The National Antimicrobial Resistance (AMR) Surveillance Strategy of Bangladesh 2020-2025

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List of abbreviations

AMC	Antimicrobial consumption
AMR	Antimicrobial resistance
AMU	Antimicrobial use
ARC	Antimicrobial resistance containment
AST	Antimicrobial susceptibility testing
BAHIS	Bangladesh Animal Health Intelligence System
BLRI	Bangladesh Livestock Research Institute
BSMMU	Bangabandhu Sheikh Mujib Medical University
CDC	Communicable disease control
CDIL	Central Disease Investigating Laboratory
CLSI	Clinical and Laboratory Standards Institute
COVID 19	Coronavirus disease 2019
CRE	Carbapenem-resistant Enterobacteriaceae
CWG	Core Working Group
DFID	United Kingdom Department for International Development
DGDA	Directorate General of Drug Administration
DGHS	Directorate General of Health Services
DLS	Department of Livestock Services
ECOFF	Epidemiologic cut-off values
EQA	External quality assurance
ESBL	Extended-spectrum beta-lactamase
ETP	Effluent treatment plant
EUCAST	European Committee on Antimicrobial Susceptibility Testing
FDIL	Field Disease Investigation Laboratory
GAP	Global Action Plan on Antimicrobial Resistance
GHSA	Global Health Security Agenda
GLASS	Global Antimicrobial Resistance Surveillance System
GoB	Government of Bangladesh
GMP	Good manufacturing practice
icddr,b	International Centre for Diarrheal Disease & Research
IEDCR	Institute of Epidemiology, Disease Control, and Research
IPH	Institute of Public Health
LIMS	Laboratory management information system
M&E	Monitoring and evaluation
MIC	Minimum inhibitory concentration
MOHFW	Ministry of Health and Family Welfare
MSRA	Methicillin-resistant *Staphylococcus aureus*
NARC	National Antimicrobial Resistance Control Programme

NCC	National Coordination Centre
NRA	National Regulatory Authority
NRL	National Reference Laboratory
NSC	National Steering Committee
NTC	National Technical Committee
OIE	World Organisation for Animal Health
OP	Operational Planning
PDR	Pan-drug resistant
PPNG	Penicillinase-producing *Neisseria gonorrhoeae*
PRSP	Penicillin-resistant *Streptococcus pneumoniae*
PT	Proficiency testing
QAP	Quality assurance program
SCC	Sectoral coordination committee
SOP	Standard operating procedure
STP	Sewage treatment plant
SWG	Sectoral Working Group
TDR	Total drug-resistant
US CDC	United States Centers for Disease Control and Prevention
VISA	Vancomycin-intermediate *Staphylococcus aureus*
VRE	Vancomycin-resistant enterococci
VRSA	Vancomycin-resistant *Staphylococcus aureus*
WHA	World Health Assembly
WHO	World Health Organization
XDR	Extensively drug-resistant

Contents

Executive summary

Antimicrobial resistance (AMR) has emerged as a major global health crisis, including in Bangladesh. AMR has resulted in an alarming increase in infections due to multidrug-resistant bacteria and limited the choice of antimicrobials for treatment, adversely affecting clinical as well as financial outcomes. In most instances, resistance emerges because of the irrational use of antimicrobials and is perpetuated by diverse risk factors and maintained within environments because of poor infection control practices.

The World Health Organization (WHO) Global Strategy for Containment of Antimicrobial Resistance (2001) recognises antimicrobial resistance surveillance as essential to combating and managing AMR. A proper surveillance system provides important information to guide containment interventions, as well as a baseline against which to assess the effectiveness of those interventions. At the national level, surveillance enables the monitoring of susceptibility patterns of microorganisms to antimicrobial agents, thus revealing the AMR status and informing the development of empirical recommendations for the treatment of community or hospital-acquired infections. In addition, evidence supports surveillance as a cost-effective strategy to contain AMR in that it can contribute to reduced infection-related costs, which leads to overall savings.

Bangladesh has some experience and knowledge of successful interventions for AMR containment (e.g. improved infection control practices, antibiotic restriction policies, AMR surveillance, etc.). Since 2016, the Institute of Epidemiology, Disease Control, and Research (IEDCR) has conducted countrywide AMR surveillance, beginning with five sentinel sites, then scaling up to nine, with the support of the Government of Bangladesh (GoB), the Global Health Security Agenda (GHSA), and the World Health Organization (WHO); this support is anticipated to end by March 2021. The Bangladesh Livestock Research Institute (BLRI), Central Disease Investigating Laboratory (CDIL), and the Department of Livestock Services (DLS) epidemiology unit are also conducting AMR surveillance on a small scale.

The lessons learned from these surveillance initiatives have informed the current national AMR surveillance strategy, as have strategic objectives in other government documents such as the National Action Plan, which lists 'Establishment of AMR Surveillance System' as its fourth strategic objective, and the Road Map of the National Action Plan of Antimicrobial Resistance Containment (ARC) program, which lists 'Activities of AMR surveillance in human health' in Section 4.1.1.

The National AMR Surveillance Strategy aims to establish a robust, cross-sectoral AMR surveillance system to generate data that can inform policy decisions and the prudent production, distribution, and use of antimicrobials in Bangladesh. The main **objectives** of the surveillance programme are to:

- Establish a national surveillance system to monitor the prevalence and evolving trends of AMR in organisms using a One Health approach.
- Facilitate evidence-based decision making for antimicrobial resistance containment.
- Establish a genomic-based AMR surveillance system.
- Make available surveillance data that can be combined with antimicrobial use (AMU) and antimicrobial consumption (AMC) data to facilitate evidence-based decision making for antimicrobial resistance containment.
- Enable the surveillance of antibiotic resistance and antibiotic residues in the environment.
- Establish a national laboratory network with a monitoring and evaluation (M&E) framework.
- Contribute data to global and regional data-sharing mechanisms (e.g., the WHO Global Antimicrobial Resistance Surveillance System (GLASS), the World Organisation for Animal Health (OIE) system).
- Promote research on antimicrobial resistance containment.

The National AMR Surveillance Strategy covers the next five years (2020-2025), at which point the strategy will be revised based on an evaluation and the country's emerging needs and priorities.

National commitment: As a signatory to the Jaipur Declaration on AMR, Bangladesh is fully committed to combating AMR. Evidence of this commitment can be seen in the country's National Action Plan on AMR, which aligns with the WHO Global Action Plan on AMR (2015).

Surveillance system: The AMR surveillance system will be established using the One Health approach. The network of national laboratories and surveillance sites for both the human health and animal health sectors will include hospital laboratories as well as laboratories at animal health and fish research institutes, preferably in different regions across the country. Ideally, selected laboratories should have quality microbiological facilities that will enable them to identify pathogens and susceptibility patterns. These laboratories will provide uniform, validated data to the National Coordination Centre (NCC), the apex body for the AMR surveillance system and the central site for the collation of national surveillance data (the Disease Control Unit of Directorate General of Health Services (DGHS) has been designated as the NCC). The NCC will analyse antimicrobial resistance patterns, disseminate timely surveillance to potential users, and share data with WHO GLASS as per system requirements. It will also establish a national data dashboard on AMR surveillance that will be connected to the data dashboards of both the DGHS and the One Health Secretariat. In addition, the NCC will have the mandate to coordinate nationwide surveillance activities.

Governance and coordination: The country will establish a separate sectoral coordination centre for each sector. In addition to coordinating activities within its respective sector, each centre will develop a surveillance plan, build surveillance capacity at sentinel sites, provide supportive supervision and monitoring of surveillance activities in all sites, and coordinate with other sectors.

To facilitate the implementation of the national and sectoral AMR surveillance plans and the planning and coordination of activities, multisectoral committees at different levels with appropriate terms of reference should also be established.

