World Health Organization
Western Pacific Region

Guidance on establishing national and local AMR surveillance systems in the Western Pacific Region

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Using the disk diffusion method to evaluate antimicrobial resistance. National Center for Laboratory and Epidemiology, Lao People's Democratic Republic.

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ABBREVIATIONS

AMC	antimicrobial consumption
AMR	antimicrobial resistance
AMS	antimicrobial stewardship
AMU	antimicrobial use/utilization
ASIARS-Net	Asian Antimicrobial Resistance Surveillance Network
AST	antimicrobial susceptibility testing
ATCC	American Type Culture Collection
CLSI	Clinical and Laboratory Standards Institute
CPE	carbapenemase-producing Enterobacterales
CRE	carbapenem-resistant Enterobacterales
CSF	cerebrospinal fluid
EBS	event-based surveillance
EGASP	Enhanced Gonococcal Antimicrobial Surveillance Programme
EQA	external quality assessment
EUCAST	European Committee on Antimicrobial Susceptibility Testing
GLASS	Global Antimicrobial Resistance Surveillance System
IPC	infection prevention and control
IQA	internal quality assessment
LIMS	laboratory information management system
LMIC	low- and middle-income countries
MDR	multidrug-resistant
MIC	minimum inhibitory concentration
MRSA	methicillin-resistant *Staphylococcus aureus*
NCC	national coordinating centre
NRL	national AMR reference laboratory
PDR	pandrug-resistant
QC	quality control
SOP	standard operating procedure
WPRACSS	Western Pacific Regional Antimicrobial Consumption Surveillance System
XDR	extensively drug-resistant

GLOSSARY OF TERMS

Surveillance	
Active	The collection of data through targeted investigation to identify cases of disease, such as screening of patients at risk to identify those who are colonized with a multi-resistant organism.
Enhanced	Collection of additional information on characteristics of cases, pathogens, risk factors and transmission to gain deeper understanding or conduct further investigation, for example, after a signal of new resistance or a potential outbreak has been detected.
Event-based	Rapid reporting and investigation of ad hoc information on public health events. This enables reporting of new or unusual events that occur outside the case definitions and reporting structures in place for routine, passive surveillance.
Isolate-based	Surveillance in which data are collected and analysed by pathogen type. It provides information on the proportion of patients with positive samples whose infections are caused by target pathogens resistant to specific antimicrobials.
Notifiable condition	A type of comprehensive surveillance in which cases of a condition are required to be reported by health-care providers and laboratories to authorities by law. For AMR, this is usually isolate-based surveillance.
Passive	The collection of data through routine sample collection, testing and reporting, such as routine diagnostic testing for clinical care.
Sample-based	Surveillance of microbiological data from all clinical specimens from patients with suspected infection. It includes patients with laboratory-confirmed infection caused by the target pathogens or other pathogens and commensal organisms, and those with no microbial growth. It enables calculation of the frequency of different pathogens and frequency of resistance in the population under surveillance
Sentinel	Collection of data from a pre-defined sample of health-care facilities, laboratories or providers that cover a subset of the population under surveillance or targeting particular pathogens, diseases or populations. In this document "sentinel" is used in the context of "sentinel surveillance". Facilities that contribute routine passive data as part of the national AMR surveillance system are referred to as "surveillance sites".
WHONET	Database software for management and analysis of microbiology laboratory data developed by the WHO Collaborating Centre for Surveillance of Antimicrobial Resistance at the Brigham and Women's Hospital in Boston, United States of America.

Antimicrobial usage	
Antimicrobial consumption (AMC)	A quantitative description of the volume of antimicrobials used in a specific setting (community, hospital) during a specific period of time (days, months or year). This is usually calculated as defined daily doses (DDD) to allow for international comparisons. In surveillance, this also refers to estimates of aggregated data derived from import, sales or reimbursement databases usually accessible, and can serve as a proxy for actual use of antimicrobial drugs.
Antimicrobial stewardship (AMS)	A range of activities that promote the safe and appropriate use of antimicrobials, reduce patient harm and prevent and contain antimicrobial resistance.
Antimicrobial use (AMU)	A qualitative description of the reasons why antimicrobials are being prescribed, for which indications, and the appropriateness of these prescriptions. This also refers to data on antimicrobials collected at the individual patient level, such as information on indication, treatment schemes and patient characteristics.

Infection	
Community-associated	An infection or pathogen normally associated with transmission in the community (for example, sexually transmitted infections or gastroenteritis).
Community-origin	Used as a proxy for an infection or pathogen contracted in the community, and not as a direct or indirect result of obtaining health care. Global Antimicrobial Resistance Surveillance System (GLASS) definition: patient cared for at an outpatient clinic or hospitalized for ≤ 2 calendar days when the specimen was taken.
Health-care-associated	An infection that was contracted as a direct or indirect result of obtaining health care.
Hospital-origin	Used as a proxy for an infection or pathogen contracted in hospital. GLASS definition: patient hospitalized for > 2 calendar days when the specimen was taken (or transferred from another facility after being admitted there for ≥ 2 calendar days).

Pathogens	
Extensively drug-resistant (XDR) pathogen	A pathogen that is not susceptible to at least one agent in all but two or fewer antimicrobial categories indicated in Annex 1.1 for that bacterial species.
Key AMR pathogen	AMR pathogen of local or global significance relevant to the country.
Multidrug-resistant (MDR) pathogen	A pathogen that is not susceptible to at least one agent in three or more antimicrobial categories indicated in Annex 1.1 for that bacterial species.
Pandrug-resistant (PDR) pathogen	A pathogen that is not susceptible to any agent in all the antimicrobial categories indicated in Annex 1.1 for that bacterial species.

Quality assurance	
External quality assessment (EQA)	A formal periodic evaluation of the performance of a laboratory undertaken by an independent, external laboratory to establish inter-laboratory comparability and improve performance. For microbiology, EQA is conducted by sending panels of undisclosed but known contents for examination and testing using pathogen identification and antimicrobial susceptibility testing (AST) and providing feedback and suggestions for improvement.
Internal quality assessment (IQA)	A process similar to EQA, except that the test materials are prepared, distributed, evaluated and results assessed internally by the laboratory. Any discrepancies are observed, recorded and analysed by a senior professional in consultation with a quality manager and possible solutions suggested.
Internal quality control	A set of procedures followed on a day-to-day basis by laboratory staff to ensure the quality of the testing process, from specimen collection through testing and analysis of results, as well as quality control of media and reagents, with the objective that test results released are reliable.

EXECUTIVE SUMMARY

Antimicrobial resistance (AMR) is a global issue that poses a formidable and growing threat to human health, health security and global and national economies. If unabated, AMR is predicted to cause more than 5 million cumulative deaths and a total economic cost of nearly US$ 150 billion in the Western Pacific Region from 2020 to 2030. While the effects will be felt by all, the health and economic impacts of AMR will be greatest for low- and middle-income countries (LMICs).

The vision for the World Health Organization (WHO) Western Pacific Region, *For the Future: Towards the Healthiest and Safest Region (1),* endorsed by the Regional Committee in 2019, identifies health security including AMR as a strategic priority. It outlines a suite of operational shifts to guide WHO's work in the Region. These operational shifts are applied in the *Framework for Accelerating Action to Fight Antimicrobial Resistance in the Western Pacific Region (2)* to drive implementation of the 2014 regional Action Agenda and national AMR action plans by countries in the Region.

Strategic objective two of the 2015 *Global action plan on antimicrobial resistance (3)* requires Member States to "strengthen knowledge and evidence through surveillance and research". AMR surveillance informs the evidence base to measure, monitor, evaluate and address AMR. This document provides step-by-step guidance for countries in the Western Pacific Region on setting up national multilevel AMR surveillance systems. It focuses on AMR in fast-growing bacteria causing common infections in humans and emphasizes the importance of strengthening surveillance in hospitals to inform clinical practice and policy to tackle AMR. AMR surveillance in other pathogens such as *Mycobacterium tuberculosis* and HIV is covered in other WHO documents (see Section B7.2).

The backbone of AMR surveillance is passive surveillance based on aggregated data from microbiological testing of routine patient samples collected as part of clinical care. Several active surveillance methods are proposed to address some of the limitations of routine surveillance data and increase their quality, completeness and representativeness. The guidance complements *Responding to Outbreaks of Antimicrobial-resistant Pathogens in Health-care Facilities: Guidance for the Western Pacific Region (4)*, and explains how surveillance can be used to detect and respond to AMR threats within a facility, while effectively contributing to national, subnational and regional AMR surveillance activities.

The guidance is arranged as follows.

Part A presents a stepwise approach to setting up a multilevel AMR surveillance system.

Establishing multilevel AMR surveillance involves a series of actions which are presented in this guidance as discrete steps for clarity and simplicity although the steps may overlap and the order in which they are undertaken will vary depending on the local context.

Part B includes details of laboratory components of AMR surveillance, target specimens and pathogens, and data collection, management, analysis and reporting procedures. Guidance is provided on active surveillance methods, including periodic monitoring, sentinel surveillance, research studies, event-based surveillance (EBS) and enhanced surveillance. There are descriptions of how to use AMR surveillance data for action, quality assurance processes, and there is information on the monitoring of antimicrobial consumption through the Western Pacific Regional Antimicrobial Consumption Surveillance System (WPRACSS).

Strengthening AMR surveillance in hospitals includes taking practical steps to:

- establish strong governance of AMR surveillance activities;
- ensure good diagnostic stewardship;
- promote quality assurance to strengthen microbiological testing in hospital diagnostic laboratories;
- collect, record and report routine surveillance data using software such as WHONET to provide local and facility-level analysis and reporting;

- develop hospital antibiograms based on local AMR surveillance data and use them carefully to respond to AMR within the health-care facility;
- use surveillance data to drive control and preventive measures; and
- contribute quality data to national, global or other surveillance programmes.

Part C contains "How to" guides that provide additional practical information on laboratory assessment, analysis methods, periodic monitoring, developing antibiograms and evaluating AMR surveillance.

The Annexes provide additional technical information on surveillance definitions, notifiable AMR pathogens for AMR surveillance and examples of recording and reporting forms. In particular, Annex 4 contains a link to the AMR Surveillance System assessment tool, an Excel-based tool developed to accompany this guidance, that can be used to understand AMR surveillance and laboratory capacity in countries, and to identify strengths and gaps where support is needed.

AMR has the potential to cause devastating health and economic effects across the Region and globally. Surveillance is critical to identify, investigate and respond to present and emerging AMR threats, and to monitor containment efforts, as well as to inform clinical management guidelines, and rationalize the use of antibiotics. Local health-care facilities, laboratories and communities constitute the AMR front line. Strengthening their capacity, engagement and participation is critical to implementing effective surveillance and to achieving success in containing AMR locally, nationally and globally.

Introduction

1.1 OBJECTIVES OF THE GUIDANCE

This document provides step-by-step guidance for countries in the Western Pacific Region on setting up national multilevel antimicrobial resistance (AMR) surveillance systems. It focuses on AMR in fast-growing bacteria causing common infections in humans and emphasizes the importance of strengthening surveillance in hospitals to inform clinical practice and policy to tackle AMR. The guidance complements *Responding to Outbreaks of Antimicrobial-resistant Pathogens in Health-care Facilities: Guidance for the Western Pacific Region (4)*. The document is accompanied by an Excel-based assessment tool developed as part of the guidance to support Member States to evaluate AMR surveillance and laboratory capacity in their country and to identify strengths and gaps where support is needed.

The purpose of this document is to support national health authorities and hospitals to implement AMR surveillance appropriate to their setting, collecting and using data to drive action to improve patient care, rationalize the use of antibiotics and reduce the impact of AMR. It applies to hospital and other microbiology laboratories, both public and private, whether part of formal national or subnational surveillance programmes or not.

Participation in the Global Antimicrobial Resistance and Use Surveillance System (GLASS)[1] *(6)* and regional initiatives such as the Western Pacific Regional Antimicrobial Consumption Surveillance System (WPRACSS) *(7)* is encouraged. AMR surveillance in humans should be aligned with One Health principles: integrated AMR surveillance across sectors is challenging but sharing of information and coordinated analysis of data should be a priority.

While recognizing the global importance of AMR among viruses, fungi and parasites, this document focuses only on bacterial pathogens, both those covered by GLASS as well as other locally relevant bacterial pathogens.

WHO provides technical assistance to countries to develop national AMR action plans and national AMR surveillance systems. WHO promotes a systems approach to the collection, analysis and sharing of AMR-related data to inform national and regional action on AMR.

1.2 TARGET AUDIENCE

The intended readership includes:

- national public health professionals and health policy-makers;
- personnel in hospitals and other clinical facilities and laboratories involved in AMR surveillance or clinical care; and
- other sectors involved in developing One Health surveillance of AMR.

[1] The WHO AMR Surveillance and Quality Assessment Collaborating Centres Network *(5)* assists WHO in supporting Member States to build capacity to develop and implement AMR surveillance, particularly in low- and lower-middle-income countries.

1.3 AMR SURVEILLANCE IN THE WESTERN PACIFIC REGION

AMR is a global issue which threatens human and animal health, health security and global and national economies. If unabated, AMR is predicted to cause more than 5 million cumulative deaths at a total economic cost of nearly US$ 150 billion in the Western Pacific Region from 2020 to 2030 *(8)*. AMR is driven by many factors including the overuse and misuse of antimicrobials. Surveillance and antimicrobial stewardship (AMS) must be strengthened in the Region to mitigate the impact of AMR.

WHO's 2014 *Action Agenda for Antimicrobial Resistance in the Western Pacific Region (9)* and the 2015 *Global action plan on antimicrobial resistance (3)* outline priority actions for Member States to control AMR by developing national AMR action plans, strengthening health systems and surveillance and increasing awareness of AMR in other sectors.

WHO's vision for the Western Pacific Region, *For the Future: Towards the Healthiest and Safest Region (1)* endorsed by the Regional Committee in 2019, identifies health security including AMR as a strategic priority. It outlines a suite of operational shifts to guide WHO's work in the Region.

These operational shifts are applied in the *Framework for Accelerating Action to Fight Antimicrobial Resistance in the Western Pacific Region (2)* to drive implementation of the 2014 regional Action Agenda and national AMR action plans by countries in the Region.

1.4 CURRENT SITUATION ANALYSIS

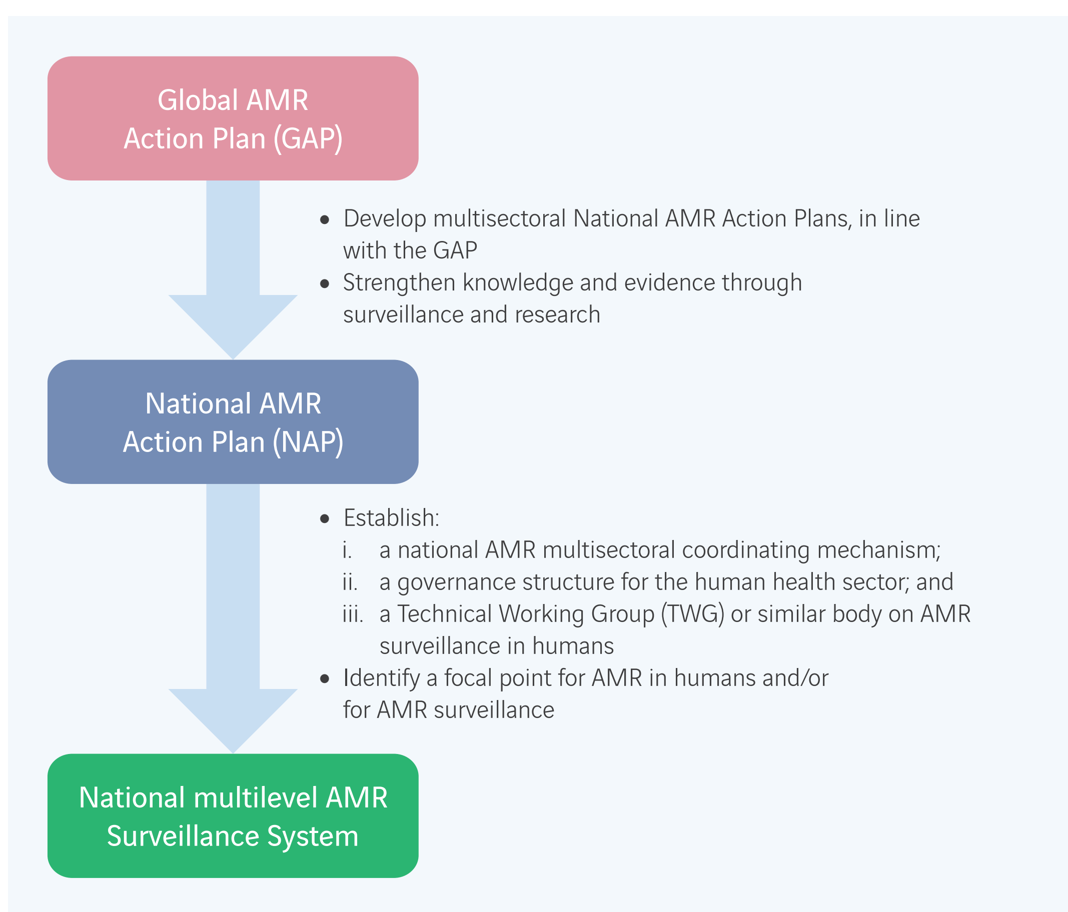
Many countries in the Western Pacific Region have developed national AMR action plans. Some have established or are setting up national AMR surveillance and/or antimicrobial consumption (AMC) systems and antimicrobial stewardship (AMS) programmes and are reporting to GLASS and/or WPRACSS. However, implementation of national action plans is inconsistent, and the overuse and misuse of antimicrobials continues to be a serious problem, with around 50% of prescribed antimicrobials considered inappropriate *(2)*.

Infections with pathogens resistant to "last-resort" antimicrobials, including penicillin- and macrolide-resistant *Streptococcus pneumoniae*, carbapenem-resistant Enterobacterales (CRE) and methicillin-resistant *Staphylococcus aureus* (MRSA), have been isolated in many countries in the Region. The prevalence of New Delhi metallo-beta-lactamase-producing Enterobacterales has been increasing since it was first reported in the Region in 2011. Patients with infections caused by these and other AMR pathogens can require prolonged hospital stays and have high mortality, resulting in increased health-care and other economic costs. Other pathogens with increasing rates of resistance in the Region include *Acinetobacter baumannii*, *Neisseria gonorrhoeae*, and *Pseudomonas aeruginosa*.

1.5 RATIONALE FOR AMR SURVEILLANCE AND RESPONSE

Surveillance is required to monitor the burden of AMR and is a key component of a systems approach to responding to AMR (Fig. 1). It facilitates the early detection of resistant strains of public health importance, supports the prompt notification and investigation of outbreaks and, together with clinical and epidemiological investigation, provides data for action and understanding of key drivers and factors that contribute to AMR. Surveillance informs evidence-based decisions on clinical care, contributing to better outcomes at the individual and systems level. It provides information for policy-making and guides public health strategy and planning.

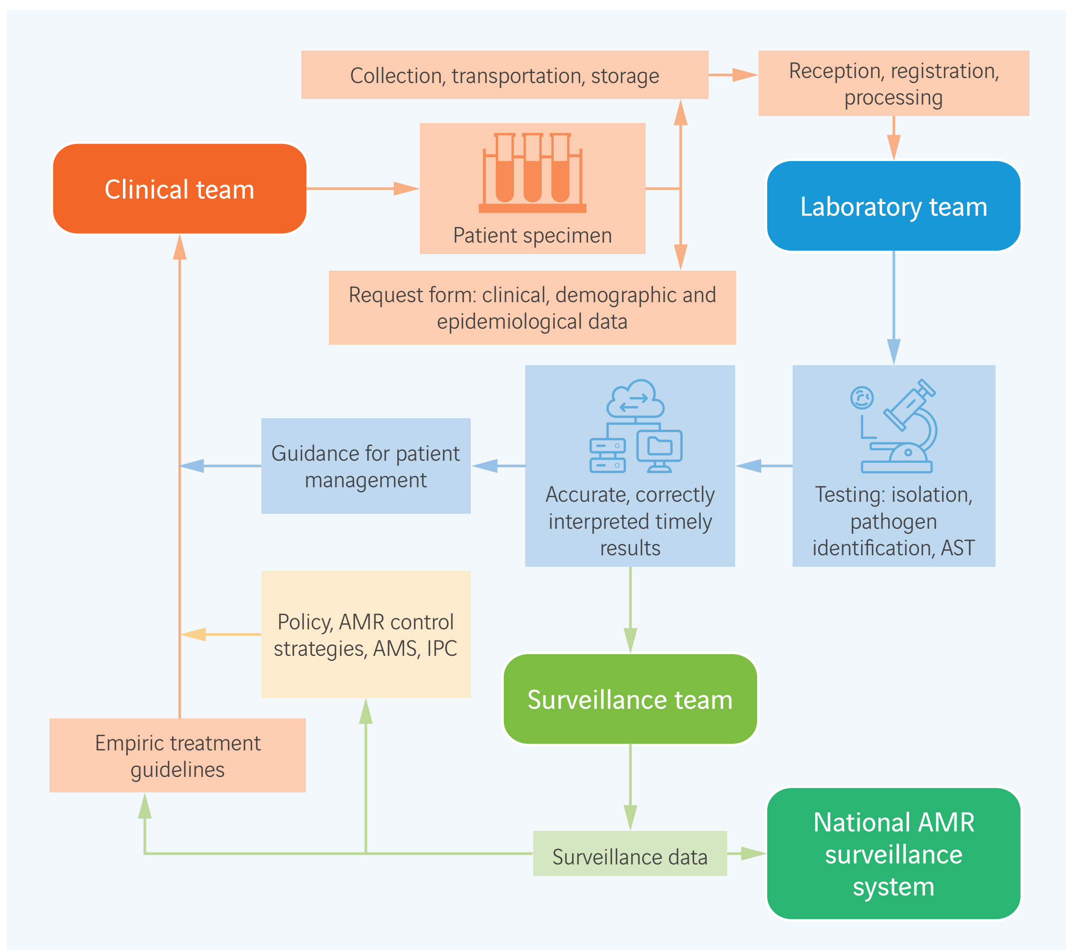
Fig. 1. Policy basis for setting up national AMR surveillance systems



Source: WHO

AMR surveillance supports diagnostic stewardship, the process by which microbiological testing (pathogen identification and antimicrobial susceptibility testing [AST]) informs treatment decisions and contributes data to AMR surveillance (Fig. 2). Microbiological testing results guide clinicians to choose the most appropriate antibiotics to treat their patients and infection prevention and control (IPC) teams to implement IPC measures to reduce transmission and prevent outbreaks. Surveillance data inform antibiotic treatment guidelines, AMS programmes and local, national, regional and global policy recommendations for action on AMR.

Fig. 2. Relationship between individual patient care and surveillance



Source: WHO

GLASS-AMR collects surveillance data on specific combinations of high-risk pathogens and antimicrobials to inform local, national and regional actions to address AMR and monitor the effectiveness of interventions. It is important, however, that countries build laboratory and epidemiologic capacity to monitor all microbiological testing for AMR, including pathogens not covered by GLASS-AMR, to improve the detection of and response to emerging AMR.

1.6 SURVEILLANCE METHODS

The backbone of AMR surveillance is passive surveillance of data from routinely collected clinical samples from health-care facilities (referred to here as surveillance sites) participating in a national surveillance system. Countries are also encouraged to include AMR pathogens in their notifiable or reportable disease surveillance. Passive surveillance may be complemented by active surveillance methods such as periodic monitoring (including national AMR prevalence surveys), sentinel surveillance, research studies, EBS and enhanced surveillance (Fig. 3). These active methods can be used, for example, to cover community-associated infections, perform deep-dives into particular pathogens and to identify signals of potentially important emerging threats or other public health events.

Initially AMR surveillance may target high-priority pathogens, but as part of systems strengthening, it is important to include all locally relevant pathogens. Limitations of passive surveillance based on routine clinical sampling such as poor access to health care, limited and/or late microbiological testing

and inaccurate results due to poor-quality testing, which lead to non-representative sampling and introduce bias into the data, should be recognized and efforts made to increase quality, completeness and representativeness of data where possible.

Routine passive surveillance may include isolate- and/or sample-based data (see Table 1 and Section B2.4 for further details).

