concerning outbreak support in a Western Pacific Region country.

Box 4. Case Study 2: Global Outbreak Alert and Response Network (GOARN) deployment for support in investigation of *Acinetobacter baumannii* outbreak

Increased case numbers of *A. baumannii* detected from either blood or cerebrospinal fluid in a neonatal intensive care unit (NICU) were reported to the Ministry of Health of a country in the Western Pacific Region. It was reported that over a six-month period 12 neonates in a NICU had died with an *A. baumannii* strain resistant to all tested antibiotics. An initial assessment conducted locally indicated a high risk of additional cases occurring, and therefore further possible deaths, due to suboptimal IPC practices and the particularly resistant nature of the organism. The Ministry of Health requested support from WHO, including epidemiological investigation with deployment of experts through the Global Outbreak Alert and Response Network (GOARN). Technical support was provided, including deployment of two epidemiologists and one IPC specialist, as well as support for further isolate characterization and WGS. Multilocus sequence typing (MLST) of the isolates showed 14 belonging to sequence type 2 genotype, but two different subgroups clustering by sample collection date based on WGS, with one group evolving from the other. The investigation identified multiple IPC gaps and varied exposures of the cases. This suggested that cross-contamination probably resulted from multiple sources of transmission within the ICUs and not a one-point source.

3. Investigation and response to AMR pathogens in a health-care facility

An outbreak is defined as when the number of cases of an illness (or organism) observed exceeds the usual number expected.

In this section, we first look at the 10 steps of an outbreak response (that is, the *process* of responding to an outbreak), then the essential components of an outbreak response (that is, the *tools* required to respond to an outbreak). While this section primarily focuses on AMR pathogen outbreaks in HCFs, information about responding to an outbreak in the community can be found in Section 3.3.

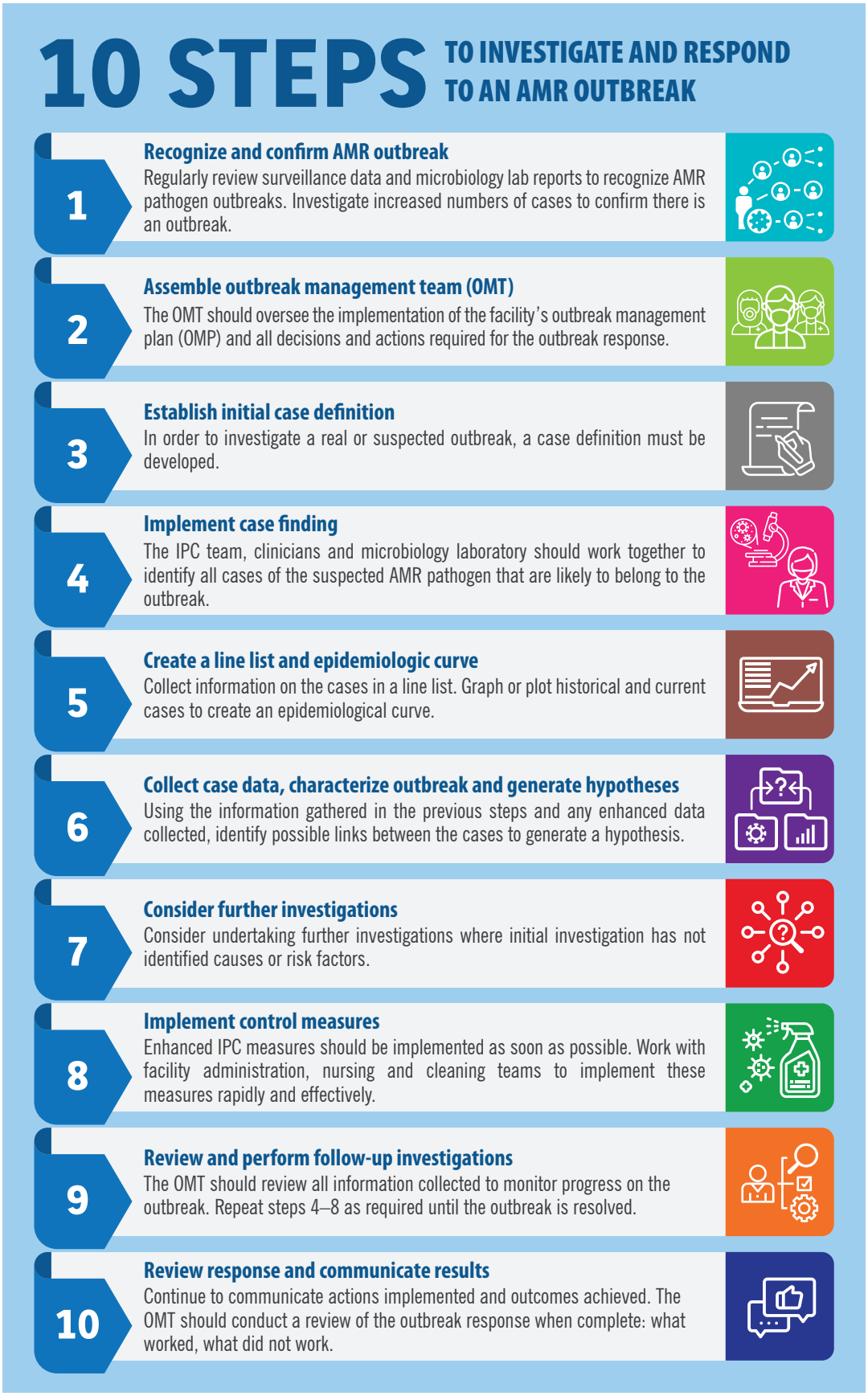
3.1 TEN STEPS TO INVESTIGATE AND RESPOND TO AN AMR PATHOGEN OUTBREAK

When an outbreak of an AMR pathogen is suspected, there is a series of steps (outlined in Fig. 5) that should be followed to investigate the possible outbreak. These steps are usually led by the IPC team, involving other members of the OMT, including the microbiology laboratory, administration, cleaning services, clinicians and others as required.

While these actions are presented as a series of steps, in reality many of these steps will be undertaken at the same time. Teams will often need to go back and repeat some steps once new information is available (for example, refine the case definition, implement a second round of control measures if the first round failed to stop the outbreak). A checklist is also provided in Annex 3, which lists actions outlined in the 10 steps below.

Above all, communication between all involved parties is critical during an outbreak investigation, often requiring frequent meetings for a period of time to ensure that everyone is aware of new information.

Fig. 5. Overview of the 10 steps to investigate and respond to an AMR pathogen outbreak



STEP 1 Recognize and confirm AMR outbreak

i) Recognize outbreak

IPC focal point/team **Hospital epidemiologist**	• Review surveillance data (clinical data, routine surveillance data, microbiology results, including patterns of antimicrobial susceptibility) to identify potential outbreaks.
Microbiology laboratory	• Notify IPC team of a single case of significant AMR pathogens, or suspicion of local transmission of an AMR pathogen. • Assist IPC focal point/team to review antibiograms (antimicrobial susceptibility profiles) to identify strains that may be related (or molecular typing methods, if available).

ii) Confirm outbreak

IPC focal point/team **Hospital epidemiologist**	• Compare observed number of cases to historical data (clinical, laboratory or routine surveillance data from a comparable period of time – see Table 2). • Attempt to identify other potential explanations for increased case numbers. • Liaise with national coordination committee (NCC)/national reference laboratory (NRL)/local public health authorities to identify other recent outbreaks of the same pathogen.
Microbiology laboratory	• Assist IPC team to obtain and analyse microbiology data. • Assist IPC team to identify recent changes in laboratory testing that may explain an elevated number of cases.

Outbreaks can generally be defined as an occurrence of more cases of disease, or pathogen, than expected in a given area (for example, ward or hospital) or among a specific group of people (for example, receiving a given procedure) over a particular period of time.

A suspected outbreak may first be detected by the IPC team, clinicians or microbiology laboratory, noting patient infection or colonization with an unusual AMR pathogen for the HCF or specific ward – for example, first detection of a carbapenemase-producing organism (CPO), or an unusually high number of cases of a certain pathogen, for example, higher than expected number of MRSA wound infections. Alternatively, an outbreak may be identified through routine collection and analysis of AMR surveillance data.

To determine whether the observed number of cases is unusual and should be classified as an outbreak, it is important to compare current data to those observed over a comparable time period, usually the previous few weeks, months, or a comparable time of year in previous years. Use available surveillance data from clinical records or microbiology laboratory results, or formal surveillance data to compare the current cases to previous cases (Table 2). In some cases, there may not be any accessible historical or baseline data available and therefore discussions with HCWs (including laboratory staff and clinicians) may need to be used to assess the situation.

When using available data, it is important to consider other possible explanations for an increased number of cases, such as:

- changes in testing or reporting practices;
- changes in test availability;
- changes in laboratory methods, for example, change to a more sensitive test method; or laboratory errors, such as incorrect antimicrobial susceptibility test (AST) results due to failure of internal quality controls; contamination of equipment, reagents, samples or cultures;
- any changes in the population or other factors that may increase test numbers; and
- laboratory, diagnosis and/or data management errors, such as counting the same person more than once due to duplicate testing or reporting.

Table 2. Data sources and approaches to support identification of an outbreak

Data	Purpose	Approaches
Formal surveillance systems	• Look at observed and expected occurrence of the disease or pathogen.	• Statistical tests or descriptive epidemiology (e.g. analyses on WHONET-SaTScan).
Laboratory testing data	• Confirmation and characterization of the suspected pathogen to determine the correct diagnosis, exclude or support likely relatedness of pathogens between cases.	• Obtain appropriate specimens/ isolates as soon as possible to support confirmation and characterization of the pathogen. • Confirmation testing at NRL or another reference laboratory. • Further characterization methods (e.g. pulsed-field gel electrophoresis, multilocus sequence typing or WGS).
Clinical records	• Ensure disease has been properly identified.	• Review of clinical records or discharge summaries to compare to previous occurrences or observations of disease or pathogen.

It may also be useful to consider whether the AMR pathogen has been identified more frequently in the local area, or whether similar outbreaks have been described through communication channels with the NCC and/or NRL.

STEP 2 Assemble outbreak management team

IPC focal point/team **Facility administration**	• Assemble the OMT. • Activate the facility's outbreak management plan (OMP).

When an outbreak has been confirmed, an OMT should be convened to coordinate the response. The OMT should oversee the implementation of the facility's OMP and all decisions and actions required for the outbreak response (see Section 3.2) including:

- implementation of recommended control measures;
- surveillance, screening and reporting processes;
- notifying relevant health authorities that there is an outbreak;
- timely notification/reporting of suspected/confirmed cases;
- implementing processes and resources for communicating with staff, patients and visitors;
- ensuring media and risk communication is undertaken with the agreement of relevant health authorities;
- determining what additional resources and personnel may be required: for example, for the microbiology laboratory to manage additional testing, additional personal protective equipment (PPE) requirements for management of patients in TBPs; and
- ensuring processes are in place for de-escalation of outbreak management measures when the outbreak is deemed to be over.

STEP 3 Establish initial case definition

IPC focal point/team **Microbiology laboratory** **Hospital epidemiologist**	• Create a case definition (clinical features, laboratory definition, time period, patient population, location).

In order to investigate a real or suspected outbreak, a case definition must be developed.

A case definition is a standardized set of criteria for determining who should be classified as a case within a suspected or confirmed outbreak to help ensure consistency of reporting and case identification.

The case definition includes four components:

1. well defined clinical symptoms or laboratory findings
2. a time period during which the cases could have occurred
3. the people affected by the outbreak
4. the place or location where the outbreak has occurred or is occurring.

It is recommended that case definitions (see Box 5) cover a substantial period of time prior to the identification of the index case. A 12-month period is often used, but this may vary based on evidence concerning the duration of colonization for the organisms(s) under investigation.

Box 5. Example of a case definition

At least one positive blood culture with MRSA (defined by disk diffusion susceptibility testing in accordance with European Committee on Antimicrobial Susceptibility Testing 2020 guidelines) within the last six weeks in patients with a central line, admitted to intensive care for at least 24 hours.

The case definition should be established early in the outbreak and may be revised or updated during the course of the investigation. Case definitions may have multiple levels, such as suspected, probable or confirmed, which often differ by the degree of diagnostic or epidemiological data available *(5)*. Especially in an AMR pathogen outbreak, how to define the resistance is critical, and detailed criteria (for example, version of antimicrobial susceptibility test guidelines) need to be included in the case definition. This is because subtle changes in the definition may cause significant differences in case numbers.

STEP 4 Implement case finding

IPC focal point/team **Hospital epidemiologist**	• Assess laboratory, clinical and surveillance data to identify potential cases. • Communicate case definition to clinical and laboratory staff to facilitate rapid reporting and retrospective case identification. • Ask officials, other facilities, community groups and/or any other stakeholders relevant to the setting to identify potential related cases or clusters.
Microbiology laboratory	• Culture patient specimens (clinical or screening specimens) for suspected outbreak pathogen, confirm bacterial identification and perform AST. • Store all sterile-site isolates and epidemiologically important isolates. • Consider testing alternative antibiotics for patient treatment. • Liaise with NRL or subnational representative for confirmatory and/or further testing (for example, typing or extended susceptibility testing).

The IPC team, clinicians and microbiology laboratory should work together to identify all cases of the suspected AMR pathogen that are likely to belong to the outbreak. This means using the case definition to include or exclude patients from the outbreak investigation. This is likely to involve further screening of patients using the various screening strategies detailed in Section 3.2 and the preferred specimen types (for example, pathogens and testing methods), as detailed in Table 7.

During an outbreak, it is important for the microbiology laboratory to screen clinical samples more widely for the AMR outbreak pathogen. This may include selected bacterial identification and AST for organisms that would not normally be worked up: for example, urine cultures with more than one organism, or wound cultures with mixed organisms. Additionally, case definitions may have to consider the possibility of plasmid spread of the AMR gene. This is particularly the case for carbapenemase genes, where an AMR gene (for example, NDM-1) may spread between multiple different Gram-negative species, and cases could be missed in an outbreak investigation if only one species is included in the analysis.

Rapid detection of AMR pathogens in the microbiology laboratory is also important, leading to early implementation of infection prevention measures, both in the prevention of and response to outbreaks (examples in Box 6).

Box 6. Examples of methods for rapid detection of AMR pathogens

- rapid AST directly from blood culture bottles[a]
- rapid detection of phenotypic carbapenemase production[b]
- rapid phenotypic detection of colistin resistance[c]
- molecular assays for specific AMR pathogens: e.g. MRSA, CPE

[a] EUCAST rapid antimicrobial suspectibility testing (RAST) in blood cultures *(6)*.
[b] CarbaNP assay *(7)*; carbapenem inactivation method (CIM) test *(8)*.
[c] Assay for rapid detection of colistin resistance *(7)*.

Role of the reference laboratory

In the event of an AMR pathogen outbreak, the NRL (or subnational representative) should serve as a resource for advice and additional testing for the hospital laboratory. Roles may include:

- confirming bacterial identification and AST results for outbreak pathogens;
- performing extended AST, if unavailable at primary laboratory;
- advising primary laboratory about culture of screening and environmental samples; and
- offering additional services to characterize the outbreak pathogen, such as molecular testing, bacterial typing or WGS *(9)*.

STEP 5

Create a line list and epidemiologic curve

IPC focal point/team **Hospital epidemiologist**	• Create a line list of data on suspected cases. • Update daily with new cases or information. • Compare the current cases to baseline historical data (for example, from the previous few months). • Create an epidemiologic curve of cases across the baseline and current time periods.
Microbiology laboratory	• Assist IPC team to collect laboratory data for historical cases. • Rapidly notify IPC team of all potential new cases detected by the microbiology laboratory.

Using the initial case definition, screen the possible cases, current and historical, to identify cases. Collect information on cases in a line list, including details such as:

- identification number
- patient details
- patient location (ward/bed, and previous locations if they moved beds/wards/units whilst in hospital)
- symptom onset date
- admission and discharge dates
- details of microbiology test results
- relevant clinical information (for example, location of wounds, surgery/procedures during admission, medical conditions that may predispose to infection)
- relationship or contact between patients (if relevant: for example, when the initial or index case is known)
- date when IPC precautions were instituted (for example, contact precautions).

An example of a line list can be found in Annex 4, but should be adapted to the needs of each facility and outbreak. The line list should be updated daily with new cases, and any new information on previous cases added.

Use the line list (current cases) and historical data to create an epidemiologic curve – that is, to plot the historical and current cases visually over time, usually incorporating other data such as ward location. An example of an epidemiologic curve can be found in Annex 5.

During the course of these investigations, the case definition may need to be refined based on new or updated information: for example, if suspected transmission becomes localized to a single ward or patient group.

Assess these data to determine whether further investigation is warranted.

STEP 6

Collect case data, characterize outbreak and generate hypotheses

IPC focal point/team **Hospital epidemiologist**	• Collect any enhanced data required (see Section 3.2). • Review the line list to identify common exposures between patients. • Generate hypotheses (best guesses) about the possible cause/s of the outbreak. • Observe IPC practices that may be contributing to the outbreak.
Microbiology laboratory	• Liaise with NRL for advice regarding further testing or typing studies, if available.

Using the information gathered in the previous steps (line list and epidemiologic curve) and any enhanced case data collected (see Section 3.2), identify any possible links between patients ("descriptive epidemiology"). These may include:

- patient location (specific ward or bed)
- contact with other patients, particularly room contacts
- patients having the same surgery or procedure
- patients with the same type of device (for example, central line).