The Directorate General of Drug Administration (DGDA), which is a directorate of the Ministry of Health and Family Welfare (MOHWF), is the designated National Regulatory Authority (NRA) and, as such, plays an important role in the AMC programme. The participation of DGDA in implementing the National AMR Surveillance Strategy is essential, especially for establishing a mechanism for monitoring AMU and AMC. Data on both AMU and AMC should feed into the AMR surveillance system to deepen the country's understanding of the relationship between antimicrobial use, consumption, and resistance.

Mainstreaming and sustainability: AMR surveillance must be incorporated into Bangladesh's human health system, as well as in the animal health sector, the food chain (including aquaculture) and the environment. In the human health sector, the government should incorporate resources for the National AMR Surveillance Strategy and ARC into the budget of the National Health, Population, and Nutrition Sector Programme during its mid-term revision and the planning of the new cycle of sector programming. Beyond the health sector, relevant departments and agencies will develop and implement sector-specific action plans. Each sector is responsible for examining the National AMR Surveillance Strategy and deciding how to meet the national objectives, including by building on and refining current initiatives that produce relevant data and information.

One Health approach: The One Health approach recognises the connection between the health of people, animals, plants, and the environment. Harmonizing the connections between those sectors to optimise health outcomes is the goal of One Health, which uses a collaborative multi-sectoral approach at the national, regional, and global levels. This approach is particularly important for AMR surveillance, as a growing body of evidence shows the importance of a standardised protocol for AMR monitoring and antimicrobial susceptibility testing (AST) across sectors.

Fortunately, Bangladesh has a national One Health Strategy that recognises AMR as a multisectoral problem best addressed using a One Health approach. Moreover, the country has a successful 15-year track record of applying the One Health approach, including the development of the National AMR Strategy and Action Plan. The country also has a One Health Secretariat that is strategically placed to ensure coordination between all major stakeholders and policymakers active in AMR surveillance and control in Bangladesh. Apart from coordination, the One Health Secretariat could be used as a data-sharing centre for all sectors and as the national data repository of microbial isolates (the physical repository will remain with the concerned national reference laboratories or NRLs).

Sector-specific surveillance: Core AMR surveillance in **human health** will focus on priority organisms/specimens to generate harmonised data for global surveillance reporting (e.g., WHO GLASS). In addition, laboratories should strive to extend their surveillance to include critical resistance profiles. The antimicrobial panel should be decided following the latest European Committee on Antimicrobial Susceptibility Testing (EUCAST) or Clinical and Laboratory Standards Institute (CLSI) guidelines and considering the organism and drug combination as well as the country perspective. The antimicrobials that are categorised by the WHO as critically important and highly important to human medicine will be included in the panel. The final list of antimicrobials to be included in the panel per organism needs to be reviewed and experts/working groups to be consulted. The panel will be updated over time according to the changing data on AMR.

The **animal health and aquaculture** sectors will adhere to similar principles. All labs will use uniform AST methods. In addition, for the animal health and aquaculture sectors, the AMR Surveillance Strategy describes the sampling frame and sample size.
The strategy emphasises capacity building in the selected sentinel sites, starting from basic or core level and progressing gradually to higher levels- to the extended and advanced levels. This approach of capacity development at smaller number of facilities is preferable to the geographical expansion, which refers to increase in number of facilities under surveillance to have wider geographical representation.

Data management: AMR surveillance collects national- and local-level data from relevant sectors to guide evidence-based decision-making by the National AMR Containment Programme. As such, surveillance data must be of the highest quality, regardless of sector. The overarching objectives of establishing a strong data management system within the AMR surveillance system include:

- Build data management capacity at all levels across all sectors.
- Establish standards for data management that improve data quality and facilitate the flow of data between the sentinel sites, NRLs, and the NCC.
- Integrate the AMR surveillance data into the DGHS health information system, DHIS 2, and the Bangladesh Animal Health Intelligence System (BAHIS).
- Establish standards of use and analysis for national AMR data through a national AMR data dashboard, accessible to all sectors and sentinel sites.

The data management system must entail strong systems and data management practices. The database to store AMR surveillance data, for example, must be capable of storing a large volume of complex data for an undetermined amount of time. And, while data sets from the human health, animal health, and aquaculture will differ due to varies surveillance settings and reporting requirements, they must lend themselves to cross-sectoral analysis at the apex level.

In the human health sector, AMR surveillance facilities are required to use a laboratory information management system (LIMS) to capture the clinical bacterial culture and AST results. Surveillance site LIMS should collect the minimum required AMR surveillance data elements defined by country priorities and GLASS requirements. In the animal health and aquaculture sectors, LIMS will be prepared as per the OIE's Terrestrial Animal Health Code, Chapter 6.8, Article 6.8.8 (OIE, 2018).

Data will be in electronic formats and stored in a structured data management system (e.g., an Excel file, LIMS, WHONET) for ease of sharing and to facilitate further data analysis. Data will be collected and analysed at the levels recommended by the National Technical Committee (NTC) and/or Core Working Group (CWG) and at the national level and be presented in a consistent format.

Surveillance data flow: Data collected at the surveillance sites will be shared with the NRLs for analysis (IEDCR for human health and CDIL/BLRI for the animal health and aquaculture). They will then transmit the data to the One Health Secretariat and the NCC, where AMR surveillance data from all three sectors will be analysed and correlations of the inter-sectoral data explored. The overall data will be stored at the national data repository based at the One Health Secretariat.

Monitoring and evaluation: Monitoring and evaluation (M&E) of the national AMR surveillance system will begin soon after the start of surveillance activities. A monitoring and evaluation team will be identified, with representatives from the NCC, the NRLs, representatives from each sectoral coordination committee, the One Health Secretariat, and international partners. The M&E team will collaboratively design a programme evaluation strategy to assess the performance and overall effectiveness of the programme. Routine monitoring of the surveillance programme will obtain data on inputs, processes, and outputs. A formal evaluation of the surveillance system will be based on an established framework and should evaluate outcomes and impacts; the design of the evaluation may take place after a certain period of programme implementation. The M&E team will make all reports available to stakeholders to guide system improvements and help ensure success moving forward.

The NCC and the Core Working Group (CWG) (see Chapter 2 for details) will review the logical framework and indicators annually to evaluate the AMR surveillance and decide on appropriate actions. Such M&E will aim to improve the surveillance system in the long term.

Chapter 1: Antimicrobial resistance surveillance

Introduction

Antimicrobial resistance (AMR) has emerged as a major global health crisis, including in Bangladesh. AMR has resulted in an alarming increase in infections due to multidrug-resistant bacteria and limited the choice of antimicrobials for treatment, leading to adverse clinical—and financial—outcomes. For example, individuals who do not respond to traditional therapies may require expensive or alternative drugs. In addition, there are issues related to the high social cost of increased morbidity and mortality rates, longer hospital stays, increased health care costs, and, changes in empirical therapy. In most instances, resistance emerges because of the irrational use of antimicrobials. It is perpetuated by diverse risk factors; and is maintained within environments because of poor infection control practices.

Antimicrobial resistance surveillance is an essential component of combating and managing AMR, as outlined in the World Health Organization (WHO) Global Strategy for Containment of Antimicrobial Resistance (2001). More recently, in May 2015, the 68th World Health Assembly (WHA) adopted the "Global Action Plan on Antimicrobial Resistance" (GAP). The goal of the GAP is to ensure, for as long as possible, the continued, successful treatment and prevention of infectious diseases with effective, safe, quality-assured medicines that are used responsibly and accessible to all who need them.

To achieve this goal, the GAP sets out five strategic objectives:

1. Improve awareness and understanding of antimicrobial resistance.
2. Strengthen knowledge through surveillance and research.
3. Reduce the incidence of infection.
4. Optimise the use of antimicrobial agents.
5. Develop the economic case for sustainable investment that takes account of the needs of all countries and increase investment in new medicines, diagnostic tools, vaccines, and other interventions.