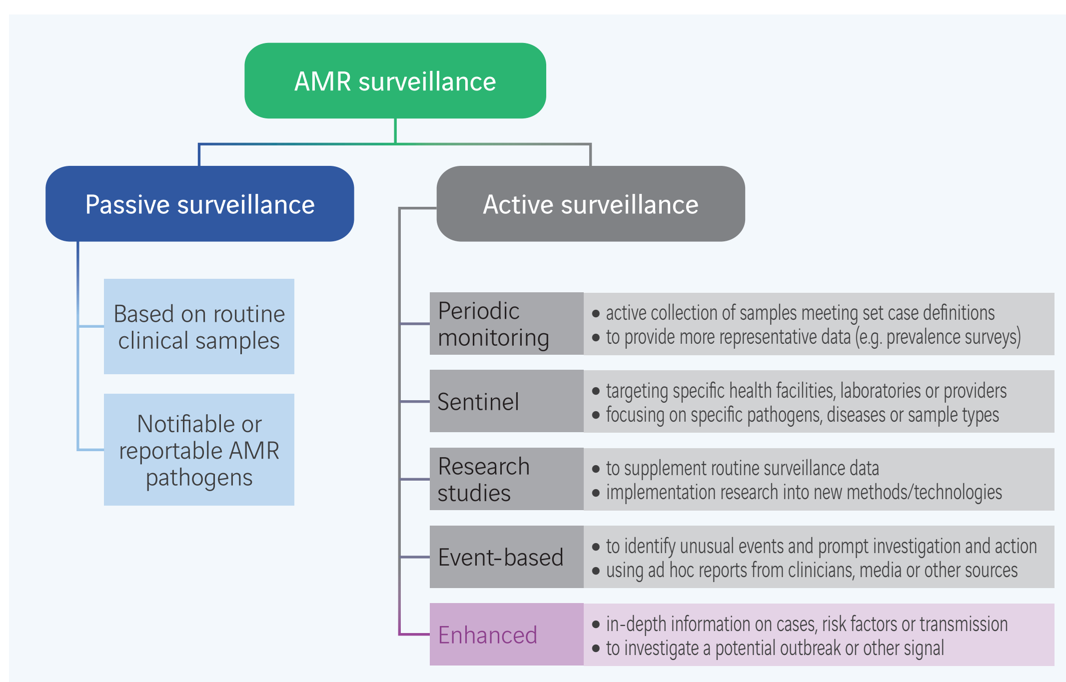
Table 1. Isolate-based and sample-based data

Data	Population (denominator in calculations)	Information provided
Isolate-based data	Patients with laboratory-confirmed infections caused by the defined target pathogens under surveillance	Proportion of patients with positive samples whose infections are caused by target pathogens resistant to specific antimicrobials
Sample-based data	All patients with suspected infection from whom clinical specimens have been collected, including patients with: • laboratory-confirmed infection caused by the target pathogens • no microbial growth in collected specimens • growth of any other organisms, including other pathogens and commensal organisms.	Frequency of infection and resistance patterns in the patient population under surveillance

Source: Adapted from GLASS manual for antimicrobial resistance surveillance in common bacteria causing human infection *(22)*

Isolate-based data are a subset of sample-based data. In both approaches, patients include only people with a specific syndrome that: (1) seek care at a health-care facility; and (2) from whom clinical specimens are collected and tested. Due to differences in access to care, patients meeting defined clinical criteria may be missed from routine surveillance.

Fig. 3. AMR surveillance methods



Source: WHO

1.7 HOW TO USE THIS DOCUMENT

This document provides guidance for establishing national AMR surveillance.

- Core activities form the basis of AMR surveillance and should be prioritized.
- Additional activities are presented for local adaptation and expansion over time.

Part A presents a stepwise approach to setting up a multilevel AMR surveillance system.

Part B presents technical details on laboratory and data management components of AMR surveillance.

Part C contains “How to” guides that provide additional practical information, such as detailed analysis methods.

The Annexes provide additional technical information.

Annex 4 contains a link to the AMR Surveillance System assessment tool, an Excel-based tool developed to accompany this guidance, that can be used to understand AMR surveillance and laboratory capacity in countries, and to identify strengths and gaps where support is needed.

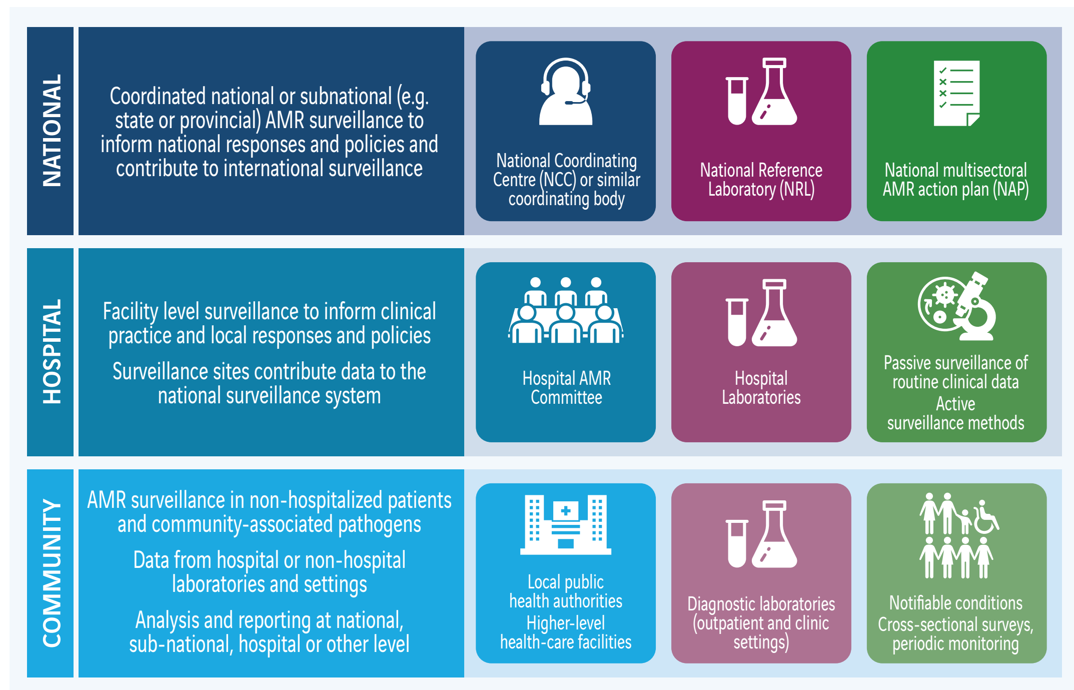
PART A:
ESTABLISHING A MULTILEVEL AMR SURVEILLANCE SYSTEM

Overview of a multilevel AMR surveillance system

A multilevel AMR surveillance system is composed of structures with specific expertise and particular roles and responsibilities at the national, hospital and community levels, that work together to develop and implement surveillance policies, procedures and activities (Fig. 4).

Surveillance data are collected, compiled, analysed and used to generate representative and actionable information on AMR. The information informs clinical management of patients, public health and infection control activities in health-care facilities and in the community, and contributes to the local, national and global AMR evidence-base.

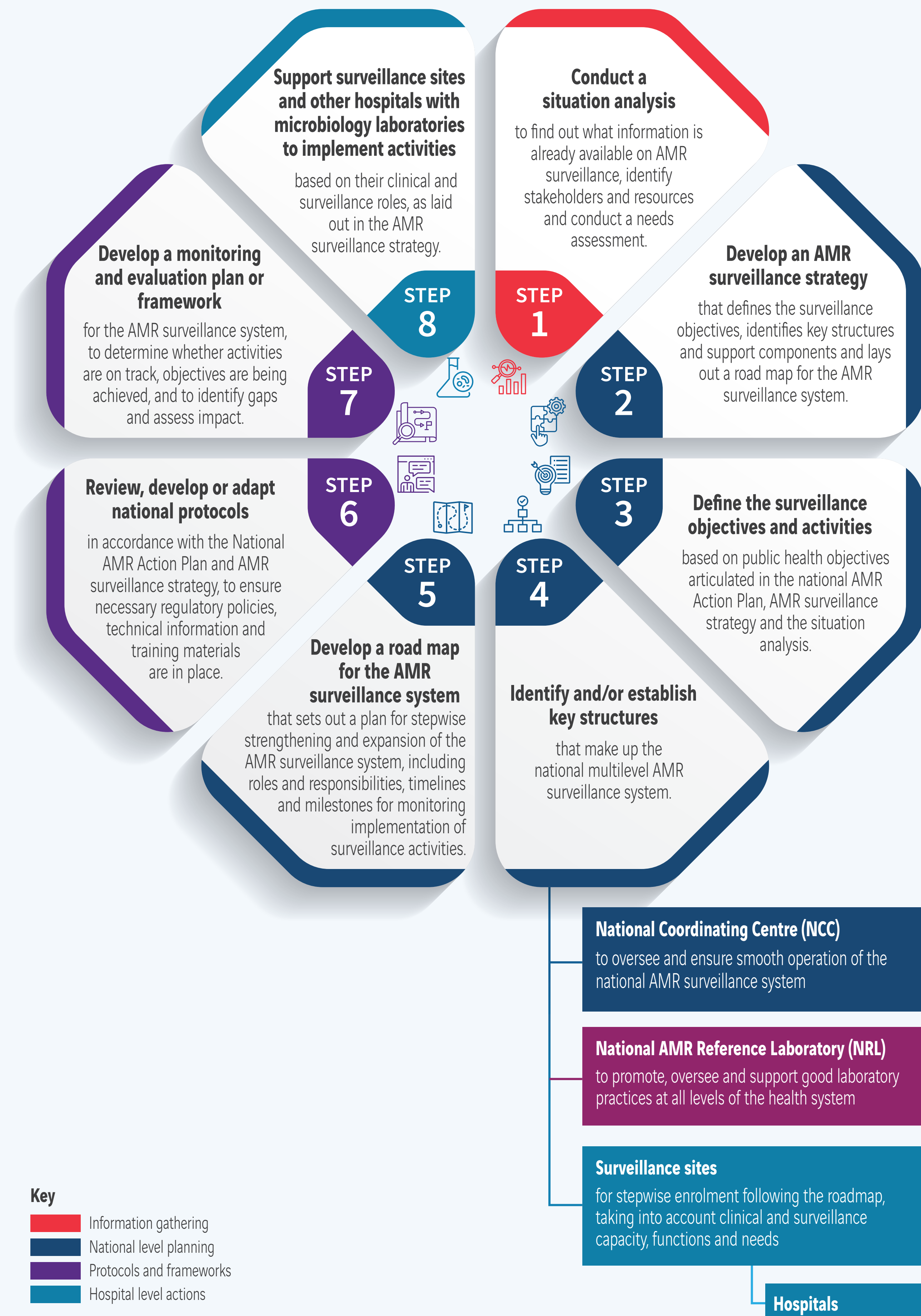
Fig. 4. Structures that make up a multilevel AMR surveillance system



Source: WHO

Establishing a multilevel AMR surveillance system involves a series of actions. The order in which the steps are undertaken will vary depending on the local context – for example, whether governance structures already exist or need to be identified, and some of the steps overlap and may not always be followed in sequence. However, these actions are presented here as discrete steps for clarity and simplicity (Fig. 5).

Fig. 5. Steps to developing a multilevel AMR surveillance system



Source: WHO

Step 1. Conduct a situation analysis

to find out what information is already available on AMR surveillance, identify stakeholders and resources and conduct a needs assessment.

Responsible body	Key points
National AMR coordinating structure for the human health sector (and/or) Technical working group on AMR surveillance (or similar) Staff and institutions with responsibilities for AMR - Clinical - Laboratory - Surveillance - Policy	Develop an evidence base to inform AMR surveillance ■ Data on the AMR situation in the country ■ Data management ■ Policies, regulations, guidelines ■ Procedures and practices ■ Resources and capacity ■ Structures ■ Stakeholders
	Use the evidence base to determine the priorities and needs for AMR surveillance and to inform the development of a national AMR surveillance strategy (Step 2)

AMR surveillance systems require multidisciplinary expertise and input at all levels:

- **clinical**, to conduct clinical sampling, collect patient information and use data for clinical decision-making;
- **laboratory**, to advise on clinical sample collection, conduct testing and provide results to clinicians and surveillance reporting mechanisms;
- **surveillance**, to advise on and perform data management, epidemiological analysis and reporting; and
- **policy and regulatory**, to obtain appropriate governance and agreements, and facilitate the use of data to inform policy.

The scope of the **situation analysis** may be broader than AMR surveillance alone, depending on resources and national AMR action plan priorities. However, it should cover all aspects of AMR surveillance, including:

Data on the AMR situation

- What is known about the burden of infection and resistance in the country?
- What are the AMR pathogens of local or global significance relevant to the country (hereafter referred to as key pathogens)?
- What is the impact of AMR?

Data management

- What data sources and data exist?
- Where do data come from? Are data representative?
- How are data collected, stored, analysed and used?
- What are the current gaps in sampling and data?

Policies, regulations and guidelines

- What policies, legislation or other governance mechanisms relevant to AMR surveillance are in place?
- What clinical, laboratory and/or surveillance guidelines, tools and standard operating procedures (SOPs) are available?

Procedures and practices

- What clinical sampling methods are used?
- What laboratory practices are followed?
- What surveillance methods are used?

Resources and capacity

- What financial resources are available?
- What human resources are available and what are the clinical, laboratory and/or surveillance capacities? Is AMR covered in pre-service and in-service training?

Structures

- What existing or potential AMR surveillance system structures are there at national, hospital and community level?

Stakeholders

- Who are the stakeholders? Consider public and private institutions, implementing partners, donors, research institutes and universities.

Once this information has been collected and compiled, it is used to determine the priorities and needs for the multilevel surveillance system and inform the development of a national AMR surveillance strategy (Step 2).

Step 2. Develop an AMR surveillance strategy

that defines the surveillance objectives, identifies key structures and support components and lays out a road map for the AMR surveillance system.

Responsible body	Key points
National AMR coordinating structure for the human health sector (and/or) Technical working group on AMR surveillance (or similar body)	Develop an AMR surveillance strategy: ■ Define the surveillance objectives and activities (Step 3) ■ Identify and/or establish key structures (Step 4) and ■ Identify support components ■ Develop a road map (Step 5)

The AMR situation analysis is used to develop an AMR surveillance strategy that includes AMR surveillance objectives, organizational structures and support components and a road map. The surveillance strategy may be included in the national AMR action plan – see *Antimicrobial Resistance: A Manual for Developing National Action Plans (10)*.

Surveillance objectives (for further details see Step 3)

- What are the overall objectives of the national AMR surveillance system in terms of:
- Policy development
- Clinical and laboratory practice and patient care
- Infection control and public health actions
- Research and development
- National surveillance
- Contribution to global and regional surveillance.

Key structures (for further details see Step 4)

- What organizational structures underpin the surveillance system?
- What are the roles and responsibilities of component organizations?

Support components

- Other mechanisms/activities needed to ensure a high-quality, well-functioning AMR surveillance system, include:
- Training and capacity-building
- Quality assurance
- Advocacy, demand-generation, communication
- Monitoring and evaluation
- Research and development.

Road map for expansion of the AMR surveillance system (for further details see Step 5)

- Formulate a plan that describes the timelines and roles and responsibilities for strengthening or expanding the AMR surveillance system.

Step 3. Define the surveillance objectives and activities

based on public health objectives articulated in the national AMR Action Plan, AMR surveillance strategy and the situation analysis.

Responsible body	Key points
National AMR coordinating structure for the human health sector (and/or) Technical working group on AMR surveillance (or similar body)	Objectives of national AMR surveillance: ■ Inform AMR policy development ■ Inform clinical care and laboratory practice ■ Inform infection control and public health actions ■ Inform research and development ■ Contribute to global and regional surveillance. Surveillance methods can include: ■ Passive surveillance of routine clinical laboratory data ■ Passive reporting of notifiable pathogens ■ Periodic monitoring and research ■ EBS. Surveillance data can be used to: ■ Estimate and monitor AMR burden ■ Inform clinical decision-making and policy ■ Identify emerging or new AMR ■ Identify outbreaks of AMR pathogens ■ Conduct monitoring and evaluation including impact assessment.

Objectives

National AMR surveillance data contribute to the evidence base needed to inform policy, clinical care and laboratory practice, infection control and public health actions, research and development as well as to global and regional surveillance. Surveillance objectives may differ at national, hospital and community level, but all levels must work together to achieve the overall objectives.

Surveillance methods

AMR surveillance activities are guided by national and local priorities and surveillance objectives. Resource limitations mean that comprehensive, routine (passive) surveillance of AMR cannot cover all pathogens in all settings, but active surveillance methods can be used to supplement routine and legislated surveillance (Table A1).

Uses and analysis of surveillance data: (see Section B5)

- **Estimating the AMR burden** – collecting and monitoring data on key pathogens, defined antimicrobial-pathogen combinations, resistance patterns and mechanisms.
- **Informing clinical decision-making and policy** – analysing and reporting AMR data, including patterns and trends, to clinicians and policy-makers to inform empiric therapy and policy-making.
- **Identifying emerging or new AMR** – detecting and reporting "newly detected antimicrobial resistance findings that may influence surveillance and control practices" *(11)* so that appropriate countermeasures can be taken (see Section B5.3.1).
- **Outbreak identification and response** – detecting the emergence and controlling the spread of AMR pathogens to reduce their health and economic impact (see Section B5.3.2).
- **Monitoring and evaluation** of AMR surveillance policies, guidelines and interventions – including NAP implementation, IPC, AMS and AMC/AMU, so that data lead to action and inform continuous improvement of the system, and action leads to greater impact.

Table A1. Surveillance methods and activities

Passive surveillance	Activity	Purpose
Routine surveillance	Systematic collection of data from microbiological testing of routine clinical samples from surveillance sites Continuous analysis and reporting of resistance on priority pathogens, defined antimicrobial-pathogen combinations, resistance patterns and mechanisms	Use information to guide policy, clinical treatment, AMS, and IPC Develop local/national antibiograms Inform advocacy for enhancing AMS Monitor prevalence and trends in AMR pathogens (AMR burden) and resistance patterns to identify opportunities for intervention Outbreak detection, investigation and response Assess the impact of surveillance activities and engage in continuous improvement Contribute data to global, regional and national surveillance Identify trends/new phenomena to prompt research and development
Notifiable and reportable AMR pathogen surveillance (Annex 2)	Reporting by health-care providers and microbiology laboratories of patients with critically resistant pathogens of high public-health importance, mandated in notifiable disease legislation or following reporting requirements stated in policy or guidelines	Use reports to guide immediate public health action Outbreak detection, investigation and response Monitor prevalence and trends in key multi-resistant pathogens and identify opportunities for intervention Identify trends/new phenomena to prompt research and development

Active surveillance	Activity	Purpose
Periodic monitoring	Point prevalence surveys for specific pathogens, diseases or populations National AMR prevalence surveys Active collection of samples meeting a set case-definition to provide more representative data than routine surveillance	Focus on individual pathogens, diseases, locations or populations of interest including community- or health-care-associated infections Identify trends, if monitoring activity is repeated over time
Sentinel surveillance	Surveillance targeting particular pathogens, diseases, patient populations or specific settings, for example, sexual health clinics	Obtain information on specific pathogens of importance, for example, *N. gonorrhoeae* Gather information on diseases where routine culture and sensitivity testing may be infrequent (for example, urinary tract infections)
Research studies	Investigation of new or emerging findings Implementation research	In-depth study of specific pathogens or settings (for example, to supplement surveillance data) Study of new methods or technologies
Event-based surveillance	Rapid capture and reporting through formal or informal pathways of signals of ad hoc, undefined or emerging AMR issues that may be of public health importance	Identify an unusual event and prompt investigation and action to contain the event, particularly for emerging issues that may not be captured under existing surveillance case definitions and methods
Enhanced surveillance	Collecting specified epidemiological or patient-level data in addition to what is routinely collected, finding additional cases, conducting environmental surveillance, and performing analytical epidemiology (for example, case-control or cohort investigations)	Provides in-depth information on cases, such as, pathogens, risk factors, transmission, often used to investigate a potential outbreak or other signal

Source: WHO

Step 4. Identify and/or establish key structures

that make up the national multilevel AMR surveillance system.

Responsible body	Key points
National AMR coordinating structure for the human health sector (and/or) Technical working group on AMR surveillance (or similar body) NCC, ministry of health, NRL and other relevant stakeholders	Structures that make up the AMR surveillance system: ▪ **National coordinating centre** (NCC) or mechanism, to oversee and ensure smooth operation of the national AMR surveillance system (Step 4a); ▪ **National AMR reference laboratory** (NRL), to promote, oversee and support good laboratory practices at all levels of the health system (Step 4b); and ▪ **AMR surveillance sites** in hospitals for stepwise enrolment following the road map, taking into account clinical and surveillance capacity, resources and needs (Step 4c).

National public health surveillance is usually legally mandated by the national government and requires political support and dedicated resourcing. AMR surveillance involves collating, reporting and sharing data between health-care facilities, national authorities and other stakeholders to drive clinical practice and public health policy. Data collection and management should be interlinked or interoperable with national health information systems wherever possible. National-level structures coordinate AMR surveillance and provide technical oversight while hospitals are the cornerstone of the system, providing the bulk of the data on which AMR surveillance is based.

National surveillance may be supported or replaced by subnational structures (state or provincial), though data collation and/or coordination by a single national entity is still recommended. In this guidance, all surveillance involving data collection at administrative levels above and outside clinical settings, is referred to as "national AMR surveillance".

The structures for national AMR surveillance are set out in *National antimicrobial resistance surveillance systems and participation in the Global Antimicrobial Resistance Surveillance System (GLASS): a guide to planning, implementation, and monitoring and evaluation (12).*

Step 4a. Establish the National Coordinating Centre (NCC)

to oversee and ensure smooth operation of the national AMR surveillance system.

The NCC is usually a public health institute or health authority designated by the ministry of health but can be a research institute or university. It should have a defined structure for surveillance coordination and data management and access to expertise in epidemiology, clinical care and microbiology. The NCC oversees and coordinates the national AMR surveillance system, working with the NRL for microbiology expertise. A national AMR focal point should be appointed to guide the activities of the NCC.

Roles and responsibilities of the NCC:

- working with the national AMR coordinating structure/AMR technical working group to define the AMR surveillance strategy and national AMR surveillance objectives;

- collaborating/engaging with:
  - NRL, AMR surveillance sites and other clinical and laboratory facilities
  - animal, plant and environment sectors
  - other relevant stakeholders (such as donors, private sector institutions);
- coordinating data management:
  - AMR data collection, analysis and reporting
  - data storage, cleaning, deduplication, validation, aggregation;
- information-sharing:
  - global reporting of nationally aggregated data to GLASS
  - regional reporting such as to WPRACSS
  - national reporting of routine surveillance data, survey results, EBS etc. to contributing sites and other stakeholders;
- outbreak identification and response;
- developing and disseminating national policies, guidelines, tools and SOPs;
- advising on regulatory matters;
- AMR surveillance training for clinical, laboratory and surveillance staff;
- ensuring quality assurance mechanisms are in place for data management and laboratory practice (in close collaboration with NRL);
- advocacy and communication with relevant stakeholders;
- developing a monitoring and evaluation plan or framework; and
- coordinating research.

Step 4b. Identify/establish the National AMR Reference Laboratory (NRL)

to promote, oversee and support good laboratory practices at all levels of the health system.

A coordinating AMR laboratory should be identified or established as the NRL for AMR surveillance. If country capacity is lacking, a reference laboratory in another country can act as an interim reference laboratory *(5)*. Although some countries have several NRLs specializing in specific diseases or pathogens such as HIV and tuberculosis, designation of a single AMR NRL to support the national AMR surveillance system avoids duplication and fragmentation, and promotes efficient use of resources.

Roles and responsibilities of the NRL

The NRL collaborates with the NCC to coordinate AMR surveillance activities and oversee support components. It performs AMR-related reference laboratory functions, promotes good laboratory practice and facilitates diagnostic stewardship *(13)* through:

- defining microbiological indicators for AMR surveillance;
- integrating laboratory, clinical and epidemiological data;
- developing AMR-related national guidelines, tools and SOPs;
- advising health authorities and other policy-makers on laboratory matters;
- harmonizing methods and standards for AMR laboratory activities, including pathogen isolation, identification and AST, following:
  - recommendations from the European Committee on Antimicrobial Susceptibility Testing (EUCAST) and/or the Clinical and Laboratory Standards Institute (CLSI) for antimicrobial susceptibility testing (AST)
  - national standard operating procedures (SOPs) for samples and pathogens under surveillance, including but not limited to, GLASS-AMR target pathogens;

- performing reference laboratory functions, including:
  - confirmatory testing for bacterial identification, serotyping and subtyping/AST/MIC
  - conducting or arranging specialized testing
  - identifying, confirming and characterizing AMR mechanisms
  - detecting or confirming emerging or new AMR strains;
- overseeing procurement, specimen storage and transport processes;
- coordinating and collating microbiology data for national reporting and reporting to GLASS-AMR;
- assisting in outbreak investigations;
- liaising with other reference microbiology laboratories, international laboratories and the international community regarding observations of potential global concern;
- coordinating quality assurance activities (EQA, IQA), reviewing performance and overseeing corrective actions;
- coordinating AMR training and supervision for capacity-building of staff at NRL and other laboratories;
- conducting accreditation/certification activities for surveillance and diagnostic laboratories; and
- conducting research.

The NRL may also perform primary microbiological testing for affiliated hospitals. For further details, see Part B, Table 3.

Step 4c. Identify surveillance sites

for stepwise enrolment following the road map (Step 5), taking into account clinical and surveillance capacity, functions and needs.