The IPC focal point/team should also go to the affected location/s to investigate the most likely source of the outbreak, so that interventions can be designed to prevent further AMR pathogen spread. Investigations undertaken may include, but not be limited to, the following:

- Observe staff compliance with IPC practices: for example, hand hygiene, appropriate use of PPE, aseptic technique and care of invasive devices. This should also consider the ability of staff to comply with correct IPC practices. For example, is there an adequate supply of PPE or hand hygiene products for staff to use?
- Look for possible common vehicle sources of the pathogen: for example, shared medical devices and equipment or medicines, such as multi-use ointments or gels. Ask staff not to discard such items before the investigation has been undertaken.
- Undertake interviews or discussions with staff to learn more about the practices on the ward or any issues they may be able to highlight that could be contributing to the outbreak. For example, are there patient watchers or companions who spend long hours with patients and provide close personal care and who may not have been provided with adequate education and information about appropriate IPC practices?

Once potential links are discovered, the aim is then to identify or generate a hypothesis or hypotheses about which factors may have led to the outbreak, such as lapses in IPC precautions. Examples might include:

- poor compliance with hand hygiene on a certain ward;
- inadequate terminal/discharge cleaning of patient rooms;
- inadequate aseptic technique for intravenous line insertion;
- contamination and inadequate cleaning of shared patient equipment;
- transmission of AMR pathogens through shared bathroom facilities or crowded facilities;
- potential transmission of respiratory pathogens between patients in the same room or ward;
- an environmental source: for example, contaminated hand washing sinks; and

- multi-use medications, products or devices that may have been contaminated:
  - at point of manufacture: for example, ultrasound gel sachets in CVC line insertion kit; and
  - during use, for example, multi-use tapes used to secure indwelling devices, multi-use ointments/medications, or ultrasound gel in a multi-use squeezy dispenser bottle.

STEP 7 Consider further investigations

IPC focal point/team
Hospital epidemiologist
	• If environmental contamination is suspected to be contributing to the outbreak, consider environmental sampling.
	  - Most suitable for multidrug-resistant Gram-negative (MRGN) and VRE.
	  - Discuss with the microbiology laboratory first.
	• If required, undertake an analytical investigation such as a case-control or cohort study to test hypotheses generated.
	  - Only required where specific hypotheses have been generated in Step 6 and resourcing allows.
	  - If potential interventions have been identified, implement immediately; do not wait for results of analytical study.

Microbiology laboratory	• Consider processing environmental samples if there is adequate local expertise; advise IPC team on sampling techniques. • Alternatively, liaise with the NRL for advice and/or testing of environmental samples.

Sometimes, initial investigations undertaken may not clearly indicate the cause of an outbreak, or other risk factors may need to be considered and studied further. In these instances, further investigations may be required, such as environmental sampling or analytical studies.

Environmental sampling or screening

Targeted environmental sampling (screening swabs from the environment for AMR pathogens) may be considered as part of an outbreak investigation where a specific environmental focus is suspected. Random sampling of the environment may result in spurious hypotheses or associations made and therefore care should be taken when planning environmental sampling. The efficacy of environmental screening to help control an outbreak will be dependent on:

- the AMR pathogen – most suited to MRGN (for example, CPE) or VRE
- sites sampled and collection methods
- the ability of the laboratory to process these types of samples.

Before proceeding with environmental screening, the local laboratory must be consulted to determine whether it has the capacity and capability to process such samples. If the local laboratory is unable to process environmental samples, consider discussing with the NRL (if it is deemed an essential component of the outbreak investigation). The time and resources of the IPC focal point/team should also be considered. Where resources are limited, environmental screening should not be undertaken, or at least should be postponed until other interventions have been implemented (for example,

education and training for HCWs regarding the importance of hand hygiene). Environmental sampling should not detract from the IPC focal point/team's other key IPC activities.

Lack of local or international standards on environmental sampling and testing methodologies for CPE has also made it difficult for health services to undertake environmental screening, and to interpret the results where environmental screening has been conducted.

Table 3. Recommendations for sample collection and processing when conducting environmental screening

Environmental screening	
MRGN **VRE**	• Surface swabs of hospital and patient environment (pre-moistened with sterile water or saline); swab frequently touched surfaces in patient and hospital environment, or those suspected to be involved in AMR pathogen transmission. • Use the same microbiology testing methodology as for patient screening samples. • *Note*: does not apply for MRSA and respiratory pathogens. • Consider sampling liquid solutions: e.g. ultrasound gel, if epidemiologically linked. If water quality is known to be poor, this may also need to be tested; or test other environmental liquid samples that may be commonly found in the affected ward or unit. Testing of these types of samples should be coordinated with an appropriate environmental health laboratory or NRL that would usually undertake such testing. • Where the same AMR pathogen from an outbreak is found in an environmental sample, molecular testing (e.g. WGS) is recommended to confirm links.

Analytical studies

In some situations, an analytical epidemiological study may be required to test hypotheses identified through analysis of the collected case data. The goal of analytical studies is to test the relationship between the risk factors identified and the condition under study using statistical methods (for example, the hypothesis that people who have had an endoscopy are more likely to have the outbreak pathogen). Such studies can be useful when there is uncertainty about what factors may be contributing to the spread of disease.

However, analytical studies can be time- and resource-intensive and there are many factors that need to be considered prior to designing and conducting an analytical study. These include which study design to use, control group selection, statistical power, potential confounding variables, bias and many other factors. It is recommended that analytical studies are only used when clear hypotheses and potential infection control impact have been identified. Also, an experienced epidemiologist should be consulted prior to commencement.

Key to controlling any outbreak is the timely implementation of control measures. It is therefore critical that, when hypotheses are well supported by initial investigation, control measures are not delayed by waiting for results of any analytical investigations.

STEP 8

Implement control measures

IPC focal point/team	• Implement general enhanced IPC precautions as described in Section 3.2, Table 4. • Identify and implement specific IPC measures based on suspected cause/s of the outbreak (see Step 6).

Enhanced IPC measures should be implemented as soon as possible, working with the facility administration, nursing and cleaning teams to implement these measures rapidly and effectively. These will include general measures aimed at reducing the spread of the AMR pathogen, such as those listed in Table 4, as follows:

- patient placement in single rooms (or cohorting patients where this is not possible)
- TBPs (tailored to AMR pathogen) with additional signage
- limiting movement or transport of patients
- limiting ward activity and/or closing a ward (if outbreak not controlled)
- enhanced cleaning of patient and hospital environment
- enhanced cleaning of shared patient equipment.

Additionally, more specific control measures may be required to address the potential causes of the outbreak identified in Steps 6 and 7. For example:

- intensive hand hygiene education, auditing and feedback for an MRSA outbreak in wounds in a surgical ward noted to have low compliance with hand hygiene; and
- for an outbreak ward (for example, CPE) where a cleaning product was used incorrectly due to poor product design – introduction of a new, easier-to-use cleaning product with clear instructions, plus re-education of cleaning staff and supervisors, followed by auditing and feedback +/- environmental cultures.

STEP 9

Review and perform follow-up investigations

IPC focal point/team **Microbiology laboratory** **Hospital epidemiologist**	• Continue case finding and surveillance. • Review the case definition; refine as required. • Review control measures and effectiveness. • Hold regular meetings with OMT and other key stakeholders to communicate findings and progress. • Repeat Steps 4–8 if outbreak continues.

At this stage, consider all the available information to date with the assistance of the multidisciplinary OMT:

- Have the case numbers decreased or gone back to the baseline?
- Based on newer information, does your case definition need to be refined?
- Is further patient or environmental screening indicated?
- Have all the suggested interventions been implemented successfully? Are there any barriers to implementation?
- Do you think the specific control measures (based on the suspected outbreak cause) have been successful? If not, what else could be causing the outbreak? How could this be controlled?

Most outbreak investigations do not completely resolve with the first round of interventions, requiring additional control measures to be implemented. Go back through Steps 4–8 to identify any new control measures that may be effective, or identify any proposed control measures that were not adequately implemented (for example, due to non-compliance or other barriers).

It is important for the hospital OMT to lead the process with support from key stakeholders as needed, since support from international partners is often only for the short term. The responsibility for any response and interventions lies with the hospital. As such, it is best for the OMT to remain the primary coordinator of the AMR outbreak investigation. The OMT should not relinquish this role to outside organizations or partners (who should only be there to provide expert advice or support). It is also important for the OMT to continue to communicate with all stakeholders to ensure they understand what is happening, are engaged and willing to implement the suggested changes to try to stop the outbreak. Remember to keep administrators and public health authorities updated as required. See Section 3.2 for further information regarding risk communication.

STEP 10

Review response and communicate results

Coordination and risk assessment

The OMT should continue to be responsible for the coordination and risk assessment of the outbreak and return-to-normal phases.

Risk communication

As the outbreak response is de-escalated, communication with stakeholders should continue. Information should be provided regarding the current situation and plans to return to normal activities.

When reviewing the outbreak response, stakeholders should also be given the opportunity to feed back their evaluation of the outbreak response, including about communication strategies such as frequency and appropriateness.

Surveillance

Collection and monitoring of enhanced surveillance data should continue at least until case identification returns to baseline levels. If needed, routine surveillance activities should be modified in line with recommendations from the after-action review explained below. Any increase in cases should prompt a resumption of the collection of enhanced surveillance data and repetition of the outbreak investigation steps outlined in this section.

Infection prevention and control

Enhanced or additional IPC precautions that were implemented to combat the outbreak may be de-escalated during the return-to-normal phase while ensuring that IPC standard precautions are always in place. The OMT should only do this when it is considered that these additional measures are no longer required and that returning to accepted standard IPC practices is safe. If gaps are identified in the IPC or WASH programmes which may have contributed to the outbreak, actions should be implemented to address these on an ongoing basis and not just return to pre-outbreak practices. Regular monitoring/audit and evaluation of IPC and WASH practices should continue.

Antimicrobial stewardship

Following an outbreak of an AMR pathogen, there needs to be a review of any changes or procedures implemented during the outbreak. The HCF should consider reinstating any AMS policies or procedures that were ceased, relaxed or altered during the outbreak period. This is important, as improving antimicrobial prescribing and encouraging more narrow spectrum antimicrobials will help to prevent a second outbreak and prevent new resistant pathogens from emerging.

This may include changes to the:

- antimicrobial formulary, including any introduced during the outbreak
- standard treatment guidelines for infections
- restriction policies, including the Access, Watch, Reserve (AWaRe) classifications *(10)*.

When all the required alterations are complete and the policies and procedures have been finalized following the outbreak, there will need to be communication with the prescribers as to the new changes. It may be difficult to convince clinicians not to prescribe broad-spectrum antimicrobials empirically following an outbreak. This will require re-education and reassurance. See Section 3.2 for further information regarding AMS.

After-action review

The OMT should also conduct a thorough evaluation of the overall outbreak response. This will help determine which measures implemented were successful and which were not, and areas for improvement. Aspects of the outbreak response for evaluation may include *(11)*:

- timeliness of outbreak detection and identification of source;
- preparedness for this type of investigation, for example, resources, guidelines, questionnaires, databases;
- effectiveness of the investigation process and control measures implemented;
- coordination of outbreak meetings;
- communication with stakeholders (including media management); and
- administration and record-keeping.

The evaluation process and findings should be prepared as part of the final report.

3.2 ESSENTIAL COMPONENTS OF OUTBREAK RESPONSE

Section 3.1 outlined the steps that should be taken to investigate and respond to an AMR pathogen outbreak. In this section, the essential components or interventions required to respond effectively to an AMR pathogen outbreak are discussed in more detail. These components, as summarized in Table 4, fall under the same categories as the key components of IPC for AMR preparedness and prevention described in Section 4.

Table 4. Summary of essential components of AMR pathogen outbreak response

IPC component	Actions and responsibilities in outbreak response
Administrative controls	• Activate OMP and team. • Administration provides leadership, funding and resources. • Assess surge capacity – extra staff, PPE, alcohol-based handrub (ABHR).
Surveillance	• Determine whether additional screening strategies are required (e.g. point-prevalence surveys or environmental sampling). • Collect enhanced epidemiological and clinical data. • Undertake additional epidemiological investigations (such as case-control or cohort study).
Enhanced IPC precautions	• Identify transmission risk area(s). • Optimize patient placement (single room, cohort, close ward). • Implement enhanced or additional IPC measures for target AMR pathogen, including PPE use and education. • Monitor/audit enhanced and standard IPC precautions. • Implement targeted IPC measures (e.g. hand hygiene compliance focus).
Environmental cleaning	• Enhanced cleaning programme, terminal cleaning for rooms of patients with target AMR pathogen. • Increase cleaning staff training and auditing. • Need access to a safe, adequate and reliable water supply.
AMS	• Optimize AMS (appropriate use of antimicrobials) and treatment guidelines. • Ensure adequate treatment options for AMR pathogen(s).
Education and communication	• Communicate risk to all stakeholders. • Education of staff and patients.

Administrative controls

Outbreak management plan

All HCFs should develop an OMP that is based on local policy and consultation with the IPC team, facility management and local public health authorities, as appropriate. The OMP should encompass AMR pathogens or be broadly applicable to an AMR pathogen outbreak. The IPC committee should oversee the facility's plan and ensure it is regularly reviewed so that it remains fit for purpose and includes emerging pathogens.

An OMP should include:

- how to determine if there is an outbreak
- when to convene an OMT
- membership of an OMT, with defined roles and responsibilities
- who the OMT should report to
- actions the OMT should oversee and conduct
- resources and funding required
- when to request external support.

Membership of the OMT may include the following representatives, depending on the initial assessment of the outbreak:

- health service executive
- IPC team
- manager/clinical representative from the affected area(s)
- infectious disease physicians
- clinical microbiologists
- environmental or support services
- public health physician
- epidemiologist
- media relations officer.

An outline of the roles and responsibilities of the members of an OMT can be found in Annex 6.

Resources

HCF management should provide leadership and support for any additional measures recommended by the OMT. They should also make available, wherever possible, appropriate funding and resources for the OMT to implement its recommended interventions and actions. This may be in the form of additional staff, PPE or other consumables such as hand hygiene or cleaning products.

The HCF may identify, at any stage during an outbreak investigation and response, that it does not have the resources or technical expertise required to respond adequately. Section 5 provides information about where further support during an AMR pathogen outbreak may be accessed.

Enhanced IPC precautions

Identify transmission risk area

In addition to the actions for managing identified cases and contacts, a transmission risk area(s) should be identified when an outbreak is suspected or has been confirmed. "Transmission risk area" refers to a distinct geographical area or ward in which local transmission has occurred.

Transmission risk areas should be defined by considering whether:

- there are two or more confirmed cases of the same AMR pathogen;
- at least one case is locally acquired;

- there is a plausible epidemiological connection between the cases through proximity, shared room or equipment or other exposures in the health-care setting; or
- acquisition from an environmental source is hypothesized, with clustering in time and place without a direct patient-to-patient epidemiological link.

Defining transmission risk areas assists the IPC team to determine where actions and support need to be focused for the outbreak response.

Implement enhanced IPC measures

The level of additional or enhanced IPC precautions should take into consideration the AMR pathogen and resources available in the health facility. The considerations to determine the level of enhanced IPC required are outlined in Table 5.

Table 5. Enhanced or additional IPC measures for implementation during an AMR pathogen outbreak

Intervention	Actions for consideration
Patient placement	Patients with high-risk AMR pathogens (see Section 2.2) should, where possible, be placed into a single room with their own bathroom facilities. When a single room is not available, patient placement should be prioritized as below: 1. Single room with separate dedicated bathroom facilities. 2. Single room with dedicated commode, but shared showering facilities. 3. Shared room and bathroom facilities with same AMR pathogen-colonized/infected patient(s). 4. Shared room with other AMR-colonized or non-AMR-colonized patient(s) with dedicated commode, but shared showering facilities. 5. Risk factors for further transmission (to be considered when determining patient placement or prioritization of single/shared rooms) are: • expected length of stay and acuity of patient; • patient's ability to comply with IPC recommendations; • presence of infected/colonized wounds and ability to contain exudate; • presence of copious or uncontained respiratory secretions or urine; and • patient has diarrhoea, is incontinent of faeces or has an intestinal/urinary stoma.
Cohorting patients and/or staff	• Consider when there are large numbers of cases, transmission is ongoing and resources may be limited to manage increased numbers of cases. • Only arrange cohorts of patients with the same organism and resistance gene(s). • If a patient has a number of risk factors for further transmission or there are significant difficulties in ensuring compliance with IPC precautions, then consider one-to-one nursing.