In addition, the WHA urged its member states to develop and enact national action plans on AMR aligned with the GAP by 2017.

Evidence shows that surveillance is a cost-effective way to contain AMR. A proper surveillance system captures data that inform the design of interventions and serve as a baseline against which to measure the effectiveness of those interventions. These interventions, in turn, reduce infection-related costs, which leads to overall savings with long-term gains like reduction in hospital stay, reduction in morbidity and mortality, etc.. AMR surveillance data will help formulate, monitor, and identify the prevailing and emerging antimicrobial resistance phenotypes, which can then be effectively contained. The purpose of surveillance at the national level is to monitor susceptibility patterns of microorganisms to antimicrobial agents, which will reveal the antimicrobial resistance status.

AMR surveillance data can be used to advance numerous objectives. Data can drive empirical revisions to treatment guidelines for both community and hospital-acquired infections, for example. Moreover, the regular dissemination of AMR information to physicians may improve the empirical selection of antimicrobial agents when treating community or hospital-acquired infections. Data can also help quantify the consumption of antibiotics in a particular area covered by the network of hospitals. In addition, surveillance data on the prevalence and resistance patterns of different pathogens can inform recommendations and guidelines on controlling community and hospital-acquired infections, as well as interventions to reduce the rate of resistance. Data can also be used to raise awareness of the AMR crisis among both medical personnel and citizens. In sum, an efficient surveillance system for AMR can play a critical role in improving the efficacy of health services and reducing mortality and morbidity due to infectious diseases.

Importance of surveillance of antimicrobial resistance

Antimicrobial resistance surveillance is necessary to:

- Understand when, where, how, and why drug resistance is emerging.
- Reveal antimicrobial efficacy.
- Improve the management of patients and infection control in hospital settings.
- Improve the management of community-infection control.
- Guide evidence-based action by policymakers on drug policy, essential medicines list, standard treatment guidelines, procurement strategies, resource allocation, and health professional curricula and training.
- Improve the empirical selection of antimicrobial agents when treating community or hospital-acquired infections.

Background

Bangladesh has some experience with and knowledge of successful interventions for AMR containment (e.g., improved infection control practices, antibiotic restriction policies, AMR surveillance, etc.). The Institute of Epidemiology, Disease Control, and Research (IEDCR) has conducted countrywide AMR surveillance at five sentinel sites (later scaled up to nine) since 2016, with the support of the Government of Bangladesh (GoB), the Global Health Security Agenda (GHSA), and World Health Organization (WHO). This support is anticipated to end by March 2021. The Bangladesh Livestock Research Institute (BLRI), Central Disease Investigating Laboratory (CDIL), and Department of Livestock Services (DLS) epidemiology unit are also conducting AMR surveillance on a small scale.

The lessons learned from these surveillance initiatives have informed the National AMR Surveillance Strategy, as have strategic objectives from the National Action Plan ("Establishment of AMR Surveillance System") and the Road Map of the National Action Plan of the Antimicrobial Resistance Containment (ARC) program, which prioritises the institutionalisation of the surveillance system and the rational use of antimicrobials.

Establishing an efficient surveillance system requires improved microbiology laboratory capacity; sound mechanisms to report surveillance data at the local, national, regional, and global levels; and increased awareness and access to information. Moreover, it is crucial to incorporate the surveillance information into updates of standard treatment guidelines, which can later be adopted by medical and veterinary prescribers. The National AMR Surveillance Strategy provides guidance on selecting and establishing laboratory networks to generate high-quality antibiotic sensitivity data on local, national, and global priorities. While the containment of AMR primarily involves the human health sector, an effective surveillance system will use a multisectoral One Health approach to synthesise data from the human health, animal health, environment, and food sectors. As such, this strategy establishes a broad framework for generating evidence over a large landscape and provides multiple targets to contain AMR.

1.1 Aim of the strategy

The National AMR Surveillance Strategy aims to establish a robust, cross-sectoral AMR surveillance system to generate data that inform policy decisions as well as the prudent production, distribution, and use of antimicrobials in the country.

1.1.1 Objectives of the surveillance system

The main objectives of the National AMR Surveillance Program are to:

- Establish a national surveillance system for monitoring the prevalence and evolving trends of AMR in organisms using a One Health approach.
- Facilitate evidence-based decision making for antimicrobial resistance containment.

- Establish a genomic-based AMR surveillance system.
- Make available surveillance data that can be combined with antimicrobial use (AMU) and antimicrobial consumption (AMC) data to facilitate evidence-based decision-making for antimicrobial resistance containment.
- Enable the surveillance of antibiotic resistance and antibiotic residues in the environment.
- Establish a national laboratory network with a monitoring and evaluation (M&E) framework,
- Contribute data to global and regional data-sharing mechanisms (e.g., the WHO Global Antimicrobial Resistance Surveillance System (GLASS) and the World Organisation for Animal Health (OIE) system).
- Promote research on antimicrobial resistance containment.

1.1.2 Expected outcomes

The National AMR Containment Programme is expected to attain the following outcomes by the end of 2025:

- National AMR data is generated, antibiotic usage in all sectors is monitored, at the local and national levels.
- Using a One Health approach, a system is developed to enable stakeholders to regularly access and analyse AMR data.
- Standard treatment guidelines on evidence-based usage are updated based on AMR data (guidelines for antibiotic use in hospital and primary healthcare settings).
- Laboratories are capable of identifying pathogens and performing AST according to guidelines and standard procedures, thereby generating quality data across the surveillance system, including national reference laboratories (NRLs).
- A system is established for evidence-based advocacy, communication, and social mobilisation initiatives on AMR containment among policymakers, producers, prescribers, consumers, farmers, and the general public.
- Sharing of data with regional and global agencies WHO (GLASS) and OIE established as a routine practice.
- A national repository for AMR isolates and data is established.
- AMR data inform the implementation of an evidence-based antimicrobial stewardship programme.
- Progressive changes in the rational use of antibiotics are visible in prescriber, producer, distributor, and consumer behaviour.
- Policymakers use surveillance data to make evidence-based decisions.
- AMR data contribute to in-depth research on AMR containment.
- An advanced AMR surveillance system, including molecular and genetic sequencing, is established.

1.2 Duration

The National AMR Surveillance Strategy covers the next five years (2020-2025), at which point it will be revised based on a programme evaluation and the country's emerging needs and priorities.

Chapter 2: AMR surveillance framework

National commitment

As a signatory to the Jaipur Declaration on Antimicrobial Resistance, Bangladesh is fully committed to combating antimicrobial resistance (AMR). This commitment is evident in the country's National Action Plan on AMR, which is aligned with the WHO Global Action Plan on AMR (2015). Moreover, Bangladesh is implementing and monitoring plan with a firm resolve.

2.1 Surveillance system

Bangladesh will establish its AMR surveillance system using a coordinated, One Health approach. The surveillance system in the human health sector, which will be hospital-based, will follow two different strategies: 1) Sentinel surveillance, initially through case-finding based on priority specimens sent routinely to laboratories for clinical purposes in the selected sentinel sites, and 2) Passive surveillance, through a national laboratory networking system.

After establishing a case finding-based surveillance system with core epidemiological information in selected tertiary hospitals, Bangladesh will begin the second phase of establishing its surveillance system. In this phase, surveillance will be vertically expanded to follow case-based surveillance of clinical syndromes with additional epidemiological information linking the clinical case [3,4] . The second phase will also entail identifying the catchment areas for sentinel surveillance sites so that epidemiological and laboratory data can represent a defined population.

The network of national laboratories and surveillance sites for both human health and animal health sectors will include laboratories in hospitals as well as animal health and fish research institutes, preferably in different regions of the country. These laboratories should ideally have quality microbiological facilities that enable them to identify pathogens and susceptibility patterns. These laboratories should provide uniform and validated data to the apex body for the AMR surveillance system, the National Coordination Centre (NCC) (see below for details), which will analyse antimicrobial resistance patterns and disseminate timely surveillance information to potential users.