Responsible body	Key points
NCC in collaboration with NRL, hospital management, local public health authorities, and clinical, laboratory and surveillance staff	Identify surveillance sites, taking into account: ▪ local AMR priorities, resources and executive support ▪ site characteristics and capacity ▪ factors that affect the coverage of AMR data ▪ plans for expansion of the AMR surveillance system articulated in the road map (Step 5).

AMR surveillance sites are usually primary, secondary or tertiary care hospitals or outpatient clinics that generate clinical, epidemiological and microbiological information from patients, as well as estimates of hospital and population data.

Clinical sites provide medical care to patients; laboratories provide clinicians with results of microbiological testing that inform individual patient care. In addition, hospitals are the front line of AMR surveillance. AMR surveillance may include patients attending outpatient clinics and laboratories (public and private), public health units, pharmacies and located in non-health-care settings such as elderly care facilities, community centres and schools.

The choice of surveillance sites depends on the size of the country, its population distribution, the availability of resources (funding, infrastructure, human resources and technical capacity) and the feasibility of achieving representative national coverage. Countries may start with a single surveillance site and expand to others in a phased approach. Specialty clinics may be included for specific pathogens, such as sexually transmitted infection clinics for surveillance of AMR in *N. gonorrhoeae*.

Site characteristics to consider include:

- **Governance structures:** Does the hospital have an AMR committee and an AMR focal point? Is there anyone who can act as an AMR champion?
- **Financial resources:** Is there funding to support AMR surveillance activities?
- **Capacity:**
  - What human resources are available for clinical management of patients, microbiological testing, data management and epidemiology support?
  - Can the site provide capacity-building, mentoring and supervision?
- **Health systems components:**
  - Logistics – what is the capacity for sample collection and transportation?
  - Information systems – are they electronic, paper-based, linked to or interoperable with other systems?

The choice of surveillance sites should also consider factors that affect the representativeness of AMR surveillance data:

- demographic, socioeconomic and geographic factors;
- health service levels (primary, secondary, tertiary), in-/outpatient settings, public/private facilities;
- patient and diagnostic volume; and
- capture of hospital- and community-onset infections.

For further guidance on surveillance site selection see *National antimicrobial resistance surveillance systems and participation in the Global Antimicrobial Resistance Surveillance System (GLASS): a guide to planning, implementation, and monitoring and evaluation (12).*

Step 5. Develop a road map for the AMR surveillance system

that sets out a plan for stepwise strengthening and expansion of the AMR surveillance system, including roles and responsibilities, timelines and milestones for monitoring implementation of surveillance activities.

Responsible body	Key points
National AMR coordinating structure for the human health sector (and/or) Technical working group on AMR surveillance (or similar body) Ministry of health, NCC, NRL and other relevant stakeholders	Components of the AMR surveillance system road map: ■ Policy development ■ Clinical guidelines, tools and SOP development ■ Data collection and management ■ Surveillance activities ■ Data sources ■ Enrolment of surveillance sites ■ Support components

The road map sets out a plan for establishing and expanding AMR surveillance towards a comprehensive national AMR surveillance system. Planning requires a review of the situation analysis, the AMR surveillance strategy, and available resources and capacity to identify gaps and opportunities for strengthening the AMR surveillance system. The road map includes roles and responsibilities, timelines and milestones for monitoring implementation.

The following questions can be used to identify components that may need to be developed, strengthened or updated.

Policies

- What policy gaps need to be filled?
- Which existing policies need to be revised or updated?

Clinical, laboratory, surveillance and/or other guidelines, tools and protocols

- What guidelines, tools or SOPs need to be developed?
- Which existing materials need to be revised or updated?

Data collection and management systems (Section B2)

- What is needed to shift from a paper-based to an electronic system or to link or integrate AMR data collection with other health information systems?
- What AMR indicators are already collected? What is the plan for introduction of additional indicators?
- What consent, confidentiality, anonymity policies are in place to safeguard personal data and protect individual privacy while facilitating the collection and sharing of AMR surveillance data across multiple health service levels?
- What technical, legal and/or political barriers to data sharing must be overcome, to ensure best practices for data collection are followed?

Surveillance activities

- What pathogens and sample types are included in routine passive AMR surveillance? What pathogens and sample types should be added? (Section B1.2)
- What diseases and pathogens are currently notifiable/reportable? What AST data are collected for notifiable/reportable pathogens? (Annex 2)
    - If AST data are not currently collected, what scope is there for collecting AST data and/or adding critical multi-resistant organisms to the list of notifiable/reportable diseases or pathogens?
- What scope is there for periodic monitoring to evaluate trends? (Section B4.1)
- What need is there for sentinel surveys or research directed at specific pathogens? (Section B4.2, B4.3)
- What mechanisms for EBS exist? Do they need to be established or expanded? (Section B4.4)

Data sources (Section B2.1)

- What data sources need to be strengthened or added? For example:
    - AMR surveillance reports;
    - microbiology results, such as species identification and AST results;
    - clinical information, such as specimen type and reason for collection, clinical case definitions, patient location/ward;
    - epidemiological data, such as patient age, sex, residence, exposures and other risk factors;
    - demographic/population-level data; and
    - data from other sectors (such as animal, food, environment).
- Can different data sources be linked and data from different sites combined where needed? Does data linkage or standardization need improvement?

Enrolment of surveillance sites

- What or where are the current gaps in representative national coverage of AMR surveillance? Look at demographic, socioeconomic and geographic factors, hospital in/outpatient and community settings and health service levels.
- What clinical and laboratory services (public or private sector), public health units or other structures could be designated as surveillance sites?
- What interest, resources and capacity for clinical care and AMR surveillance are there at individual sites?
- What laboratory capacity and capabilities exist at potential surveillance sites (Section B1.1.2)? Are there differences in capacity between laboratories, areas, or settings that might impact representativeness?

Support components

Which of the following components need to be established or strengthened to support the AMR surveillance system:

- **Training plan**, for staff in all disciplines at all levels;
- **Quality assurance plan**, overseen by NRL and implemented in surveillance sites;
- **Communications/advocacy plan**, to alert stakeholders to the purpose and importance of AMR surveillance;
- **Monitoring and evaluation plan**, to monitor implementation, outcomes and impact of surveillance activities; and/or
- **Research and development plan**, to supplement surveillance data and/or implement new methods or technologies?

Step 6. Review, develop or adapt national protocols

in accordance with the National AMR Action Plan and AMR surveillance strategy, to ensure necessary regulatory policies, technical information and training materials are in place.

Responsible body	Key points
NCC, ministry of health, NRL and other relevant stakeholders	Develop policies, guidelines and tools identified in the AMR surveillance strategy and road map Plan for dissemination, training and technical support ■ Clinical guidelines ■ Laboratory protocols ■ Surveillance guidelines.

The AMR surveillance road map lays out the plan for developing or updating policies and other protocols, guidelines and tools that are needed to support AMR surveillance.

In addition to developing materials, plans are needed for disseminating the materials, conducting and documenting pre-service, in-service or refresher training for different cadres of staff, supervising staff in different disciplines and for providing technical support.

Step 7. Develop a monitoring and evaluation plan or framework

for the AMR surveillance system, to determine whether activities are on track, objectives are being achieved, and to identify gaps and assess impact.

Responsible body	Key points
NCC, ministry of health, NRL and other relevant stakeholders	Components of the AMR surveillance monitoring and evaluation plan: ■ Elements to be monitored ■ Indicators ■ Reporting timelines ■ Reporting responsibilities.

Monitoring and evaluation is needed to assess the implementation and impact of AMR surveillance across planning, resources, activities, results and outcomes, and to inform course correction.

The monitoring and evaluation plan should cover:

Elements of the system to be monitored, including:

- policy and planning: governance, budget, national AMR action plan;
- surveillance objectives: clinical care and laboratory practice, infection control and public health actions;
- surveillance system structures (NCC, NRL(s), surveillance site(s));
- surveillance methods and activities:
  - case detection, data collection, data analysis
  - pathogens, specimen types, antimicrobial-pathogen combinations
  - new and emerging AMR and outbreak recognition;
- national and global reporting; data management and reporting;
- methods, standards and guidelines; and
- support components: training, quality assurance, advocacy and communication, research and development.

Indicators that cover each of the elements listed above should also be included. Examples of input, process, output and outcome indicators are listed in *National antimicrobial resistance surveillance systems and participation in the Global Antimicrobial Resistance Surveillance System (GLASS). A guide to planning, implementation, and monitoring and evaluation (12).*

Reporting timelines, defining when and how often data should be submitted and reports generated.

Also included should be reporting responsibilities, defining who reports to whom.

Step 8. Support surveillance sites and other hospitals with microbiology laboratories to implement activities

based on their clinical and surveillance roles, as laid out in the AMR surveillance strategy.

Responsible body	Key points
NCC, ministry of health, NRL and other relevant stakeholders	Elements of AMR surveillance: ● Microbiological testing ● Data – collection, management, analysis and reporting ● Governance ● Quality assurance ■ Advocacy and communication ■ Monitoring and evaluation ■ Research and development ■ Staff roles and responsibilities, capacity-building.

Step 8a. Strengthen the functions of hospital surveillance sites

based on their clinical and surveillance roles, as laid out in the AMR surveillance strategy.

AMR surveillance activities in hospitals are guided by AMR priorities stated in the national AMR surveillance strategy and in their own hospital plan. Microbiological testing of clinical samples informs the treatment of patients and the aggregated data generated from testing form the cornerstone of AMR surveillance.

Provincial laboratories may serve as an additional level of expertise between hospital laboratories and the NRL and hospital laboratories may provide microbiological services and advice for outpatient clinics, and smaller or more remote facilities.

Hospitals and private laboratories that are not designated as AMR surveillance sites may be the first to identify a local increase in an AMR pathogen or emergence of a new AMR pathogen. By informing the NRL and seeking confirmation of their findings, such facilities can make important contributions to national AMR surveillance and to the detection of outbreaks.

Many of the activities described in this section are relevant for hospitals with microbiology laboratories that are not formally contributing data to the national AMR surveillance system but are seeking to strengthen their capacity to tackle AMR by generating high-quality microbiological data to inform clinical practice.

Surveillance activities

Passive surveillance by hospital surveillance sites is based on data collected through routine testing of clinical samples. Sites may also conduct active surveillance to complement passive surveillance as stated in their national or local hospital surveillance plans.

Hospital microbiology laboratory activities that contribute to surveillance include:

- bacterial identification and AST;
- sending isolates to NRL for confirmatory and/or further testing, for example, extended AST for resistant organisms, when bacterial identification or AST results are unusual or inconclusive (for example, unusual phenotypes, Annex 1.2), or if required for notifiable infections/pathogens; and
- engaging in quality control procedures instituted by NRL and NCC.

Surveillance data collected by hospital sites are reported to the NCC or NRL for national collation. Hospital data can also be used locally to monitor changes in pathogens, antimicrobial resistance patterns and trends to:

- inform local clinical and prescribing practice, antibiograms and treatment protocols, infection control and AMS;
- identify transmission or outbreaks of key AMR pathogens;
- detect, report and respond to new/emerging resistance; and
- assess the impact of interventions and/or control strategies.

Sites should collect, analyse and report data on locally relevant pathogens as well as AMR pathogens targeted in GLASS-AMR. Sites should also develop capacity to identify and report emerging and new AMR and increasing rates of key AMR pathogens, using active or enhanced surveillance methods where needed.

Routine passive surveillance can be expanded by:

- increasing capacity for requesting, taking and testing blood cultures and other specimen types;
- including more hospital departments and patient populations;
- broadening the range of pathogens and antibiotics covered by AST; and
- increasing capacity for collecting, managing, analysing and sharing data.

Data collection

Passive AMR surveillance data should be collected on routine sample request forms, completed fully and accurately. Additional data collection tools may be developed for active and enhanced surveillance activities. Electronic data collection is preferable to paper-based systems. For more details on data management, see Section B2.

Reporting

Microbiological data reported from the laboratory to clinicians and other hospital staff inform clinical care, treatment decisions, AMS and infection control policy and practices. AMR data reported from surveillance sites to national level structures for compilation, analysis and dissemination drive local, national and global actions to contain AMR.

Laboratory staff may report microbiology test results to clinicians through phone calls, instant messaging, uploading results onto the laboratory information management system (LIMS) or sending paper reports to the ward where the patient is located. Other reporting includes written summaries, statistics and graphs; rapid communication of emerging issues; and information on system performance and impact for use in policy, research or external surveillance systems.

Reports may cover:

- monitoring and reporting of AMR prevalence and trends or changes in resistance patterns and/or frequency of critical AMR pathogens;
- identification of potential outbreaks through comparison with historical data and/or through automated alerts;
- ad hoc reporting of unusual events (EBS) by clinical, laboratory or other staff;

- monitoring and reporting AMR in defined populations, such as patients in certain wards or units, people with particular demographic characteristics or patients undergoing specific treatments and procedures; and
- enhanced surveillance for key AMR sample-, pathogen- or antimicrobial susceptibility-combinations identified through a local situation analysis, EBS, or following signal detection through other surveillance activities.

Governance

Each hospital should identify an AMR committee and an organizational structure for AMR surveillance. Where the hospital IPC or AMS committee acts as the AMR committee, it should include staff with specific knowledge and expertise in AMR surveillance (see below). Local executive and national-level ministry support is critical to ensure adequate resourcing.

The hospital AMR committee should include:

- an executive member of the facility with the authority to allocate resources and take remedial action as required;
- one or more medical professionals, such as a clinical microbiologist, infectious disease physician or antimicrobial stewardship champion;
- an infection-control professional;
- a pharmacist;
- a laboratory manager or person-in-charge of AMR testing; and
- a manager or custodian of AMR data – ideally an epidemiologist or staff member with epidemiological training.

Roles and responsibilities of the hospital AMR committee

Oversight:

- engaging with executive and clinical staff to identify local and national priorities, and ensure adequate resourcing and executive support for AMR committee actions;
- developing a local AMR surveillance plan that covers:
  - governance, coordination and communication;
  - current and planned AMR surveillance activities;
  - roles, responsibilities and training of clinical, laboratory and surveillance staff;
  - local SOPs adapted from national policy and guidelines;
  - awareness and prevention of AMR, including AMS and IPC activities;
  - procedures for local and external reporting of AMR surveillance data; and
  - procedures for reporting and responding to AMR outbreaks – see *Responding to outbreaks of antimicrobial-resistant pathogens in health-care facilities: guidance for the Western Pacific Region (4)*.

Training and quality assurance:

- supporting training, capacity-building and supervision in AMR activities; and
- working with the NCC/NRL on internal/external quality assurance and quality control measures, audits and laboratory accreditation.

Advocacy and communication:

- liaising with the IPC, AMS and drug committees to coordinate AMR activities, including those that support outbreak or transmission investigation and response; and
- awareness-raising and communication with stakeholders on AMR surveillance.

Monitoring and evaluation:

- developing and implementing lines of communication and timelines for feedback of AMR results to clinicians and AMR summary reports to stakeholders (hospital administration, clinical, laboratory and data management staff);
- monitoring surveillance data for AMR prevalence and trends;
- reporting EBS events;
- outbreak identification; and
- impact assessment.

Research and development:

- in-depth studies of, for example, specific pathogens or hospital settings to supplement surveillance data; and
- implementation research, for example, of new methods or technologies.

Staff roles and responsibilities for AMR surveillance

All staff should follow requirements stated in the AMR surveillance plan and facility guidelines/SOPs. Communication and collaboration between different cadres of staff is important for optimal patient care and is highly encouraged.

Clinical staff:

- request/collect clinical samples and refer them to the microbiology laboratory;
- record patient data for sample referral and surveillance accurately and completely;
- use laboratory testing results for optimal treatment of patients;
- recognize current and potential infection control threats;
- report unusual AMR events; and
- participate in audit activities.

Laboratory staff:

- perform core laboratory functions, including sample collection and storage, isolate identification, and AST;
- communicate AMR results to clinicians, IPC teams, public health authorities, and others according to local regulations, in a clear, concise and timely manner;
- refer isolates with unusual, unexpected or indeterminate resistance patterns to the NRL for further testing;
- routinely refer a subset of isolates to the NRL for surveillance purposes, following national surveillance procedures/guidelines
- adhere to local SOPs for internal quality control procedures; and
- work with NRL to participate in a recognized EQA scheme and work towards laboratory accreditation.

Surveillance staff with responsibility for data management and analysis may be drawn from clinical, laboratory or other hospital staff, but should be resourced for participation in surveillance activities. Their responsibilities can include:

- core functions including data collection, cleaning, validation, analysis and reporting;
- communicating AMR surveillance findings, including possible outbreaks to the laboratory, clinicians, AMR and IPC committees, and other stakeholders;
- reporting AMR surveillance data to NRL/NCC; and
- working with NCC and NRL to participate in internal audit and data quality improvement activities.

IPC staff play a key role in preventing and responding to facility transmissions and outbreaks, including those involving AMR pathogens.

- IPC staff should be aware of AMR surveillance activities and receive regular AMR surveillance reports.
- In many surveillance systems, IPC staff are involved in the collection of enhanced surveillance data due to their role in the management of patients with critical AMR pathogens; in smaller facilities they may act as surveillance staff.

Further details can be found in *Guidelines on core components of infection prevention and control programmes at the national and acute health care facility level (14)*.

Staff with responsibilities for antimicrobial stewardship:

- implement and provide access to standard treatment guidelines for infections;
- implement an antimicrobial formulary;
- implement restrictions on the use of antibiotics, for example from the "Reserve" category of the WHO AWaRe antibiotic classification *(15)*;
- review antimicrobial prescribing and implement point-of-care interventions, including directed therapy, intravenous-to-oral switch and dose optimization;
- promote behaviour change in antimicrobial prescribing [2]; and
- audit antimicrobial use and report to clinicians and management.

Step 8b. Strengthen community surveillance

as laid out in the AMR surveillance strategy.

Surveillance of samples collected outside hospitals and of community-associated pathogens is generally coordinated by local public health authorities and/or hospitals. Designating a local AMR champion to raise awareness of AMR and promote AMR surveillance in the community may be useful.

Community AMR surveillance may include activities conducted in or with:

- outpatient clinics and laboratories (public and private);
- public health units;
- community pharmacies; and
- non-health-care settings (elderly care facilities, community centres and schools).

Community surveillance may be used to detect and respond to pathogens that generally circulate in community settings, such as food poisoning or sexually transmissible infections. Community surveillance of AMR pathogens can be challenging to implement and most AMR surveillance is based on data collected in hospitals. National AMR surveillance should, however, aim to cover community-origin infections and community-associated pathogens, through the selection of surveillance sites and surveillance activities.

In many settings, patients self-treat at home or receive antibiotics from a local pharmacy. This inappropriate use of antibiotics is a driver of AMR. Routine surveillance may be supplemented with additional studies, such as community-based surveys, to estimate AMR in populations not captured by hospital-based surveillance.

[2] This could include financial incentives if approved by hospital management.

Mechanisms for conducting and strengthening community AMR surveillance include:

- ensuring outpatient physicians have access to and use routine microbiological testing (including AST) and receive AMR surveillance reports, for use in clinical decision-making and AMS activities in outpatient clinics;
- implementing EBS of suspected public health events, including AMR, by health-care workers in outpatient settings, as well as from public sources in the community;
- strengthening communication and data sharing between laboratories providing testing for community-associated infections and/or outpatient samples, outpatient clinical services and local public health units;
- implementing periodic monitoring (such as repeat cross-sectional surveys) of AMR in key community-associated infections not under continuous surveillance;
- integrating monitoring of key antimicrobials into routine surveillance and reporting for community-associated infections of public health concern (for example, notifiable conditions); and
- developing and implementing case management and response protocols for critically resistant community-associated pathogens, such as XDR *N.gonorrhoeae*.

PART B:

AMR SURVEILLANCE COMPONENTS AND METHODOLOGIES

B1. Laboratory data and methods for AMR surveillance

B1.1 Laboratory components for AMR surveillance

B1.1.1 National reference laboratory

Core NRL requirements and activities are shown in Table B1, together with additional activities, such as coordination of training and EQA programmes, use of advanced techniques for AMR pathogen identification, and conducting research into AMR that can be incorporated as NRLs become better established. In larger countries, some NRL functions may be delegated to provincial laboratories.

Table B1. Core and additional requirements and activities of the NRL

Category	Core requirements/activities	Additional requirements/activities
Physical requirements	Laboratory space, stable electricity supply, clean running/piped water, distilled or filtered water Internet access, separate refrigerators for samples and reagents/media	
Laboratory equipment, reagents and materials	Functioning laboratory equipment[a] Established equipment maintenance programme Adequate supply of reagents and materials Established procurement programme	Assist hospital and provincial laboratories with procurement of equipment, reagents and materials
Laboratory safety	Occupational health and safety training and supervision, including management of biohazard and chemical risks	
Training and competency	Trained laboratory staff, with ongoing training, supervision and management programmes System to develop, maintain and share reference materials for hospital and provincial laboratories	Provide training programmes for hospital and provincial laboratories, including surveillance sites Function as a regional centre for international AMR training programmes, adapting training materials for international use

Category	Core requirements/activities	Additional requirements/activities
Quality management system	Laboratory accreditation to ISO standard or local equivalent (or actively working towards accreditation) Documented SOPs and internal quality control processes Participation in EQA programmes	Provide hospital and provincial laboratories with internal quality assurance and feedback Coordination and administration of national or regional EQA programme
Storage of samples or isolates	Freezer storage of resistant isolates (–20 ^{0}C), with linkage to paper or electronic database	Reliable freezer storage (–80 ^{0}C) with linkage to electronic database
Accurate bacterial identification	Use recommended phenotypic methods from international standards or textbooks Perform additional identification using automated/semi-automated methods, such as MALDI-ToF, Vitek, Phoenix	Identify unusual organisms using advanced phenotypic or molecular methods, for example, API galleries, end-point PCR Identify unusual organisms by 16S rRNA sequencing or whole genome sequencing
AMR testing	Perform phenotypic testing for AMR, including confirmation of results from hospital or provincial laboratories Extended AMR testing[b] (for example, MIC testing) and testing of select antimicrobials[c] on a subset of isolates Detect or confirm unusual or new resistance patterns[d]	Use molecular testing or whole genome sequencing (in-house or in collaboration with external partners) to investigate exceptional or emerging resistance patterns[e] Engage in research and innovation to develop AMR capacity
Data reporting	Collate and report national microbiological data to NCC Confirm and report emerging AMR to GLASS-EAR[d]	

[a] For more details see Part C1. How to conduct an AMR laboratory assessment.

[b] If extended AMR testing including MIC methods (such as gradient diffusion testing, broth microdilution or agar dilution) is not yet feasible, collaborate with external partners while the NRL works towards implementing these methods.

[c] May include antimicrobials that are newly available or restricted, or difficult to test, such as colistin. Refer to the GLASS guidance on *The detection and reporting of colistin resistance (16).*

[d] GLASS-Emerging Antimicrobial Resistance Reporting (GLASS-EAR) provisional watch list includes pandrug-resistant (PDR) and extensively drug-resistant (XDR) phenotypes (not previously reported in a country), novel genetic determinants and critical resistance phenotypes, see Annex 1.3 *(11).*

[e] Refer to guidance documents on molecular methods for AMR diagnostics and whole genome sequencing (WGS) *(17,18).*

B1.1.2 Diagnostic laboratories

The primary function of diagnostic laboratories is to conduct microbiological testing to inform patient care. Data generated from microbiological testing and reported to NRL/NCC form the basis of AMR surveillance locally and nationally. Core and additional requirements and activities conducted by diagnostic laboratories are shown in Table B2. See also an example tool for assessing laboratory activities and capacity in Section C1.

Table B2. Core and additional requirements and activities of hospital laboratories[a]

Category	Core requirements/activities	Additional requirements/activities
Physical requirements	Laboratory space, clear work benches, stable electricity supply, clean running/piped water, distilled or filtered water Internet access, separate refrigerators for samples and reagents/media	
Laboratory equipment, reagents and materials	Functioning laboratory equipment Established equipment maintenance programme Adequate supply of reagents and materials 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, with ongoing training, supervision and management programmes	Provide training programmes for other laboratories
Quality management system	Documented SOPs and internal quality control processes	External quality assessment or accreditation
Data management	Paper-based laboratory data system	Electronic LIMS interfaced with AST instruments, for example, Vitek Electronic laboratory data system – linked with national system for reporting AMR data
Storage of samples or isolates	Freezer storage of resistant isolates (–20 °C) with linkage to paper database	Freezer storage of resistant isolates (–20 °C) with linkage to electronic database Reliable freezer storage (–80 °C) with linkage to electronic database
Culture of samples	Manual or automated blood culturing	Automated blood culture system Culture of cerebrospinal fluid (CSF), urine, stool, swabs, respiratory and urogenital samples

Category	Core requirements/activities	Additional requirements/activities
Accurate bacterial identification	Isolate identification using recommended phenotypic methods (Annex 1.4)	Additional identification using automated or semi-automated methods, for example, MALDI-ToF or Vitek Molecular methods for specific AMR pathogens, such as MDR Gram-negatives, MRSA, TB
AMR testing	Disk susceptibility testing performed according to SOPs following EUCAST or CLSI guidelines	Perform susceptibility testing by MIC methods such as gradient diffusion, agar dilution or broth macro/ microdilution Additional phenotypic testing for AMR mechanisms, such as carbapenemases[b] Automated susceptibility testing (for example, Vitek, Phoenix, MicroScan) Collaborate with NRL/partners to investigate emerging AMR patterns or methods

[a] Provincial laboratories may perform all core functions, as well as activities from the additional categories.