Intervention	Actions for consideration
Standard and TBPs	• Use of standard precautions, with a particular emphasis on the importance of hand hygiene, should be reinforced for all patients. Additional education and training should be provided to staff to reinforce these. • Appropriate TBPs should be implemented for all patients with the AMR outbreak pathogen. These will more commonly be contact precautions for an AMR pathogen. Assessment of additional precautions required should be based on the mode of transmission of the particular AMR pathogen and the resources or facilities available to implement best practice TBPs. • Implement and continue actions for patient's complete length of stay. • Ensure WASH aspects are assessed and are adequate, safe and reliable.
PPE	• PPE provided should be adequate and appropriate for the TBPs required; that is: o contact precautions: fluid-resistant long-sleeved gown or long-sleeved gowns with water resistant apron and gloves; o droplet precautions: medical mask and eye protection; o airborne precautions: respirator (N95, FFP2 or equivalent); and o in combination if the pathogen has various transmission routes. • PPE should be located in an area with adequate space to enable staff to put on PPE safely and prevent clean PPE from becoming contaminated. • There should also be adequate space in the area for taking off PPE to prevent self-contamination. • Wherever possible, PPE should be single-use only. If reusable, ensure it is appropriately cleaned and disinfected before reuse (e.g. launder cloth gowns, clean and disinfect reusable eyewear).
Signage and communication	• Place sign on door of patient room or at bedspace to alert staff and/or visitors to IPC precautions required before entering room/area. • Place an alert in the patient's medical record with name of AMR pathogen, date isolated and site it was isolated from, e.g. CPE isolated from urine 16/07/2021.
Movement or transport of patients	• Limit patient movement from their rooms. • If patients must attend other clinical areas for diagnostic tests or procedures, appropriate TBPs should be maintained. • Advise clinical areas that will be receiving patients for procedures or investigations well in advance of patient arrival to enable adequate preparation to manage the patient, e.g. allowing enough time to perform environmental cleaning and disinfection before the next patient.
Limiting ward activity and ward closure	• If, after initial control measures have been implemented, new cases continue to be identified, consideration may be given to closing the affected ward or area to admissions. • If transmission is occurring on a surgical ward, consider cancelling elective surgery.
Monitoring/audit and evaluation	• Monitor/audit compliance with enhanced or additional IPC measures as well as with standard IPC precautions (e.g. hand hygiene). • If non-compliance issues are found, determine what actions are required to correct problems, e.g. are more supplies or further education and training required? • Feed back results to the OMT and staff in the affected area(s).

Enhanced environmental cleaning

During an outbreak, it is important to enhance existing cleaning processes to minimize contamination of the hospital environment and subsequent transmission of AMR pathogens between patients. It is also important to engage the cleaning and clinical staff (especially nursing and theatre staff) in the outbreak response to clean and disinfect shared patient equipment appropriately (Table 6).

Table 6. Enhanced environmental and equipment cleaning during an AMR pathogen outbreak

Cleaning focus	Actions for consideration
Equipment and instruments	• Wherever possible, use disposable equipment (e.g. tourniquet or stethoscope). • Dedicate non-disposable equipment to one patient. • Ensure any shared equipment is cleaned and disinfected before use on another patient (even for cohorts of patients with the same AMR pathogen).
Environmental cleaning and disinfection	• Increase routine cleaning and disinfection in the ward/area. • Increase frequency of cleaning and disinfection of frequently touched surfaces (e.g. bed rails, over-bed table, door handles, intravenous infusion pumps) in affected area. • Clean and disinfect the patient's room and bathroom at least daily. • Increase monitoring/audit of cleaning and disinfection practices. • Conduct terminal/discharge cleaning in accordance with the standard procedure by trained cleaning staff.

Enhanced surveillance

Surveillance is critical to the identification, investigation and control of an outbreak. Where a suspected outbreak of an AMR pathogen has been identified, additional surveillance activities are recommended. These may include:

- active surveillance for additional cases or patients who may meet the outbreak case definition, such as through enhanced prospective screening and/or retrospective laboratory or clinical review;
- collection of enhanced epidemiological and clinical data to assist in formulating hypotheses regarding risk factors for acquisition or transmission;
- environmental surveillance; and
- epidemiological investigations, including descriptive analyses, cohort or case-control studies, if required.

The collection of enhanced epidemiological and clinical outbreak data must be guided by the epidemiology observed, microbiology of the pathogen and known risk factors relevant to the pathogen and each hospital setting.

During an outbreak, data collection on a case (or patient) level is recommended. This is in contrast to isolate or sample-level surveillance that is often undertaken for routine surveillance.

Data may be collected from record review, patient or clinician interview, or a number of other mechanisms. Recommended data to be collected include:

- patient and demographic details;
- laboratory results, as relevant to the suspected outbreak;

- additional characterization of pathogens: for example, through referral to the NRL, extended AST and other tests if available (for example, molecular testing or WGS);
- clinical presentation and investigations; and
- risk factors for acquisition, as relevant to the pathogen and setting, such as:
  - specific medication or equipment use
  - bed/ward/unit admission and transfer data
  - high-level acute care or greater assistance with activities of daily living.

It is also advisable to do the following when collecting data:

- Assign a unique patient identifier to each case. Different data sources (for example, laboratory, clinical, public health) often have different identification numbers. A single identifier facilitates linkage between different data sources, which helps avoid duplicate reporting.
- Collect all data on a standardized data collection form (for example form, see Annex 7).
- Use electronic data collection forms such as mobile phone apps, wherever possible.
- Provide training on use of data collection forms and a standardized data dictionary.
- Minimize free text recording of data. Provide options for "unknown", "not stated" and "not applicable".
- Include a "notes" or "further comments" section to allow for circumstances that might not be captured well within standardized fields. These notes should be reviewed when entering and data clarified where needed.
- Audit data collected to identify discrepancies within or between data collectors.

Box 7 presents details of Case Study 3 involving an outbreak of extended-spectrum beta-lactamase *Klebsiella pneumoniae* in a NICU.

Box 7. Case Study 3: Outbreak of ESBL *K. pneumoniae* in a NICU

Neonatal intensive care units (NICUs) are important settings for outbreaks of AMR pathogens. Patients in NICUs have *(12)*:

- long length of stay in the intensive care environment
- presence of invasive devices
- frequent manipulation
- immature immune systems, immature digestive systems and poor skin barriers.

These factors can make outbreaks, including AMR pathogens, more frequent and difficult to eradicate, and can cause higher morbidity and mortality. As in other settings, transmission in NICUs is usually from patient to patient via health-care workers' hands or from contaminated equipment *(13)*.

The following case study, while not based on a real event, illustrates how an outbreak investigation could proceed.

Situation

Over a three-week period, three patients in a NICU developed a bloodstream infection with an ESBL-producing *K. pneumoniae* strain. This was noted as unusual by the microbiology laboratory and reported to the IPC committee. A retrospective review of laboratory data was conducted and an additional three samples from three neonates were identified as a similar organism, collected over the previous four weeks. Retrospective review also identified that this organism had not been seen in the NICU in 12 months prior to the first infection. The IPC committee decided an outbreak investigation should commence, and infection control actions were implemented.

Development of a case definition and case finding

A case definition was developed, and a data collection form was created to collect data appropriate to the organism and setting (see Annex 7). Data were collected on the six existing patients and any newly identified patients meeting the case definition. Active surveillance cultures of stool, nasal cavity and skin were commenced on all patients admitted to the NICU. Their mothers were screened weekly for colonization with the outbreak pathogen.

Control measures implemented

IPC practices were reviewed and strengthened, which included increasing hand hygiene compliance, appropriate use of PPE, cleaning and disinfection of frequently touched surfaces, appropriate laundering and management of linen, and introduction of appropriate zoning (physical separation of colonized and non-colonized patients).

Further investigations

A brief literature review of previous outbreaks caused by similar pathogens was conducted. Following the literature review, it was decided that further environmental screening of possible reservoirs should be performed *(12,13)*. Screening was conducted and included frequently touched sites within the patient environment, linen, medical devices, pharmaceuticals, food (including breast milk), water and other care equipment.

Environmental swabs of frequently touched surfaces such as the diaper scale and glove box were positive for ESBL-producing *K. pneumoniae*. Efforts to improve environmental cleaning and hand hygiene (such as performing hand hygiene before putting on gloves) and reducing equipment sharing were implemented.

Generating hypotheses

Descriptive analysis of the data collected identified that at least one patient with the outbreak strain had been present on the ward at all times since identification of the first patient, and cases were commonly cared for in the same area as another case, prior to identification with the outbreak organism. Patients with conditions requiring frequent procedures, such as arterial catheterization or mechanical ventilation, appeared to be overrepresented *(14)*. No other factors were identified that were common between cases. Person-to-person transmission was suspected and efforts to reduce patient overcrowding, understaffing and patient movement were increased.

Declaring the outbreak over and return to normal

While a definitive cause of the outbreak was not identified, cases ceased following increased IPC interventions, and the outbreak was declared over. Ongoing periodic active surveillance, of patients (for example, admission and weekly point-prevalence screening) admitted to the NICU was implemented to assist in the early identification of re-emergence of the outbreak pathogen and/or future outbreaks in this high-risk setting.

Screening strategies

Screening strategies beyond screening contacts should be considered. Factors to take into consideration when determining whether further screening is required are the:

- impact of screening on patients
- cost benefit of screening versus not screening
- capacity of local microbiology laboratory to process samples
- workload of staff in affected area(s) to conduct additional screening
- available epidemiological evidence.

Point-prevalence screening

A point-prevalence screen is when a point in time is chosen to screen an entire cohort of patients: for example, all patients in a ward on a particular date *(15)*. This could be conducted as a one-off screening – as a snapshot in time to gauge the prevalence of colonization with AMR pathogen(s). Alternatively, they could be conducted on a regular basis (for example, weekly) to identify ongoing transmission during an outbreak or changes in prevalence over time.

Conducting a point-prevalence screen will require coordination with the area/ward to be screened and the laboratory. The laboratory, in particular, will need advance warning of a point-prevalence screen to ensure that it has enough staff, culture media and other consumables to process a large batch of samples. The laboratory request forms should clearly indicate which AMR pathogen(s) is/are to be screened for (rather than routine microscopy, culture and susceptibility testing) to facilitate correct processing of specimens.

Determine who will undertake the screening of all patients: for example, ward nurses and/or members of the IPC team. All staff involved in the process should be briefed before screening takes place.

Admission/discharge screening

Admission screening may be considered for areas with vulnerable patients (for example, ICU, burns or haematology units). Discharge screening may be considered for areas where transmission is ongoing and the whole ward is considered to be a risk for transmission to patients admitted. It is usually only implemented for the duration of the outbreak or for a limited period afterwards to ensure patients, particularly when being transferred to other wards or HCFs, do not become the cause of the outbreak extending to other areas.

Staff screening

Screening of staff as part of an outbreak investigation is not generally recommended. International guidelines indicate that there is no or poor evidence to recommend screening of HCWs during an outbreak. Screening of staff should only occur when there is epidemiological evidence implicating a HCW as a source of ongoing transmission *(5,16)*. In the absence of a decolonization regimen with proven efficacy, the decision to screen HCWs for AMR pathogens should only be undertaken following multidisciplinary input and expert advice from an infectious disease physician/medical microbiologist and an IPC professional.

Clusters of surgical site infections and outbreaks with AMR pathogens have been associated with exposure to HCWs with artificial nails or evidence of paronychia *(17)*. Assessment of HCWs' hands and hand cultures may be considered when an outbreak is ongoing and other IPC measures have not been successful.

If it is found that a staff member is colonized with an AMR pathogen, results should be interpreted with caution. A positive screening result does not necessarily mean the staff member is the source of transmission. Work restrictions for staff found to be positive with an AMR pathogen are not generally required. Instead, staff should receive education on standard precautions, particularly hand hygiene. If staff are epidemiologically linked to the transmission of an AMR pathogen, review IPC practices as well as predisposing factors that may increase the risk of transmission (for example, paronychia). If concerns about transmission persist, it may be necessary to reallocate the staff member to non-clinical tasks until the issue has been resolved (for example, successful treatment of paronychia). Irrespective of AMR pathogen colonization, staff should not work if they are experiencing acute diarrhoea.

Laboratory methods for screening during an outbreak

When screening of patients for AMR pathogen colonization is to be performed, the IPC team should liaise with the microbiology laboratory to ensure that it has relevant standard operating procedures (SOPs), adequate media and staffing to complete the testing, particularly when a large screening effort such as a point-prevalence survey is planned. The laboratory may recommend the preferred specimens or collection methods for screening and must decide upon the testing method to be used. Detection of AMR pathogens from screening samples can be improved by using selective media, although these are not always readily available (Table 7).

Table 7. Culture of patient screening specimens during an outbreak investigation

Organism	Specimens	Testing
MRSA	Preferred: nasal swab Alternative: throat, axilla, groin, wounds	Routine culture and AST (48–96 h) Selective media[a]
VRE	Faeces or rectal swab	Selective media +/- enrichment broth[b] Identification and AST
MRGN[c]	Faeces or rectal swab Clinical specimens, e.g. endotracheal aspirate or sputum[d]	Selective media[e] Rapid detection of carbapenemase activity[f] or colistin resistance[g] Identification and AST
Candida auris	Required: bilateral axilla and groin swabs Other specimen types to consider: swabs from nares, oropharynx, external ear canal, vagina or rectum	Phenotypic identification methods[h] Molecular assays, e.g. real-time polymerase chain reaction Antifungal susceptibility testing[i]

[a] Selective media for MRSA, e.g. mannitol salt agar-cefoxitin *(18)*.

[b] Selective media +/- enrichment broth for VRE, e.g. bile-esculin-azide agar with vancomycin *(19)*.

[c] MRGN may include extended-spectrum beta-lactamase-producing Enterobacterales, CPE, *Pseudomonas aeruginosa* or *Acinetobacter baumannii* and other carbapenem-resistant (non-carbapenemase-producing) organisms.

[d] Especially for ICU patients.

[e] Selective media for MRGN, e.g. chromogenic screening agar *(20)*.

[f] Assays for rapid phenotypic detection of carbapenemase activity include CarbaNP assay *(7)*, carbapenemase inactivation method (CIM) test *(8)*.

[g] Assay for rapid detection of colistin resistance *(7)*.

[h] Phenotypic identification of *Candida auris* is complex and evolving *(21)*. Laboratories should discuss identification of *Candida auris* with their NRL or similar. Countries without this capacity should refer to their regional *Candida* reference centre *(22)*.

[i] Antifungal susceptibility testing should be performed using reference broth microdilution methods by an experienced laboratory.

Antimicrobial stewardship

During an outbreak of an AMR pathogen, the principles of AMS should be retained as much as practical, with the intention of preventing the spread of AMR through minimizing selection pressure when prescribing broad-spectrum antimicrobials unnecessarily.

For AMR pathogens, treatment options are often limited. The antimicrobials that are required for effective therapy are usually broad-spectrum and expensive, and can have increased toxicity associated with their use. Therefore, prescribing should preferably be initiated with the oversight of infectious disease units, clinical microbiology or clinical pharmacy. Broad-spectrum empiric therapy

should be de-escalated with negative microbiological results or as soon as an alternative diagnosis has been identified.

Antimicrobial formulary

The HCF's antimicrobial formulary or Essential Medicines List (EML) should be reviewed in an active outbreak setting. This is to ensure that there are antimicrobials available on the formulary list that have a spectrum of activity to treat the pathogen identified in the outbreak.

Issues that may need to be considered:

- possible required additions to the antimicrobial formulary, including newer antimicrobials or those previously excluded due to cost or toxicity;
- review of current antimicrobial stock levels and possible need to increase the purchasing of some antimicrobials; and
- management of stock shortages.

In hospitals or health-care organizations that do not have an antimicrobial formulary, the procurement process should be evaluated to ensure adequate supply of necessary antimicrobials.

Review restriction policies

Restriction policies of the HCF should be reviewed and revised to ensure that, if patients meet the case definition as defined for the outbreak *and* have evidence of an active infection, empiric antimicrobials are administered in a timely manner.

In particular, if there is a requirement to gain approval prior to prescribing a particular antimicrobial (for example, from infectious disease units, the AMS team or a responsible member of management), these restriction policies may need to be reviewed. This will allow greater access to the necessary antimicrobials in a timely manner. It may be necessary to allow an initial dose or up to 24 hours of therapy before an approval is required.

Treatment guidelines

If the HCF has standard treatment guidelines for infections, these should be reviewed and updated to include the case definitions for the AMR pathogen associated with the outbreak and recommendations for empiric treatment. There may even be a need for a review of the WHO AWaRe classifications for some antimicrobials, to adjust the restriction classification within the HCF for the duration of the outbreak. Again, any changes to treatment guidelines or restriction classifications should be made in consultation with infectious disease units, clinical microbiology, or the AMS team.

The following are examples of how the AWaRe classifications in the EML may be reviewed in order to update for the outbreak situation:

- review/update national or local EMLs with any new antimicrobials that may be required;
- align empirical antibiotic treatment guidelines with Access antibiotics to include outbreak pathogen indications and clinical presentation;
- continue to target other Watch and Reserve classification groups for AMS actions; and
- communicate any updates or changes to relevant health professionals.

Stock shortages

Antimicrobial stock shortages are becoming a global issue, which can adversely affect clinicians' ability to treat infections.

In an outbreak setting, there may be an increase in the use of particular antimicrobials that may previously have been rarely utilized in the clinical setting. This may lead to both local and national shortages of these antimicrobials. This is a particular issue in LMICs, where the usual supply chain of essential medicines is often already fragile.

Timely communication to and from suppliers facilitates quicker local responses to such shortages. Locally, there is a need to have a coordinated system to respond quickly to stock shortages. This should include the following:

- review of stock in hand and duration of expected use before stock runs out;
- communication of possible stock shortage situations to stakeholders early, including medical staff (infectious disease specialists, if available), so that they can be prepared; and
- provision of recommendations for alternative treatments, if available.

Anticipate the impact on the alternative drugs and monitor their supply too. For example, ceftriaxone shortages may follow ampicillin shortages. Obtain updates from suppliers and review the situation regularly.

Education and communication

Communication is an essential component of any outbreak investigation and response, not just with the OMT but also with all relevant stakeholders. Appropriate and timely communication about the situation and actions being taken will facilitate a cooperative and coordinated response.