2.1.1 The National Coordination Centre

The key component of a coordinated, multisectoral approach to AMR surveillance is the designation of a national coordination centre. Bangladesh has designated the Director (Disease Control) of the Directorate General of Health Services (DGHS) as the National Focal Point on AMR control and the Disease Control Unit of DGHS as the NCC for AMR surveillance. The NCC will act as a central site for the collation of national surveillance data and will have the mandate to coordinate nationwide activities. At the same time, NCC will communicate with the WHO, sharing data as per Global Antimicrobial Resistance Surveillance System (GLASS) and other requirements. The NCC will also establish a national data dashboard on AMR surveillance that will be connected to the data dashboards of both DGHS and the One Health Secretariat.

Roles and responsibilities within the NCC

AMR Focal Point

- Plan and facilitate the implementation of the AMR surveillance activities in the country.
- Represent the national AMR surveillance programme in meetings, conferences, stakeholder meetings, and other relevant national and international forums.
- Engage district, national, and international stakeholders.
- Provide interpreted AMR surveillance data to guide the development of policies and guidelines.
- Facilitate linkages with AMR surveillance across human health, animal health, aquaculture, and any other sectors relevant in the One Health context.
- Review and finalise surveillance reports.
- Facilitate the submission of national AMR surveillance data to WHO GLASS.

AMR surveillance coordinator

- Coordinate the implementation of the AMR surveillance plan by the sectoral coordination centres. At the beginning of the year, the AMR sectoral coordinator, in consultation with the AMR surveillance coordinator, will develop the detailed activity plan of workshop, training, monitoring, supervision, etc., which will be approved and implemented throughout the year.
- Oversee AMR surveillance data management and reporting by the sectoral coordination centres.
- Oversee AMR surveillance monitoring and evaluation.
- Review and comment on draft surveillance reports prepared at the sectoral coordination centres and incorporate them to the national report on AMR.

Data manager for the NCC

- Provide IT support to the NCC.
- Organise site-specific data.
- Facilitate laboratory information management system (LIMS) data exports from surveillance sites.
- Coordinate data transmission from surveillance sites, i.e.:
    - Prepare surveillance site data for analysis.
    - Add the facility identifier.
    - Combine site-specific flat-file databases into a consolidated analytic database.
- Analyse consolidated data and draft surveillance reports.
- Securely maintain AMR surveillance data.

2.1.2 Sectoral coordination centres

Sectoral coordination centres will be established for each sector. The sectoral coordination centres will coordinate surveillance in their respective sectors, develop surveillance plans, build surveillance capacity at the sentinel sites, provide supportive supervision and monitoring of surveillance activities in all their sites, and coordinate with the other sectors.

The sectoral coordination centre for human health will be at the Institute of Epidemiology, Disease Control, and Research (IEDCR), while the centre for animal health will be at the Department of Livestock Services (DLS).

AMR sectoral coordinator

There should be a focal person designated as a sectoral coordinator at the sectoral coordination centre to coordinate all sectoral activities.

Data manager

The data manager will provide IT support to the sectoral coordination centres. Each sentinel site and sectoral coordination centre will have ownership of its data. Data collected at the sectoral coordination centres will be analysed and shared with One Health Secretariat and NCC for further dissemination, as appropriate.

2.1.3 National reference laboratories

The national reference laboratories (NRLs) will play the following roles:

- Provide supportive supervision of the sentinel sites, using on-site visits and online support to ensure sites achieve technical excellence.
- Perform the primary analysis of samples (when necessary), as well as specialised and confirmatory testing for identification and antimicrobial susceptibility testing (AST) serotyping by analysing samples and identifying species, including subtyping.

- Perform confirmatory testing for the characterisation of AMR that cannot be performed at surveillance sites.
- Provide external quality assurance (EQA) to the sentinel laboratories by establishing a quality control and quality assurance programme (QAP), e.g. cross-checking a certain portion of the samples processed in the sentinel laboratories and preparing and providing proficiency testing (PT) panels for tests in the sentinel labs.
- Participate in an internationally-recognised EQA programme to ensure the attainment of an acceptable level of quality.
- Develop the capacity to identify and perform molecular characterisation of different species and organisms.
- Support outbreak investigations.
- Build the capacity of sentinel sites through the provision of training and supportive supervision.
- Support capacity building of laboratories/surveillance sites through oversight and training.
- Support the development of standard operating procedures (SOPs) for the sentinel laboratories and ensure they are implemented.
- Collate and analyse AMR data from respective sectors and share them with the NCC.
- Play a major role in planning and implementing monitoring and evaluation activities.
- Serve as the physical repository for microbial isolates.
- Publish periodic reports reflecting current AMR patterns.

2.1.4 Sentinel site laboratories

While the specific roles of the sentinel laboratories may vary based on who they serve, the general roles will include the following:

- Maintain a functional microbiology laboratory with adequate capacity to perform culture and sensitivity testing.
- Perform timely tests and share the reports with the concerned recipients/clients.
- Commit to and retain the capacity to adhere to the SOPs developed by the NRL.
- Collect, generate, and share data with the respective NRLs.
- Participate in the national EQA programme run by the NRL to ensure an acceptable level of quality (annual accreditation).
- Share AMR data with the stakeholders in their catchment area, enabling them to make evidence-based decisions on antimicrobial use.

2.1.5 Antimicrobial resistance in the environment

The environment also plays a key role in the emergence and spread of AMR. A growing concern is the waste from factories, healthcare settings, farms, and communities that could contain antibiotic residues, resistant bacteria, or genes that confer resistance to antibiotics.

As such, the surveillance of antibiotic resistance and antibiotic residues in the environment is important and any AMR surveillance strategy should adopt a coordinated approach to data collection. The surveillance framework should address an optimised sampling design for antimicrobial resistance and residues in environmental samples. Specific guidelines should be developed following the WHO guideline detailing sample collection and testing.

2.2 Governance and coordination

Coordination setup

The prevention and containment of AMR require integrated, well-coordinated efforts among stakeholders operating at different levels (and in both the public and private sectors) of the animal health, human health, and aquaculture sectors. To facilitate the implementation of the national and sectoral AMR surveillance plans, as well as the planning and coordination of activities, multisectoral committees with clear terms of reference should be established.

The committees are:

- National Steering Committee (NSC)
- National Technical Committee (NTC)
- Core Working Group (CWG) at DGHS
- Sectoral Working Group (SWG)
- Committee for Tertiary Level Hospital
- District Multisectoral Committee
- *Upazila* Multisectoral Committee

A. National Steering Committee

Operating at the ministerial level, the National Steering Committee is the highest executive body for AMR surveillance. It will include ministers, secretaries, and other senior officials from the Ministry of Health and Family Welfare and the Ministry of Fisheries and Livestock. It is the apex body for AMR, responsible for policy approvals, decision-making, and overall monitoring of the progress of the National Antimicrobial Resistance Control Programme (NARC). The terms of reference (TOR) and a list of current members of the NSC are included in Annex 1.

B. National Technical Committee

The National Technical Committee (NTC) is the highest multisectoral, multidisciplinary executive technical body. Operating at the directorate level, the NTC is headed by the Director-General of Health Services, with the Director, Disease Control, DGHS, as member secretary. Representatives from the Drug Administration, Livestock and Fisheries directorate, as well as senior DGHS officials, leaders of professional bodies of different disciplines, and executives of United Nations organisations are included this committee. The NTC also includes eminent technical experts from different sectors. It is supported by the Core Working Group (CWG). The TOR, present structure, and members of the NTC are included in Annex 1.

C. Core Working Group

The Core Working Group is the technical group made up of experts from all the concerned sectors involved in antimicrobial resistance surveillance. The CWG acts as the secretariat of the NTC and carries out day-to-day activities. The TOR, present structure, and a list of members of the CWG is included in Annex 1.