[b] Phenotypic testing methods for carbapenemases, for example, carbapenemase inactivation method (CIM) test *(19)* or CarbaNP *(20)*.

B1.2 Target specimen types and pathogens for AMR surveillance

B1.2.1 Specimen types

Data collection, analysis and reporting are recommended for all specimen types listed in Annex 1.5 (blood, CSF, urine, stool, sputum, urethral, cervical, rectal and pharyngeal swabs). Surveillance systems may initially focus only on certain key specimen types, adding others later as capacity and experience increases.

Invasive specimens (blood cultures and CSF) should be the focus of attention where resources and capacity are limited. However, inclusion of non-invasive specimens (such as urine and sputum) can provide important information about AMR burden, influence treatment decisions as resistance patterns may differ from invasive isolates, and assist in identifying emerging threats and/or outbreaks.

Recovery of an organism from blood cultures or CSF is likely to indicate true infection if no contamination occurs during specimen collection. Recovery of selectively cultured target pathogens, such as *Salmonella* and *Shigella* from stool samples or *Neisseria gonorrhoeae* from genitourinary tract and pharyngeal specimens, is always considered to represent true infection.

Urine and lower respiratory tract specimens are more likely to be contaminated and clinical and laboratory expertise is required to judge whether a cultured organism is significant (meaning causing disease) or a colonizing or contaminating organism. These specimen types should be collected only from patients with a compatible clinical illness (for example, with symptoms of a urinary tract or lower respiratory tract infection) and not from asymptomatic individuals, to reduce the risk of false positive

results. Bacteria and/or white cells found in a Gram stain and/or the presence of a pure growth of a predominant organism rather than mixed cultures increase the likelihood that a cultured pathogen is clinically significant.

B1.2.2 Pathogens

GLASS-AMR targets pathogens and antimicrobial combinations with increasing rates of AMR that cause common bacterial infections in health facility and community settings. The list includes AMR pathogens on the WHO list of priority pathogens to guide research and development of new antibiotics *(21)*, with the addition of *Streptococcus pneumoniae* and *Haemophilus influenzae* in CSF and lower respiratory tract specimens, and *Neisseria meningitidis* in CSF *(22)* (Annex 1.5).

Hospital laboratories must focus their resources on key AMR pathogens, but are encouraged to develop capacity to identify and act on AMR in all locally relevant pathogens, taking into account the following factors:

- Organism – how likely is the pathogen to cause disease or invasive disease (for example, bacteraemia or meningitis) versus colonization?
- AMR pattern – what is the spectrum of resistance against locally available antibiotics (including "Reserve" and "Watch" antimicrobials), multiple drug classes, or all relevant oral antimicrobials?
- Population – does the pathogen affect high-risk populations (for example, intensive care unit or haematology/oncology patients, children)?
- Context – is this an increasing or emerging AMR pathogen in the area, country or region?

B1.2.3 Emerging, new and other critical AMR

Consistent detection of emerging, new and other critical AMR is important to identify affected patients or outbreaks, implement infection control or public health actions to limit transmission, and reduce clinical and public health impact.

Emerging and new AMR is defined in the *GLASS emerging antimicrobial resistance reporting framework (11)* (Annex 1.3) as:

- new types of phenotypic resistance, that is, exceptional phenotypes that have not previously been reported or are very rare; and
- new genetic determinants of AMR, meaning novel resistance genotypes that are associated with mechanisms of resistance with a high potential for spread and health impact or that pose serious challenges in laboratory detection and surveillance.

Other critical AMR can include:

- pan-drug resistant (PDR) phenotypes (Annex 1.1);
- extensively drug-resistant (XDR) phenotypes not previously detected in the country (Annex 1.1); and
- other pre-defined critical resistance phenotypes specified in national and/or hospital surveillance plans.

Routine testing at surveillance sites should include the antimicrobial-pathogen combinations needed to detect emerging and critical AMR, and/or identify isolates that require referral to the NRL for further testing and confirmation.

B2. Data collection, management and analysis for routine passive surveillance

To facilitate collation of data from multiple surveillance sites, the NRL/NCC should develop national SOPs for data collection and management that also reflect the requirements of external surveillance programmes if the country reports to WPRACSS or GLASS. National SOPs should be consistently implemented by all surveillance sites, using standardized sample request and referral forms (see Annex 3.1 and 3.2 for examples). Surveillance sites that undertake local analysis and reporting may also need to develop their own SOPs. All procedures should be supported by documented training for relevant surveillance site staff.

This section focuses on routine passive surveillance but indicates where methods also apply to other active and enhanced surveillance activities.

B2.1 Data required for AMR surveillance

Data should be collected, recorded and retained on all pathogens, sample types and results (including negative results), to support streamlining of processes and:

- to allow analysis targeted at current priorities, but also of historical data in response to emerging AMR issues or changing priorities;
- to address the differing requirements of national, regional and global surveillance;
- to allow flexibility to include different results in different analyses, depending on the local analysis question or external surveillance programme;
- to allow calculation of the proportion of a sample type positive for a given pathogen and/or resistance by recording the total number of samples collected (sample-based surveillance); and
- recognizing that any pathogen may be associated with outbreaks or important resistance.

In routine passive surveillance programmes, the minimum dataset is generally small whereas active or enhanced surveillance may require more patient information or microbiological details (Table B3). Data collected with an individual sample may also differ according to the specimen or pathogen type and/or risk factors associated with the setting.

Table B3. Data required for AMR surveillance of all samples collected for surveillance

Surveillance activity	Data to be collected
Routine surveillance – core data	**Patient** ▪ Person-level identifiers ▪ Demographic data: date of birth or age, sex, residential location (region or province, at minimum) ▪ Clinical presentation ▪ Reason for specimen collection (clinical presentation/screening) ▪ Patient admission date ▪ Patient location at time of specimen collection (inpatient/outpatient at minimum) ▪ Hospital- or community-origin of infection **Specimen/sample** ▪ Sample identifier ▪ Specimen type ▪ Sample collection date ▪ Sample receipt or testing date ▪ Microbiological testing results relevant to the sample and/or isolate type
Routine surveillance – additional data	More details on patient location at the time of specimen collection facility type: referral/district hospital, health centre, community clinic admission ward if applicable Clinical presentation: clinical signs and symptoms, onset dates Epidemiological risk factors relevant to the pathogen and setting, such as international travel, residence in a care facility, surgical or other procedures during acquisition period
Enhanced surveillance	Initial antimicrobial treatment (both inpatient and outpatient) More detailed epidemiological risk factor data: recent hospitalizations, surgical procedures or community exposures More detailed hospitalization data for the identification of potential transmission, such as detailed ward movement data More detailed microbiological testing results or pathogen characterization (for example, whole genome sequencing)

B2.2 Data collection

Surveillance data usually originate from multiple sources, such as hospital administrative, clinical and laboratory records, as well as interviews with patients, family members and/or clinicians (targeted surveillance), which presents challenges for data linkage and accuracy.

Patient identifiers should be collected to enable data linkage and appropriate deduplication during analysis (Sections 2.3.4 and 2.4):

- In countries with national systems, unique patient identification numbers allow clinical and laboratory data entered or collected separately to be linked to one individual whenever/wherever an individual presents at a health-care facility.
- More commonly, facility-based patient medical record numbers allow duplicate samples from the same patient to be identified within but not between facilities.
- If a unique person identifier is not available, a unique "episode" identifier should be used to identify all samples from a patient within the same illness episode or health-care presentation.

Unique specimen numbers should be assigned to each sample.

Data collection methods should support timeliness, accuracy and completeness of data and minimize extra work for staff. Wherever possible, raw data should be collected and recorded in addition to any reported interpretation: for example, MIC and/or disk diffusion zone diameters for AST testing results. This allows more detailed analysis and reinterpretation if criteria for interpreting susceptibility or other data categories change.

Additional data collection may be required for enhanced surveillance activities following the identification of a critical phenotype or genotype, or for a subset of cases meeting specific laboratory criteria. For example, core data may be collected for all STI screening swabs, with additional data collected for patients from whom *N. gonorrhoeae* with high-level azithromycin resistance or ceftriaxone non-susceptibility is cultured. Additional data should be collected on standardized forms specific to the sample, isolate or condition under surveillance (see Annex 3.3 for an example for carbapenemase-producing Enterobacterales).

B2.3 Data management

B2.3.1 Data management software and systems

Several options exist for managing AMR surveillance data and test results, including specialized software such as WHONET, other LIMS and locally developed software, that allow data to be validated on entry and each entry or record to be stored independently. To increase efficiency and sustainability, it is helpful if the same system is used across all surveillance sites. Ideally, AMR data should be aligned with other health data, with the LIMS linked to or embedded within existing national health information systems, avoiding stand-alone systems as much as possible.

Microsoft Excel and other spreadsheets are not recommended because of the comparative lack of data validation and the ease with which fields can be independently sorted, resulting in incorrect data associated with a sample or patient. Such mistakes often go unnoticed and lead to incorrect analysis and reporting.

WHONET is a desktop Windows application used in many countries for the local management and national collation of microbiology data. It can be freely downloaded from www.whonet.org and used on hospital and laboratory computers or linked with existing information systems to manage microbiological data including AST results. Patient, sample and raw AST data can be manually entered into WHONET. Microbiology test results stored in laboratory information systems, Microsoft Access databases, or instrument software (such as Vitek or MicroScan) can be imported into WHONET using the BacLink data import utility bundled with WHONET, to avoid the need for double data entry. WHONET supports laboratory configuration, data entry, encryption, analysis and public health reporting, and can be customized to incorporate additional surveillance data as required.

B2.3.2 Data validation

Data validation rules and pre-defined values imposed by software during data collection and/or entry support standardization and reduce data entry errors, ambiguous data recording and other common errors. They include using pre-defined categorical options, enforcing logical date orders, valid identifier strings and specified ward or unit classification (Table B4).

Table B4. Examples of data validation and pre-defined values for key surveillance fields

Variable name	Type of variable	Description, allowed values and validation considerations
SampleID	String	Unique sample ID Allowed values such as string length and structure specified
PatientID	String	Unique patient ID Allowed values such as string length and structure specified
Sex	Categorical	Sex of the patient. Allowed values: Male, Female, Other, Unknown, Not stated
BirthDate	Date	Patient date of birth Allowed values: Date Validation: Not after sample collection Specify default values for inexact dates
Age	Numeric	Age of the patient in years when the sample was taken Allowed values: Number, 0–130 Consider automatic calculation, and capture if < 2 years
ClinicalPresentation	Categorical	Clinical presentation associated with sample collection Allowed values: Specify as per clinical case definitions, Other, Unknown, Not stated Validation: Select pre-defined response
DateOfHospitalization	Date	Date of hospital admission Allowed values: Date Validation: Not before birth date
PatientLocation	Categorical	Location of patient at sample collection Allowed values: Inpatient, Outpatient, Unknown, Not stated
DateCollection	Date	Date of sample collection Allowed values: Date Validation: Not after today
Pathogen	Categorical	Allowed values: pre-defined list
Below as a repeatable block for each antimicrobial		
Antimicrobial	Categorical	Allowed values: pre-defined list Validation: Must match pre-defined list of pathogen and susceptibility combinations for chosen pathogen
SIR	Categorical	Final interpretation result of all different susceptibility tests performed: S/I/R
ResultZoneSign	Categorical	Sign used in the zone diameter Allowed values: >, <, =
ResultZoneValue	Numeric	Zone value (mm) Allowed values: Specify as per antimicrobial
ResultZoneSIR	Categorical	Interpretation of susceptibility from the zone Allowed values: S/I/R

Variable name	Type of variable	Description, allowed values and validation considerations
ResultMICSign	Categorical	Sign used in the MIC (> < =) Allowed values: >, <, =
ResultMICValue	Numeric	MIC (mg/L) Allowed values: Specify as per antimicrobial
ResultMICSIR	Categorical	Interpretation of susceptibility from the MIC: S/I/R Allowed values: S/I/R
ResultEtestSign	Categorical	Sign used in the MIC from a gradient strip test Allowed values: >, <, =
ResultEtestValue	Numeric	MIC value from gradient strip test (mg/L) Allowed values: Specify as per antimicrobial
ResultEtestSIR	Categorical	Interpretation of susceptibility from the gradient strip test Allowed values: S/I/R

Source: Modified from *GLASS manual for antimicrobial resistance surveillance in common bacteria causing human infection (22).*

B2.3.3 Data cleaning

AMR surveillance data should be cleaned on an ongoing basis to ensure the data are accurate, complete, not duplicated, correctly linked to patient data, and free of inconsistencies (for example, exceptional/highly unusual phenotypes, Annex 1.2). Cleaning should, at a minimum:

- assess reported cases against surveillance criteria and/or case definitions
- identify missing data
- identify data that violate validation rules
- identify data-entry errors such as nonsensical data or misspelled words.

A data dictionary describing the appropriate values and definitions for each field is useful to improve data quality during data collection and reduce the amount of data cleaning needed. Where paper forms are used, the original documents should be checked to identify data-entry errors, and data-entry periodically audited. All data cleaning should be documented and logged to enable auditing of data changes, process improvement and training.

B2.3.4 Deduplication of data

Bias arises in surveillance data if resistant organisms are over or selectively tested or reported. For example, patients with a resistant organism are more likely to be tested multiple times during an illness than patients with a susceptible infection, resulting in overrepresentation of the resistant organism unless data are deduplicated.

For surveillance purposes, data should be collected and reported for all samples from all patients. However, when aggregate data analysis is performed, samples and isolates are selected from the database based on the questions being asked. Deduplication procedures may differ between local, national and global surveillance systems.

Options for deduplication:

- data can be exported complete, and deduplication performed externally from the database, leaving the original records unaltered, or (preferably); and
- the database is configured to export only the results required for a specific analysis or report.

Many databases allow configuration of multiple export templates, which automatically apply deduplication criteria for specified routine analyses. Alternatively, variables can be created to indicate whether a database entry is unique or a repeat sample or pathogen identification, which can then be filtered on export or during analysis.

Deduplication guidelines for standardized aggregate reporting typically include the following.

- Reporting by sample type only – include only the first sample per sample type per patient in a reporting period, meaning, include only the first blood sample taken from a patient when calculating "the number of blood culture isolates collected during the surveillance period".

  Examples:

  - if two blood cultures from the same patient yield growth of *E. coli*, include only the first isolate in aggregate reporting;
  - if there is growth of *E. coli* in one blood culture and in one urine culture from the same patient, include both specimens when reporting by sample type.

- Reporting by pathogen type only – include only the first sample per species per patient regardless of sample type, meaning include only the first *E. coli* from any sample from an individual patient when calculating "the proportion of *E. coli* resistant to meropenem during the surveillance period".

  Examples:

  - if *E. coli* is detected in one culture and *K. pneumoniae* in the other, include both results in *E. coli* and *K. pneumoniae* statistics respectively, however, when reporting by sample type only, report only one of the samples;
  - if there is growth of *E. coli* in one blood culture and in one urine culture from the same patient, include only the first sample collected when reporting by pathogen type.

- Reporting by sample and pathogen type – include the first sample per species per sample type, meaning include only the first *E. coli* isolate from a blood culture from a patient when calculating "the number of *E. coli* obtained from blood cultures resistant to meropenem during the surveillance period".
- Reporting samples collected for clinical and screening purposes – include all samples unless the analysis is to inform clinical care and/or treatment decisions, when screening samples may be excluded as they are not representative of patients with clinical disease.

For some analyses, repeat samples of the same sample type and/or pathogen type may be required, for example:

- identification of emerging resistance in a patient during therapy
- calculation of the duration of carriage or colonization, or
- development of invasive infection from a colonizing or non-invasive organism.

B2.4 Data analysis

Routine data analysis is conducted to assess AMR burden and trends by determining the frequency and proportion of, for example:

- target pathogens identified in different specimen types
- resistance to specific antibiotics
- unusual or critical AMR pathogens.

Sample-based surveillance requires the number of patients from whom a sample was collected for microbiological testing, both with and without growth of the bacterial pathogens under surveillance for the denominator. Isolate-based surveillance includes only positive tests in the denominator (Section 1.6).

Analyses may be disaggregated by patient population, geographical location, facility or other risk factors. Additional analysis may be required for active and enhanced surveillance activities.

Analysis is recommended for:

- specimen types and pathogens listed in Annex 1.5
- pathogen-specific antimicrobial susceptibility combinations listed in Annex 1.6.

To identify unusual, emerging or new AMR and isolate resistance patterns for a given setting *(23)*, additional analyses may be needed, including:

- additional species and antimicrobial susceptibility combinations relevant to the setting
- routine rapid analysis for identification of emerging threats and/or outbreak detection (Section B5.3).

Examples of AMR surveillance data analysis:

1. Frequency and proportion of a given organism by specimen type under surveillance, for example, the number and proportion of patients with cultured bloodstream infections caused by *K. pneumoniae* in the reporting period, where:

$$Frequency = Number\ of\ patients, per\ sample\ type, where\ the\ given\ organism\ has\ been\ identified$$

$$Proportion = \frac{Frequency}{Total\ number\ of\ patients\ tested, per\ specimen\ type} * 100\%$$

2. Frequency and proportion of a given organism resistant to an antimicrobial under surveillance (see Annex 1.6), for example, the number and proportion of patients with positive blood cultures caused by *K. pneumoniae* resistant to any third-generation cephalosporin tested, where**:**

$$Frequency = Number\ of\ patients, per\ specimen\ type\ and\ organism, \\ resistant\ to\ the\ antimicrobial\ under\ surveillance$$

$$Proportion = \frac{Frequency}{\begin{array}{c}Total\ number\ of\ patients\ tested, per\ specimen\ type\ and\ organism, \\ with\ a\ valid\ AST\ result\ for\ the\ antimicrobial\ under\ surveillance\end{array}} * 100\%$$

Note that here, patients without a valid result are excluded from the denominator.

3. Number or frequency of unusual or critical AMR pathogens, for example, the number of patients with *K. pneumoniae* meeting the case definition of a suspected or confirmed carbapenemase-producing organism in any sample type, where:

$$Rate = \frac{\begin{array}{c}\text{Number of patients, per specimen type, with infection by pathogen}\\ \text{and resistant to the antimicrobial under surveillance}\end{array}}{\begin{array}{c}\text{Population tested during the reporting period per specimen type}\\ \text{with valid AST result}\\ \text{for the antimicrobial under surveillance}\end{array}} * 100\,000$$

Note: if colonized or asymptomatic patients (for example, identified through active screening programmes) are captured in surveillance data, the decision to include or exclude them in analysis and reporting will depend on the intended use of the data, for example:

- the results should be excluded when analyses inform treatment decisions and/or patient care, such as in antibiograms;
- the patients should be included in analyses of trends in frequency and outbreak detection, as they may be involved in transmission of critical AMR pathogens; and
- data should be stratified by reason for specimen collection and/or by colonization/infection when reporting analyses of trends or incidence because identification of colonized patients is strongly influenced by screening practices – increases in cases identified through screening but not in those identified clinically, may reflect increased screening, not increased incidence.

Other denominators may also be used, for example, the population under surveillance or the number of patient bed days or admissions during the surveillance period.

Hospital level analysis: frequencies, proportions and rates can be calculated using all data for the surveillance period. Data can be stratified by specimen type, department, clinic, ward and demographic or clinical variables such as age, procedures undergone, risk factors and/or clinical conditions, to identify patient populations at higher or lower risk of specific resistance profiles or pathogens.

Analysis of trends: generation of epidemiologic curves and similar graphs over time enables the detection of trends and/or clusters of resistant organisms for further investigation and/or intervention.

Outbreak identification: if more people than expected appear to have a particular resistance, resistance pattern or AMR pathogen in a given time period, area or population, the findings should be immediately reported to the relevant AMR and IPC committees for investigation and follow up (see Section B5.3.2).

A guide to implementing routine data analysis can be found in How to conduct routine data analysis for AMR data in Part C.

Limitations in data completeness, quality and consistency, and biases must be considered during analysis. Routine surveillance relies on samples collected for clinical care. Data reflect only individuals who experience symptoms, present for medical care to a health practitioner who requests a diagnostic sample, and where laboratory testing is performed. Over time, there may be changes in testing availability or awareness, methodologies, case definitions, populations under surveillance and data capture (Section B5) that must be taken into account when making comparisons against historical data.

B2.4.1 Analysis using WHONET

WHONET can be used for data interpretation, storage and reporting of individual patient results (Section B2.3.1), to perform the analyses outlined in Section B2.4 and generate facility-level summary reports without the need for external processing. Data from surveillance sites can be prepared and transferred to the NCC. Alerts to detect potential spatial and temporal clusters can be implemented using WHONET-SaTScan *(24,25)*.

The WHONET software has automated export functions that generate Research Information Systems (RIS), sample and individual dataset files for upload to the GLASS IT platform and data can also be exported for further analysis in ASIARS-Net. WHONET is available in 45 languages and used in more than 130 countries. The software is updated regularly, and new features added. Online training is available at https://whonet.org/training.html.

B2.4.2 Analysis using ASIARS-Net

The Asian Antimicrobial Resistance Surveillance Network (ASIARS-Net) is an open-source, international web-database system developed by the National Institute of Infectious Diseases, Japan, a WHO Collaborating Centre for AMR surveillance and research *(26)*. Users of ASIARS-Net own a secure, confidential, cloud-based database and can upload and process large amounts of data and create hospital-specific, national and/or GLASS-AMR reports.

ASIARS-Net has been developed in collaboration with the WHO Collaborating Centre responsible for WHONET. Data can be imported into ASIARS-Net from WHONET (or from Excel files converted using a data conversion tool publicly available at https://github.com/bioprojects/Excel_to_ASIARS-Net). Uploaded files are automatically removed from the server after data processing for data security.

ASIARS-Net functions include:

- data validation
- automatic data aggregation and processing
- comparison from multiple files and/or multiple facilities for a single analysis generation of:
    - hospital-level feedback reports
    - inter-hospital comparisons
    - benchmarking using the same criteria and graphical outputs (such as box-plots)
    - aggregate files for submission to WHO GLASS.

ASIARS-Net can be used as a stand-alone system or to complement WHONET software. Development of ASIARS-Net is ongoing and a team from the National Institute of Infectious Diseases is available to support ASIARS-Net users, providing assistance with preparation, cleaning and conversion of data, customization and utilization of reports.

B3. Data reporting

Data reporting is bidirectional: local reports of AMR data inform local actions; local to national reports provide core data for national AMR surveillance; national to local reports provide feedback and guidance to surveillance sites and other hospitals; and GLASS depends on national to global reporting. Sites should follow relevant protocols outlined in hospital AMR surveillance plans, the national AMR action plan, AMR surveillance strategy and GLASS or WPRACSS.

B3.1 Local: reporting surveillance data to inform local actions

Reporting protocols may include:

- immediate reporting of data indicating a potential outbreak to the AMR/IPC committee or other appropriate party, for investigation and action (see Section B5.3.2); and
- routine reporting of surveillance data to inform local policy and hospital practices.

Depending on the available data and surveillance objectives, reports may include:

a. statistics: frequencies, proportions, rates and trends by specimen type, pathogen and/or antimicrobial-pathogen combinations;
b. epidemiologic curves for critical AMR and/or key pathogens;
c. reports of EBS, additional surveillance activities or other investigations;
d. changes in testing or surveillance practices, new initiatives or programmes; and
e. identification of findings specific to any ward or patient-group.

It is helpful if reports include an interpretation of the data and a brief executive summary highlighting any changes or areas that require investigation or attention.

B3.2 Local to national: reporting to the NCC/NRL by surveillance sites

AMR surveillance sites that use an LIMS or WHONET software can aggregate surveillance data into the required format, and report data electronically to the NRL/NCC for collation. Sites using paper-based systems send their aggregate reports to NCC/NRL at regular intervals, for example, monthly. Signals that may require immediate action should be accompanied by phone calls to the appropriate authorities.

Reporting to national authorities includes:

- immediate reporting of samples or patients meeting case definitions for notifiable or reportable conditions;
- immediate reporting of events identified through EBS for follow-up and investigation; and
- periodic reporting of routine passive sample- or isolate-based surveillance data.

B3.3 National to local: development of a national AMR surveillance annual report

Reporting protocols may include:

- feedback and guidance to surveillance sites
- national statistics to inform policy and practice.

In addition to the details outlined in 3.1 a-e above, routine reporting from the national to the local level may include:

- region- or population-specific findings sufficient to drive action at the local level
- assessment of participation and representativeness of surveillance sites and regions
- feedback on data quality and performance as part of quality assurance activities
- an interpretation of data and executive summary highlighting any changes or areas that require investigation or attention.