Communication with or between members of the OMT is especially important to ensure that all members are aware of who is responsible for undertaking which investigation and response actions. Care should be taken to avoid placing blame or criticizing people based on the outbreak investigations.

In the early phases of the outbreak, OMT meetings may need to be held relatively frequently (for example, at least weekly). This will mean that results of investigations and actions implemented can be reported back and further actions, if required, determined. Meeting minutes/notes with actions as assigned should be kept and circulated in a timely manner to help keep the OMT on track. Set achievable time frames for implementing actions and reporting back to the OMT.

Risk communication

Risk communication is the process of informing people about potential hazards to their health, well-being or community. The purpose of risk communication is to help affected people and stakeholders understand potential or actual health threats and to participate in making decisions about how the risks can be managed *(23)*.

Developing a communications plan, which is endorsed by the OMT, will help to identify the messages and information you wish to communicate, to whom it needs to be communicated and by what methods. For example, are education/information sessions sufficient for staff or should there be information sheets developed and provided to them as well?

Determine who your stakeholders are and who needs to be informed of the risks associated with the outbreak. This may include:

- health service management;
- staff, including those who are non-clinical;
- patients, families, carers;
- other health facilities or services that may have affected patients transferred to their care: for example, general practitioners;
- public health authorities; and
- local communities

Strategies used for communicating risk are based on the level of hazard the risk poses as well as the level of concern about that hazard *(23)*. Communication must be adapted to meet the needs of your stakeholders, who may differ with respect to literacy, language, culture, race/ethnicity, disability and information required to make informed decisions.

Communication materials may include:

- pamphlets/leaflets for patients, families and carers
- education, training, information sessions and/or pamphlets/leaflets for staff
- transfer or discharge letters to receiving health facilities or services
- situation reports to health service management and public health authorities
- social media e.g. tweets

Communication must be done in a timely manner and allow the opportunity for people to raise concerns, ask questions and seek clarification. Establishing a clear communication strategy is essential. For example, who will be responsible for answering queries from staff, patients, the public or the media? Ensure all information provided has contact details for stakeholders to direct their questions. Publicly released media communications should be done in consultation with relevant health authorities.

Being open and transparent with communications is very important to ensure your stakeholders have confidence in the team managing the outbreak and in the actions being taken. This in turn will encourage their compliance with additional measures that are implemented, which may be perceived to be onerous or difficult to do.

Education and provision of information to staff

Education opportunities for staff should be identified and utilized wherever possible. This may occur in a formal manner, with dedicated time set aside for staff to attend an education session. Alternatively, it could be on an ad hoc or opportunistic basis: for example, when an IPC professional is reviewing an outbreak area and can speak to individual staff members.

Where available, information provided to staff about the outbreak should include:

- factors that may have led to the outbreak
- a timeline of the outbreak, investigation and interventions
- a summary of the investigations undertaken and the findings
- actions or interventions implemented
- short-, medium- or long-term recommendations to prevent similar outbreaks in the future.

Every effort should be made to ensure as many staff as possible are provided with education/information sessions, particularly during the early phases of an outbreak. This may include running sessions more than once and at different times to cover different shifts (for example, for night duty staff). Staff should be enabled to attend such sessions, with time away from clinical duties facilitated.

Education sessions or provision of information are best presented in a number of formats that support people's different ways of learning. For example, verbal presentations can be enhanced with visual displays such as posters, or participants practising particular techniques such as donning and doffing PPE. Written instructions or information should also be provided for staff to read later, which reinforces messages provided during education/information sessions.

Further information sessions may need to be provided at different stages of the outbreak to update staff on outbreak progress. After the outbreak has been declared over, there should also be debriefing or lessons learnt session(s) where staff can provide feedback about their experiences during the outbreak and the measures implemented.

3.3 RESPONDING TO AN OUTBREAK OF AMR PATHOGENS IN THE COMMUNITY

While AMR pathogen outbreaks are commonly recognized in HCFs, AMR is also a substantial problem in a wide range of pathogens associated with community-acquired infections, such as foodborne and waterborne diseases and sexually transmitted infections.

Methods for surveillance, investigation and control of such pathogens are largely dependent on the mode of transmission. Many such pathogens are incorporated into existing surveillance programmes due to public health concerns. A list of resources for responding to community outbreaks with different modes of transmission is provided in Table 8.

Additionally, where an AMR concern is identified in a community outbreak, focus should be placed on:

- ensuring sufficient and representative samples are collected from cases;
- referring samples to the NRL or other reference laboratory for further AST and characterization;
- rapidly reporting affected populations, resistance profiles and available treatment options to those providing empiric antimicrobial therapy in health-care settings or through community pharmacy or health posts; and
- appropriate risk communications for the community.

Table 8. Resources for the outbreak investigation of pathogens of public health importance where AMR concerns have been identified

Type	Document
Foodborne disease	*Foodborne Disease Outbreaks: Guidelines for Investigation and Control.* WHO (2008)
Sexually transmissible infections	*A Tool for Strengthening STI Surveillance at the Country Level.* WHO (2015)
	Managing Outbreaks of Sexually Transmitted Infections. Public Health England (2017)

Risk communication and engagement

It is critical to communicate to the public and at-risk population(s) what is known about the outbreak, what is not known, what is being done and what the public can do to help mitigate their own personal risk *(24)*.

Recommended actions for risk communication and engagement are:

- Identify one or more official spokesperson(s) and provide training if needed.
- Prepare mechanisms to approve and disseminate messages and materials rapidly.
- Prepare communication materials on the AMR pathogen and public health measures for at-risk population(s) and the broader public.
- Establish systems to collect and respond to public concerns, frequently asked questions, rumours and misinformation (for example, monitoring media coverage, social media).
- Identify networks, communication channels and potential influencers for the at-risk population(s).
- Identify and communicate with health-care providers who may be the primary health-care contacts for the at-risk population(s) through mechanisms such as urgent health-care advisories.

These should provide targeted communications about the AMR pathogen, presentation of disease/infection, treatment options/recommendations, recommended laboratory investigations and notification requirements.

- Consider establishing a webpage or telephone hotline to provide information.

4. AMR preparedness and prevention

In this section, we look at the ways in which HCFs can review their IPC programmes to focus on areas that could be improved to reduce the risk of AMR pathogen outbreaks.

4.1 STAKEHOLDER ROLES AND RESPONSIBILITIES

AMR is a complex problem that extends across many different areas of expertise, both within HCFs and in the wider community. This includes local public health authorities, government and national bodies (for example, NCC for AMR and NRL) as well as animal, environmental and plant health authorities.

The roles and responsibilities of stakeholders involved in the preparedness for and prevention of AMR should be clearly defined during the development of a framework to support AMR activities. A guide to the roles and responsibilities at each level of the system is outlined in Table 9.

Table 9. Roles and responsibilities of stakeholders in the preparedness for and prevention of AMR pathogen outbreaks

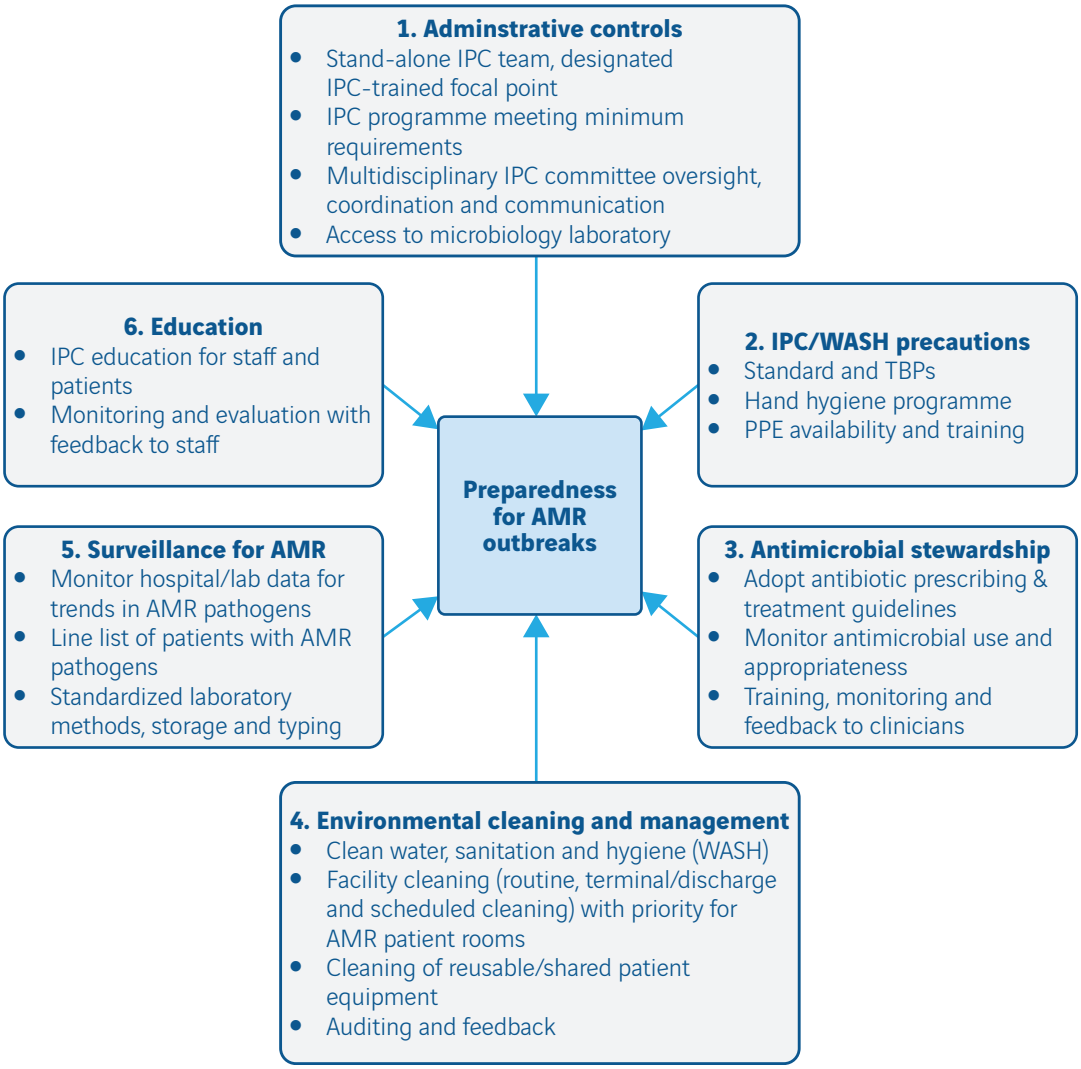
Stakeholder	Roles and responsibilities
Health services	• Ensure compliance with local and national standards and guidelines that pertain to IPC and AMR pathogens. • Develop and implement a set of guidelines, policies and/or plans that outline the management of AMR pathogens, including an OMP. • Regularly monitor and evaluate the OMP. For example, conduct an annual tabletop exercise to test that the OMP is still fit for purpose. • Develop and implement surveillance for AMR pathogens, which may be situated within a broader health-care-associated infection (HAI) surveillance plan. • Ensure notification of notifiable/reportable diseases and organisms occurs according to national requirements. • Ensure stakeholders are identified and communication strategies are established. • Establish relationships with key health-care and public health partners. • Liaise with public health and/or government authorities in a timely manner about significant changes in AMR pathogens, including AMR pathogen outbreaks.

Stakeholder	Roles and responsibilities
Hospital laboratory (or laboratory servicing hospital, including private laboratory)	• Meet core laboratory requirements (see WHO's *Guidance on setting up local and national AMR surveillance systems for countries in the Western Pacific Region*), including quality systems, data management, specimen collection and isolate storage. • Perform accurate bacterial identification and AST according to national and international standards. • Report detection of target or unexpected AMR pathogens to local IPC team, pharmacy and clinicians. • Contribute to local surveillance for AMR pathogens and development of OMP. • Establish a bilateral relationship with NRL/NCC to optimize testing methods and quality, and where possible, contribute to AMR surveillance.
NRL (Note: in some countries, a subnational public health or reference laboratory may provide all or some of these functions)	• Meet core NRL requirements (see WHO's *Guidance on setting up local and national AMR surveillance systems for countries in the Western Pacific Region*), including quality systems, data management, specimen transport and isolate storage. • Promote good laboratory practice and harmonization of laboratory and AMR methods within the country. • Monitor surveillance data together with NCC and HCFs for the identification of outbreaks and to establish trends and baseline resistance rates. • Assist hospital and provincial laboratories to prepare OMPs. • Serve as reference laboratory for confirming bacterial identification, AST results and typing for potential AMR outbreaks. • Consider the role of advanced molecular techniques such as genomics for AMR in the national context and provide or arrange advanced testing where indicated *(9)*.
National or subnational AMR coordinating centre (NCC)	• Meet core requirements for national AMR coordinating centres as defined by the global AMR surveillance system (GLASS) *(1)*, international standards and guidelines. • Coordinate national/subnational AMR data collection, analysis and reporting. • Provide timely and accurate reporting of national and local AMR data and events to HCFs and other stakeholders to inform local practice, planning and response. • Prepare and disseminate guidance and protocols on AMR – surveillance and outbreak investigation activities and assist HCFs to prepare and implement surveillance and outbreak plans. • Provide advice and support to HCFs for outbreak preparedness and response. • Provide training to HCWs and facilitate surge capacity for hospitals to respond to critical AMR events and outbreaks.
Public health and government authorities	• Establish links with NRL and/or subnational public health or reference laboratories.

4.2 KEY COMPONENTS OF PREPAREDNESS FOR AMR

The key components of preparedness for AMR in HCFs can be divided into six domains (Fig. 6).

Fig. 6. Components of preparedness and prevention of AMR at the HCF level



Key component 1: Administrative controls

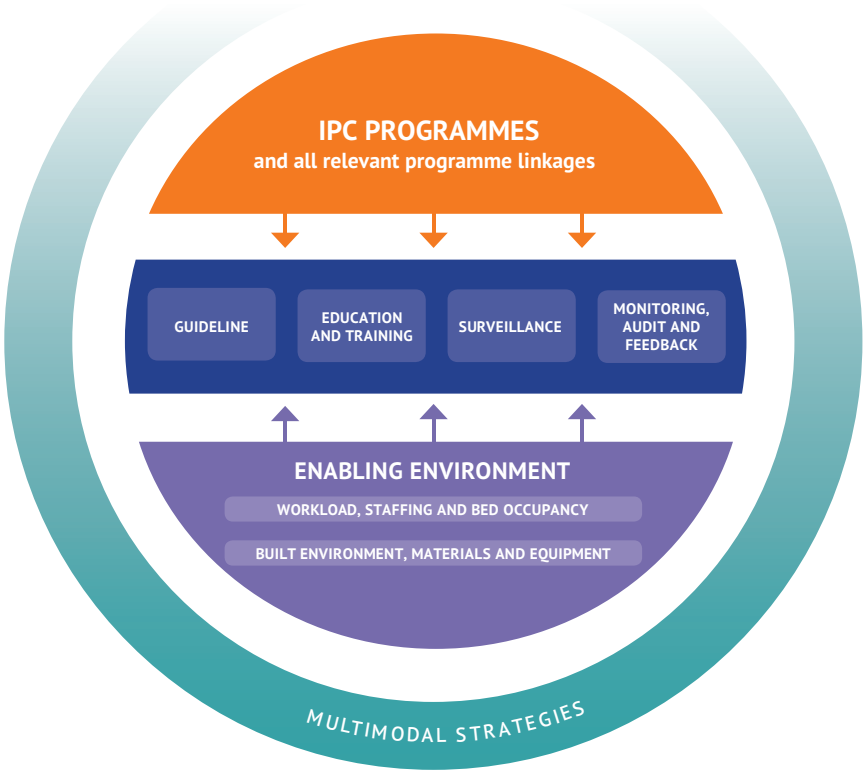
Administrative controls are used to improve safety by putting in place the policies, procedures and training required to reduce hazards. Having an effective IPC programme is essential for the prevention of, and response to, AMR pathogens and AMR pathogen outbreaks. WHO has defined eight core components of IPC programmes at the national and HCF levels *(4)*. These include:

1. IPC programme
2. evidence-based IPC guidelines
3. IPC education and training
4. HAI surveillance
5. multimodal strategies
6. monitoring, audit and feedback of IPC practices
7. workload, staffing and bed occupancy
8. built environment, materials and equipment for IPC.

Implementation of all the recommended WHO core components for IPC is required to build a functioning programme to reduce HAIs and AMR effectively *(25)*. WHO has outlined the minimum requirements for each of the core components for IPC programmes (see Annex 8) *(25)*. It is critical that the minimum requirements for IPC are implemented as an initial step, with the development and implementation of locally determined priority plans to ensure progression to full achievement of all requirements of the IPC core components as an overall goal.

Fig. 7 shows a representation of the relationship between the WHO core components of IPC programmes *(25)*.

Fig. 7. Visual representation of the relationship between the WHO core components of IPC programmes



To support the implementation of the WHO *Guidelines on Core Components of Infection and Control Programmes at the National and Acute Health Care Facility Level*, WHO has developed an *Infection Prevention and Control Assessment Framework* (IPCAF) tool *(26)*. The IPCAF tool can provide a baseline assessment of the IPC programme and activities within an HCF, as well as ongoing evaluations, to document progress over time and facilitate improvement.