D. Sectoral Working Group

A Sectoral Working Group (SWG) will be the apex coordination body for each sector. Therefore, a Human Health Sectoral Working Group will be constituted for the human health sector, and an Animal Health Sector Working Group will be constituted to coordinate activities in the animal health sector. At present, there is no apparent need for a separate SWG for the aquaculture sector; however, a provision will be kept for establishing a stand-alone SWG for the aquaculture sector, as well as for the environment and food safety sectors, as may be required.

E. Committees in Services Delivery setup

Antimicrobial resistance containment (ARC) committees will need to be established at the district and *upazila* levels; and at the service delivery setups in both in human health and animal health at the primary to tertiary levels. The TOR and structure of ARC committees at the local levels are attached in Annex 1.

Committee to address pandemics and emergencies

***Plan for adaptation and specific response during a major outbreak or pandemic situation**:*

During pandemics, including the ongoing COVID-19 crisis, there is evidence of irrational use of antimicrobials. As such, a special plan is needed to:

- address any possible disruption of surveillance activity.
- clarify how the surveillance platform can be used to monitor AMU and support the rational use of antimicrobials during emergencies including pandemic.

2.3 Other stakeholders

2.3.1 Directorate General of Drug Administration

The Directorate General of Drug Administration (DGDA), one of the directorates of the Ministry of Health and Family Welfare, is the designated National Regulatory Authority (NRA). It has the following functions:

- Regulate, control, standardise, and enforce all aspects of drug legislation, including drug production, quality control, and import; the procurement of raw materials and finished drugs; good manufacturing practise (GMP); and licensing, sales, and pricing.
- Ensure drugs and medical devices are affordable, to encourage consumers to comply with treatment regimens.
- Protect against pharmaceutical frauds.

DGDA has developed several different standard manuals of policies and procedures that highlight the regulations of antibiotic use and counsel patients on the proper use of antibiotics (i.e. to comply with the treatment course).

DGDA's participation in implementing the National AMR Surveillance Strategy is essential, especially for establishing a mechanism for monitoring AMU and AMC. AMU and AMC data should feed into the AMR surveillance system to further understanding of the relationship between use, consumption, and resistance.

2.4 Mainstreaming and sustainability

The AMR surveillance system must be incorporated into the health system of Bangladesh. At the same time, the system must encompass numerous sectors beyond human health, including animal and plant health, food chain sectors such as aquaculture, and the environment. Building a strong AMR surveillance system of this sort—one that embodies the One Health approach—requires a fair amount of resources. At the outset, as in many countries, Bangladesh's surveillance system is being supported by multiple non-government and partner agencies, as well as public resources. However, as Bangladesh's economy grows and it graduates from a least-developed to a middle-income country, external resources will decrease, and it will be expected to budget for the surveillance system. As such, planning for the sustainability of the AMR surveillance system must begin now.

In the human health sector, the National AMR Surveillance Strategy and ARC will need to be incorporated in the government budget for the National Health, Population, and Nutrition Sector Program (HPNSP) during its mid-term revision and the planning of the new cycle of sector programming for the next phase. As the Director, Disease Control is the focal point for NARC, it will be responsible for incorporating the AMR surveillance programme into the Operational Planning (OP) budget. Beyond the health sector, relevant departments and agencies will need to develop and

implement sector-specific action plans as appropriate. Each sector and agency are responsible for examining the National AMR Surveillance Strategy and deciding how best to meet the national objectives, including by building on and refining current initiatives to make the greatest use of available data.

The following issues need to be addressed by the respective departments:

- Human resource development, recruitment, and replacement.
- Linkage and demand generation by stakeholders.
- Resource mobilisation.
- Advocacy on AMR at all levels.
- The effective role of the lab head in planning and procurement at the hospital level.
- Empowerment of the lab head in local level planning.

Chapter 3: One Health approach

Rationale

One Health recognises the connection between the health of people, animals, plants, and their environment. The goal of One Health is to achieve optimum health outcomes by harmonising the interconnection among all these components using a collaborative, multi-sectoral approach at the national, regional and global levels. According to the World Health Organization (WHO), "One Health is an approach to designing and implement programs, policies, legislation, and research in which multiple sectors communicate and work together to achieve better public health outcomes."

Antimicrobial resistance (AMR), which affects human, animal, and plant health, as well as food and the environment, is best addressed using a One Health approach. Resistance to antimicrobials commonly used in human and veterinary medicine has been increasing globally in both human and veterinary health settings. AMR in bacteria, viruses, protozoa, and fungi has become a major threat to public health globally.

A One Health approach is crucial for effective AMR surveillance, as a growing body of evidence shows the importance of harmonising AMR monitoring and antimicrobial susceptibility testing (AST) protocols across sectors. Robust, science-based technical methodologies adapted to national and regional requirements should be put in place for everything from sample collection to data analysis and reporting. Methodologies should enable quantitative analysis of temporal trends in the occurrence and spread of AMR and allow identification of emerging or specific resistance patterns.

Commonalities across sectors

- Similar data quality standards, to be ensured by standard laboratory setups, guidelines, and protocols across sectors.
- Standard biosafety and biosecurity measures are followed across sectors.
- Staff running surveillance sites and laboratories in both sectors are trained on similar procedures and protocols using the same platform and training modules.
- Data generated by any of the sectors are used by stakeholders, policymakers, and managers across the sectors.
- All sectors share experiences, challenges, and solutions to benefit the surveillance programme.

Differences between sectors

- Different surveillance methods, e.g., mostly active surveillance in the animal sector and passive/sentinel site surveillance in the human health sector.
- Different sampling methods, sample sizes, and target organisms under surveillance.
- Different approaches to managing surveillance sites.

3.1 One Health in Bangladesh

Today, Bangladesh has a national One Health Strategy that recognises AMR as a multisectoral, One Health problem. In addition, the country has incorporated the One Health approach into various strategies and initiatives, including the National AMR Strategy and Action Plan and a national antibiotic surveillance system and laboratory network. The country is also collaborating with WHO/Regional Office for South-East Asia member countries and others to strengthen the One Health approach.

These successes are the latest in more than 15 years of experience using a One Health approach. Bangladesh's One Health work began in earnest in 2005, when the veterinary, public health, and wildlife sectors worked together to manage the highly pathogenic Avian Influenza A (H5N1) virus under the framework of the Avian Influenza and Pandemic Influenza Preparedness and Response Plan. After the pandemic, the human and animal health sectors continued to collaborate and, in 2008, 'One Health Bangladesh', a One Health professional network and the national coordination committee, with representation from different organisations, was formed. Since its establishment, One Health Bangladesh has hosted 10 annual conferences involving physicians, veterinarians, agriculturists,