B3.4 National to international: reporting to GLASS

In Member States that report to GLASS, the NCC (or NRL) is responsible for preparing and submitting national datasets to GLASS, comprising data aggregated from surveillance sites.

B4. Active AMR surveillance

Active methods of AMR surveillance complement routine passive AMR surveillance by targeting locations, pathogens, diseases or specimen types that are insufficiently covered by passive surveillance. Active surveillance methods can be used to increase representative coverage of, for example, community-associated infections, perform deep-dives into particular pathogens or to identify signals of emerging threats or outbreaks.

B4.1 Periodic monitoring for AMR

Periodic monitoring, included in national or hospital AMR surveillance plans or conducted as research studies, can be a resource-efficient way of capturing cross-sectional AMR data from clinical presentations, sample types, pathogens or locations that are not adequately captured by routine surveillance. Data collected repeatedly over time using the same methodology and similar populations can be compared to assess trends.

WHO recommends that where representative coverage of routine passive AMR surveillance is still in development, countries may use periodic, active surveillance of blood stream infections at selected nationally representative hospitals (AMR prevalence surveys) to provide more accurate estimates of AMR burden *(27)*.

B4.1.1 Uses of periodic monitoring in hospital settings

Examples of how periodic monitoring of AMR can be used in hospital settings include:

- active screening of patients admitted to a hospital or specific ward to determine the proportion of patients colonized or infected with a multi-resistant organism;
- extended AST on all bacterial isolates of a pathogen, clinical presentation or sample type to determine the prevalence of resistance to non-routinely tested antimicrobials;
- additional sample collection for culture and AST for clinical presentations or sample types that are not routinely submitted for microbiological testing;
- collecting additional data to determine the number and proportion of hospitalized patients with a health-care-associated infection (HAI). These data can be collected at the same time as AMU data are collected *(28)*, or as part of the Global Point Prevalence Survey of Antimicrobial Consumption and Resistance (Global-PPS) *(29)*; or
- additional data collection (such as treatment, epidemiological or clinical data) from hospitalized patients diagnosed with a specific illness, pathogen or resistance profile to better understand risk factors and transmission.

B4.1.2 Cross-sectional surveys of community-associated infections

Examples of periodic monitoring for community-associated infections include, for a set time-period conducting additional:

- collection of samples for culture and AST from people with a defined clinical syndrome where samples are not commonly submitted for microbiological testing (for example, gastroenteritis, urinary tract infections) to better understand AMR and inform treatment guidelines for these conditions;

- extended AST on all isolates of a particular pathogen (for example, *N. gonorrhoea*) identified as part of outpatient clinical care, to determine the prevalence of resistance to non-routinely tested antimicrobials; and
- data collection (for example, treatment, epidemiological or clinical data) from outpatients diagnosed with a specific illness, pathogen or resistance profile to better understand risk factors and transmission.

A How to guide to conducting periodic monitoring studies is provided in Part C.

B4.2 Sentinel surveillance for AMR

Sentinel surveillance targets a subset of locations, pathogens, diseases or sample types and is a systematic and efficient way to collect data in a timely manner when routine surveillance is unable to collect such data continuously, either because of limited resources or because the sampling base is too big.

Sentinel AMR surveillance is useful for collecting information on resistance patterns to estimate AMR burden and monitor trends or inform antibiotic treatment but is often not sensitive to the detection of outbreaks. Samples, locations and patients selected for sentinel surveillance should be consistent over time to minimize bias but data may not be representative of the population, and this must be considered when interpreting the data.

Sentinel surveillance may be directed at:

- specific locations such as sexual health clinics, where people with a particular infection (for example, *N. gonorrhoeae*) are more likely to present; and
- a sample of patients and/or health-care facilities, for example, for surveillance of common infections such as respiratory- or urinary-tract infections, where analysis of samples from all patients would be impossible due to high numbers.

B4.3 Research studies

Research studies can take advantage of alternative funding mechanisms such as research grants and use active surveillance methods to generate important information to supplement routine passive surveillance.

Institutions with particular interests or expertise, time and/or resources can also contribute to or lead in-depth studies of specific pathogens, settings, new/emerging AMR or other interesting findings or unanswered questions. Implementation research may study, for example, use of new methods or technologies and thus contribute to development.

B4.4 Event-based surveillance for AMR

EBS is the rapid capture, reporting and investigation of ad hoc information on public health events. EBS is a core component of surveillance under the *Asia Pacific Strategy for Emerging Diseases and Public Health Emergencies* and has been established in many Western Pacific Region Member States. EBS enables reporting of new or unusual AMR events that fall outside standard case definitions and reporting structures. It can be more sensitive for detecting outbreaks than routine, passive AMR surveillance, especially in LMICs *(30,31)*.

EBS mechanisms enable health-care workers and/or laboratory staff to report events for further investigation, including clusters of cases or unusual increases in resistance that may indicate AMR outbreaks. EBS data may also originate from publicly available sources such as news media sites, disease reporting networks or other formal or informal channels.

Reporting, verification and investigation of AMR events

Data collected for EBS fall into two categories:

- active or passive surveillance for rumours, news or other reports of disease clusters or cases, usually done at a national or international level; and/or
- ad hoc reporting by the media, health-care workers and/or the public, of unusual events occurring in the community, in health-care settings or at a national or international level.

To maximize early detection of outbreaks or clusters, EBS reporting should be quicker and more flexible than other forms of surveillance. EBS protocols should include:

- broad definitions of suspected cases or clusters of AMR pathogens that must be reported
- loose data formats that are not pre-defined, with as much information (quantitative and/or qualitative) collected on each report as is available
- a wide range of sources including the public and other untrained individuals
- immediate data submission, analysis and/or response rather than at pre-defined intervals.

An example of an EBS report form is shown in Annex 3.3. Mobile or online methods of reporting should be used wherever possible to maximize the speed and reach of reporting.

Once a report is received, further information can be sought from the reporter and from local or treating health-care practitioners, community leaders or other investigators, and a risk assessment performed. Depending on the signal, an outbreak investigation may trigger additional sample collection and/or laboratory testing and support for outbreak verification and response (see Section B5.3.2).

Further information on EBS can be found in WHO's *A guide to establishing event-based surveillance (31).*

B4.5 Enhanced surveillance

Enhanced surveillance provides in-depth microbiological, clinical and/or epidemiological information on a subset of specimens or patients of particular interest, such as:

- patients meeting specified laboratory criteria, for example, emerging or critical resistances, to investigate outcomes of infection or identify risk-factors;
- prevalence of resistance to antibiotics which are not routinely tested; and
- patients suspected to be part of an outbreak, to investigate transmission.

For example, the Enhanced Gonococcal Antimicrobial Surveillance Programme (EGASP) builds on sentinel surveillance for *N. gonorrhoeae* by collecting demographic, clinical and behavioural data from patients. EGASP improves detection of emerging AMR, trends, repeat *N.gonorrhoeae* infections and possible treatment failures and generates evidence for treatment guidelines and public health strategies and policies.

In outbreak investigation, enhanced surveillance involves specific, targeted data collection to find additional cases, collect more detailed epidemiological or patient-level data, conduct environmental surveillance and perform epidemiological investigations. The information obtained allows an outbreak to be characterized, hypotheses about transmission to be generated and mitigating measures to be identified (see Section B5.3.2).

B5. Data for action

Surveillance data should inform and support measurable action to respond to, contain and minimize the impact of AMR, as defined by the surveillance system objectives and priorities.

Key uses of surveillance data for action include:

1. estimating the AMR burden and trends
2. informing clinical decision-making and policy
3. identifying and responding to emerging and new AMR and outbreaks
4. monitoring and evaluation to inform system improvement.

Factors that may lead to bias in datasets and which should be considered when interpreting surveillance data include:

Population factors: are patients captured in the surveillance data:

- more unwell, with more complicated infections?
- more likely to have accessed health facilities with laboratory capacity, such as in urban areas?
- wealthier and able to afford laboratory tests?
- more likely to have failed initial empiric therapy?

Surveillance methods: changes in the number of tests conducted or testing practices can bias the assessment of trends or differences between subpopulations:

- Testing numbers: changes in the populations, patients, facilities or regions captured in the data may affect the number of tests.
- Testing or reporting practices: surveillance data may be affected by changes in:
    - tests or laboratory methods;
    - availability of testing materials or laboratory staff;
    - screening or testing numbers due to suspected outbreaks, studies or other testing programmes;
    - laboratory errors (such as use of more sensitive test methods, incorrect AST results due to failure of internal quality controls, contamination of equipment, reagents, samples or cultures); or
    - diagnosis and/or data management errors (for example, incorrect data deduplication).

B5.1 Estimating the AMR burden

Estimating the AMR burden involves collecting and monitoring data on key pathogens, defined antimicrobial/pathogen combinations, resistance patterns and mechanisms. An understanding of the AMR burden forms the basis of AMR surveillance, informs interventions to mitigate AMR and underpins further uses of surveillance data described below.

The burden of AMR can be estimated by hospitals and as a part of national AMR surveillance by calculating indicators such as:

- the proportion of specimens from which a target pathogen was identified; and
- the proportion of isolates of each pathogen resistant to tested antimicrobials.

Indicators may be disaggregated by, for example, ward, geographical location or age, to determine how AMR affects different groups of people.

Enhanced data collection or research studies may be used to estimate additional measures of the burden of AMR, such as:

- incidence of AMR infections in the population
- morbidity and mortality associated with, and attributable to, these infections.

For detailed methods for calculating the burden of AMR, see Section B2.4.

B5.2 Informing clinical decision-making and policy

B5.2.1 Clinical decision-making – antibiograms

What is an antibiogram?

An antibiogram (or cumulative antibiogram) is a table summarizing the antimicrobial susceptibility of different organisms over a specific period of time that is used to inform local or national antimicrobial prescribing, empiric treatment guidelines and formulary management. For more details, see How to develop a cumulative antibiogram in Part C. Knowledge of local or national patterns of AMR supports clinicians to prescribe antibiotics appropriately.

Application of antibiograms to clinical practice

WHO has developed guidance indicating when "Access" group antimicrobials (narrow-spectrum, widely available) should be chosen over "Watch" and "Reserve" antibiotics (broader-spectrum antibiotics with restricted indications for use). Antibiograms play a key role in AMS and laboratories should provide annual analyses and interpretation of local data to those responsible for developing or reviewing standard treatment guidelines, recommendations for empirical antimicrobial therapy and formulary management.

The antibiogram can be used:

- to inform selective reporting of antimicrobials by the laboratory, only reporting broader-spectrum antimicrobials when there is resistance to narrow-spectrum ones;
- to inform empirical treatment guidelines by identifying the narrowest-spectrum antimicrobial to which each organism is reliably susceptible;
- to inform formulary updates by identifying new antimicrobials for inclusion; and
- for audits of antimicrobial use, providing data and feedback to clinicians to influence prescribing.

Example: an audit of prescribing practices for sepsis identifies that 75% of patients are prescribed anti-MRSA therapy using vancomycin. However, the rate of MRSA in blood cultures is only 5%, indicating that vancomycin should not be used routinely as empiric treatment.

Limitations of antibiograms

Antibiograms are useful tools to summarize AMR data for common organisms and commonly tested antimicrobials, but have limitations and potential sources of bias:

- susceptibility estimates are less reliable (or cannot be included) when there are small numbers of isolates (for example, fewer than 30); this particularly affects smaller hospitals or laboratories, and less common organisms or antimicrobials; and
- a tendency to overestimate AMR, as sampling is biased towards resistant pathogens, often excluding infections in outpatients, or infections that have responded to first-line empiric

therapy, and through the use of cascade-testing strategies, meaning only testing more resistant isolates against "Watch" or "Reserve" antimicrobials.

Although producing an annual antibiogram is a good opportunity to summarize AMR data, laboratories should continuously be looking for emerging AMR threats, including in less common pathogens that are not the main focus of routine AMR surveillance.

Antibiograms must be interpreted with caution when used to inform individual patient management, taking into account their tendency to overestimate resistance due to sampling biases, particularly of community-origin infections, to minimize the risk of overusing "Watch" and "Reserve" antibiotics as a result. Clinicians should also consider individual risk factors, such as previous antimicrobial therapy, travel history or colonization with AMR pathogens when deciding on empiric therapy.

B5.2.2 Policy

Surveillance data should be used to support evidence-based policies, such as:

- regulation and restriction of antimicrobial access, use or prescribing across sectors
- treatment guidelines and empiric antibiotic therapy decisions
- AMS, behaviour change interventions, training and education
- hospital quality and safety regulation, such as accreditation requirements.

Common barriers to the use of surveillance data to inform policy decisions include:

- lack of access to, coordination or collaboration with policy-makers
- data privacy and governance restrictions on data sharing, within or between sectors
- inappropriate communication of complex data and data analyses
- opposition or lack of motivation from key stakeholders.

Actions to improve the use of data in policymaking include:

- engaging with key stakeholders and policy-makers during the situation analysis to build understanding and trust
- collaborating with stakeholders to identify policy priorities and processes
- presenting concise, synthesized information, with clear recommendations and conclusions.

Integrating antimicrobial resistance and use data from human and non-human sources has the potential to demonstrate the multisectoral impact of policy and regulation of antimicrobials on AMR but is challenging to implement. AMR surveillance systems should, however, be developed, designed and governed to facilitate intersectoral data sharing, analysis and collaborative reporting, wherever possible.

B5.3 Identifying and responding to emerging and new AMR and outbreaks

B5.3.1 Emerging, new and other critical AMR

Emerging and new AMR includes new or recently identified phenotypic resistance (such as resistance to a previously susceptible antimicrobial in a particular species) or new genetic mechanisms of AMR. Critical AMR may also include PDR/XDR pathogens and other resistance profiles and mechanisms

defined in national or hospital surveillance plans. Rapid identification, confirmation and communication of emerging resistance is needed so measures can be put in place to identify affected people and limit further spread.

Even a single case of emerging, new or critical AMR may indicate an outbreak and should be managed as outlined in B5.3.2 below. Contacts should be screened to identify the extent of spread and enhanced data collection conducted to characterize affected people and identify risk factors for infection.

The surveillance site should immediately communicate any finding of emerging and new AMR to the NRL/NCC, who should inform other surveillance sites and relevant stakeholders. A retrospective review looking for previous specimens with the same resistance should be conducted across all surveillance sites. Prospectively, a heightened level of suspicion is needed to rapidly identify future cases. Protocols for additional routine testing at surveillance sites or the NRL may need to be developed.

B5.3.2 Outbreak identification and response

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

An outbreak may be detected by hospital staff noting an unusual AMR pathogen, through EBS signals or when AMR surveillance data indicate an increase in frequency of a particular pathogen or resistance type. Real-time monitoring of data (local or national) allows outbreaks to be detected early and interventions to contain the emerging threat to be implemented quickly. Current data are compared to historical data observed over a similar period, usually the previous few weeks, months, or a comparable time of year in previous years (particularly for infections with seasonal variation in frequency). Alternative explanations for an increased number of cases should also be considered (Section B5). A true outbreak is more likely if the AMR pathogen has been identified more frequently in the local area, or similar outbreaks have been described elsewhere.

A suspected outbreak should immediately be reported, for example, to the hospital AMR committee and local public health unit. Subsequent investigation usually requires a multidisciplinary approach, to assess the source data to confirm the existence of an outbreak and collect additional samples and/or conduct laboratory testing to find additional cases, conduct environmental surveillance and perform epidemiological investigations. Note that data from additional testing conducted as part of outbreak investigation should not be included in routine surveillance data.

See also Sections B4.4 and 4.5 and *Responding to Outbreaks of Antimicrobial-resistant Pathogens in Health-care Facilities: Guidance for the Western Pacific Region (4).*

B5.4 Monitoring and evaluation to inform system improvement.

AMR surveillance data support public health action, programme planning and impact assessment. Developing a monitoring and evaluation framework can help countries to assess the effectiveness of AMR surveillance; the implementation of activities and their impact on, for example, AMR burden; and to identify areas for system strengthening.

A framework and resources for evaluating a surveillance system can be found in How to evaluate a surveillance system in Part C. For further details see the United States Centers for Disease Control and Prevention publication, *Updated Guidelines for Evaluating Public Health Surveillance Systems (32).*

The assessment should begin with a review of the surveillance system's objectives and its effect on policy decisions and disease-control programmes:

- can the system detect resistance in pathogens of public health importance?
- is this being done in a timely manner that permits:
    - accurate identification of pathogens and resistance?
    - prevention or treatment initiatives to be put in place?
    - infection control procedures to be implemented?
    - contact tracing when appropriate?

The evaluation must be focused, efficient and directed to its specific purpose (for example, a change in practice). The steps involved may include:

1. identifying stakeholders who will receive the findings and recommendations
2. considering what will be done with the information generated
3. specifying the questions that will be answered
4. determining the standards for assessing surveillance system performance.

The NCC monitors progress in developing and implementing the AMR surveillance system and evaluates impact at the national level as described in the national AMR action plan *(3)*. The NCC outlines roles and responsibilities for collecting and analysing data, the frequency of monitoring and how reports are reviewed and acted upon.

The NRL monitors the quality of AMR methods used in laboratories and provides guidance and support to AMR surveillance sites and other hospital laboratories to implement, monitor and build capacity for microbiological testing and AMR surveillance. Participation in GLASS supports standardization to ensure uniform global AMR monitoring and reporting *(33)*.

AMR surveillance sites conduct regular monitoring and evaluation, for example, as part of their hospital quality management system.

B6. Quality assurance

AMR surveillance depends on high-quality clinical, epidemiological and laboratory data. Quality assurance processes and programmes evaluate the accuracy, reliability and consistency of results, identify problems and recommend actions for quality improvement.

B6.1 Quality assessment of clinical and epidemiological data

Clinical data include information about the individual patient's infection, medical history, outcomes and treatment, with cases identified using case definitions and clinical (clinical syndrome) or microbiological (culture results) diagnosis. Epidemiological data include parameters such as the number of affected individuals, patients with positive/negative cultures by specimen type and patients with susceptible/resistant pathogens by priority pathogen, stratified by, for example, age, sex and location.

Quality control of clinical and epidemiological data involves data reviews and audits at all levels of surveillance in all settings. As AMR surveillance data originate from multiple sources, consistency is a particular challenge and bias may be introduced to the dataset. Actions that improve the quality of clinical and epidemiological data are shown in Table B5. Relevant staff must be trained appropriately, and data audits performed regularly to optimize data quality.

Table B5. Actions that improve the quality of clinical and epidemiological data

Process	Actions
Data collection	• Use standardized data collection forms (examples in Annexes 3.1 and 3.2). • Include a "notes" section, reviewed and clarified at data entry, to capture additional information. • Record a unique patient identifier where available in line-listed data. • Use electronic data collection forms such as mobile phone apps, with inbuilt data validation mechanisms to simplify data entry. • Include a data dictionary, to ensure standardized data interpretations. • Minimize free text recording of data, and provide options for unknown, not stated and not applicable. • Train staff on correct and complete data collection for all cases.
Data entry and analysis	• Minimize use of spreadsheets to store and manipulate data. • Maximize use of data validation rules at data entry. • Periodically audit manually entered data against the original forms to assess data accuracy. • Document procedures for data analysis and use reporting templates. • Use analysis software to create reproducible and auditable analysis scripts.
Data review and audit	• Ensure clinical diagnoses are based on consistent case definitions. • Identify opportunities for training and improvement by reviewing forms for completeness, format and validity. • Audit data collection processes (disaggregated by surveillance site at NCC/NRL level or by staff member at surveillance sites).

B6.2 Quality assessment of microbiological data

High-quality microbiological data are essential for accurate AMR surveillance. Laboratory quality management systems aim to ensure accurate, reliable and timely microbiology test results through management of all aspects of laboratory practice and performance *(34)*. Participation in external and internal quality assessment programmes (EQA and IQA) is essential for continuous quality improvement. Countries reporting to GLASS are encouraged though not mandated to participate in EQA and IQA of microbiological data.

The NRL should participate in an EQA scheme administered by an independent external (usually international) provider to check on its own performance. NRL oversees and coordinates EQA of microbiological testing (bacterial identification and AST) conducted in AMR surveillance sites and other laboratories and provides feedback about performance. Based on the EQA findings, laboratories review the feedback and take corrective actions when discrepancies are identified *(5)*.

Quality assurance programmes ensure that all elements of the laboratory system and processes are working well to deliver accurate and appropriate microbiological results:

- Organization – leadership, management, policies;
- Personnel – staff competence, training, proficiency;
- Environment – infrastructure that is safe, healthy, and secure;
- Equipment – that is appropriate and well-maintained;
- Management of consumables – availability, quality, storage;
- Information and document management – accuracy, confidentiality, accessibility;
- Communication – among laboratory staff, clinicians, management;
- Safety and occurrence management – policy, detection, corrective action;
- Assessment and process improvement – internal and external standards and benchmarks (including EQA and IQA); and
- Quality control procedures – sample management, method verification/validation.

Quality control procedures are control steps included in each assay to verify that the test is working properly, such as using American Type Culture Collection (ATCC) bacterial control strains for pathogen identification and AST. Internal quality control procedures should be applied to each of the following steps or items and performed correctly to ensure high-quality results:

- **Pre-test**
  - test request, selection
  - completion of laboratory request forms
  - sample collection, labelling, transportation.
- **Test**
  - equipment
  - reagents, media
  - technical procedures.
- **Post-test**
  - reporting, recording
  - analysis, interpretation
  - timely communication.

For more details, see the WHO *Laboratory Quality Stepwise Implementation Tool (35)*.

Laboratory accreditation

Microbiology laboratories should be accredited or working towards laboratory accreditation by international quality standards, such as ISO 15189 or 17025, or national quality standards (if available). If there are no national quality standards, the NRL should work with relevant stakeholders to develop and implement these standards *(36)*.

Standardized, harmonized procedures

The NRL is responsible for developing national guidelines and working with hospital and subnational laboratories to standardize and harmonize organism identification, AST methods, materials, quality control and interpretation, following the latest international standards, for example, EUCAST, CLSI or *UK Standards for Microbiology Investigations (37–41)*.

An example of a quality framework for AST by disk diffusion is presented in Table B6.

Table B6. Example of quality framework for AST by disk diffusion method

Preparation	• Ensure the surface of the agar and inside the lid is dry before use. • Store agar plates and disks as recommended by the manufacturer and use before the expiry date. • Store disks, including those in dispensers, in sealed containers with a moisture-indicating desiccant and protect from light. • Store plates prepared in-house at 4–8 °C. • Use the correct media for AST (some organisms require media other than Mueller Hinton agar). • Prepare the inoculum correctly (usually 0.5 McFarland turbidity standard). • Use the recommended quality control (QC) strains. • Ensure incubators and fridges are temperature-monitored.
Inoculation	• Follow the 15/15/15-minute rule: ▪ use the inoculum suspension within 15 minutes of preparation ▪ apply disks within 15 minutes of inoculation ▪ incubate plates within 15 minutes of disk application. • Ensure agar plates are at room temperature prior to inoculation. • Spread the inoculum evenly over the entire agar surface, ensuring that there are no gaps between streaks by swabbing in three directions.
Disk placement	• Allow disks to reach room temperature before opening storage containers. • Apply disks firmly and evenly to the surface of the inoculated agar plate and do not move them once applied. • Limit the number of disks on a plate to avoid overlapping of zones and interference between agents (6 and 12 disks are usually the maximum number possible on 90 mm and 150 mm circular plates respectively). • Perform frequent quality control of working supplies to ensure that disks have not lost potency during storage.

Incubation	• Invert agar plates and ensure disks do not fall off the agar surface. • Put a maximum of five plates in each stack (appropriate for most incubators) to reduce uneven heating. • Incubate plates in conditions appropriate for the organism: ■ for the correct time (usually 18 +/- 2 hours, incubating for longer may result in false resistance results); ■ in the correct atmosphere (air or CO_2); and ■ at the correct temperature (usually 35 °C +/– 1 °C).
Reading	• Measure the inhibition zone diameter to the nearest millimetre with a ruler or calliper and check that zones for QC strains are within the acceptable range. • Interpret zone diameters into susceptibility categories according to current formal breakpoint tables, for example, http://www.eucast.org. • Check for purity. Repeat the test if there is mixed growth or unusual results.

Source: WHO

B7. Other AMR surveillance

B7.1 One Health AMR surveillance

Antimicrobials used to treat infections in humans are often the same, or in the same class, as those used in the animal sector, and AMR may be transferred within and between these sectors and to the environment. One Health recognizes that the health of humans, animals and the environment are interconnected and that a multisectoral approach is required to tackle the rising threat of AMR *(3,42)*.

One Health supports multisectoral coordination, antimicrobial regulation and registration, guidelines for infection control and the prudent use and disposal of antimicrobials in all sectors. The Quadripartite Joint Secretariat on AMR leads the collaboration between the Food and Agriculture Organization of the United Nations, United Nations Environment Programme, WHO and the World Organisation for Animal Health and promotes integrated AMR surveillance through the Quadripartite Technical Group on Integrated Surveillance on antimicrobial use and resistance.