Ensuring that appropriate water, sanitation and hygiene (WASH) measures are in place in health facilities is another important component for prevention of transmission of AMR pathogens. The WHO document *WASH in Health Care Facilities: Practical Steps to Achieve Universal Access to Quality Care (27)* outlines eight practical steps to improving and sustaining WASH services and practices in a range of health-care settings in LMICs. Actions may be taken at the national, subnational or facility level or at all levels.

In a similar manner to implementing the IPC core components, a WASH situation analysis and assessment should be undertaken first to determine gaps and priorities for improvement.

WASH in a HCF covers:

1. Water: supply, storage, quality, conservation
2. Sanitation: toilets, treatment, wastewater
3. Waste management from generation to final disposal
4. Hand hygiene: infrastructure, training, compliance
5. Environmental cleaning: staff, protocols, equipment, training

The WHO/UNICEF *Water and Sanitation for Health Facility Improvement Tool* (WASH FIT) *(28)* uses a risk-based approach to improving and sustaining water, sanitation, hygiene and health-care waste management services. Improvement activities are designed to be integrated into a facility's existing efforts on IPC and quality improvement. A mobile application of WASH FIT is available and free to download (www.washfit.org).

IPC committee

To guide the implementation of the WHO core components, HCFs should establish an IPC committee. A multidisciplinary IPC committee should review and guide the HCF's IPC programme, strategies and plans (Fig. 8).

Fig. 8. IPC committee and IPC team members

IPC committee	IPC team
IPC committee members	**IPC team**
• Administration representative (lead) • IPC focal point ± other IPC team members • Clinical microbiologist and/or infectious diseases physician • Sterilization services manager • Representatives from all major departments/ units (preferably consultant level) • Cleaning or housekeeping services manager Consider additional linkages with: • epidemiology expertise (if available) • AMS staff/activities • occupational health and safety officer/team	• IPC professionals responsible for day-to-day activities of the IPC programme. • Each health-care facility should have an IPC focal point or designated person responsible for implementing the IPC programme. This should be someone with knowledge of infections which could include any of the following: – nurse – medical officer – laboratory staff – epidemiologist. • Ideally, the IPC focal point and other IPC team members should have specialist training in IPC.

An assessment of the IPC programme should be undertaken on a regular basis (for example, annually) to determine existing strengths and progress towards or establishment of core components. It should also identify gaps or weaknesses to guide further action planning. The WHO IPCAF tool is validated and designed to measure the IPC situation at an HCF level *(26)*. The IPC committee should oversee and track progress of the implementation of the IPC programme.

IPC team

The IPC team is responsible for the day-to-day activities of the IPC programme (Fig. 9). The number of staff needed will depend upon the size and resources of the facility, type of patient and complexity of care provided, as well as other roles and responsibilities of the IPC professionals.

Fig. 9. Personnel roles and responsibilities for IPC

Roles and responsibilities

IPC committee members

- Review and provide guidance for the health-care facility's IPC programme, strategies and plans.
- Oversee and track progress of the implementation of the IPC programme, including regular programme assessment.
- Implement and support rapid communication systems for AMR outbreaks across the facility and with public health authorities.

IPC team

- Coordinate and conduct education and training activities.
- Develop and disseminate IPC policies and procedures, including AMR pathogen and outbreak management.
- Coordinate surveillance and outbreak investigation activities, including for AMR pathogens.
- Monitor and manage IPC critical incidents and breaches in practice.
- Monitor IPC practices and implement remedial actions.
- Communicate with patients & staff about AMR and HAIs.

Facility administration responsibilities

- Provide adequate resources for stand-alone IPC programme with dedicated budget and trained staff.
- Provide adequate supplies of materials and equipment, including PPE and cleaning materials.
- Arrange microbiology laboratory services (in-house or links with external laboratory).

The IPC programme should be led by at least one nominated, trained and dedicated IPC focal point, who ideally leads a trained and multidisciplinary team and reports to the highest level in the health-care organization. The IPC focal point and team will be responsible for the implementation of the IPC programme overall and IPC activities on a daily basis. WHO recommends, at a minimum, a ratio of one full-time trained IPC professional (nurse or doctor) for every 250 beds or a higher ratio (one IPC professional per 100 beds) when there is increased patient acuity or complexity *(25)*.

If not directly included as part of the IPC team, the team and IPC programme should be supported, wherever possible, by specialists in epidemiology, infectious diseases and clinical microbiology. The IPC team should also have access to a microbiological laboratory, either on- or off-site for routine day-to-day engagement/discussion. Access to and notification of relevant microbiological reports to the IPC team is essential to enable timely implementation of IPC actions.

The IPC team needs to be supported by the facility with resources, authority and time to maintain clinical and professional currency.

Communication of patients' AMR pathogen status

HCFs must have a system in place to ensure there is rapid communication of identification of patients colonized or infected with an AMR pathogen to patient care staff and other health facilities *(29)*. This will ensure appropriate IPC practices are implemented in a timely manner and protect the patient from incorrect treatment, for example, inappropriate antibiotic use. This should be in place for all defined AMR pathogens relevant to the health facility, but is especially important for high-risk AMR pathogens such as CPE.

Communications systems that need to be considered are:

- laboratory to ward/unit health-care staff and IPC team;
- ward/unit communication to other areas of the HCF where patients may require procedures (for example, radiology or operating theatres);
- hospital epidemiology team;
- HCF to other health facilities that patient may be transferred to (for example, general practitioner or other hospital); and
- medical record alert to ensure patient is "flagged", should he or she be readmitted.

Communication with public health authorities and other agencies

HCFs are responsible for notifying local public health and/or government authorities of any notifiable diseases according to local regulations. These may include infection or colonization with AMR pathogens such as CPE, or a suspected outbreak of an AMR pathogen. Effective communication with public health authorities, following local guidelines and regulations, is important to ensure national coordination in the efforts against AMR, including prevention of outbreaks.

As HCFs are the key front-line players in identifying and responding to AMR pathogens, they are also a key component in the surveillance of AMR. Ideally, HCFs should contribute to national AMR surveillance, where possible, by collecting AMR data for submission to their NCC for AMR. HCFs should also liaise with their NRL or subnational representative, as an important collaboration to enhance laboratory detection of AMR, confirm local findings and perform additional testing as required.

Role of the microbiology laboratory

Primary diagnostic laboratories, including hospital laboratories, play an important role in the detection, investigation and management of AMR pathogen outbreaks. Before outbreaks occur, it is essential that primary laboratories engage with stakeholders at local HCFs, including the IPC team, pharmacy and other members of the IPC committee. Hospitals may consider developing a system to alert clinicians rapidly when a high-risk AMR pathogen is detected – for example, via SMS, telephone or email.

Laboratories should have regular contact with local IPC teams and establish how AMR pathogens should be reported. For example, a CPO may be considered urgent and should be notified by telephone, but isolation of MRSA, particularly if not considered to be an active infection, may be notified in writing. Lab staff should discuss local trends in AMR pathogens of interest with IPC teams.

All laboratories should meet the core laboratory requirements, as detailed in Annex 9. These include adequate quality management systems, staff training, data management, isolate storage and accurate bacterial identification and AST. Ideally, all isolates from blood cultures and CSF, plus significant AMR pathogens, should be routinely stored in a freezer (at least -20^{0}C) for two to three years.

Laboratories should also strive to implement diagnostic stewardship principles, providing optimum patient management guided by timely testing and reporting data to deliver safer and more effective patient care, improving use of resources and ensuring more accurate AMR surveillance data. Examples of diagnostic stewardship relevant to AMR include:

- Cascade or selective reporting of antimicrobials – selective reporting of AST results based on the resistance of the isolate, for example, ensuring broad-spectrum antibiotics such as carbapenems are only reported for isolates with resistance to first- and second-line agents such as penicillins and cephalosporins.
- Only reporting clinically significant pathogens in order to prevent inappropriate treatment of contaminants or colonizing pathogens.
- Education of medical and nursing staff to minimize inappropriate use of urine cultures in patients who are asymptomatic or have an indwelling catheter, hence preventing inappropriate treatment of asymptomatic bacteriuria or catheter-related cultures.

WHO has developed a guide for implementing diagnostic stewardship programmes in LMICs *(6)*.

Monitoring, audit and evaluation of IPC programme

Routine monitoring, auditing and evaluation of the IPC programme are important to measure the programme's effectiveness and identify areas for adjustment or improvement. Key activities to support the development of a monitoring, auditing and evaluation plan to support routine implementation are outlined below.

a. Develop a monitoring and audit plan

The plan should have clear goals, targets and activities and be practical and achievable. The plan may need to focus on high-risk activities or processes that will provide high-value outcomes in the initial stages of implementation, for example, hand hygiene auditing. The plan can be expanded and updated as goals are achieved.

b. Identify and/or develop tools for data collection

Monitoring and audit plans should include tools for systematic collection of data. Tools for the evaluation of different aspects of an IPC programme are suggested in other sections where they may be relevant and available. Tools can also be developed locally, based on need, for example, an education/training feedback questionnaire.

c. Dissemination of results

Results of monitoring and audit activities should be shared and discussed with health-care staff in a timely manner to ensure staff understand the purpose of the audit and areas of achievement or potential improvement.

Feedback to staff should be constructive and should not just focus on the areas where incorrect actions may have occurred. Discussions should focus on possible reasons for non-compliance and how practices could be improved. Non-compliance with correct procedures and practices may be due to a number of reasons, including lack of equipment or supplies or lack of training and education. Understanding the barriers that prevent or make adherence to safe practices possible is an important part of the monitoring/audit process. Staff should be consulted when developing and implementing improvement strategies for the IPC programme, to ensure strategies are acceptable, achievable and sustainable.

There should also be a framework in the monitoring and auditing plan for reporting to relevant management committees – for example, the infection control committee (ICC), outlining the process and timelines for reporting. Generally, results should be reported on a regular basis, for example, hand hygiene audit results monthly and an overall IPC programme assessment annually. At times there may be ad hoc audits conducted that will require appropriate feedback and reporting as well.

Key component 2: IPC/WASH precautions

Standard precautions

Standard precautions are the basic work practices that apply to all patient care, regardless of the patient's suspected or confirmed infection status. These work practices minimize the risk of transmission of infections to HCWs and other patients. They apply in all settings where care is provided.

The foundation of any IPC programme is the implementation of standard precautions. The use of standard precautions is an essential IPC strategy for the successful minimization of transmission of infections, including AMR pathogens.

Colonization with an AMR pathogen is frequently undetected. Patients may not be screened for them or surveillance cultures may fail to identify colonized patients due to lack of sensitivity, incorrect specimen collection, laboratory deficiencies or intermittent colonization due to antimicrobial therapy *(5)*. Therefore, standard precautions must be used to prevent transmission of AMR pathogens from potentially unidentified colonized patients. All clinical policies, procedures and guidelines developed by an HCF should encompass compliance with standard precautions.

All staff, clinical and non-clinical, must receive education and training in standard precautions as relevant to their roles and responsibilities within the organization.

Transmission-based precautions

TBPs are the second tier of basic IPC, used when standard precautions alone are not sufficient to prevent transmission of an infectious disease or organism of significance. TBPs are tailored according to the mode of transmission of the disease or microorganism (Table 10) and are used in addition to standard precautions.

Table 10. Modes of transmission

Mode of transmission	Description
Contact transmission	Direct contact transmission occurs when there is physical contact between an infected person and a susceptible person, for example, when providing oral or skin care to a patient.
	Indirect contact transmission occurs when a susceptible person comes into contact with a contaminated object, for example, a shared blood-pressure cuff that has not been adequately cleaned between use on different patients.
Droplet transmission	Transmission of microorganisms through larger respiratory droplets (> 5–10 µm in size) generated when a person coughs, sneezes or talks. Droplet transmission requires close contact as the droplets are not dispersed over long distances in the air and settle quickly.
Airborne transmission	Transmission of microorganisms through small droplet nuclei or particles (< 5 µm in size) generated when a person coughs, sneezes or talks. Airborne transmission can occur at a distance as particles remain infective over distance and time, that is, particles can remain suspended in the air for prolonged periods, even after the infected person has left the area.

TBPs (see Table 11) utilize additional infection control measures, including PPE and environmental controls, such as patient isolation and enhanced cleaning and disinfection practices. More information on TBPs or the enhanced IPC precautions that may need to be implemented during an AMR pathogen outbreak can be found in Section 3.2.

Table 11. Standard and transmission-based precautions

Standard precautions Use for ALL patients at ALL times	Examples of transmission-based precautions (TBPs) Use standard precautions, PLUS	
• Hand hygiene • Appropriate use of PPE • Safe use and disposal of sharps • Routine environmental cleaning • Reprocessing of reusable medical equipment and instruments • Respiratory hygiene and cough etiquette • Aseptic technique, including safe injecting practices • Waste management • Appropriate handling of linen	**Contact transmission** *e.g. MRSA, CPE, VRE*	Gloves and fluid-resistant gown/apron Single room if high-risk for transmission, e.g. exudative wound for MRSA
	Droplet transmission *e.g. influenza*	Medical mask Single room if possible
	Airborne transmission *e.g. tuberculosis*	Respirator (N95, FFP2 or equivalent) Single, well-ventilated room where possible (negative-pressure ventilation, if available)

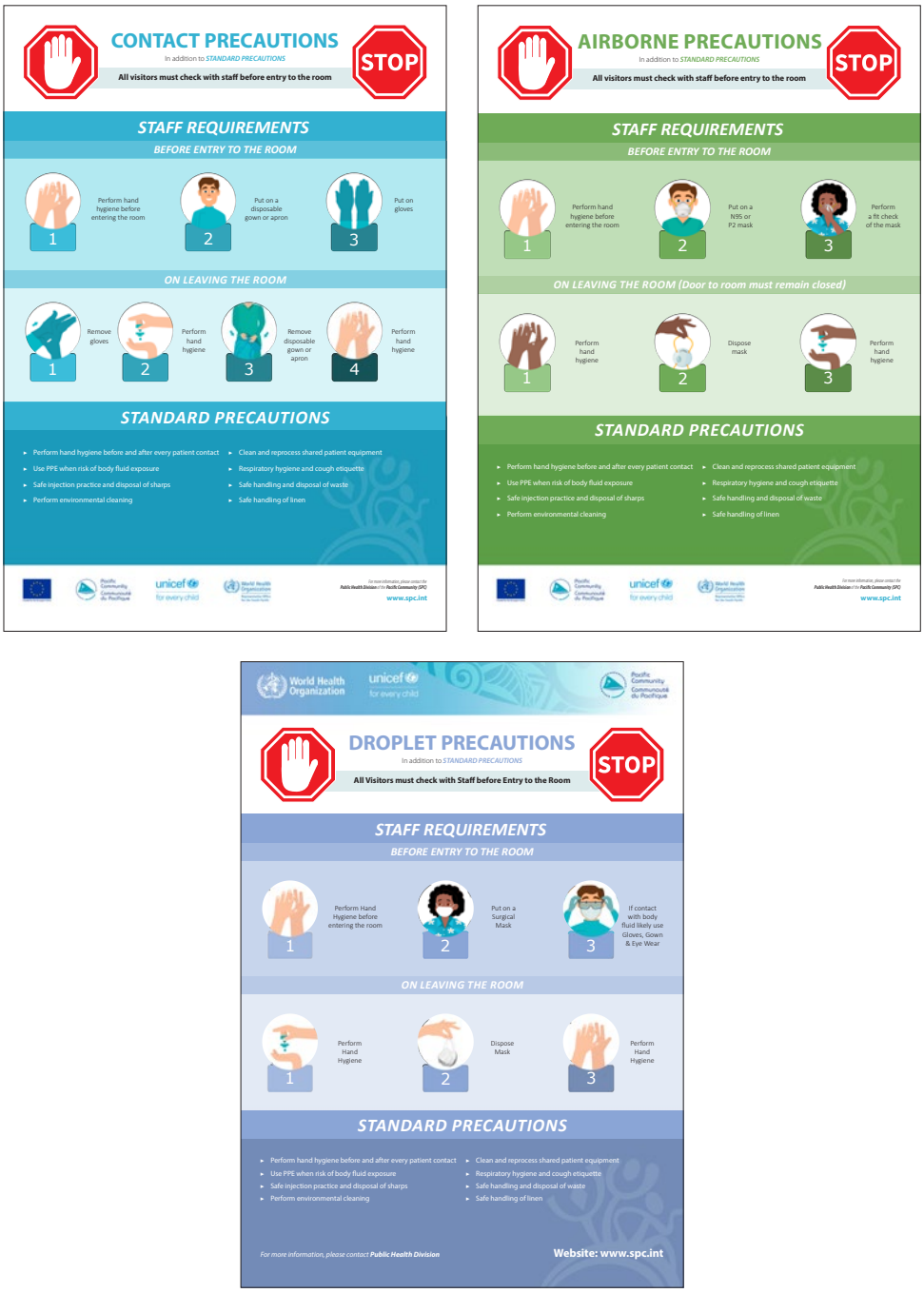
Source: Guidelines on core components of infection prevention and control prorrammes at the national and acute health care facility level. Geneva: World Health Organization; 2016.
Australian guidelines for the prevention and control of infection in healthcare. Canberra: National Health and Medical Research Council; 2019.

TBPs may be used separately from each other or in combination, depending on the organism involved. In the health-care setting, transmission of AMR pathogens, such as MRSA, VRE or MRGNs (for example, carbapenem-resistant *Acinetobacter, Pseudomonas* or Enterobacterales) occurs primarily through contact transmission *(5,30)*, although droplet transmission may occur from lower-respiratory tract infections or heavily colonized sputum.