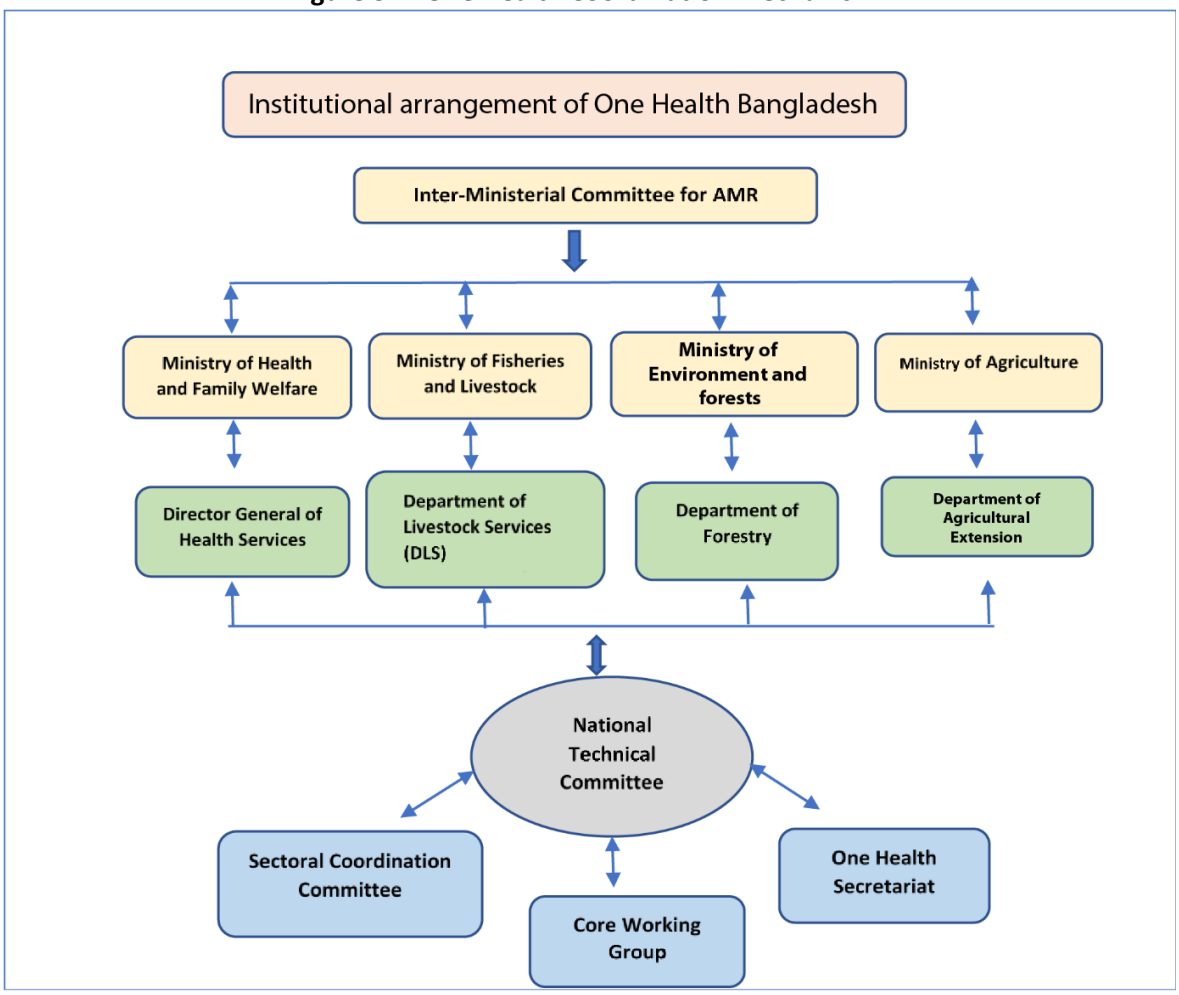
environmentalists, wildlife experts, ecologists, anthropologists, economists, allied scientists, practitioners, and activists. It is also a member of One Health Network South Asia and One Health Hub Bangladesh, which was established in 2013.

The country has also made significant progress formalising One Health governance, including the establishment of an Inter-Ministerial Steering Committee and a One Health Secretariat located at the Institute of Epidemiology, Disease Control, and Research (IEDCR). With support from the USAID Preparedness and Response project, the Food and Agriculture Organization (FAO) and the US Centers for Disease Control and Prevention (CDC), the Secretariat has strengthened its logistic capacity. In addition, the terms of references of the One Health Platforms were approved at the first meeting of the Inter-ministerial Steering Committee on One Health.

3.2 The coordination mechanism

The coordination mechanism of the One Health approach is provided in the diagram below:

Figure 3.1: One Health Coordination Mechanism



As indicated above, Bangladesh's One Health Secretariat is strategically placed within the One Health structure, which should enable it to ensure meaningful coordination on AMR surveillance and control among stakeholders and policymakers. The One Health Secretariat could also serve as an AMR data-sharing centre for all sectors and as the national data repository of microbial isolates (the physical repository will remain with the national reference laboratories).

Chapter 4: Sector-specific surveillance

The following sector-specific surveillance recommendations are based on the guidelines of international organisations, including the World Health Organization (WHO), the World Organisation for Animal Health (OIE), and the Food and Agriculture Organization (FAO).

4.1 Human health

4.1.1 The sampling point, priority organisms, and critical resistance profile

All samples from the inpatient and outpatient departments of hospitals will be processed in the laboratories designated as sentinel sites. For core antimicrobial resistance (AMR) surveillance, the focus will be on the priority organisms listed in Table 4.1.1-1 (this focus will also facilitate data reporting to global surveillance networks like the WHO Global Antimicrobial Resistance Surveillance System or GLASS). The laboratories should strive to extend their level of surveillance to include critical resistance profiles. The priority specimens and pathogens for core AMR surveillance are described in Table 4.1.1-1.

Table 4.1.1-1: Priority pathogens by specimen for inclusion in AMR surveillance

	Specimen	AMR priority pathogen
	Blood	*E. coli* *Klebsiella pneumonia* *Acinetobacter baumannii* complex *Staphylococcus aureus* *Salmonella* spp. *Streptococcus pneumoniae* *Pseudomonas* spp. *Enterobacter*
	Urine	*E. coli* *Klebsiella pneumonia* *Salmonella* spp. *Enterococcus* species *Enterobacter*
	Stool	*Shigella* spp. *Vibrio cholera* *Salmonella* spp.
	Urethral and cervical swabs	*Neisseria gonorrhoeae*

Table 4.1.1-2: Critical resistance profiles and pathogens of clinical significance for the human health sector

Sl No.	Critical resistance profiles and pathogens
1	Extended-spectrum beta-lactamase (ESBL) producing Enterobacteriaceae
2	Carbapenem-resistant Enterobacteriaceae (CRE)
3	Methicillin-resistant *Staphylococcus aureus* (MRSA)
4	Vancomycin-intermediate *Staphylococcus aureus* (VISA)
5	Vancomycin-resistant *Staphylococcus aureus* (VRSA)
6	Vancomycin-resistant enterococci (VRE)
7	Penicillin-resistant *Streptococcus pneumoniae* (PRSP)
8	Penicillinase-producing *Neisseria gonorrhoeae* (PPNG)
9	*Burkholderia pseudomallei*
10	Pan-drug-resistant pathogens

4.1.2 Antimicrobial panel

The antimicrobial panel should follow the latest European Committee on Antimicrobial Susceptibility Testing (EUCAST) or Clinical and Laboratory Standards Institute (CLSI) guidelines, considering the organism and drug combination, the specimen, and the country perspective. The panel will be updated over time according to the changing data on AMR. There is a need to mention the zone diameter of antibiotics, as well as the resistant pattern. In addition, minimum inhibitory concentration (MIC) is mandatory in certain cases. In those cases, if the resistant property is important, then the MIC should be performed by the sentinel site if it has the capability or the sample sent to the reference lab for MIC determination.

Antimicrobials to be included in susceptibility testing are summarised in Table 4.1.2-1. Antibiotics will be used in the test panel, specific for the isolates recommended by guidelines for the different sectors. The panel will include antimicrobials that are categorised as critically important and highly important to human medicine by WHO. The final list of antimicrobials to be included in the panel per organism should be reviewed from time to time by an expert working group.