Truly integrated AMR surveillance across sectors is challenging to achieve, but exchange and sharing of information between sectors and coordinated analysis must be a priority and should be facilitated by establishing a national multisectoral coordinating mechanism to coordinate strategic planning and implementation of activities *(43)*.

B7.2 Surveillance for other pathogens

Although this document is about AMR in fast-growing bacteria, AMR also affects other important pathogens. Three pathogens with the largest global burden of morbidity and mortality in LMICs, HIV, tuberculosis and malaria, have well-established programmes for AMR surveillance (Table B7).

Table B7. WHO AMR surveillance guidance for pathogens not covered in this document

Condition	Reference for pathogen-specific AMR surveillance guidance
HIV	*WHO Global action plan on HIV drug resistance 2017–2021 (44)*
Tuberculosis (TB) (*Mycobacterium tuberculosis*)	*Guidelines for surveillance of drug resistance in tuberculosis, sixth edition 2020 (45)*
Malaria (*Plasmodium* spp.)	*World malaria report, 2022 (46)*

B7.3 Surveillance on antimicrobial consumption and antimicrobial use

Overuse and misuse of antimicrobials are among the key drivers of AMR. GLASS-AMC monitors national level AMC to understand patterns of consumption, inform interventions for the optimal use of antimicrobials and provide insights into the drivers of AMR *(47)*. Data on AMC in the human sector are collected and analysed in many countries, and global monitoring in animals is ongoing. All countries have data related to the import, procurement, distribution, sales or clinical use of antimicrobials that can be used to estimate AMC and antimicrobial use at the patient level, assess trends and inform national policy and AMS.

B7.3.1 The Western Pacific Regional Antimicrobial Consumption Surveillance System

The Western Pacific Regional Antimicrobial Consumption Surveillance System (WPRACSS) was launched in 2020 to support countries to combat overuse and misuse of antibiotics and provide local/national intelligence on AMR by monitoring AMC and AMU in hospitals and the community. WPRACSS aims to increase multi-stakeholder accountability, strengthen AMS and improve health outcomes, by:

- setting up and building capacity for national AMC/AMU monitoring systems, using data on the import, procurement, distribution, sales or clinical use of antimicrobials;
- using information on AMC and AMU to inform national AMR policies, strengthen AMS and improve clinical management of AMR infections;
- setting up a web-based regional database to capture national-, hospital- and community-level data as a basis for regional analysis and technical advice to countries; and
- establishing community monitoring through online reporting of antibiotics dispensed in the community, using a mobile application connected to retail outlets across the Region.

For further details on WPRACSS, see *Antimicrobial Consumption in the WHO Western Pacific Region: Early implementation of the Western Pacific Regional Antimicrobial Consumption Surveillance System (WPRACSS) (7)*.

B7.3.2 Reporting of antimicrobial consumption and use

Surveillance sites in countries reporting to GLASS-AMC submit their data via NCC/NRL. Regular reporting of AMR, AMC and AMU back to facility stakeholders is essential to drive local improvements in medication safety, IPC, AMS and management of patients. Reports should identify good performance as well as areas of risk or poor performance and include:

- targets or goals
- comparison with previous audit results, to demonstrate any changes in practice
- benchmarking or comparisons with other units, or hospitals in the Region
- suggested actions for improvement.

Dissemination strategies and communication of information on AMC/AMU should be tailored to the target audience using a range of methods, including presenting data to senior staff at hospital management meetings (Table B8). Information should be specific, accurate and clear and given in a concise and timely manner.

Table B8. Reporting of AMC/AMU surveillance data to different stakeholders

Target group	Information reported	Method of presentation
National or international programmes	Raw data	Programme protocol
Senior hospital executive or management	AMC and AMU data (disaggregated by ward or specialty) Audit results on quality of prescribing	Standing reports Dashboard reports
Relevant hospital committees (AMR, AMS, IPC)	AMC and AMU data (disaggregated by ward or specialty) Audit results on quality of prescribing	Standing agenda items Oral discussions PowerPoint presentations
Specialist units and senior medical staff	AMC and AMU data (disaggregated by ward or specialty) Audit results on quality of prescribing Compliance with standard treatment guidelines Benchmarked reports	Departmental/unit meetings Morbidity and mortality meetings Dashboards Hospital grand rounds Email
Individual prescribers	AMC and AMU data (disaggregated by ward or specialty) Feedback on the quality of prescribing Compliance with standard treatment guidelines	While implementing point-of-care interventions during ward rounds Face to face, phone calls, email Written in medical notes Education sessions
Pharmacists, nurses and other hospital staff	Quality of prescribing/audit results/ compliance with guidelines Antimicrobial use	Education sessions Drug and therapeutics or medication safety committee Posters/newsletters

Source: WHO

B8. Research for development and innovation

Research studies can be important to supplement surveillance data, but analysis of routine AMR surveillance datasets also provides opportunities for development and innovation by identifying gaps in knowledge, hypotheses and questions for further study. The samples and data collected provide a rich dataset for further investigation that can be used to strengthen surveillance through, for example:

- innovations such as the use of genomic technologies to improve pathogen characterization, outbreak detection and understanding of resistance mechanisms;
- increased automation of data capture and system interoperability to improve data completeness and accuracy and reduce resource requirements; and
- use of modelling to improve cluster detection and characterization.

Engaging with local, national and international academic institutions, clinicians and health authorities can help to share data and knowledge between research, clinical and surveillance institutions; assist in alignment of research and surveillance goals; and identify resources for research and development activities.

PART C:
“HOW TO” GUIDES

C1. How to conduct an AMR laboratory assessment

Sample checklist for conducting a systematic, standardized laboratory assessment – see Sections B1.1.1 and B1.1.2. Further examples can be found in *National antimicrobial resistance surveillance systems and participation in the Global Antimicrobial Resistance Surveillance System (GLASS): core components checklist and questionnaire (48)* and the *WHO Laboratory Assessment Tool (49)*.

1. Laboratory information

Assessors and affiliations: Date: / /

Laboratory name and address:

____

Laboratory type (*check all that apply*):
☐ Health clinic laboratory
☐ Local hospital laboratory
☐ District hospital laboratory
☐ Provincial hospital laboratory
☐ Regional non-hospital laboratory
☐ National/reference/public health laboratory
☐ Other, specify ____________________

Laboratory affiliation (*check all that apply*):
☐ Public
☐ Private
☐ Academic institution
☐ Nongovernmental organization (NGO)
☐ Faith-based institution
☐ Military
☐ Other, specify ____________________

Is the bacteriology laboratory currently accredited? ☐ Yes, to ISO 15189 ☐ Yes, to CAP standards ☐ No

If accredited, by which accrediting body? ____________________ Date: / /

2. Basic laboratory infrastructure

Is deionized water (DI) or distilled water available at the laboratory?	☐ Yes	☐ No
Is there a generator to provide backup power in case of power failure?	☐ Yes	☐ No
Is critical equipment supported by uninterrupted power source (UPS) systems?	☐ Yes	☐ No
Has the laboratory had a safety audit within the last year?	☐ Yes	☐ No

Indicate in the table below whether the laboratory has at least one functional piece of each equipment listed.

Equipment present			Annual calibration	Thermometer present	Comments
Wickerham card	☐ Yes	☐ No			
McFarland QC standards of known densities including 0.5	☐ Yes	☐ No			
Ruler or calliper with mm markings	☐ Yes	☐ No			
Bunsen burner or micro-incinerator	☐ Yes	☐ No			

Wire loops for streaking	☐ Yes ☐ No			
Calibrated loops for plating urines	☐ Yes ☐ No	☐ Yes ☐ No		
Optical densitometer	☐ Yes ☐ No	☐ Yes ☐ No		
Pipettes (e.g. Eppendorf)	☐ Yes ☐ No	☐ Yes ☐ No		
pH meter/paper	☐ Yes ☐ No	☐ Yes ☐ No		
Weighing balance	☐ Yes ☐ No	☐ Yes ☐ No		
Centrifuge	☐ Yes ☐ No	☐ Yes ☐ No		
Microscope	☐ Yes ☐ No	☐ Yes ☐ No		
Thermometers	☐ Yes ☐ No	☐ Yes ☐ No		
Biological Safety Cabinet class I	☐ Yes ☐ No	☐ Yes ☐ No		
Biological Safety Cabinet class IIA	☐ Yes ☐ No	☐ Yes ☐ No		
Biological Safety Cabinet class IIB	☐ Yes ☐ No	☐ Yes ☐ No		
Biological Safety Cabinet class III	☐ Yes ☐ No	☐ Yes ☐ No		
(tick) ¨ CO_2 incubator or candle	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
Non-CO_2 incubator	☐ Yes ☐ No		☐ Yes ☐ No	
Refrigerator (2–8 °C)	☐ Yes ☐ No		☐ Yes ☐ No	
Freezer, -20 °C	☐ Yes ☐ No		☐ Yes ☐ No	
Freezer, -80 °C	☐ Yes ☐ No		☐ Yes ☐ No	
Hot air oven	☐ Yes ☐ No		☐ Yes ☐ No	
Autoclave	☐ Yes ☐ No		☐ Yes ☐ No	
Hot plate with magnetic stirrer	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
Water bath	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	

Does the laboratory have an inventory control system in place?	☐ Yes	☐ No
Are all media, reagents and test kits currently within the expiry dates?	☐ Yes	☐ No

Where does the laboratory record the bench testing results (*e.g., colony morphology, haemolysis, zone sizes/MICs*)?

- ☐ Handwritten on a paperwork card or logbook
- ☐ Recorded in another electronic database
- ☐ Recorded in a commercial LIMS
- ☐ These results are not systematically recorded

Where does the laboratory record the bench testing results (*e.g., colony morphology, haemolysis, zone sizes/MICs*)?

- ☐ Handwritten paper form
- ☐ Electronically via HIS or EMR interface with the LIMS
- ☐ Printout from LIMS or other electronic database
- ☐ Other, specify: ______________________

Are data shared with the National Reference Laboratory or Ministry of Health?	☐ Yes	☐ No

3. Specimen processing and organism isolation					
Does the laboratory have an SOP for how to process:					
Blood for bacterial culture?	☐ Yes	☐ No	*Neisseria gonorrhoeae* (GC) culture?	☐ Yes	☐ No
Urine for bacterial culture?	☐ Yes	☐ No	Stool for bacterial culture?	☐ Yes	☐ No
Sputum for bacterial culture?	☐ Yes	☐ No			

Are blood agar plates reconstituted on site? *If yes, specify type and source.* ___			☐ Yes	☐ No
Which blood culture incubation systems are used?	☐ Manual ☐ Automated ☐ N/A			
Which media are used for primary culture of urine?				
Blood agar	☐ Yes	☐ No	Other, specify: ___	
MacConkey/EMB	☐ Yes	☐ No		
Which media are used for primary culture of sputum?				
Blood agar	☐ Yes	☐ No	Chocolate agar	☐ Yes ☐ No
MacConkey/EMB	☐ Yes	☐ No	Other, specify: ___	
Are GC specimens either inoculated directly into selective culture media at the time of collection or received in appropriate transport media within 24 hours?			☐ Yes	☐ No
Which media are used for primary culture of specimens for GC?				
GC selective agar	☐ Yes	☐ No	Other, specify: ___	
GC non-selective agar	☐ Yes	☐ No		
Which media are used for primary culture of stool?				
Blood agar	☐ Yes	☐ No	Selective enrichment broth	☐ Yes ☐ No
MacConkey/EMB	☐ Yes	☐ No	Other, specify: ___	
SS/HE/XLD/DCA	☐ Yes	☐ No		
Which organisms are cultured for in every stool culture?				
Salmonella spp.	☐ Yes	☐ No	*Shigella* spp.	☐ Yes ☐ No

4. Identification of bacterial isolates

Indicate in the table below whether the laboratory uses the reagents listed.

Reagent used in laboratory			SOP present		Does the SOP include QC?		Comments
Catalase	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Coagulase plasma	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Staph latex agglut	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Staph CHROMagar	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
PYR	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Bile solubility (deoxycholate)	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Optochin “P” disk	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
S. pneumo latex	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Oxidase	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Indole	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Methyl Red	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Voges-Proskauer	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Citrate	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
TSI or KIA	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Urease	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Motility	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
LIA or LDC	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Shigella serology	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Salmonella serology	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
OF Glucose	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	

Nitrate reduction	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Gelatin hydrolysis	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	
Arginine hydrolysis	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	

Does the laboratory use rapid biochemical kits for organism identification?	☐ Yes	☐ No
If yes, specify type: ☐ API ☐ Liofilchem ☐ RapID ☐ Other ______		
Does the laboratory have an SOP for use of these rapid biochemical kits?	☐ Yes	☐ No
Is the instrument software up to date?	☐ Yes	☐ No
Does the laboratory use automated biochemical methods for organism identification?	☐ Yes	☐ No
If yes, specify type: ☐ MALDI ☐ Vitek ☐ MicroScan ☐ Phoenix ☐ Other ______		
Does the laboratory have an SOP for use of these automated biochemical methods?	☐ Yes	☐ No
Is the database used for result interpretation up to date?	☐ Yes	☐ No

5. Antimicrobial susceptibility testing (AST)

Indicate whether the following AST methods are used for each bacterium listed below.

Organism	Disk diffusion		Etest/gradient		Microdilution		Automated	
S. aureus	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
S. pneumoniae	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
H. influenzae	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
N. gonorrhoeae	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
N. meningitidis	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
E. coli	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
K. pneumoniae	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Salmonella spp.	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Shigella spp.	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
P. aeruginosa	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No
Acinetobacter spp.	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No	☐ Yes	☐ No

When preparing a bacterial inoculum for AST, is a 0.5 McFarland suspension used? ☐ Yes ☐ No

Which AST interpretation standard does your laboratory use? ☐ CLSI ☐ EUCAST ☐ Other ______

For disk diffusion for AST, what kind of disks are used?

☐ Commercially manufactured

☐ Other, specify: ______

☐ Prepared in-house after antibiotic reconstitution

☐ N/A, disk diffusion is not used

In what atmosphere are the disk diffusion/gradient strip plates incubated?

☐ 5% CO_2

☐ Ambient air

Which antibiotics does your laboratory use to detect methicillin resistance in *S. aureus?*

☐ Oxacillin disk

☐ Cefoxitin disk or MIC

☐ Oxacillin MIC

☐ Other, specify: ______

Which agar is used for disk diffusion/gradient strip AST testing of *S. aureus?*

☐ Mueller Hinton agar

☐ Blood agar

☐ Mueller Hinton with blood agar

☐ Other, specify: ______

For AST testing on *S. pneumoniae*, which of the following are available in your laboratory?

☐ Oxacillin disk
¨ Penicillin G MIC method
¨ Ceftriaxone and/or cefotaxime MIC method
☐ Mueller Hinton with blood agar
☐ Trimethoprim-Sulfamethoxazole (Co-trimoxazole)
☐ Other, specify: ____________________
☐ N/A, AST testing not performed

Which agar is used for disk diffusion/gradient strip AST testing of *S. pneumoniae?*

☐ Blood agar
☐ Mueller Hinton with blood agar
☐ Chocolate agar
☐ Other, specify: ____________________

Indicate whether the following antibiotics are used for AST in Enterobacterales, *Pseudomonas* and *Acinetobacter* spp.

☐ Ampicillin
☐ Ceftriaxone or cefotaxime
☐ Ceftazidime
☐ Cefepime
☐ Imipenem or meropenem
☐ Ertapenem or doripenem
☐ Ciprofloxacin or levofloxacin
☐ Trimethoprim-Sulfamethoxazole
☐ Colistin (Polymyxin B)
☐ Azithromycin
☐ Minocycline or tigecycline
☐ Amikacin
☐ Gentamicin

Which agar is used for disk diffusion/antibiotic gradient AST of Enterobacteriales, *Pseudomonas* and *Acinetobacter* spp.?

☐ Mueller Hinton agar
☐ Mueller Hinton with blood agar
☐ Blood agar
☐ Other, specify: ____________________

Does the laboratory test for the following during routine AST?

☐ ESBL production ☐ Mechanism of carbapenem resistance ☐ Neither

Does the laboratory use automated biochemical methods for organism identification?	☐ Yes	☐ No

6. Quality assurance		
Is there a designated quality manager for the laboratory?	☐ Yes	☐ No
Is there a manual describing the quality system policy and procedures for the laboratory?	☐ Yes	☐ No
Are there bacteriology-specific training policies and procedures for orienting new employees?	☐ Yes	☐ No
Is there a record of which benches/tests each staff member has been trained on?	☐ Yes	☐ No
Do staff have appropriate qualifications or competences to perform laboratory work?	☐ Yes	☐ No
Do staff receive competency assessments for each areas in which they perform testing? *If yes*, are these: ☐ at least yearly ☐ at least three-yearly ☐ greater than three-yearly	☐ Yes	☐ No
Does policy require specimens to be labelled with patient identification, date and time of collection?	☐ Yes	☐ No
Does policy require that all specimens are accompanied by a test requisition form?	☐ Yes	☐ No
Is each specimen assigned a unique identifying number upon arrival at the laboratory?	☐ Yes	☐ No
Are results reviewed and authorized before being released?	☐ Yes	☐ No
Is there a process for immediate notification to physicians when results are critical for patient care?	☐ Yes	☐ No
Is there a list of notifiable diseases the laboratory must report on?	☐ Yes	☐ No
Is there a process for notification to the relevant ministry/surveillance network when results are critical?	☐ Yes	☐ No

Are specimens stored properly prior to and following testing?				☐ Yes	☐ No
Are media, consumables and reagents appropriately stored (temperature, humidity, etc.)?				☐ Yes	☐ No
Is QC performed on each newly reconstituted batch or newly received lot number of media?				☐ Yes	☐ No
Is QC performed on each new lot number for commercial kits (e.g. API, Liofilchem, RapID)?				☐ Yes	☐ No
Is QC performed on each newly prepared batch or lot numbers of antibiotic disks?				☐ Yes	☐ No
Have acceptable min/max temperature ranges been clearly defined and are they documented daily for the following:					
Room temperature	☐ Yes	☐ No	Incubators	☐ Yes	☐ No
Refrigerators	☐ Yes	☐ No	Ovens	☐ Yes	☐ No
Freezers	☐ Yes	☐ No	Water baths	☐ Yes	☐ No
Are the following indicators used to monitor autoclave performance?					
– Mechanical indicators (i.e. cycle time, temperature, pressure recorded on a log)				☐ Yes	☐ No
– Chemical indicators (e.g. autoclave tape)				☐ Yes	☐ No
– Biological indicators (e.g. Attest or another spore testing)				☐ Yes	☐ No
What kind of quality control organisms does the laboratory use?					
– Commercial provider (specify which: e.g. ATCC, NCTC, other)				☐ Yes	☐ No
– Organisms retained from prior patient specimens and/or EQA challenges				☐ Yes	☐ No
– Other, specify source: ______________________________				☐ Yes	☐ No
Does the laboratory use the following ATCC (or ATCC-derivative/equivalent) reference strain(s) for AST QC?					
☐ *S. aureus* 25923			☐ *E. coli* 25922		
☐ *S. aureus* 43300			☐ *K. pneumoniae* 700603		
☐ *S. aureus* 29213 (for MIC methods only)			☐ *Pseudomonas aeruginosa* 27853		
☐ *S. pneumoniae* 49619			☐ Other, specify: ______________________________		
☐ *E. coli* 25922					

7. Safety					
Are biosafety procedures available for the following?					
Personal protective equipment	☐ Yes	☐ No	Access restrictions	☐ Yes	☐ No
Disinfection and sterilization	☐ Yes	☐ No	Biosafety equipment	☐ Yes	☐ No
Waste disposal	☐ Yes	☐ No	Emergency protocols, *e.g. contamination*	☐ Yes	☐ No
Are hazardous chemicals stored appropriately (*acids from alkaline, flammables in a flame cabinet*)?				☐ Yes	☐ No
Are Material Safety Data Sheets available for review in the immediate laboratory area?				☐ Yes	☐ No
Is a staff vaccination policy defined and implemented?				☐ Yes	☐ No

Abbreviations used in the laboratory assessment checklist

API	analytical profile index	ISO	International Organization for Standardization
AST	antimicrobial susceptibility testing	KIA	Kligler's iron agar
ATCC	American Type Culture Collection	LDC	lysine decarboxylase
CAP	College of American Pathologists	LIA	lysine iron agar
CLSI	Clinical and Laboratory Standards Institute	LIMS	laboratory information management system
DCA	deoxycholate citrate agar	MIC	minimum inhibitory concentration
DI	deionized water	NCTC	National Collection of Type Cultures
EMB	eosin methylene blue agar	NGO	nongovernmental organization
EMR	electronic medical record	OF	oxidative fermentation
EQA	external quality assessments	PYR	pyrrolidonyl–β–naphthylamide
ESBL	extended spectrum β–lactamases	QC	quality control
EUCAST	European Committee on Antimicrobial Susceptibility Testing	SOP	standard operating procedure
		SS	Salmonella Shigella agar
GC	*Neisseria gonorrhoeae*	TSI	triple sugar iron
HE	Hektoen enteric agar	UPS	uninterrupted power source
HIS	health information system	XLD	xylose lysine deoxycholate agar

C2. How to conduct routine data analysis for AMR data

This tool can be used to guide data analysis and outlines steps which should be considered when developing national and local SOPs for data analysis. See Section B2.4.

Step	Method	Considerations
1. Identify time period	As per surveillance plan	Standardized time frames for reporting assist in assessment of differences between time periods.
2. Extract data	Extract electronic data from surveillance database or similar for relevant time period.	
3. Data "cleaning" (Section B2.3.3)	Assess reported cases against surveillance criteria and/or case definitions Identify missing data. Rectify if possible. Identify data violating validation rules Identify common data-entry errors such as nonsensical data orders or misspelt words. Ensure organism and antimicrobial names are consistent Ensure all required fields are provided	Log all data-cleaning activity to identify opportunities for process improvement and training.
4. Deduplicate data and apply any additional exclusion criteria (Section B2.3.4)	For sample or isolate datasets, include only the first sample for each organism and specimen combination per patient for that time period. Remove repeated negative results for the same specimen type in the same patient in sample-based surveillance Apply any other exclusion criteria	Consider exclusion of samples collected through active screening for analyses that may be affected by screening activities.
5. Decide which sample, pathogen and antimicrobial combinations to include	Based on local AMR surveillance plan Exclude combinations with small numbers of patients: e.g. < 5, but depending on sample numbers	Consider appropriate grouping of sample types, pathogens and antimicrobial classes for ease of analysis and data visualization.
6. Calculate summary descriptive statistics (Section B2.4)	Calculate frequencies, proportions and rates, as appropriate	Display raw data (frequency/total number tested) and percentages.

Step	Method	Considerations
7. Stratify results by relevant sub-populations	Stratify summary statistics by specimen type, patient department, clinic, ward or relevant demographic or clinical variables such as age, procedures, risk factors and/or clinical conditions.	Examine for potential differences between groups that could indicate localized outbreaks or at-risk populations
8. Plot trends over time	Generate epidemiologic curves and other plots Consider automatic generation of summary reports and cluster detection through WHONET/WHONET-SaTScan.	Include comparison to historical data to assist in outbreak detection
9. Interpret data (Section B2.4)	Assess limitations and biases present in the data before reaching conclusions Identify changes in testing or reporting practices that may affect results, such as increased screening or testing, change in laboratory methods or case definitions. Identify changes that warrant further investigation or opportunities for intervention – see *Responding to outbreaks of antimicrobial-resistant pathogens in health-care facilities: guidance for the Western Pacific region (4).*	Can the data be generalized to other populations? What may differ over time and between subpopulations, other than what is being measured, which may explain any observed trends?
10. Communicate results	Generate written report Summarize findings Include graphs and summary statistics Rapidly communicate emerging issues that may require further action	Consult with data generators through reporting process Disseminate to AMR/IPC committees, clinicians, pharmacy, specialist services, AMS teams and other interested parties.

C3. How to conduct a point-prevalence survey or other periodic monitoring

This method can be used to guide development of a point-prevalence survey and may be adapted for other types of periodic monitoring. The considerations listed may assist when developing relevant SOPs or other study documentation. See Section B4.1.

Step	Method	Considerations
1. Select a time for the survey	Often a single day, week or month. If the prevalence of the outcome is low, a longer period may be needed. Repeated cross-sectional surveys should be conducted at the same time(s) every year to account for seasonal variation. If possible, conduct the survey at the same time as national or regional cross-sectional or point prevalence studies.	Standardized time frames for data collection assist in assessment of differences between locations or time periods. Collection of multiple data types at the same time can facilitate combined analysis (e.g. AMU and AMR data), but cannot determine causality.
2. Define a study population for the survey	Select the study population and define clear inclusion and exclusion criteria. The study population may be all those in a geographical or patient population such as a facility, department or ward, or it may be limited to those with a clinical syndrome, sample type or pathogen.	Study populations can have implications for sample size, resourcing required and generalisability of results. Definitions should be specific enough that there would be limited variability between study staff. If you are including multiple locations (e.g. wards/facilities), ensure location and patient factors are considered.
3. Define the sample size	Usually all people meeting the inclusion criteria during the survey period. Random sampling may be used and results generalized to the study population if a population-based survey is not feasible.	Sample size may be larger if sub-populations will be analysed.
4. Define the condition(s) or other outcome(s) being measured	Create a clear case definition for the condition or outcome you are measuring, such as a health-care acquired infection, or a resistant isolate.	Include "what, where, when and who" categories in the case definition. Ensure the outcome/condition is only counted if present during the survey period. Definitions should be specific enough to limit variability in case-finding between study staff.