Various methods for communication of TBPs required for a patient are necessary to ensure staff and visitors are aware of any actions or PPE they may need to comply with before entering a patient's room or when a patient is transferred to another area of the hospital (see also Section 4.2 Communication of patient's AMR pathogen status). Signage is one method to communicate TBPs required, and this should be placed outside the patient's isolation room. A range of TBP posters can be found on the Pacific Community website: <https://phd.spc.int/covid19-infection-prevention-control>.

Fig. 10 shows TBPs posters by the Pacific Community (SPC).

Fig. 10 Transmission-based precautions posters



Hand hygiene

Most AMR pathogens in the health-care setting are spread via contact transmission. This means through indirect spread via HCWs' hands, contaminated equipment/items, or touching a contaminated environment. Effective hand hygiene is a critical and cost-effective intervention in the prevention and control of AMR pathogens, with studies demonstrating an association between improved hand hygiene compliance and reduced AMR pathogen transmission *(29)*.

Hand hygiene includes handwashing with soap and water, or the use of an ABHR. All HCWs, including ancillary staff such as cleaners and maintenance staff, should be trained in when and how to perform hand hygiene, including WHO's *5 Moments for Hand Hygiene (17)*.

For optimal compliance with hand hygiene, hand hygiene facilities, for example a hand basin with soap and water or ABHR, should be readily accessible in all areas where patient care is provided. ABHR should be available either through dispensers close to the point of care or in small bottles for on-person carriage. WHO guidelines are available to provide information for local production of ABHR where commercial handrubs may not be readily available *(31)*.

The *WHO Guidelines on Hand Hygiene in Health Care* outline best practices for hand hygiene across facilities, for HCWs and patients *(17)*.

WHO also has a range of hand hygiene tools and resources that can be used to implement and assess a hand hygiene programme. They include a *Hand Hygiene Self-Assessment Framework 2010 (32)* and *Template Action Plan for WHO Framework (33)*. These resources are designed for use by individual HCFs to obtain a situation analysis of hand hygiene practices and develop action plans for continuous improvement.

Personal protective equipment

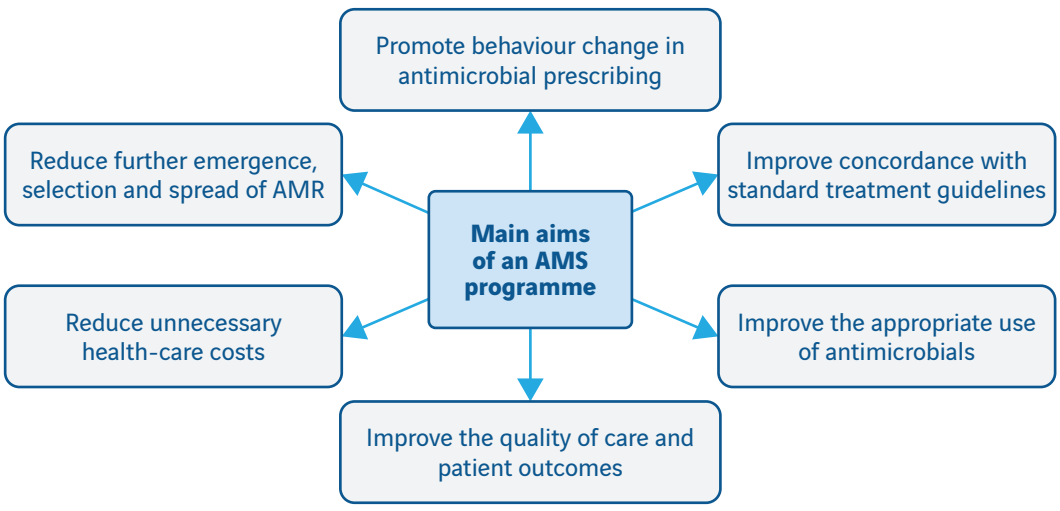
The rational, correct and consistent use of PPE helps reduce the spread of pathogens. PPE may be used as part of standard precautions when there is a risk of contamination from blood or body fluids, or as part of TBPs where particular PPE is required to prevent transmission of infections according to the mode of transmission.

Selection of PPE must be based on an assessment of the risk of transmission of microorganisms to the HCW and patients. Staff must be trained in selection and use of PPE, particularly how to put on and remove PPE correctly. Indications for when to use different types of PPE are detailed in Annex 10.

Key component 3: Antimicrobial stewardship

In order to be prepared for and potentially to prevent the emergence, selection and spread of AMR, HCFs should have an AMS programme in place *(33)*. A robust and effective AMS programme will help a facility to respond to an outbreak situation by rapidly implementing the necessary measures to help reduce the extent and duration of the outbreak. The main aims of an AMS programme are outlined in Fig. 11.

Fig. 11. Main aims of an AMS programme at the HCF level



Core components of AMS

The essential core elements of an AMS programme *(34)* are summarized in Annex 11. It highlights that AMS providers should be responsible for the development of standard treatment guidelines and provide ongoing education of doctors, nurses, pharmacists, microbiologists and laboratory staff regarding AMR, AMS and the optimal use of antimicrobials. This should include regular training sessions to keep pace with changes in AMS practices and staff turnover.

At a minimum, each facility should develop an antimicrobial formulary, a list of antimicrobials available, including those suggested in WHO's *Model list of essential medicines (35)* or any national EML. This formulary should ideally include restriction policies, so that certain antibiotics require approval by the designated AMS champion, based on the WHO AWaRe classification, which classifies these into three groups (Access, Watch and Reserve), with recommendations on when to use the antibiotics in each category *(10)*.

Ideally, the clinical microbiology laboratory should produce local antibiograms. These are tables of antimicrobial susceptibility results, grouped by pathogen and used to help create and update standard treatment guidelines, aid in developing the antimicrobial formulary, and inform specific AMS interventions. They will also track changes in susceptibility over time, which will help to identify local outbreaks. WHONET *(36)* is a software programme available from WHO that can assist in the development of cumulative antibiograms.

Key component 4: Environmental cleaning and management

The role of the environment in the transmission of HAIs, including AMR pathogens, has been well established *(37,38)*, with major outbreaks of AMR pathogens associated with environmental contamination *(39)*. Studies have shown that a patient has an increased risk of acquiring an AMR pathogen if the previous room occupant was colonized or infected with one *(40)*.

A patient colonized or infected with an AMR pathogen can contaminate environmental surfaces or equipment/items. These microorganisms can then be transferred to other patients in two ways:

- through the patient's direct contact with contaminated surfaces or equipment; and
- indirectly via hands that have come into contact with contaminated surfaces or equipment and then touch the patient.

As such, environmental cleaning and disinfection are essential components for reducing the risk of transmission of AMR pathogens.

Effective cleaning and disinfection occurs in two parts:

1. the physical removal of foreign materials (such as dust and soil) or organic matter (such as blood and bacteria), usually using products containing detergents, followed by;
2. disinfection (inactivation of microorganisms by exposure to chemicals) using products containing disinfectants *(39)*.

These two steps can be combined by using products containing both detergents and disinfectants.

In addition to routine cleaning, WHO guidelines recommend effective environmental cleaning of the immediate surrounding areas of patients colonized or infected with AMR pathogens *(41)*. Once patients with AMR pathogens are discharged, their room or bed-space should be cleaned more intensively (terminal or discharge cleaning and disinfection). This should include replacement of privacy curtains and steam cleaning of soft furnishings where possible.

The *Best Practices for Environmental Cleaning in Healthcare Facilities: in Resource Limited Settings* document outlines the key programme elements for effective environmental cleaning programmes *(39)*, and how these fit within the WHO core components of an IPC programme. A summary of effective

environmental cleaning is outlined in Annex 12. The elements of best-practice cleaning and disinfection programmes are outlined in Table 12.

Table 12. Best-practice cleaning and disinfection programmes

Programme element	Description
Organization and infrastructure	• Designated supervisor(s) reporting to hospital administration and IPC team and/or the ICC. • Appropriate design/engineering/construction and cleaning and disinfection supplies. • A resourced WASH programme.
Staff	• Adequate staffing, with uninterrupted cleaning time for staff also required to perform other roles. • Training of cleaning staff to understand general IPC principles, how to clean and disinfect and product use (e.g. required contact time for disinfectant).
Procedures and processes	• Clear policies and procedures for cleaners and other health-care staff who may be required to clean equipment (e.g. shared patient equipment). • Appropriate posters/charts showing correct dilution and use of products, particularly disinfectants. • Monitoring, feedback and audit processes to ensure adherence to cleaning protocols and standards.

Key component 5: Surveillance for AMR

To facilitate timely identification of potential AMR outbreaks, methods and systems for in-facility surveillance of AMR pathogens should be developed. These could include:

- routine collection and analysis of indicator-based surveillance data
- reporting of unusual events by clinical, laboratory or other staff.

Monitoring of routine surveillance data

Monitoring of routine surveillance data may occur at both the hospital and/or national level, where the facility participates in an external surveillance system. Monitoring of surveillance data must be rapid and precise in order to facilitate the identification of potential outbreaks. Channels must exist to facilitate communication of suspected outbreaks to the HCF, in the case of analyses performed elsewhere, and to the ICC, facility administration and regional health authorities. Such channels should be defined within the hospital's surveillance and OMPs and, where applicable, national or subnational surveillance plans.

Monitoring of formal surveillance data should be alert to identify:

- changes in facility-wide trends in resistance patterns and/or incidence of pathogens of concern (core); and
- changes in resistance patterns and/or incidence of AMR pathogens in defined patient populations, such as within certain wards, units or those undergoing specific treatments and procedures.

Routine analyses should include, at a minimum, examination of temporal trends in organism frequencies and proportion resistant through graphs and descriptive statistics. Automatic generation of such summary reports, as well as alerts for the detection of potential spatial and temporal clusters, can be

implemented through WHONET and WHONET-SaTScan *(36)*. Any identification of a larger number of people than expected who appear to have a particular resistance, resistance pattern or AMR pathogen in a given time period, area or population should be reported to the ICC for investigation and follow-up.

Event-based reporting

Early detection of outbreaks in a health-care setting often occurs through observations of treating clinicians and/or laboratory testing staff. It is critical that communication channels for such observations are known by relevant staff to enable timely investigation and response by the ICC and/or OMT. It is recommended that a simple event-based surveillance system is in place within the hospital to ensure such reports are received and recorded and that actions are auditable. See Box 8 for examples of how event-based surveillance reports may be generated.

Box 8. Examples of event-based surveillance reports

Example 1 – Ad hoc event reporting

- Ad hoc reporting to ICC by laboratory staff of five patients with carbapenem inactivation method-positive *K. pneumoniae* from different sample types, collected while they were inpatients on the same ward over a six-month period.

Example 2 – Systematic event reporting

- Completion of the following form as part of a formalized intra- or inter-hospital event-based surveillance programme *(42)*:

Cluster or Event Report Form Please send this form to <ICC, or other details as appropriate>		
1	Date (today's date)	21/03/2020
2	What do you want to report? What happened?	We have noticed an increase in patients with MRSA in blood cultures in the ICU over the past few weeks
3	When did this happen? (Month, day, year)	March 2020
4	Where did this happen? (e.g. ward, facility, clinic)	ICU
5	How many have been affected?	Unknown; at least 10 patients
6	Has anyone died? How many?	No
7	Has any laboratory testing been performed or requested and, if so, where?	Yes, hospital laboratory
8	Other information you have (e.g. clinical presentation, known contact between cases or other similarities)	Observed patients have had *S. aureus* (MRSA) isolated from blood cultures
9	What is your name and your contact details?	John Lee, nurse unit manager, ICU

Key component 6: Education

Education of staff about IPC policies and practices is an essential step towards successful implementation of IPC in an HCF. The IPC focal point or team should receive IPC-specific training to be able to train others. If the expertise of the IPC focal point is limited, external support should be sought, for example, at the regional or national level.

WHO has described the core competencies for IPC professionals in *Core Competencies for Infection Prevention and Control Professionals (43)*. The purpose of this document is to define who an IPC professional is and identify what core competencies are needed to be qualified in this discipline and at what level (that is, junior versus senior). It can be used to support the achievement of the specific expertise and competencies of IPC professionals needed at the national and facility levels.

To maintain a high level of expertise, it is important that all IPC professionals pursue continuing education to achieve a higher level of knowledge, develop new skills and keep up to date with current IPC practices. The WHO document can be used by health-care organizations as a guide for identifying the training and education needs of their IPC professional staff. A list of existing training courses and certificates provided by organizations participating in WHO's Global Infection Prevention and Control Network is available on WHO's website *(44)*. Courses cover from basic to advanced IPC concepts and may be available online and/or in person.

The IPC team is also responsible for training front-line HCWs, cleaners, and non-clinical or auxiliary staff in IPC guidelines and practices at the start of their employment. This includes training on infection risks, PPE use, aseptic technique, cleaning shared equipment, and standard precautions and TBPs, among other topics.

Ideally, IPC education should be incorporated into the pre-service curricula of all health-care occupations. Health services should also provide IPC training at commencement of employment to orientate new staff to local IPC practices such as PPE used and provide refresher training on a regular basis, for example annually. Where adherence to IPC precautions has been found to be substandard or particular practices have been identified that are not compliant with standard infection control requirements, targeted education sessions should be conducted to address such issues in as timely manner as possible.

Patients and visitors should also be educated about basic IPC, such as hand hygiene, to limit the spread of AMR pathogens across clinical areas. This is particularly important when there is a patient watcher or companion who spends long periods of time with a patient. They should be provided with information and education about appropriate IPC practices.

5. Potentially available human resources to support AMR outbreak response

When there is an outbreak caused by an AMR pathogen, HCFs need to deal with a wide range of tasks. These include risk assessment, epidemiological investigation, case management, strengthening IPC and risk communication. It is often difficult to undertake all these tasks with only the human resources and expertise available at the facility. It is important to consider obtaining support from HCWs or professionals with expertise from outside of the facility, for example, from nearby HCFs or local public health authorities.

This section introduces other potentially available support for an outbreak response with AMR pathogens. This includes the Field Epidemiology Training Programme (FETP) and internationally available resources such as the GOARN or support from WHO collaborating centres and other institutions. If interested in obtaining support from international experts including GOARN or the WHO collaborating centres, consult with the WHO country office or country liaison office via a focal point in the government.

5.1 FIELD EPIDEMIOLOGY TRAINING PROGRAMME (FETP)

Many countries and areas in the Western Pacific Region have set up the FETP or a modified programme, which may be able to support outbreak responses. The FETP trains field epidemiologists who can take rapid and appropriate actions to assess the risk and investigate the cause of infectious diseases at the time of an epidemic or outbreak. They can also contribute to the maintenance and improvement of high-quality surveillance systems for infectious diseases.

The following countries and areas in the Region have established FETP programmes: Australia, Brunei Darussalam, Cambodia, China, Hong Kong (China), Japan, the Lao People's Democratic Republic, Malaysia, Mongolia, Papua New Guinea, the Philippines, the Republic of Korea, Singapore and Viet Nam. They may be available upon request to support an outbreak response.

Indeed, FETP fellows or alumni have been deployed to support outbreak responses due to AMR pathogens. In 2019, Cambodia, Japan and the Republic of Korea reported one, seven and 33 outbreaks respectively, where FETP fellows or alumni were deployed. Box 9 illustrates the deployment of FETP graduates to support the investigation of an infection.

Box 9. Case Study 4: Deployment of FETP graduates to support investigation of *K. pneumoniae* infections

This outbreak was reported by the media following the release of a statement by a provincial government. Eleven neonates were reported to have died as a result of drug-resistant *K. pneumoniae* infections in the neonatal ward, in addition to another 35 deaths in other parts of the hospital. WHO deployed a team of four investigators including physicians, pathologists and FETP graduates to conduct the outbreak investigation. Investigations revealed that cases of sepsis and fatality, for which the *Klebsiella* infection was one of the causes, had significantly increased over a six-month period when compared to the previous two years. Further investigation confirmed the existence of HAI in the special care nursery and other wards. Although the exact source of the outbreak was not found, issues identified as contributing to HAI transmission included: the special care nursery was overcrowded; general hygiene in all wards was poor; poor IPC practices; and poor-quality water supply to the hospital. Recommendations were made by the investigating team to correct identified gaps.

5.2 GLOBAL OUTBREAK ALERT AND RESPONSE NETWORK (GOARN)

GOARN is a WHO network of over 250 technical institutions and networks globally that respond to acute public health events with the deployment of staff and resources to affected countries. Coordinated by an operational support team based at WHO headquarters in Geneva and governed by a steering committee, GOARN aims to deliver rapid and effective support to prevent and control infectious disease outbreaks and public health emergencies when requested. If international support is needed, deployment of experts from GOARN may be an option.

5.3 SUMMARY OF INFORMATION ON THE OUTBREAK

If experts from outside of the facility are invited, summarizing the information on the outbreak prior to their arrival is desirable and will facilitate their support. For example, developing a line list (see Annex 4 for an example) will be helpful for the expert(s) as well as for the outbreak response team to gain an overview of the outbreak.