Table 4.1.2-1: Pathogen-antimicrobial combination for GLASS priority pathogens

Pathogen	Antibacterial class	Antibacterial agents for AMR surveillance*
E. coli, Klebsiella pneumoniae	Sulphonamide and trimethoprim	Cotrimoxazole
	Fluoroquinolones	Nalidixic acid, Ciprofloxacin, or Levofloxacin
	Second-generation cephalosporins	Cefixime
	Third-generation cephalosporins	Ceftriaxone or Cefotaxime and Ceftazidime
	Fourth-generation Cephalosporins	Cefepime
	Carbapenems	Imipenem, Meropenem, Ertapenem, or Doripenem
	Polymyxins	Colistin
	Penicillin	Ampicillin
***Acinetobacter* species**	Fluoroquinolones	Nalidixic acid, Ciprofloxacin, or Levofloxacin
	Second-generation Cephalosporins	cefoxitin
	Third-generation Cephalosporins	Ceftriaxone or Cefotaxime and Ceftazidime
	Fourth-generation Cephalosporins	Cefepime
	Carbapenems	Imipenem, Meropenem, Ertapenem, or Doripenem
	Polymyxins	Colistin
	Penicillins	Ampicillin
	Fluoroquinolones	Nalidixic acid, Ciprofloxacin, or Levofloxacin
	Tetracyclines/Glycylcycline	Minocycline/Tigecycline
	Aminoglycosides	Gentamicin and Amikacin
***Salmonella* species**	Third-generation Cephalosporins	Ceftriaxone or Cefotaxime and Ceftazidime
	Fluoroquinolones	Nalidixic acid, Ciprofloxacin, or Levofloxacin
	Carbapenems	Imipenem, Meropenem, Ertapenem, or Doripenem
***Shigella* species**	Fluoroquinolones	Ciprofloxacin or Levofloxacin
	Third-generation Cephalosporins	Ceftriaxone or Cefotaxime and Ceftazidime
	Macrolides	Azithromycin
Staphylococcus aureus	Penicillin	Ampicillin
	Second-generation Cephalosporins	Cefoxitin
S. pneumoniae	Penicillin	Oxacillin and Penicillin G
	Third-generation Cephalosporins	Ceftriaxone or Cefotaxime

Pathogen	Antibacterial class	Antibacterial agents for AMR surveillance*
	Sulphonamides and Trimethoprim	Cotrimoxazole
	Macrolides	Azithromycin
Neisseria gonorrhoeae	Third-generation Cephalosporins	Cefixime, Ceftriaxone
	Macrolides	Azithromycin
	Aminocyclitols	Spectinomycin
	Fluoroquinolones	Ciprofloxacin
	Aminoglycosides	Gentamicin
***V. cholerae* / *Enterococcus* species / *Enterobacter* species / *Pseudomonas* species**	These are not GLASS priority organisms; as such, a GLASS combination does not exist. These organisms are included based on clinical and national significance and should be tested as per the antibiotic combination recommended by CLSI or EUCAST.	

* These are the minimum WHO recommended antibiotics for AMR surveillance. The laboratories should test the complete panel of antibiotics as per CLSI or EUCAST for generating patient reports.

Table 4.1.2-2: List of antimicrobials in addition to WHO GLASS recommended drugs to be included in the core AMR surveillance as per CLSI or EUCAST pathogen-drug combination

	Antimicrobial class	Antimicrobial
	Fifth-generation Cephalosporin	Ceftaroline
	Beta-lactam/beta-lactamase inhibitor	Amoxicillin-Clavulanate
	Beta-lactam/beta-lactamase inhibitor	Piperacillin-tazobactam
	Fosfomycin	Fosfomycin
	Glycopeptides	Vancomycin/Teicoplanin
	Monobactam	Aztreonam
	Nitrofurantoin	Nitrofurantoin
	Oxazolidinone	Linezolid
	Lincosamide	Clindamycin
	Penicillin	Flucloxacillin
	Penicillin	Mecillinam
	Penicillin	Piperacillin

4.1.3 Laboratory methods

Considering the present status of the capacity of the AMR surveillance network, Bangladesh's AMR laboratories require capacity strengthening to apply the following laboratory methods:

Organism identification

Organisms should be identified up to the species level. Sentinel sites should use conventional methods like culture and biochemical identification methods; these methods should also be used for critical cases. Automated identification system-based capacity will be developed gradually. Until then, the reference laboratory equipped with automated culture and sensitivity system (VITEK-2, MALDI TOF MS) will support the sentinel sites. Newer methods such as the automated blood culture system should be introduced in phases. If resources allow, advanced technologies like MALDI TOF MS and other high-throughput methods should be introduced. Whole-genome sequencing will help laboratories quickly identify the pathogen in any outbreak investigation, antimicrobial resistance pattern, and multi-locus sequence typing, and the source of infection. Sequencing capacity will be developed in phases.

Antibiotic Susceptibility Testing (AST)

Disk diffusion – Due to its practicality sustainability (cost), disk diffusion will be the routine method for AST and the core AMR surveillance protocol used in the early stages of the national AMR surveillance programme. All isolates, including the priority organisms recovered from samples, will be tested using this methodology. Laboratories will document whether isolates are susceptible, intermediate, or resistant (S/I/R) according to clinical breakpoints defined by EUCAST or CLSI. Laboratories will also measure and record zone sizes (mm) to allow for retrospective adjustment if new breakpoints are defined.

Minimum inhibitory concentration (MIC) – Laboratories will use MIC testing as a complement to disk diffusion when recommended by CLSI. Laboratories will also use MIC in cases of special antibiotic-resistant mechanisms to gain a deeper understanding of resistant phenotypes. Priority will be given to cases where isolates exhibit unusual resistance patterns and to isolates with emerging resistance to certain antimicrobials deemed critically important to human medicine (e.g. multiclass resistant, carbapenem-resistant, colistin-resistant, and tigecycline resistant isolates).

Special phenotypic testing – In addition to the single disk method for susceptibility testing described above, special phenotypic tests may supplement and complement traditional testing methods. These tests characterise the organism's susceptibility or resistance to an antimicrobial agent by screening for a specific resistance mechanism or phenotype. Some of these tests guide therapy, and most of them are used to understand the epidemiology and monitor infection control. These include tests for extended-spectrum beta-lactamase production (ESBL) and carbapenemase production, identification of vancomycin-intermediate *Staphylococcus aureus* (VISA)/vancomycin-resistant *Staphylococcus aureus* (VRSA), tests for methicillin-resistance in *S. aureus* (MRSA), vancomycin agar screening tests for vancomycin-resistant enterococci (VRE), and tests for the detection of penicillinase-producing *Neisseria gonorrhoeae.*

Molecular testing – Molecular testing is complementary to the above methodologies. Data will be used for source attribution and to determine the epidemiology of antimicrobial-resistant organisms in Bangladesh. Multidrug-resistant isolates from representative samples will be tested. These methods will also be used to address specific research questions not addressed by routine surveillance. Specific resistance determinants will be tested based on phenotypic data. If resources allow, laboratories should also perform genomic analysis for bacterial identification and the detection of drug-resistant genes for genomic surveillance purposes. Pan-drug resistant (PDR), extensively drug-resistant (XDR), total drug-resistant (TDR), and unusual pathogens must be sent to the NRLs for species and AST confirmation.

Automated ID/AST – Completely automated platforms for organism identification and antimicrobial susceptibility testing such as VITEK will be gradually introduced starting with the NRLs.

Automated blood culture system – Blood cultures in all human health sites will be done using an automated blood culture system.