Step	Method	Considerations
5. Create data collection tools (if needed)	Generate a data collection tool(s). Consider facility/ward, patient, sample and pathogen data to include in the analysis. If data are collected across multiple locations (e.g. facilities or wards), separate data collection tools may be needed to collect information about the location and individual participants.	If the study period is short, multiple staff can collect data simultaneously. Online data collection tools can include data validation and reduce data entry requirements. Pilot data collection tools, or use validated/published tools, if available. Denominator data are needed to calculate proportions, collected through either: The location questionnaire (e.g. collect data on how many people are admitted to a given ward on the ward questionnaire) with patient questionnaires only completed for those patients with the outcome; or By completing a patient questionnaire for all patients regardless of whether they meet the outcome definition or not.
6. Train data collection and validation team	Data collectors can be local (e.g., a nurse on the ward) or external (e.g. study staff). Where possible, train additional validation staff to collect or audit a subset of the data for validation purposes.	If using local staff, consider additional rostering requirements.
7. Collect data and samples	Collect data and samples following the study protocol.	
8. Calculate results	Summarize study population using descriptive statistics and calculate proportion of population with outcome, as appropriate.	Display raw data (number with outcome/total number in population) and percentages.
9. Stratify results by relevant sub-populations	Stratify results by surveillance site, ward or other relevant demographic or clinical variables, as appropriate.	Consider what is a real (e.g. not by chance) and meaningful difference between groups?
10. Plot trends over time (if applicable)	Generate plots comparing results between cross-sectional surveys.	Consider comparability of data prior to analysis.

Step	Method	Considerations
11. Interpret data	Assess limitations and biases present in the data before presenting conclusions. Identify any changes in study populations, survey methodologies or testing practices that may affect results, such as changes in included wards. Identify any changes that may warrant further investigation or opportunities for intervention.	Can the data be generalized to other populations? What may differ over time and between groups, other than what is being measured, which may explain any observed trends?
12. Communicate results	Generate written report Summarize findings Include graphs and summary statistics Rapidly communicate emerging issues that may require further action.	Consult with data generators through reporting process Disseminate to AMR/IPC committees, public health specialists, clinicians, pharmacy, specialist services, AMS teams and other interested parties

C4. How to develop a cumulative antibiogram

See Section B5.2.1.

Antibiograms are usually produced every 12 months. They may refer to a single ward or medical service, a hospital, region or country. Usually, only the first result per pathogen species is included for each patient in the time period, to limit bias arising from patients with prolonged infection or multiple samples.

Antibiograms are usually produced by microbiology laboratory staff, but other experts may be involved, including information technology staff, pharmacists, clinicians and others from the AMR committee. National level antibiograms are generally produced by the NRL and/or NCC (see Tables C4.1 and C4.2).

Antibiograms must be interpreted with caution when used to inform patient management, taking into account their tendency to overestimate resistance due to biases in the data, to minimize the risk of overusing "Watch" and "Reserve" antibiotics as a result. Hospital-derived antibiograms should not be used to inform antibiotic therapy in the community.

Table C4.1. Producing an antibiogram

Step	Method	Considerations
1. **Decide on a time period**	Usually annual	May be more frequent in larger hospitals
2. **Access laboratory data**	Extract data from electronic laboratory information system or paper records for the time period	Assistance from IT support
3. **Clean data:** (a) **organism names** (b) **antimicrobial names** (c) **patient identifiers**	Ensure organism and antimicrobial names[a] are consistent Ensure each patient can be identified by a unique patient number or similar	Examples: "*Staphylococcus aureus*" and "MRSA" → "*Staphylococcus aureus*" "Gentamicin" and "Gentamycin" → "Gentamicin"
4. **Classify specimen types**	Group specimen types as "Blood", "Urine" and "Other"	Exclude samples that are not thought to represent infection (e.g. contaminants[b] screening samples for CRE)
5. **Deduplicate records**	Create separate datasets for Blood, Urine and Other specimens Deduplicate each dataset based on unique patient identifier	Within each dataset, keep only the **first sample** for **each organism** for each patient for that time period
6. **Decide which organisms to include**	For each specimen group (Blood/Urine/Other), include all species with ≥ 30 isolates in time period[c]	For smaller hospitals, report the 3–5 most common species for each specimen group[d]
7. **Decide which antimicrobials to include**	Based on local or national treatment guidelines, local antimicrobial use, local or national AMR patterns, WHO GLASS pathogen-specific antimicrobial susceptibility combinations (Annex 1.6) Include "Watch" and some "Reserve" antimicrobials according to the WHO AWaRe classification[e] For each species, only antimicrobials where ≥ 30 isolates have been tested should be included in the antibiogram	Only report antimicrobials relevant for the specimen group: e.g. report trimethoprim for Urine but not Blood or Other Do not report antimicrobials used for surrogate testing (e.g. oxacillin) Exclude antimicrobials where isolates are tested selectively: for example, second-line antimicrobials that are only tested when first-line antimicrobials are resistant Consult with pharmacy and clinicians from AMR committee, if possible

Step	Method	Considerations
8. **Construct antibiogram**	Separate antibiograms for Gram-positive, Gram-negative, anaerobes and yeasts (if reported) Calculate % susceptible for each pathogen–antimicrobial combination (not including "intermediate")[f]	Identify intrinsic resistance patterns for each organism and report as "R" in antibiogram *(37)* Record raw data (No. susceptible/total number tested) and percentages Review for exceptional phenotypes or inconsistent data[g]
9. **Review and report sentinel resistances**	Consider reporting the frequency of specified organism–antimicrobial combinations ("sentinel resistances") in the same time period	Examples: MRSA, ESBL, *E. coli* and *K. pneumoniae* (or Enterobacterales), CRE, VRE Report percentage resistant out of number tested for specific organism–antimicrobial combination[h]
10. **Communicate results**	Include date, time period, facility and comment on methods (first isolates/ species//patient) on the cumulative antibiogram table Discuss value and limitations of antibiograms[i]	Involve AMR committee, AMS teams, clinicians, pharmacy, specialist services (e.g. intensive care unit, haematology/ oncology)
11. **Update antibiogram regularly**	Usually update annually	

[a] Use generic antimicrobial names to avoid confusion.

[b] Exclude likely contaminants such as coagulase-negative staphylococci (CoNS), viridans streptococci, Corynebacterium spp. from blood cultures, unless very convincing for infection: e.g. CoNS from neonatal intensive care. Exclude device cultures: e.g. catheters and drains, and environmental samples.

[c] When < 30 samples are reported in a cumulative antibiogram, susceptibility data are less reliable, and should be interpreted with caution.

[d] When < 30 isolates are included for a species, susceptibility results may be reported for the genus level or higher: e.g., *Shigella* spp., *Acinetobacter* spp., fastidious Gram-negative bacilli. Avoid combining species/genera where appropriate antimicrobials are different: e.g. do not include *Salmonella* and *Shigella* with other Enterobacteriaceæ.

[e] WHO AWaRe50 classification includes three groups of antimicrobials: "Access" – core set of relevant antimicrobials that are available and affordable on a sustainable basis; "Watch" – critical antimicrobials with high resistance potential – key targets for AMS activities *(51)*; "Reserve" – last-resort antimicrobials for multidrug-resistant infections.

[f] CLSI (M39A-4E) recommends using only "susceptible" isolates to calculate susceptibility (that is, exclude intermediate and resistant). For isolates classed as susceptible dose-dependent (SDD), enter this result separately and add a note (e.g. *Enterobacter cloacae* and cefepime). For *S. pneumoniae,* report both meningitis and non-meningitis breakpoints for blood cultures. Note that, with the introduction of the new "susceptible, increased exposure" category, EUCAST recommends combining S (susceptible) and I (susceptible, increased exposure) where necessary. Laboratories using EUCAST may choose to report on susceptible isolates, or combine with susceptible, increased exposure – either is acceptable as long as the methodology is documented.

[g] Examples of exceptional phenotypes include vancomycin resistance in *Staphylococcus aureus*; *E. coli* isolates with resistance to amikacin, but susceptible to gentamicin/tobramycin (Annex 1.2); amoxicillin-susceptible *K. pneumoniae*.

[h] Example of reporting sentinel resistances for blood cultures over 12-month period:

S. aureus 45 isolates, 33/45 MSSA (73.3%), 12/45 MRSA (26.7%)

Enterobacterales 63 isolates, 47/63 carbapenem (imipenem susceptible) (74.6%), 16/63 carbapenem (imipenem) resistant (25.4%) (CRE).

[i] Limitations of antibiogram methodology – less reliable when the number of isolates is small, do not account for individual patient risk factors (e.g. prior antimicrobial therapy, travel history, known colonization with AMR pathogens), not all isolates tested are tested for all antimicrobials due to cascade testing strategies (i.e. only more resistant isolates tested against "Reserve" antimicrobials, may overestimate resistance).

Source: M39Ed5 Analysis and Presentation of Cumulative Antimicrobial Susceptibility Test Data, 5th Edition 2023 *(50)*

Table C4.2. Example of a cumulative antibiogram for urine isolates

Cumulative antibiogram
Susceptibility of common urine isolates – 1 January 2019 to 31 December 2019
Facility name | *Pathology service name*

Number of unique isolates: 2994	Number of isolates (%)	ANTIMICROBIALS										
		Access group (routinely reported)						Watch group (restricted or second choice)				
Organism		Amoxicillin	Amoxicillin + clavulanic acid	Cefalexin	Gentamicin or Amikacin	Nitrofurantoin	Trimethoprim	Vancomycin	Meropenem	Ceftriaxone	Norfloxacin	Piperacillin +tazobactam
Escherichia coli	2543 (85)	58%	84%	90%		93%	76%	R	247	232	211	237
		2543	2543	2543		2543	2543		250	250	250	250
Klebsiella pneumoniae	227 (7.6)	R	94%	88%		73%	79%	R	39	36	36	37
			227	227		227	227		40	40	40	40
Proteus mirabilis	105 (3.5)	83%	92%	94%		R	75%	R	32	31	30	31
		105	105	105			105		32	32	32	32
Pseudomonas aeruginosa	89 (2.9)	R	R	R	95%	R	R	R	28	R		27
					89				30			30
Enterococcus faecium	30 (1.0)	8%		R	R	31%	R	80%		R		
		30				30		30				

KEY
- (red) < 70% of isolates susceptible
- (orange) 70–89% of isolates susceptible
- (green) ≥ 90% of isolates susceptible
- 93% — 93% of tested isolates were susceptible
- R — Intrinsic resistance is present with this organism–antimicrobial combination
- 2543 — 2543 isolates tested

Note: Only species for which there are 30 or more isolates are reported.
Percentages are shown only where more than 90% of isolates were tested for each organism ("Watch" antimicrobials).
Susceptibility testing method: EUCAST.

Date published

Source: WHO

C5. How to evaluate a surveillance system

Guidance for conducting an evaluation of an AMR surveillance system. See Section B5.4.

Define the AMR surveillance system to be evaluated as follows.

1. Describe the importance of the organisms and AMR mechanisms under surveillance.
2. Describe the operation of the system:
   - List the purpose and objectives of the system.
   - Describe the planned uses of the data from the system.
   - Cite any legal authority for the data collection.
   - Does the system comply with applicable standards for data formats and coding schemes?
   - What is the policy and procedure for releasing data?
3. Describe the resources used to operate the system:
   - Funding sources:
     - specify the sources of funding for the surveillance system;
   - Personnel requirements:
     - estimate the time it takes to operate the system, including the collection, cleaning, analysis, reporting and dissemination of data;
   - Other resources:
     - any other resources, including travel, training, supplies, technology and other equipment, and related services.
4. Describe the components of the system:
   - What is the population under surveillance?
   - What data are collected and how are they collected?
   - What are the reporting sources of data for the system?
   - What is the period of time for data collection, or how often are data imported into the system?
   - How are the system's data managed (for example, the transfer, entry, analysis, storage and reporting of data)?

The purpose and objectives of the system should be outlined, including the planned uses of the data, and a frame of reference established for evaluating specific components. Listing the discrete steps that are taken in processing the data and generating reports by the system, and then depicting these steps in a flowchart, may be helpful.

Describe and assess each system attribute:

1. Simplicity
2. Flexibility
3. Data quality
4. Sensitivity
5. Representativeness
6. Timeliness
7. Acceptability
8. Stability.

A full evaluation of a surveillance system requires detailed analysis of each attribute. See the United States Centers for Disease Control and Prevention publication, *Updated Guidelines for Evaluating Public Health Surveillance Systems (32)*.

The checklist below can be used to assess which activities have been performed, and where further monitoring and evaluation activities are required to improve the surveillance system.

Checklist to describe and assess each AMR surveillance system attribute

Antimicrobial resistance surveillance system checklist

1. Simplicity

Surveillance systems should be as uncomplicated as possible while still meeting their required objectives.

	Yes	No
● Is there an up-to-date flow diagram of the surveillance system?	○	○
● Has the system been assessed to identify any improvements that could be made to simplify the system?	○	○
– *If Yes, outline any improvements that could be made to simplify the system:*		

Comments:

2. Flexibility

A flexible surveillance system can adapt to changing information needs or operating conditions with little additional time, personnel or allocated funds.

● Can the system accommodate:	Yes	No
■ new resistance mechanisms?	○	○
■ resistant pathogen outbreaks?	○	○
■ changes in case definitions?	○	○
■ changes in technology?	○	○
■ variations in funding sources?	○	○
■ variations in reporting sources?	○	○
● Has the system been assessed to identify any improvements that could be made to the flexibility of the system?	○	○
– *If Yes, outline any improvements that could be made to the flexibility of the system:*		

Comments:

3. Data quality

Data quality reflects the completeness and validity of the data recorded in the surveillance system.

● Are data values recorded in the system compared to "true" values through:	Yes	No
■ a review of sampled data?	○	○
■ record linkage?	○	○
■ patient chart review?	○	○
● Are all data entered managed under a quality management system?	○	○
● Has a review been undertaken to identify errors such as unusual phenotypes, nonsensical dates and data completeness?	○	○
● Has an assessment of laboratory capacity been undertaken?	○	○
– *If Yes, outline any improvements that could be made to the data quality of the system:*		

Comments:

4. Sensitivity

Sensitivity refers to the proportion of "true" cases detected by the AMR surveillance system. Its measurement is affected by the likelihood that:

- certain resistance-related events are occurring in the population under surveillance;
- cases within the population are under medical care, receive laboratory testing, or are otherwise coming to the attention of institutions subject to reporting requirements;
- the resistance-related events will be diagnosed/identified, reflecting the sensitivity of screening and diagnostic tests (meaning the case definition); and
- cases will be reported to the system.

	Yes	No
• Can the system monitor changes in the number of AMR cases over time?	○	○
• Can the system detect outbreaks?	○	○
• Does the sensitivity of the system meet the requirements of the stakeholders?	○	○
• Have the data from the system been assessed to identify any improvements that could be made to the sensitivity of the system?	○	○

- *If Yes, outline any improvements that could be made to the sensitivity of the system:*

Comments:

5. Representativeness

A representative AMR surveillance system accurately describes the occurrence of a resistance event over time and its distribution in the population.

	Yes	No
• Do the data from the system accurately reflect the characteristics of the health-related event under surveillance?	○	○
• Have the data been assessed to identify any population subgroups that might be systematically excluded through inadequate methods of monitoring them?	○	○

- *If Yes, outline any improvements that could be made to include these population subgroups in the system:*

Comments:

6. Timeliness

Timeliness reflects the speed of the steps in an AMR surveillance system and refers to how quickly data can be analysed and disseminated.

	Yes	No
• Do the data from the system allow for the early detection of outbreaks?	○	○
• Has the system been assessed to identify any improvements that could be made to reduce time taken to disseminate reports?	○	○

- *If Yes, outline any improvements that could be made to the timeliness of the system:*

Comments:

7. Acceptability		
Acceptability reflects the willingness of persons and organizations to participate in the surveillance system.		
● Does the system quantitatively measure acceptability, including:	**Yes**	**No**
■ physician, laboratory, hospital or facility reporting rate?	○	○
■ completeness of data collected?	○	○
■ timeliness of data reporting?	○	○
● Has the system been assessed to identify any improvements to the acceptability of the system?	○	○
– *If Yes, outline any improvements that could be made to the acceptability of the system:*		
Comments:		

8. Stability		
Stability refers to the reliability and availability of the surveillance system.		
● Does the system quantitatively measure stability, including:	**Yes**	**No**
■ the number of unscheduled outages and down times for the system's reporting?	○	○
■ the percentage of time the system is operating fully?	○	○
● Has the system been assessed to identify any improvements that may affect the performance of, or access to, the system data?	○	○
– *If Yes, outline any improvements that could be made to improve the stability of the system:*		
Comments:		

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Annexes

ANNEX 1. SURVEILLANCE DEFINITIONS FOR AMR PATHOGENS, SPECIMENS AND ANTIMICROBIALS

Annex 1.1 Antimicrobial categories and agents used to define MDR, XDR and PDR pathogens and "difficult-to-treat" resistance (DTR)

Table a1. Antimicrobial agents and criteria for defining MDR, XDR and PDR

Species	Antimicrobial agents[a]	Criteria for defining MDR, XDR and PDR *(52)*
Staphylococcus aureus	Gentamicin, rifampicin/rifampin, ceftaroline, oxacillin (or cefoxitin), ciprofloxacin/moxifloxacin, trimethoprim/sulfamethoxazole, fusidic acid, vancomycin/teicoplanin/ telavancin, tigecycline, clindamycin	MDR: (≥ 1 of these have to apply): an MRSA is always considered MDR by virtue of being an MRSA; non-susceptible to ≥ 1 agent in ≥ 3 antimicrobial categories XDR: non-susceptible to ≥ 1 agent in all but ≤ 2 categories PDR: non-susceptible to all antimicrobial agents listed
Enterococcus spp.	Gentamicin (high-level), streptomycin (high-level), ciprofloxacin/levofloxacin/ moxifloxacin, vancomycin/teicoplanin, tigecycline, daptomycin, linezolid, ampicillin, quinupristin-dalfopristin, doxycycline/minocycline	MDR: non-susceptible to ≥ 1 agent in ≥ 3 antimicrobial categories XDR: non-susceptible to ≥ 1 agent in all but ≤ 2 categories PDR: non-susceptible to all antimicrobial agents listed
Enterobacterales	Gentamicin/tobramycin/amikacin/ netilmicin, ceftaroline (only approved for *E. coli, K. pneumoniae* and *K. oxytoca),* ticarcillin-clavulanic acid/ piperacillin-tazobactam, ertapenem/ imipenem/ meropenem/doripenem, cefazolin/cefuroxime, cefotaxime/ cefotetan, ceftazidime-avibactam, meropenem-vaborbactam, imipenem-relebactam, cefiderocol, ciprofloxacin, trimethoprim-sulfamethoxazole, tigecycline, aztreonam, ampicillin, amoxicillin-clavulanic acid/ampicillin-sulbactam, chloramphenicol, osfomycin, colistin, tetracycline/ doxycycline/minocycline	MDR: non-susceptible to ≥ 1 agent in ≥ 3 antimicrobial categories XDR: non-susceptible to ≥ 1 agent in all but ≤ 2 categories PDR: non-susceptible to all antimicrobial agents listed

Species	Antimicrobial agents[a]	Criteria for defining MDR, XDR and PDR (52)
Pseudomonas spp.	Gentamicin/tobramycin/amikacin/netilmicin, imipenem/meropenem/doripenem, ceftazidime/cefepime, ceftazidime-avibactam, meropenem-vaborbactam, imipenem-relebactam, cefiderocol, ciprofloxacin/levofloxacin, ticarcillin-clavulanic acid/piperacillin-tazobactam, aztreonam, osfomycin, colistin/polymyxin B	MDR: non-susceptible to ≥ 1 agent in ≥ 3 antimicrobial categories XDR: non-susceptible to ≥ 1 agent in all but ≤ 2 categories PDR: non-susceptible to all antimicrobial agents listed
Acinetobacter spp.	Gentamicin/tobramycin/amikacin/netilmicin, imipenem/meropenem/doripenem, ciprofloxacin/levofloxacin, ticarcillin-clavulanic acid/piperacillin-tazobactam, cefotaxime/ceftriaxone/ceftazidime/cefepime, ceftazidime-avibactam, meropenem-vaborbactam, imipenem-relebactam, cefiderocol, trimethoprim-sulfamethoxazole, ampicillin-sulbactam, colistin/polymyxin B, tetracycline/doxycycline/minocycline	MDR: non-susceptible to ≥ 1 agent in ≥ 3 antimicrobial categories XDR: non-susceptible to ≥ 1 agent in all but ≤ 2 categories PDR: non-susceptible to all antimicrobial agents listed

[a] Antimicrobial agents in the same category (class) are grouped together (e.g. rifampicin/rifampin are both rifamycins).

Annex 1.2 Unusual resistance phenotypes requiring confirmatory testing

Table a2. Unusual pathogen phenotypes that require confirmatory testing

Organisms lacking an expected (intrinsic) resistance
• *Pseudomonas aeruginosa* susceptible to ampicillin • Enterobacter species, *Citrobacter freundii*, *Serratia marcescens, Acinetobacter baumannii*, or *Pseudomonas aeruginosa* susceptible to ampicillin, cefazolin or cephalothin • *Klebsiella*, *Providencia,* or indole-positive *Proteus* species susceptible to ampicillin • *Enterococcus faecalis* susceptible to quinupristin/dalfopristin
Organisms demonstrating an unknown or rare resistance phenotype
• *Enterococcus faecalis* resistant to ampicillin or penicillin • *Enterococcus faecium* resistant to quinupristin/dalfopristin • *Staphylococcus aureus* resistant to vancomycin • Beta-hemolytic streptococci resistant to penicillin • Non-fastidious Gram-negative bacilli resistant to gentamicin, tobramycin and amikacin • *Stenotrophomonas maltophilia* resistant to trimethoprim/sulfamethoxazole • *Haemophilus influenzae* resistant to a third-generation cephalosporin • Any isolate demonstrating intermediate or resistant results for those organism/antimicrobial combinations for which only susceptible category criteria are defined in EUCAST or CLSI: for example, *Streptococcus pneumoniae* resistant to vancomycin
Organisms demonstrating a resistance phenotype unusual for the geographic area
• *Staphylococcus aureus* resistant to oxacillin • *Streptococcus pneumoniae* resistant to penicillin or third-generation cephalosporins • *Streptococcus viridans* resistant or intermediate to penicillin • *Enterococcus* species with high-level resistance to gentamicin from sterile body site • *Klebsiella* species or *Escherichia coli* with extended-spectrum b-lactamase • Enterobacteriaceae resistant to ciprofloxacin • Enterobacterales resistant or intermediate to carbapenems • Isolate resistant to all relevant drugs

Annex 1.3 Provisional watch list for GLASS Emerging Antimicrobial Resistance (GLASS-EAR) reporting framework

Table a3. AMR pathogens on the GLASS-EAR watch list

AMR pathogens on GLASS-EAR watch list *(11)*	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
Enterobacterales	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 Telavancin-NS *OR* Dalbavancin-NS *OR* Oritavancin-NS *OR* daptomycin-NS *OR* Linezolid-R
Streptococcus pneumoniae	Linezolid-R *OR* vancomycin-NS

AMR pathogens on GLASS-EAR watch list *(11)*	**Definition**
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 AP, 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. 2012 Mar;18(3):268–81. *(52)*

-NS = non-susceptibility, -R = resistance

Annex 1.4 Minimum phenotypic identification for target pathogens

Table a4. Phenotypic identification testing by pathogen and sample type

Species	Samples	Phenotypic identification tests	Usual results
Escherichia coli	Blood, CSF, urine, respiratory[a]	Gram stain and motility Growth on primary media (e.g. blood agar) Growth on selective media (e.g. MacConkey agar) Biochemical identification (oxidase, indole, catalase) Carbohydrate utilization tests	Gram: GNB, mostly motile Growth on BA Growth and lactose fermentation on MAC (pink colonies) Oxidase negative, indole positive, catalase positive
Klebsiella pneumoniae	Blood, CSF, urine, respiratory[a]		Gram: GNB, non-motile Growth on BA Growth and lactose fermentation on MAC (pink colonies) Oxidase negative, indole negative, catalase positive Additional biochemical testing
Salmonella spp.	Blood Stool (non-typhoidal spp.)		Gram: GNB, motile Growth on BA and MAC, no lactose fermentation Oxidase negative, indole negative, catalase positive Growth characteristics on selective/differential media from stool (e.g. H2S production on XLD) Serological typing (if available)
Shigella spp.	Stool		Gram: GNB, non-motile Growth on MAC, no lactose fermentation Oxidase negative, indole negative, catalase positive Differentiate from *E. coli* based on growth characteristics on selective/differential media (e.g. XLD), additional biochemical testing (carbohydrate utilization) and serological typing (if available)

Species	Samples	Phenotypic identification tests	Usual results
Pseudomonas aeruginosa	Blood, CSF, urine, respiratory[a]		Gram stain: GNB, motile Growth on BA and MAC (but not lactose fermentation) ± Green pigment (diffusible on Mueller-Hinton agar) and metallic sheen Oxidase positive, indole negative, catalase positive Glucose non-fermentation Growth at 42 °C
Acinetobacter spp.	Blood, CSF, urine, respiratory[a]		Gram stain: Gram variable short rods or coccobacilli, non-motile Growth on BA and MAC (but not lactose fermentation) Glucose fermentation Oxidase negative, indole negative, catalase positive
Staphylococcus aureus	Blood, respiratory[a] (CSF)	Gram stain Biochemical identification tests	Gram: GPC in clusters Appearance (large colonies) ± golden pigment on BA Catalase positive, coagulase positive *Staphylococcus aureus* latex agglutination positive Growth on selective/differential media
Streptococcus pneumoniae	Blood, CSF, respiratory[a]	Gram stain Growth on primary media Optochin susceptibility Bile solubility	Gram-positive diplococci or GPC in chains Growth on BA or chocolate agar, α-haemolytic Catalase negative Optochin susceptible Soluble in bile
Neisseria meningitidis	CSF, blood	Gram stain Growth on primary media Biochemical identification (oxidase) Carbohydrate utilization tests	Gram-negative diplococci, coffee bean-shaped Grows on BA and chocolate agar Oxidase positive Catalase positive, superoxol negative/weak reaction Carbohydrate utilization tests to differentiate from other *Neisseria:* acid production from glucose and maltose, not lactose and sucrose Serological typing (if available)

Species	Samples	Phenotypic identification tests	Usual results
Haemophilus influenzae	CSF, blood	Gram stain Growth on primary media X+V factor requirements Serological typing (if available)	Gram: small GNB or coccobacilli No growth on BA, grows on chocolate agar Non-haemolytic on BA Oxidase positive, catalase positive Both X+V factors required for growth
Neisseria gonorrhoeae	Urethral, rectal, cervical or pharyngeal swabs	Growth on selective media Gram stain	Grows on selective media, e.g. modified Thayer-Martin or Martin-Lewis) Gram negative diplococci (bean-shaped) Catalase positive, superoxol brisk reaction Oxidase positive Carbohydrate utilization: acid production from glucose; not maltose, lactose, sucrose

[a] Lower respiratory tract samples.
BA = blood agar; MAC = MacConkey agar; XLD = xylose lysine deoxycholate agar;
GPC = Gram-positive cocci; GNB = Gram-negative bacilli (rods).