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Annexes

ANNEX 1. PROVISIONAL WATCH LIST FOR THE GLOBAL ANTIMICROBIAL RESISTANCE SURVEILLANCE SYSTEM (GLASS) EMERGING ANTIMICROBIAL RESISTANCE (GLASS-EAR) REPORTING FRAMEWORK *(10)*

AMR pathogens on GLASS-EAR watch list	Definition
Pandrug-resistant phenotypes and, wherever available, responsible genes	Non-susceptibility to all agents in all antimicrobial categories[a]
Extensively drug-resistant (XDR) phenotypes that were not previously detected in a country and, wherever available, responsible genes	Non-susceptibility to at least one agent in all but two or fewer antimicrobial categories[a]
Novel genetic determinants of disease	Not previously reported globally
Defined critical resistance phenotypes	Including, wherever available, responsible genes
Shigella spp.	Extended-spectrum cephalosporin-R **or** carbapenem-NS
Salmonella spp.	Fluoroquinolone-NS **and** third-generation cephalosporin-NS **and** azithromycin-NS **or** carbapenem-NS
Neisseria gonorrhoeae	Ceftriaxone-NS **or** high-level azithromycin-R
Neisseria meningitidis	Ampicillin- or penicillin-R **or** extended-spectrum cephalosporin-NS **or** meropenem-NS **or** minocycline-NS **or** fluoroquinolone-NS
Haemophilus influenzae	Extended-spectrum cephalosporin-NS **or** carbapenem-NS
Enterobacteriaceae	XDR including colistin-R
Non-fermenting bacteria (e.g. *Pseudomonas aeruginosa, Acinetobacter* spp.)	XDR including colistin-R
Enterococcus spp.	VRE daptomycin-NS **or** linezolid-R **or** telavancin, dalbavancin, oritavancin NS
Staphylococcus aureus	Vancomycin-R **or** telavancin-NS **or** dalbavancin-NS **or** oritavancin-NS **or** tigecycline-NS **or** daptomycin-NS **or** linezolid-R
Staphylococcus, coagulase-negative	Vancomycin-R **or** telavancin-NS **or** dalbavancin-NS **or** oritavancin-NS **or** daptomycin-NS **or** linezolid-R
Streptococcus pneumoniae	Linezolid-R **or** vancomycin-NS
Streptococcus, β-haemolytic group	Ampicillin- or penicillin-NS **or** extended-spectrum cephalosporin-NS **or** daptomycin-NS **or** carbapenem-NS **or** linezolid-R **or** vancomycin-NS
Clostridium difficile	Vancomycin-R Metronidazole-R
Bacteroides spp.	Metronidazole-R Carbapenem-R
Candida auris	Any isolation of this species

[a] Refer to Magiorakos A-P, Srinivasan A, Carey RB, Carmeli Y, Falagas ME, Giske CG, et al. Multidrug-resistant, extensively drug-resistant and pandrug-resistant bacteria: an international expert proposal for interim standard definitions for acquired resistance. Clin Microbiol Infect [Internet]. 2012;18(3):268–81 (available from: http://www.ncbi.nlm.nih.gov/pubmed/21793988).

ANNEX 2. EXAMPLES OF DECOLONIZATION PROTOCOL FOR METHICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS* (MRSA) *(45,46)*

Example 1

- Bathe daily with 4% chlorhexidine
- Chlorhexidine mouthwash (0.12%) twice daily
- Mupirocin nasal ointment twice daily
- All administered for five days, twice per month for six months

Example 2

- Bathe daily with chlorhexidine or povidone-iodine soap
- Mupirocin nasal ointment three times daily
- Hygienic measures – clean underwear, clothing, washcloths and towels daily, and change bedclothes every other day during treatment
- All administered for five days

ANNEX 3. CHECKLISTS FOR RESPONDING TO AN AMR OUTBREAK

Checklist for the 10 steps to investigate and respond to an AMR pathogen outbreak

STEP 1: Recognize and confirm AMR outbreak (page 15 of the main guidance document)

STEPS	ACTIONED
There is a potential AMR outbreak requiring further investigation:	
• Surveillance data indicate increased number of cases of an AMR pathogen	☐ Yes ☐ No
• Notification received from laboratory of an AMR pathogen of significance (see Section 2.2 of the main document)	☐ Yes ☐ No
Further review of available data sources over a comparable time period has been undertaken (see Table 2)	☐ Yes ☐ No ☐ N/A
There is another explanation for increased number of cases (e.g. changes in lab testing or reporting)	☐ Yes ☐ No ☐ N/A
A risk assessment has been conducted (see Section 2.1)	☐ Yes ☐ No
Hospital management has been notified of outbreak	☐ Yes ☐ No

STEP 2: Assemble outbreak management team (OMT) (page 17)

STEPS	ACTIONED
OMP is activated (see Section 3.2) with oversight by the OMT	☐ Yes ☐ No ☐ N/A
Membership of the OMT has been determined and roles assigned (see Annex 6)	☐ Yes ☐ No
Relevant health authorities have been notified of the outbreak (see Section 2.6)	☐ Yes ☐ No ☐ N/A
OMT has determined that further assistance/resources is/are required to manage the outbreak	☐ Yes ☐ No
• Request has been put to local public health authority	☐ Yes ☐ No ☐ N/A
• Request has been put to NCC or NRL	☐ Yes ☐ No ☐ N/A

STEP 3: Establish case definition (page 17)

STEPS	ACTIONED
Case definition is established and includes:	
• well-defined clinical symptoms or laboratory findings	☐ Yes ☐ No
• a time period in which cases could have occurred	☐ Yes ☐ No
• the people affected by the outbreak	☐ Yes ☐ No
• the place or location where the outbreak has occurred/is occurring	☐ Yes ☐ No

N/A = not applicable

STEP 4: Implement case finding (page 18)

STEPS	ACTIONED
Case definition has been communicated to relevant clinical and laboratory staff	☐ Yes ☐ No
Review of laboratory, clinical and surveillance data undertaken to identify further cases	☐ Yes ☐ No ☐ N/A
To detect the AMR outbreak pathogen, the laboratory is:	
• screening clinical samples more widely	☐ Yes ☐ No ☐ N/A
• using suitable rapid detection methods (see Box 6)	☐ Yes ☐ No ☐ N/A

STEP 5: Create a line list and epidemiologic curve (page 20)

STEPS	ACTIONED
A line list has been collated using the case definition (see Annex 4)	☐ Yes ☐ No
Epidemiologic curve has been created using the line list (current cases) and historical data (see Annex 5)	☐ Yes ☐ No
Line list and epidemiologic curve are updated if case definition is changed	☐ Yes ☐ No ☐ N/A

STEP 6: Collect case data, characterize outbreak and generate hypotheses (page 21)

STEPS	ACTIONED
IPC focal point/team has been to the affected area(s) and conducted the following:	
• observed staff compliance with IPC practices	☐ Yes ☐ No
• looked for possible common vehicle sources	☐ Yes ☐ No
• interviewed staff	☐ Yes ☐ No
All data collected have been reviewed to identify possible links	☐ Yes ☐ No
A hypothesis for transmission has been generated	☐ Yes ☐ No

STEP 7: Consider further investigations (page 22)

STEPS	ACTIONED
Environmental contamination is suspected, and environmental samples are to be collected	☐ Yes ☐ No ☐ N/A
• local laboratory can process environmental samples	☐ Yes ☐ No ☐ N/A
• local laboratory cannot process samples – advice from the NRL has been sought	☐ Yes ☐ No ☐ N/A
An epidemiologist has been consulted to determine whether an analytical epidemiological study is required to test hypotheses	☐ Yes ☐ No ☐ N/A

N/A = not applicable

STEP 8: Implement control measures (page 24)

STEPS	ACTIONED
Enhanced IPC measures have been implemented (see Table 5)	☐ Yes ☐ No
• appropriate patient placement (e.g. single room with own bathroom)	☐ Yes ☐ No ☐ N/A
• TBPs have been implemented for all cases (e.g. contact precautions)	☐ Yes ☐ No ☐ N/A
• there are sufficient supplies of PPE and other consumables (e.g. hand hygiene products)	☐ Yes ☐ No ☐ N/A
• there is appropriate signage to alert staff/visitors to IPC measures	☐ Yes ☐ No ☐ N/A
• patient movement is limited and, where required, other clinical areas or health services are advised of patient AMR status prior to transfer	☐ Yes ☐ No ☐ N/A
• limiting ward activity or ward closure has been considered, if transmission is ongoing	☐ Yes ☐ No ☐ N/A
• monitoring/auditing of standard and enhanced IPC practices	☐ Yes ☐ No ☐ N/A
Enhanced environmental cleaning has been implemented	☐ Yes ☐ No ☐ N/A
Additional screening strategies have been implemented	☐ Yes ☐ No ☐ N/A
• point-prevalence screening (e.g. weekly)	☐ Yes ☐ No ☐ N/A
• admission screening	☐ Yes ☐ No ☐ N/A
• discharge screening	☐ Yes ☐ No ☐ N/A
AMS practices have been reviewed	☐ Yes ☐ No ☐ N/A
• antimicrobial formulary	☐ Yes ☐ No ☐ N/A
• restriction policies	☐ Yes ☐ No ☐ N/A
• treatment guidelines	☐ Yes ☐ No ☐ N/A
A communications plan has been developed	☐ Yes ☐ No ☐ N/A
Communications materials have been developed (e.g. pamphlets or discharge letters)	☐ Yes ☐ No ☐ N/A
Education and training sessions have been implemented for staff	☐ Yes ☐ No ☐ N/A

STEP 9: Review and perform follow-up investigations (page 25)

STEPS	ACTIONED
All suggested interventions have been implemented successfully	☐ Yes ☐ No
• if no, barriers have been identified	☐ Yes ☐ No ☐ N/A
Case numbers have decreased or gone back to baseline	☐ Yes ☐ No
• if no:	
o case definition has been reviewed	☐ Yes ☐ No ☐ N/A
o steps 4–8 have been reviewed	☐ Yes ☐ No ☐ N/A
o consideration has been given to inviting external experts for review	☐ Yes ☐ No ☐ N/A

N/A = not applicable

STEP 10: Review response and communicate results (page 26)

STEPS	ACTIONED
Debrief conducted for affected ward/unit to provide feedback	☐ Yes ☐ No ☐ N/A
OMT has conducted a post-outbreak review and evaluation	☐ Yes ☐ No ☐ N/A
OMP has been reviewed and updated as required	☐ Yes ☐ No ☐ N/A
Outbreak report has been completed with recommendations made to prevent future outbreaks	☐ Yes ☐ No ☐ N/A
Outbreak report has been tabled at appropriate committee(s)	☐ Yes ☐ No ☐ N/A

Checklist for local public health authority

Local public health unit	Actioned
A focal point has been assigned and regular communication established with the health-care service	☐ Yes ☐ No
The health-care service has been advised of reports or actions required to be undertaken for local guidance/regulations	☐ Yes ☐ No ☐ N/A
The request from the health-care service is appropriate in the current situation	☐ Yes ☐ No
Request for additional resources or support has been received from a health-care service for: o epidemiologist or personnel with epidemiological training o laboratory or additional isolate typing (e.g. WGS) o IPC consultant or personnel with IPC expertise o consumables or other funded resource requirements (e.g. PPE)	 ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A
Response has been provided to health-care service about which resources can be provided locally	☐ Yes ☐ No ☐ N/A
Based on a risk assessment, reporting to higher/NCC is necessary for reporting purposes or for additional resources determined to be required which cannot be provided locally (see Fig. 4)	☐ Yes ☐ No ☐ N/A

Checklist for national coordinating centre or equivalent

National coordinating centre	Actioned
A focal point has been assigned and regular communication established with the local public health authority	☐ Yes ☐ No
The local public health authority has been advised of reports or actions required to be undertaken for national guidance/regulations	☐ Yes ☐ No ☐ N/A
The capacity of the local public health authority is sufficient to support the health-care service	☐ Yes ☐ No
The request from the local public health authority is appropriate in the current situation	☐ Yes ☐ No ☐ N/A
Request for additional resources or support has been received from a local public health authority or health-care service for: • epidemiologist or personnel with epidemiological training • laboratory or additional isolate typing (e.g. WGS) • IPC consultant or personnel with IPC expertise • consumables or other funded resource requirements (e.g. PPE)	 ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A ☐ Yes ☐ No ☐ N/A
There is a need to request support from WHO office or other external partners for additional resources determined to be required that cannot be provided in-country	☐ Yes ☐ No

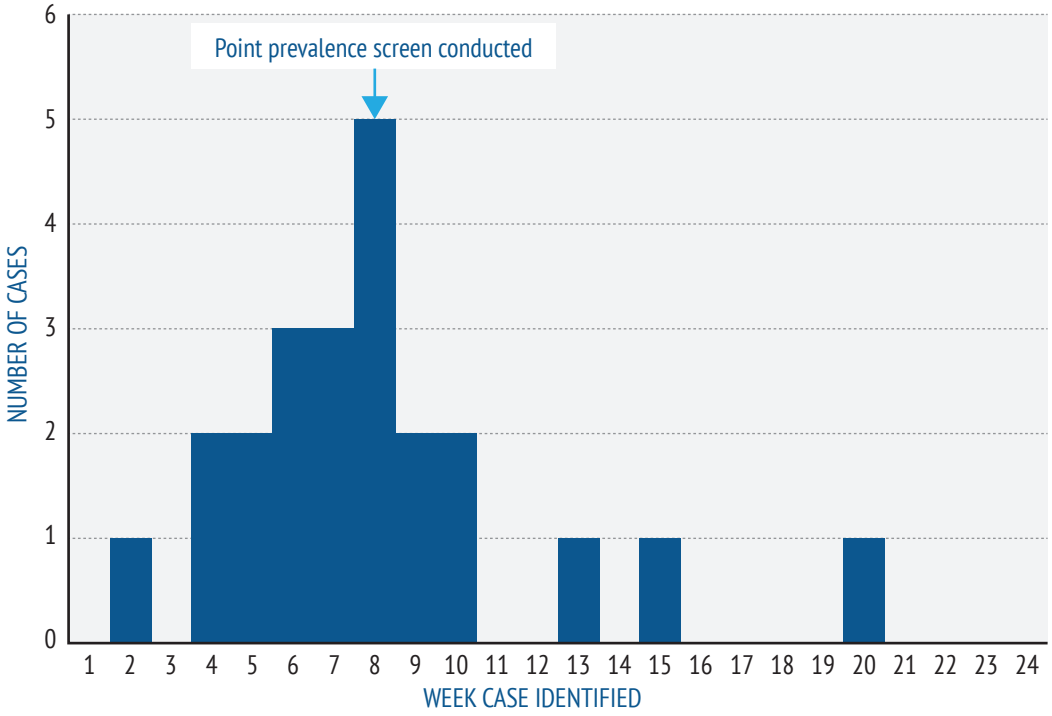
N/A = not applicable

ANNEX 4. EXAMPLE OF A LINE LIST FOR AMR PATHOGEN OUTBREAK INVESTIGATIONS

ID/case number	1	2	3	4	5
Patient hospital ID number					
Name (last, first)					
Age					
Sex/gender					
Ward/unit					
Attending physician					
Admission details					
Comorbidities					
Date of admission					
Date of discharge					
Infection caused by AMR pathogen					
AMR pathogen					
Date of isolate					
Clinical specimen					
Pattern of drug resistance					
History of antimicrobial use (dose, start and end dates)					
Previous health-care or long-term care admission/discharge dates					

ANNEX 5. EXAMPLE OF AN EPIDEMIOLOGIC CURVE FOR AN AMR PATHOGEN OUTBREAK INVESTIGATION

Epidemiologic curve *Acinetobacter baumannii* OXA-48 isolates in ICU

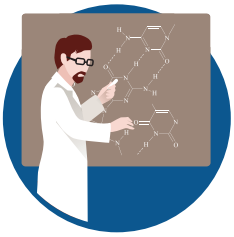


ANNEX 6. OUTBREAK MANAGEMENT TEAM ROLES AND RESPONSIBILITIES

Roles and responsibilities outlined below are a guide only. Roles and responsibilities may be allocated to other personnel within the OMT according to availability, expertise or resources. Where an OMT does not have access to a particular member or expert (for example, an epidemiologist), their role and responsibilities should be allocated to other members.

Role	Responsibilities
 **Health service executive**	• Convenes and chairs the OMT meetings. • Determines the composition of the OMT based on the size and nature of the outbreak. • Ensures all members of the OMT are clear about their roles and responsibilities. • Facilitates access to or funding for additional resources that may be required, e.g. staff, PPE or laboratory consumables. • Ensures that OMP actions are implemented within defined timeframes. • Ensures that a final outbreak report is completed and appropriately disseminated. • Ensures that external help is obtained if required. • Communicates with health facility executive on outbreak situation, measures implemented and outcomes and/or reports. • Ensures that comprehensive communication has taken place within the health facility and more broadly as required.
 **IPC focal lead or designated person with IPC experience**	• Conducts risk assessments to determine factors that may be contributing to AMR pathogen transmission. • Assists in determining and implementing appropriate outbreak measures or interventions. • Assists in development of case definition. • Maintains line list of cases. • Identifies contacts, coordinates screening and maintains a record of results. • Assists ward/unit managers to determine education and training needs and provides/facilitates such requirements. • Monitors/audits interventions to determine compliance. Reports results and provides feedback as required. • Assists with patient placement, e.g. prioritizes single rooms or determines whether cohorts of patients are required based on risk assessment. • Coordinates preparation of final outbreak report. • Implements any active surveillance protocols.