Annex 1.5 GLASS target pathogens and specimen types for AMR surveillance

Table a5. GLASS target pathogens and specimen types

Target pathogens*	Specimens					
	Blood	CSF	Urine	Stool	Lower respiratory tract	Urethral, cervical, rectal, and pharyngeal swabs
Acinetobacter spp.	●	○			●	
E. coli	●	○	●		○	
K. pneumoniae	●	○	●		●	
P. aeruginosa	●	○			●	
S. aureus	●	○			●	
S. pneumoniae	●	●			●	
N. meningitidis	●	●				
H. influenzae	○	●			●	
Salmonella spp. (non-typhoidal)	●	○		●		
Salmonella enterica serovar Typhi	●			○		
Salmonella enterica serovar Paratyphi A	●			○		
Shigella spp.				●		
N. gonorrhoeae						●

● Data collected and included in the official GLASS report when available.
○ Included in the GLASS database to accommodate data when submitted, but not necessarily included in the annual GLASS report.

* New target pathogens and specimens added to GLASS-AMR in 2023 are marked in bold font

Annex 1.6 Pathogen-specific antimicrobial susceptibility combinations

The choice of antimicrobials tested for each pathogen and specimen type depends on (i) requirements for patient treatment, and (ii) priority pathogen–antimicrobial combinations for AMR surveillance. The list below shows the pathogen–antimicrobial combinations included in GLASS v 2.0 for each specimen type. These allow for optimal AMR surveillance and inference of resistance mechanisms to "Access", "Watch" and "Reserve" antimicrobials in the WHO AwaRe classification *(15)*. This list is not intended to guide routine AST practices for patient treatment. Laboratories may not test all antimicrobials, but all antimicrobials tested should be reported for surveillance purposes.

Table a6. Pathogen-specific antimicrobial susceptibility combinations, by specimen type

B = blood, C = CSF, S = stool, U = urine, R = lower respiratory tract, G = STI screening[a]

Antimicrobial group	**Antimicrobials[b]**	*Escherichia coli*	*Klebsiella pneumoniae*	*Pseudomonas aeruginosa*	*Acinetobacter spp.*	*Staphylococcus aureus*	*Streptococcus pneumoniae*	*Neisseria meningitidis*	*Haemophilus influenzae*	*Salmonella enterica* serovar Typhi/ Paratyphi A	*Salmonella spp.* (non-typhoidal)	*Shigella spp.*	*Neisseria gonorrhoeae*
Beta-lactamase-sensitive penicillins	Penicillin G						B, C, R	C					
Extended-spectrum penicillins	Ampicillin								C, R	B			
	Mecillinam	U	U										
Beta-lactamase-resistant penicillins	Oxacillin					B, R	B, C, R[c]						
Beta-lactam/ beta-lactamase inhibitor combinations	Amoxicillin-clavulanic acid								C, R				
	Piperacillin/ tazobactam			B, R									
Second-generation cephalosporins	Cefoxitin					B, R[d]							
Third-generation cephalosporins	Ceftriaxone, cefotaxime	B, U, R	B, U, R				B, C, R	C	C, R	B	B, S	S	G*
	Ceftazidime	B, U, R	B, U, R	B, R						B	B, S	S	
	Cefixime												G
Fourth-generation cephalosporins	Cefepime	B, U, R	B, U, R										
Carbapenems[e]	Imipenem, meropenem, doripenem	B, U, R	B, U, R	B, R	B, R						B, S		
	Ertapenem	B, U, R	B, U, R								B, S		
Fluoroquinolones	Ciprofloxacin, levofloxacin	B, U, R	B, U, R					C	R	B	B, S	S	G[f]

Antimicrobial group	Antimicrobials[b]	*Escherichia coli*	*Klebsiella pneumoniae*	*Pseudomonas aeruginosa*	*Acinetobacter spp.*	*Staphylococcus aureus*	*Streptococcus pneumoniae*	*Neisseria meningitidis*	*Haemophilus influenzae*	*Salmonella enterica* serovar Typhi/ Paratyphi A	*Salmonella spp.* (non-typhoidal)	*Shigella spp.*	*Neisseria gonorrhoeae*
Aminoglycosides	Gentamicin, amikacin			B, R	B, R								G[g]
	Tobramycin			B, R									
Tetracyclines	Tigecycline, minocycline				B, R								
Macrolides	Azithromycin											S	G
	Erythromycin						B						
Sulfonamides and trimethoprim	Co-trimoxazole	B, U, R	B, U, R				B, C, R		C, R	B	S	S	
Polymyxins[h]	Colistin	B, U, R	B, U, R	B, R	B, R								
Rifamycins	Rifampicin							C					
Amphenicols	Chloramphenicol									B			
Nitrofuran derivatives	Nitrofurantoin	U	U										
Aminocyclitol	Spectinomycin												G

[a] Sample types for STI screening include urethral, cervical, rectal and pharyngeal swabs.

[b] Listed antimicrobials are priorities for AMR surveillance but may not be first-line options for treatment. One or more of the antimicrobials may be tested, but each should be reported separately with denominator data.

[c] Oxacillin disk testing is a surrogate for penicillin reduced susceptibility or resistance.

[d] Cefoxitin is used as an indicator antimicrobial for detection of methicillin resistance in MRSA.

[e] Imipenem or meropenem are preferred to represent the carbapenem group, where available.

[f] Only ciprofloxacin recommended for testing of *N. gonorrhoeae*

[g] Only gentamicin recommended for testing of *N. gonorrhoeae*

[h] Polymyxins (colistin or polymyxin B) should only be tested by the recommended reference method, broth microdilution. If this is not available locally, isolates should be referred to a laboratory with BMD capacity *(16)*.

ANNEX 2. NOTIFIABLE PATHOGENS FOR AMR SURVEILLANCE

Notifiable diseases are legally required to be reported by health-care providers and laboratories to authorities. Reportable diseases are not legally required to be reported but clinicians are encouraged or incentivized to report them. Incorporating AMR pathogens in existing notifiable disease legislation or as reportable diseases facilitates the identification of trends and outbreaks in AMR and enables coordinated and standardized responses. Centralized surveillance and investigation may provide additional capacity and expertise that is not available at the local or community level.

AMR data can be included within notifiable diseases legislation or administrative requirements:

- because antimicrobial susceptibility testing results are reported for pathogens that are already notifiable due to their public health impact (for example, gonorrhoea and tuberculosis); or
- because a pathogen with particular AMR characteristics is legislated to be notifiable (for example, carbapenemase-producing Enterobacterales (CPE).

Notification is of highest priority in settings with the capacity to investigate and respond to multi-facility and/or community outbreaks of critical AMR pathogens.

The inclusion of a pathogen or disease as a notifiable condition should be based on:

- the public health importance of the condition;
- the ability to prevent, control or treat the condition; and
- the capacity of the health system to implement appropriate control measures.

And limited to:

- high-risk pathogens (see specific risk assessment – Section B5.1 and *Responding to outbreaks of antimicrobial-resistant pathogens in health-care facilities: guidance for the Western Pacific Region* (sections 2.1 and 2.2) *(3)*;
- settings with existing public health surveillance programmes that include laboratory notification; and
- settings with the capacity to apply laboratory case definitions consistently throughout the population under surveillance.

Notifiable infection reporting systems must be clear, efficient and accessible throughout the AMR surveillance system, and based on case definitions applied through microbiological testing at primary facilities or referral of samples from suspected cases to referral laboratories such as the NRL (see Box A1).

Box A1. Case definitions for surveillance of notifiable conditions

A case definition is a uniform set of criteria that the disease or condition. Standardized case definitions ensure that cases are classified consistently by different people conducting surveillance and over time. It is common to include four components:

1. What? Laboratory and/or clinical criteria
2. Who? Specifics of the patient population (such as age, sex, patients who have undergone surgery)
3. When? Details of the time period under investigation
4. Where? Geographic, facility or ward/unit location

Surveillance case definitions are not clinical diagnostic criteria and are not intended to be used by health-care providers to make a diagnosis. Surveillance case definitions may also differ from outbreak case definitions – see *Responding to outbreaks of antimicrobial-resistant pathogens in health-care facilities: guidance for the Western Pacific Region (3).* All conditions or diseases under surveillance should have a case definition.

To be effective, case definitions must be clear, appropriate to the condition under surveillance, applicable consistently across time and throughout the surveillance system and mutually exclusive of other conditions under surveillance. Case definitions may include laboratory and/or clinical components, and multiple case classifications may be used, most commonly:

- Suspected case definitions capture patients who may have the condition while testing is still ongoing. Reporting of suspected cases allows public health or infection control action to be taken immediately.
- Probable case definitions capture patients who probably have the condition, but testing was inconclusive or could not be completed.
- Confirmed case definitions capture patients who meet all criteria in the case definition.

Example surveillance definition for CPE as a notifiable condition *(53)*

Suspected case

A person with a species of Enterobacterales isolated from routine clinical or screening specimens (infection or colonization), with any of the following:

- meropenem minimum inhibitory concentrations (MIC) ⩾ 0.25 mg/L, or disk diffusion zone ⩽ 30 mm (CLSI) or 28 mm (EUCAST); or
- phenotypic resistance to any carbapenem where the MIC is above the clinical breakpoint defined by CLSI or EUCAST, or zone diameter suggests resistance by calibrated dichotomous sensitivity (CDS); or
- positive colorimetric test for carbapenemase (CarbaNP or Blue-Carba).

Confirmed case

Laboratory criteria: a person meeting the definition of a suspected case and where a carbapenemase gene is detected in a sample or isolate irrespective of phenotypic susceptibility, for example, KPC-2 gene-positive *Klebsiella pneumoniae.*

Clinical criteria: a person who is colonized or infected with a CPE.

ANNEX 3. EXAMPLES OF FORMS FOR USE IN AMR SURVEILLANCE

Annex 3.1 Example sample request forms with core surveillance data fields

Below is an example of a sample request form containing core data fields required for surveillance. This form would be completed by the requesting doctor and provided to the diagnostic laboratory with all samples for microbiological testing. Limited use of free-text fields makes the form easy and quick for clinicians to use and helps improve data quality and completeness. All forms should be accompanied by an SOP which includes completion instructions, a data dictionary and a protocol for follow-up or rejection of samples where critical information is missing. See Section B2.1 for further information.

Form adapted from WHO Laboratory Quality Stepwise Implementation Tool *(54)* .

Microbiological Test Request Form – <*laboratory name*>

Laboratory use only
Sample ID: ______________
Received date: ____________

Requester details[a]

Name: ________________________ Phone number: ________________________
Unit/dept: ________________________ Hospital/clinic: ________________________

Patient details[b]

Family name: ________________________ Given name: ________________________
Patient identifier#: ________________________ Date of birth^: ______________ *(dd-mm-yyyy)* or age: ______
Sex: ☐ Male ☐ Female ☐ Other Ethnicity~: ☐ <*as required*> ☐ Unknown ☐ Not stated
Usual residential address: ________________________ Province*: ________________________
________________________ Phone number: ________________________
Patient location at sample collection**: ☐ Emergency ☐ <*ward*> ☐ <*ward*> ☐ <*ward*> ☐ <*clinic*>
☐ Outpatient ☐ Inpatient, admission date: ________ Ward/unit: ☐ Emergency ☐ <*ward*> ☐ <*ward*> ☐ <*ward*> ☐ <*clinic*>

Sample details

Collection date: ______________ *(dd-mm-yyyy)* or time: ________ Sample type: ☐ Blood ☐ Faeces ☐ Urine ☐ Sputum
Reason for collection: ☐ Clinically indicated ☐ Swab ☐ Pus ☐ Tissue ☐ Fluid
☐ Screening ☐ Other, specify: ________________
☐ Unknown Sample body site: ________________________

Clinical details

____
____

Microbiological tests requested

☐ Microscopy/Culture/Sensitivity ☐ AFB (ZN) Smear Only ☐ AFB Smear & Culture ☐ Addional tests, specify: ____________

Requestors signature: ________________________ **Date:** ______________ *(dd-mm-yyyy)*

Adapt this form to your own situation.

[a] Laboratories accepting samples from external clinics and doctors may require additional information such as clinic address and/or health practitioner registration numbers.

[b] Optimal collection of patient information can differ by setting. #In countries without a national identification number, a hospital patient identification number should be collected. ^Where date of birth or age is often not accurately known, checkboxes with categories such as "child" and "adult" can be provided. ~Sex and ethnicity should be collected as described in local standards, if available. *At minimum, province/state or town/postal code where the person is currently living should be collected. **Laboratories servicing community settings may wish to collect additional information about outpatient settings, e.g. if the sample is collected through general practice or from a patient in residential aged care.

Annex 3.2 Example sample referral form with core surveillance data fields

This form would be completed by the diagnostic laboratory when referring isolates to the NRL for further testing, surveillance and biobanking. Additional epidemiological or clinical data may be requested on the isolate referral form or provided with electronically submitted routine surveillance data. See Section B2.3.3.

Form adapted from WHO Laboratory Quality Stepwise Implementation Tool *(54)*

Microbiological Isolate Referral Form – <*laboratory name*>

Laboratory use only
Sample ID: ______________
Received date: ______________

Referring laboratory details

Laboratory name: ______________ Contact person: ______________
Laboratory address: ______________ Phone number: ______________

Patient details[a]

Family name: ______________ Given name: ______________
National identifier: ______________ Date of birth: ______________ *(dd-mm-yyyy)* or age: ______
Sex: ☐ Male ☐ Female ☐ < *other* > Ethnicity~: ☐ <*as required*> ☐ Unknown ☐ Not stated
Usual residential address: ______________ Province: ______________
______________ Phone number: ______________
Patient location at sample collection: ☐ Outpatient ☐ Hospital inpatient ☐ Unknown
If outpatient ☐ General practice ☐ Other outpatient If inpatient: Hospital name: ______________
☐ Hospital emergency ☐ Unknown ward/unit: ☐ ICU ☐ Other, specify: ______________
☐ Residential aged care facility admission date: ______________ *(dd-mm-yyyy)*

Specimen details

Collection date: ______________ Collection date: ______________ *(dd-mm-yyyy)*
Reason for collection: ☐ Clinically indicated ☐ Screening ☐ Unknown
Sample type: ☐ Blood ☐ Faeces ☐ Urine ☐ Sputum ☐ Swab ☐ Pus ☐ Tissue ☐ Fluid ☐ Other, specify: ______________
Sample body site: ______________

Isolate details (please provide as much detail as possible)

Testing date: ______________ *(dd-mm-yyyy)* Organism: ______________
Reason for referral[b]: ☐ Suspected MDR, XDR, PDR DTR organism
☐ Unusual pathogen phenotype that requires confirmatory testing
☐ AMR pathogen on the GLASS-EAR watch list
☐ Other
Specify reason for referral: ______________

Sensitivity data:
Testing method: ☐ Equivocal ☐ Not tested ☐ E-test ☐ Broth dilution ☐ MicroScan ☐ Other: ______________

Antimicrobial	MIC/ZD	SIR	Antimicrobial	MIC/ZD	SIR
Amikacin			Daptomycin		
Ampicillin			Gentamicin		
Azithromycin			Lincomycin		
Ceftriaxone			Meropenem		
Colistin			Tobramycin		
Co-trimoxazole			Vancomycin		

MIC = Minimum inhibitory concentration, ZD = Zone diameter

CIM/Carba NP: ☐ Positive ☐ Negative ☐ Equivocal ☐ Not tested ☐ *CIM* ☐ *CarbaNP*
Method of testing: ______________
ESBL: ☐ Positive ☐ Negative ☐ Equivocal ☐ Not tested
Method of testing: ______________
AmpC: ☐ Positive ☐ Negative ☐ Equivocal ☐ Not tested
Method of testing: ______________

Comments: (include any other laboratory results here) ______________

Adapt this form to your own situation.

[a] Optimal collection of patient information can differ by setting. In countries without a national identification number, a hospital patient identification number should be collected. Where date of birth or age is often not accurately known, checkboxes with categories such as "child" and "adult" can be provided. Sex and ethnicity should be collected as described in local standards, if available. At minimum, province/state or town/postal code where the person is currently living should be collected.

[b] Guidance on what isolates require referral should be provided by the NRL and NCC. Guidelines should include criteria for referral. "Reason for referral" stipulated on this from should match the criteria identified by the NCC.

Annex 3.3 Case report form for surveillance of critical AMR

Carbapenemase-producing Enterobacterales case report form

Case ID: ____________________ ☐ Confirmed ☐ Probable

Date reported: ___ /___ /___
Data collection period: ___ /___ /___ to ___ /___ /___

Patients details

Name Given: ______________ Family: ______________
UR number: ______________ Date of Birth: ___ /___ /___
Sex: ☐ Male ☐ Female ☐ Other, specify __________

Location at the time of initial sample collection:
☐ Acute hospital - admitted ☐ Acute hospital - emergency
☐ General practice ☐ Residential aged care
☐ Unknown ☐ Other

Initial CPE detection

Organism species: ______________________________
Carbapenemase gene(s): __________________________
Date of collection: ___ /___ /___
Reason for specimen collection:
☐ Screen ☐ Clinically indicated
if screen, reason for screening: ________________
additional microbiological results recorded overleaf

If facility, facility name ___________________________ Ward: ____________________ Date admitted: ___ /___ /___
Please provide bed movement data for admission of CPE detection electronically or overleaf

Clinical details

Clinical presentation:
☐ infection ☐ infection ☐ unknown significance
If infection, source:
☐ urinary tract ☐ intra-abdominal ☐ surgical site
☐ skin or soft tissue
bacteremia: ☐ indwelling device ☐ without obvious focus
☐ Other, specify ______________________________
Directed antimicrobial therapy for this infection: ☐ Yes ☐ No

Signs and symptoms of infection

Signs/symptom	Onset date

If patient deceased, was infection contributory to death:
☐ Yes, primary ☐ Yes, contributory ☐ No ☐ Unkown

Risk factors for acquisition

In the 4 years prior to CPE identification did the patient
Travel overseas: ☐ Yes ☐ No ☐ Unkown
If yes,

Country of travel	Approximate dates	Overseas healthcare contact
		☐ Hosp. adm. ☐ Yes, other ☐ No ☐ Unk
		☐ Hosp. adm. ☐ Yes, other ☐ No ☐ Unk
		☐ Hosp. adm. ☐ Yes, other ☐ No ☐ Unk
		☐ Hosp. adm. ☐ Yes, other ☐ No ☐ Unk
		☐ Hosp. adm. ☐ Yes, other ☐ No ☐ Unk

In the 12 months prior to CPE identification was the patient admitted to any other healthcare facilities:
☐ Yes ☐ No ☐ Unkown
If yes,

Facility name

In the 12 months prior to CPE identification did the patient have any medical or surgical procedures:
☐ Yes ☐ No ☐ Unkown
If yes,

Type of procedure	Facility	Date

At the time of CPE identification did the patient have any indwelling medical devices:
☐ Yes ☐ No ☐ Unkown
If yes,

Device	Insertion date

Page ___ of ___

Carbapenemase-producing Enterobacterales case report form

Page ___ of ___

Record electronically if available, this page can be repeated as needed

Case ID: ________________________________ Data collection period: ____ /____ /____ to ____ /____ /____

Microbiological testing

Sample identifier	Sample source Reason for sample collection	Collection date	Organism characterization	Antimicrobial susceptibility testing
	Source: ☐ Screen ☐ Clinically indicated		Organism: __________________ MLST: _____________ ☐ N/T WGS performed: ☐ Y ☐ N ☐ N/T	Results: Carb. gene(s): _______ ☐ N/T
	Source: ☐ Screen ☐ Clinically indicated		Organism: __________________ MLST: _____________ ☐ N/T WGS performed: ☐ Y ☐ N ☐ N/T	Results: Carb. gene(s): _______ ☐ N/T
	Source: ☐ Screen ☐ Clinically indicated		Organism: __________________ MLST: _____________ ☐ N/T WGS performed: ☐ Y ☐ N ☐ N/T	Results: Carb. gene(s): _______ ☐ N/T
	Source: ☐ Screen ☐ Clinically indicated		Organism: __________________ MLST: _____________ ☐ N/T WGS performed: ☐ Y ☐ N ☐ N/T	Results: Carb. gene(s): _______ ☐ N/T
	Source: ☐ Screen ☐ Clinically indicated		Organism: __________________ MLST: _____________ ☐ N/T WGS performed: ☐ Y ☐ N ☐ N/T	Results: Carb. gene(s): _______ ☐ N/T
	Source: ☐ Screen ☐ Clinically indicated		Organism: __________________ MLST: _____________ ☐ N/T WGS performed: ☐ Y ☐ N ☐ N/T	Results: Carb. gene(s): _______ ☐ N/T

Bed and ward movement, admission of CPE identification

Ward	Room	Bed	Date admitted	Date discharged		Ward	Room	Bed	Date admitted	Date discharged

Annex 3.4 Event-based surveillance report form

See Section B4.4

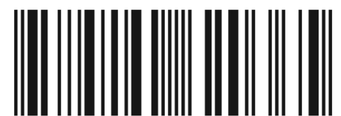
Cluster or Event Report Form Please send this form to <receiving authority>		
1	Date of report	
2	What do you want to report? What happened?	
3	When did this happen? (Month, day, year)	
4	Where did this happen? (e.g., ward, facility, clinic or village, city, province, region)	
5	How many people have been affected?	
6	Has anyone died? How many?	
7	Has any laboratory testing been performed or requested and, if so, where?	
8	What response measures have been taken already, if any?	
9	Other information (e.g., clinical presentation, contact between cases)	
10	Name and contact details of person reporting?	

ANNEX 4. AMR SURVEILLANCE SYSTEM ASSESSMENT TOOL

This Excel-based AMR Surveillance System assessment tool was developed to accompany this document. Member States can use it to understand AMR surveillance and laboratory capacity in their country, and to identify strengths and gaps where support is needed.

The assessment tool can be viewed under Databases and tools here: https://www.who.int/westernpacific/health-topics/antimicrobial-resistance. If you would like an interactive version of the tool, please email wproemt@who.int.

WHO Western Pacific Region
PUBLICATION



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