Role	Responsibilities
 **Manager/clinical representative from the affected area(s)**	• Informs and advises ward/area staff, including allied health professionals, of the outbreak as required. • Ensures that actions or interventions are implemented in the area. • Determines whether extra resources are required: e.g. nursing staff or additional PPE, and orders/organizes for them to be provided. • Facilitates collection of data: e.g. bed movement data and close contact details. • Facilitates additional screening activities: e.g. point-prevalence screen. • Consults with infectious disease physicians regarding appropriate treatment therapies. • Restricts/improves antibiotic use as required. • Communicates with affected families and carers. Determines whether further advice/communication is required, e.g. with infectious disease physician. • Reports on implementation of outbreak control measures locally and any difficulties in managing the outbreak.
 **Infectious disease physician**	• Communicates with relevant medical colleagues to ensure they are aware of the outbreak and its significance for their clinical area. • Assists in the development of case definition. • Makes recommendations regarding appropriate treatment therapies and/or decolonization regimes for cases. • Advises re. antibiotic use (restriction and/or other recommendations) as required. • Assists with determining screening strategies: e.g. point-prevalence screen.
 **Clinical microbiologist**	• Ensures laboratory capacity to conduct extra screening as required. • Provides advice on appropriate sample collection method and interpretation of clinical and environmental sample results. • Makes recommendations regarding appropriate treatment therapies and/or decolonization regimes for cases. • Implements laboratory protocols for storage and further testing as required. • Refers samples to public health laboratory as required for further or specialized testing, e.g. WGS. • Provides clinicians with antimicrobial susceptibility reports to guide antimicrobial prescribing.

Role	Responsibilities
 **Environmental or support services**	• Ensure that cleaning protocols and guidelines are fit for purpose. • Ensure sufficient supplies of cleaning products and equipment. • Intensify and reinforce training of cleaning staff. • Monitor/audit cleaning performance. Report results and provide feedback as required. • Ensure appropriate waste management in accordance with local protocols.
 **Epidemiologist**	• Assists in the development of case definition. • Develops a methodology for case finding. • Develops a protocol for active surveillance measures. • Collects and analyses data. • Designs epidemiologic curves for reporting of data. • Assists in determining whether further data collection is required.
 **Public health physician**	• Ensures that any public health implications are identified and managed. • Liaises with public health authorities as required.
 **Media relations officer**	• Assists with preparation of communication materials for staff, patients, families/carers and the public as required. • Prepares holding statements. • Clarifies the need for statements to be released to the press. • Liaises with public health or ministry of health communications lead before release of public statements. • Manages press or public requests for information.

ANNEX 7. EXAMPLE OUTBREAK CASE DEFINITION AND DATA COLLECTION FORM

Using the situation described in Case Study 3, the following is an example of a case definition and suggested data collection form.

Case definitions

Confirmed case:
Any patient treated in the paediatric clinic with the ESBL-*K. pneumoniae* outbreak strain detected since <relevant date> in any clinical or surveillance sample.

Probable case:
Any patient treated in the paediatric clinic with any ESBL-*K. pneumoniae* detected since <relevant date> in any clinical or surveillance sample, where a bacterial isolate is not available for further typing as the outbreak strain.

Case data collection form

Note: Data collection should be tailored to the setting, pathogen and population.

ESBL-*K. pneumoniae* outbreak data collection form

Case ID:_____ ☐ Confirmed ☐ Probable

Date reported: ____/_____/____

Data collection period: ____/____/____ to ___/____/____

Patient details

Name
Given: _____ Family: _____

ID number: _____ Date of Birth: ____/____/____

Sex: ☐ Male ☐ Female ☐ Other, specify_____

Location at time of data collection:

☐ inpatient, ward_____ ☐ discharged home

☐ transferred to another facility, name_____

☐ deceased, cause _____

If not inpatient, date discharged ____/____/____

Maternal details

Name
Given: _____ Family: _____

ID number: _____ Date of Birth: ____/____/____

Address: _____

_____

Mother screened for outbreak organism:

☐ Yes ☐ No : date tested:____/____/____

Result: _____

Gravidity: _____ Parity: _____

Clinical details (ESBL *K. pneumoniae identification*)

Clinical presentation:

☐ infection ☐ colonization ☐ unknown significance

If infection, source:

☐ urinary tract ☐ intra-abdominal ☐ surgical site

☐ skin or soft tissue

bacteremia: ☐ indwelling device ☐ without obvious focus

☐ Other, specify_____

Antimicrobial therapy for this infection: ☐ Yes ☐ No

Signs and symptoms or infection

Sign/symptom	Onset date

If patient deceased, was infection contributory to death:

☐ Yes, primary ☐ Yes, contributory ☐ No ☐ Unk

Risk factors

Gestation at birth: _____ Birth weight: _____

APGAR score: _____

☐ singleton ☐ multiple birth, specify:_____

Complications of pregnancy and/or birth:

_____

_____

_____

Neonatal surfactant use: ☐ No ☐ Yes,
date administered ____/___/____

Adj. age at diagnosis: _____ Weight at diagnosis: _____

Comorbid conditions: _____

_____

_____

Indwelling medical devices

Device	Date inserted	Date removed

Procedures (invasive, non-invasive, including point of care testing or manipulations)

Type of procedure	location (e.g. bedside, OR)	Date

Type of procedure	location (e.g. bedside, OR)	Date

Page ___ of ____

ESBL-*K. pneumoniae* outbreak data collection form

Case ID:_______________

Page ___ of ____

Data collection period: ____/____/____ to ___/____/____

Microbiological testing

Sample identfier	Sample source Reason for sample collection	Collection date	Organism characterization	Antimicrobial susceptibility testing
	Source: ☐ Screen ☐ Clinically indicated		Organism: ____________ MLST: __________ ☐N/T O/B strain (WGS): ☐Y ☐N ☐N/T	Results: ESBL gene(s): ________ ☐N/T
	Source: ☐ Screen ☐ Clinically indicated		Organism: ____________ MLST: __________ ☐N/T O/B strain (WGS): ☐Y ☐N ☐N/T	Results: ESBL gene(s): ________ ☐N/T
	Source: ☐ Screen ☐ Clinically indicated		Organism: ____________ MLST: __________ ☐N/T O/B strain (WGS): ☐Y ☐N ☐N/T	Results: ESBL gene(s): ________ ☐N/T
	Source: ☐ Screen ☐ Clinically indicated		Organism: ____________ MLST: __________ ☐N/T O/B strain (WGS): ☐Y ☐N ☐N/T	Results: ESBL gene(s): ________ ☐N/T
	Source: ☐ Screen ☐ Clinically indicated		Organism: ____________ MLST: __________ ☐N/T O/B strain (WGS): ☐Y ☐N ☐N/T	Results: ESBL gene(s): ________ ☐N/T
	Source: ☐ Screen ☐ Clinically indicated		Organism: ____________ MLST: __________ ☐N/T O/B strain (WGS): ☐Y ☐N ☐N/T	Results: ESBL gene(s): ________ ☐N/T

Bed and ward movement

Please supply electronically or record below

Ward	Room	Bed	Date admitted	Date discharged

Ward	Room	Bed	Date admitted	Date discharged

Additional observational infection control and/or environmental screening data may also be captured.

N/T: not tested, MLST: Multilocus sequence typing

ANNEX 8. WHO INFECTION PREVENTION AND CONTROL (IPC) CORE COMPONENTS AND FACILITY-LEVEL MINIMUM REQUIREMENTS FOR IPC PROGRAMMES

IPC core component	Minimum requirements
IPC programmes	• At least one full-time trained IPC focal point (nurse or doctor) with dedicated time to carry out IPC activities (aiming for a ratio of 1:250 beds). • Dedicated budget for IPC implementation. • Access to microbiology laboratory. • Programme aligned with national IPC guidelines.
IPC guidelines	• Standard and TBPs (e.g. detailed SOPs for prevention of airborne pathogen transmission). • Aseptic technique for invasive procedures. • Specific SOPs to prevent the most prevalent HAIs based on local context/ epidemiology. • Occupational health (specific detailed SOPs).
IPC education and training	• IPC education for all front-line clinical staff and cleaners upon hiring (and annually if possible). • IPC-specific training for IPC staff.
HAI surveillance	• Secondary care: HAI surveillance in accordance with national guidelines. • Tertiary care: active surveillance for HAIs (including AMR pathogens). • Includes enabling structures/resources (e.g. laboratories, medical records, trained staff). • Methods directed by priorities of facility and/or country. • Timely and regular feedback to key stakeholders (especially administration) to enable appropriate action.
Multimodal strategies	• Use multimodal strategies to improve each one of the standard and TBPs, triage, and those targeted at reduction of specific infections (e.g. surgical site infections or catheter-associated infections) in high-risk areas/patient groups.
Monitoring, auditing and feedback	• Identify a person responsible for conducting periodic or continuous monitoring of selected indicators for process and structure, informed by priorities of facility and/or country. • Hand hygiene is an essential process indicator to be monitored. • Timely and regular feedback needs to be provided to key stakeholders to lead to appropriate action, especially administration.
Workload, staffing and bed occupancy	• Standardize bed occupancy: establish a system to manage the use of space in the facility and set the standard bed capacity for the facility. Hospital administration to enforce the system developed. No more than one patient per bed, ≥ 1m space between edges of beds, overall occupancy should not exceed the designated total bed capacity of the facility. • Reduce overcrowding: develop a system for patient flow, triage and management of consultations. • Optimize staffing levels: assess appropriate staffing levels, depending on categories identified when using WHO/national tools (national norms on patient/staff ratio) and development.

IPC core component	Minimum requirements
Built environment, materials and equipment for IPC	• Adequate clean drinking water and sanitation facilities, power supply. • Hand hygiene facilities at points of care (ABHR or soap and water). • Appropriate waste disposal, ventilation. • Sufficient supplies and equipment for performing IPC practices. • Dedicated area for decontamination and reprocessing of medical devices according to SOPs. • Availability of single isolation rooms, or at least one room for a cohort of patients with similar pathogens or syndromes.

Adapted from *Minimal requirements for infection prevention and control*. Geneva: World Health Organization; 2019.

ANNEX 9. CORE REQUIREMENTS FOR DIAGNOSTIC MICROBIOLOGY LABORATORIES SERVICING HEALTH-CARE FACILITIES (HCFs)

Category	Core-level requirements	Enhanced activities	Additional activities
Physical requirements	Laboratory space, clear work benches, stable electricity supply, clean water (distilled or filtered), Internet access, separate refrigerators for samples and reagents/media		
Laboratory equipment, reagents and materials	Functioning laboratory equipment with established equipment maintenance programme, adequate supply of reagents and materials (may include in-house media production facilities) with established procurement programme		
Laboratory safety	Occupational health and safety training and supervision, including management of biohazard and chemical risks		
Training and competency	Trained laboratory staff, supervision and management, with ongoing training programmes		Provide training programmes for other regional laboratories
Quality management system	Documentation of SOPs and internal quality control processes	External quality assessment or accreditation	
Data management	Paper-based laboratory data system	Electronic laboratory data system, may be interfaced with AST instrument (e.g. Vitek)	Electronic laboratory data system, interfaced with national system for reporting AMR data
Storage of samples or isolates	Freezer storage of resistant isolates (-20 ^{0}C) with linkage to paper database	Freezer storage of resistant isolates (-20 ^{0}C) with linkage to electronic database	Reliable freezer storage (-80 ^{0}C) with linkage to electronic database
Culture of samples	Manual or automated blood culture	Automated blood culture system Culture of CSF, urine, stool, swabs, respiratory samples, urogenital cultures	
Accurate bacterial identification	Isolate identification using recommended phenotypic methods	Additional identification using automated or semi-automated methods: e.g. MALDI-ToF or Vitek	Molecular methods for specific AMR pathogens: e.g. MRGNs, MRSA, TB

Category	Core-level requirements	Enhanced activities	Additional activities
AMR testing	Perform disk susceptibility testing using SOPs according to the European Committee on Antimicrobial Susceptibility Testing or the Clinical and Laboratory Standards Institute guidelines	Perform susceptibility testing by MIC methods such as gradient diffusion, agar dilution or broth macro/microdilution, additional phenotypic testing for AMR mechanisms, e.g. carbapenemases[b]	Automated susceptibility testing: e.g. Vitek, Phoenix, Microscan Collaborate with NRL or external partners to investigate emerging AMR patterns or methods

[a] Provincial laboratories may perform all core-level functions, with additional activities from the enhanced or additional categories.

[b] Phenotypic testing methods for carbapenemases, e.g. carbapenemase inactivation method (CIM) test *(8)* or CarbaNP.

ANNEX 10. SELECTION AND USE OF PERSONAL PROTECTIVE EQUIPMENT (PPE) BASED ON ROUTE OF TRANSMISSION

PPE indications for standard precautions	Additional indications for PPE based on route of transmission (TBPs)		
	Airborne	Droplet	Contact
Gloves ● Touching blood or body fluids, contaminated surfaces or equipment or mucous membranes and non-intact skin ● Must be changed between contact with different patients, and between tasks on same patient ● Remove immediately after a procedure and perform hand hygiene ● Disposable gloves should not be reused, decontaminated with ABHR or washed with soap and water	As per standard precautions	As per standard precautions	Yes – for all manual contact with the patient, associated devices and immediate environmental surfaces
Fluid-resistant gown or plastic apron ● Protect skin and clothing from contamination during procedures likely to generate splashes or sprays of blood or body fluids ● Remove wet or soiled gowns as soon as possible; do not reuse ● If fluid-resistant gowns are not available, cloth gowns may be used as an alternative, but should be changed when wet, soiled or after contact with patient with an AMR pathogen or their environment; cloth gowns must be laundered between uses	As per standard precautions	As per standard precautions	Yes – when HCW's clothing will have substantial contact with the patient, items in contact with the patient, and/or their immediate environment
Medical mask ● Protect nose and mouth during procedures with risk of blood or body fluid splashes or sprays ● Dispose after use	Not effective (use a respirator)	Yes	As per standard precautions
Respirator (N95, FFP2 or equivalent) ● Not used for routine patient care (only to prevent inhalation of airborne infections) ● Dispose after use	Yes	No	No
Eye protection (goggles or safety glasses) ● Protect eyes from blood or body fluid sprays or splashes ● Dispose if single use; clean and disinfect if reusable	As per standard precautions	As per standard precautions	As per standard precautions

ANNEX 11. CORE ELEMENTS OF AN ANTIMICROBIAL STEWARDSHIP PROGRAMME

Leadership commitment

- AMS identified as a priority area by management
- AMS leadership committee in place with clear terms of reference
- AMS action plan endorsed to ensure appropriate antimicrobial use
- Dedicated and sustainable financial support for the AMS action plan (including salary, training and information technology support)

Accountability and responsibilities

- Multidisciplinary AMS team with dedicated AMS champion identified
- Other health professionals identified and involved in AMS activities
- Clearly defined collaboration between the AMS and IPC programmes
- Ensure IT, laboratory and imaging services are accessible
- Ensure the laboratory uses selective reporting of susceptibility results

AMS actions

- AMS team to conduct regular ward rounds and other point-of-care interventions
- Produce a formulary with a list of approved antimicrobials (these may be based on national recommendations or the WHO EML)
- Produce a formulary with a list of restricted antimicrobials (these may be based on the WHO AWaRe classification system)
- Produce up-to-date standard treatment guidelines

Education and training

- Initial and regular training in optimal antimicrobial use for healthcare professionals
- Initial and regular training of the AMS team in infection management

Monitoring and surveillance

- Monitoring quantity of antimicrobial use (purchased, prescribed or dispensed)
- Auditing the compliance of AMS interventions
- Auditing the appropriateness of antimicrobial use
- Monitoring of susceptibility and resistance rates for key indicator bacteria (in alignment with national and/or international surveillance systems e.g. GLASS)
- Producing a local antibiogram

Reporting and feedback

- Evaluation and sharing of quantitative data on antimicrobial use with prescribers, along with specific educational activities
- Evaluation and sharing of qualitative data on appropriateness of antimicrobial use with prescribers, along with specific educational activities
- Evaluation and sharing of resistance rates with prescribers

ANNEX 12. SUMMARY OF EFFECTIVE ENVIRONMENTAL CLEANING

Environmental cleaning	Method	Considerations
Routine surface cleaning	• Detergent and water, followed by rinsing and drying, is the most useful method for removal of microorganisms	• Day-to-day environmental cleaning implemented within the framework of an IPC programme
Surface cleaning after contamination, surfaces suspected or known to have been contaminated by an AMR pathogen and/or other potentially infectious material, including blood or body fluids	• Detergent and water, followed by rinsing and drying, is the most useful method for removal of microorganisms *combined with* • Disinfectant products on cleaned surfaces	• Disinfectants are only for disinfecting cleaned surfaces and are not a substitute for cleaning • Combined (one-step) detergent-disinfectant products or a two-step process (separate detergent and disinfectant products) can be used • Common low- and intermediate-level disinfectants include quaternary ammonium compounds, alcohol, chlorine-releasing agents (e.g. bleach) and improved hydrogen peroxide
Cleaning of shared patient equipment **Items that come into contact with intact skin (e.g. blood pressure cuffs, stethoscopes)**	• May include detergent and water **or** detergent/ disinfectant or alcohol wipes, depending on materials	• Choice of product depends on materials – using the wrong product may cause the equipment to degrade; always check the manufacturer's instructions • Level and frequency of cleaning depends on risk of contamination during routine use; items more likely to be contaminated (e.g. weigh chairs) require more frequent cleaning than general surfaces and fittings; **at a minimum**, shared patient equipment must be cleaned and disinfected between each patient use

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