4.2 Animal health

4.2.1 Target population, sampling point, and priority organisms

The target population (species or sector to be sampled), sampling point in the production chain for surveillance, and a priority list of organisms are summarised in the following table:

Table 4.2.1-1: Summary of animal species, sampling point, preferred samples, and priority organisms

Species	Sampling point	Preferred samples	Organisms
Poultry broiler, layer, spent-hen, Sonali, Deshi, and other cross-bred chickens	Wet markets, live bird markets, poultry farms, poultry submitted to diagnostic centres (such as the Central Disease Investigation Laboratory (CDIL), Field Disease Investigation Laboratories or FDIL)	Cloacal swab, oropharyngeal swab, caecal tonsil from dead birds, poultry meat, farm environmental samples (e.g. litter, water and dragging swab), live bird market environmental samples, poultry feed	• *Escherichia coli* • *Salmonella enterica* • *Campylobacter jejuni* • *Campylobacter coli* • *Enterococcus faecalis* • *Enterococcus faecium*
Cattle, sheep goats, and pet animals (dogs and cats)	Slaughterhouses, animal farms, district or *upazila* veterinary hospitals, teaching veterinary hospitals	Rectal swab, anorectal swab, nasal swab, swab from lesion, swab from oral cavity and perineal region, milk, faeces	• *Escherichia coli* • *Salmonella enterica* • *Staphylococcus aureus* • *Other Staphylococcus (S. pseudintermedius)* • *Streptococcus canis* • *Pasteurella multicoda*
Fish (cultured and wild-caught), shellfish (shrimps)	Markets, super shops, fish processing plants/ fish farms	Whole fish, skin surface, muscle, water sample (surface water, mid-water, bottom water), fisherman hand slime, draining water from fish display tray, fish processors' hand swab	• *Vibrio vulnificus* • *Vibrio parahaemolyticus* • *Vibrio cholerae* • *Listeria monocytogenes* • *Escherichia coli* • *Salmonella enterica* • *Staphylococcus aureus*

These recommendations are based on guidelines on AMR surveillance developed by the WHO, OIE, and FAO.

4.2.2 Antimicrobial panel

Table 4.2.2-1 lists antimicrobials to be included in the susceptibility testing panel

Table 4.2.2-1: Antimicrobials to include in the susceptibility testing panel

Antimicrobial class	Antimicrobial	Recommended to include in the panel for	
		Gram-Positive Bacteria	Gram-Negative Bacteria
Aminoglycoside	Gentamicin	√	√
Carbapenem	Imipenem	√	√
Cephalosporin	Cefepime	√	√
Cephalosporin	Cefoxitin	√	√
Cephalosporin	Ceftazidime	√	√
Cephalosporin	Ceftriaxone	√	√
Cephalosporin	Cefuroxime	√	√
Cephalosporin	Cephalexin	√	√

	Antimicrobial class	Antimicrobial	Recommended to include in the panel for	
			Gram-Positive Bacteria	Gram-Negative Bacteria
	Cephalosporin	Cephradine	√	√
	Folate inhibitor	Trimethoprim	√	√
	Folate inhibitor	Trimethoprim-sulfonamide	√	√
	Glycopeptide	Vancomycin	√	N/A
	Glycylcycline	Tigecycline	√	√
	Lincosamide	Clindamycin	√	√
	Macrolides	Azithromycin	√	√
	Nitrofurantoin	Nitrofurantoin	√	√
	Penicillin	Amoxicillin	√	√
	Penicillin	Ampicillin	√	√
	Penicillin	Flucloxacillin	√	N/A
	Penicillin	Piperacillin	√	√
	Phenicol	Chloramphenicol	√	√
	Polymyxin	Colistin	N/A	√
	Fluoroquinolone	Ciprofloxacin	√	√
	Quinolone	Nalidixic Acid	√ (*Staphylococcus aureus* are naturally resistant to NA)	√
	Tetracycline	Tetracycline	√	√

√ = Can be included; N/A = Not applicable

4.2.3 Laboratory methods

In light of available resources and existing capacity, AMR laboratory capacity to use the following methods should be strengthened:

1. **Disk diffusion** – Disk diffusion is the core or routine AMR surveillance protocol used in the early stages of the national AMR surveillance programme due to its practicality and sustainability (cost). Laboratories will test all isolates recovered from samples using this methodology.
2. **Broth dilution** – Broth dilution is complementary to disk diffusion. Representative isolates exhibiting unusual resistance patterns, such as multi-drug or multiclass resistant isolates or emerging resistance to certain antimicrobials (e.g., deemed critically important to human medicine), will be prioritised for testing using this method. The species-bacteria combination will be followed based on standard methods.
3. **Molecular testing** – Molecular testing is complementary to the above methodologies. Data derived from molecular testing will be used for source attribution and to provide an understanding of the epidemiology of antimicrobial-resistant organisms in Bangladesh. Laboratories will use molecular testing for multi-drug resistant isolates from representative samples as well as address specific research questions not addressed by routine surveillance. Specific resistance determinants will be tested based on phenotypic data.
4. **Automated antimicrobial susceptibility testing** – The NRLs (CDIL and the Bangladesh Livestock Research Institute or BLRI) will carry out the automated AST using the VITEK 2 system. Automated AST will help validate the test results submitted by sentinel laboratories, as well as support NRLs in generating authentic AMR data in a short time. A list of some important resistance determinants is attached in Annex 2.

4.2.4 Sampling frame

A) Poultry

As poultry is the most frequently consumed meat, chickens will be priority species for testing. Preliminary AMR data indicate no marked difference in the prevalence of resistance in all the antimicrobials included in the panel between the Sonali and the broiler chicken strains (i.e., developed by global genetic companies). For simplicity's sake, data will be aggregated and stratified by the strain of chicken. The prevalence estimates for *Campylobacter*, *Salmonella,* and *E. coli* in Bangladesh are included in Annex 2.

Table 4.2.4-1: Targeted quantity of birds to be sampled and sampling frequency (for animal health laboratories collectively)

	Organisms	Sample frequency	Sample size/quarter or year
	E. coli	Yearly	480 per year or 120 per quarter
	Salmonella enterica	Yearly	480 per year or 120 per quarter
	Campylobacter spp.	Yearly	480 per year or 120 per quarter
	Enterococcus spp.	Yearly	480 per year or 120 per quarter

Table 4.2.4-2: Recommended bird sample size per quarter: 120 per laboratory

	Location	No of samples per location	Designated laboratory
	Dhaka	120	Dhaka, CDIL
		120	Dhaka, BLRI
	Chattogram	120	Feni, FDIL
	Rajshahi	120	Jaipurhut, FDIL

Note: FDILs will send one-third of their bacterial isolates to CDIL and BLRI for test validation.

B) Ruminants and pet animals

A combination of cattle, sheep, goats, dogs, and cats (the number of animals per ruminant species will be proportional to the production profile of the country).

Table 4.2.4-3: Targeted quantity of animals will be sampled and sampling frequency (for animal health laboratories collectively)

	Organisms	Sample frequency	Sample size/quarter or year
	E. coli	Yearly	96 per year or 24 per quarter
	Salmonella enterica	Yearly	96 per year or 24 per quarter
	Pasteurella multocida	Yearly	96 per year or 24 per quarter
	*Staphylococcus aureus**	Yearly	96 per year or 24 per quarter
	Streptococcus spp.	Yearly	96 per year or 24 per quarter

*will be screened for MRSA

Table 4.2.4-4: Recommended sample size per quarter: 24 per laboratory

	Location	No of samples per location	Designated laboratory
	Dhaka	24	Dhaka, CDIL
		24	Dhaka, BLRI
	Chattogram	24	Feni, FDIL
	Rajshahi	24	Jaipurhut, FDIL

Note: FDILs will send one-third of their bacterial isolates to CDIL and BLRI for test validation.

C) Fish

To include wild-caught, cultured finfish, and shellfish (shrimp).

Table 4.2.4-5: Targeted quantity of aquatic animals will be sampled and sampling frequency (for aquatic animal health laboratory)

	Organisms	Sample frequency	Sample size/quarter or year
	E. coli	Yearly	240 per year or 60 per quarter
	Salmonella enterica	Yearly	240 per year or 60 per quarter
	Vibrio spp.	Yearly	240 per year or 60 per quarter
	Listeria spp.	Yearly	240 per year or 60 per quarter
	Staphylococcus aureus	Yearly	240 per year or 60 per quarter

Table 4.2.4-6: Recommended sample size per quarter: 240 per laboratory

	Location	No of samples per location	Designated laboratory
	Dhaka	240	Dhaka, Quality Control Laboratory, Savar

Note: The Quality Control Laboratory, Savar, will send one-third of its bacterial isolates to CDIL and BLRI for test validation.

4.3 Environmental health

The AMR surveillance framework for the environment covers samples from waste at point sources (e.g., farms, factories, and community and healthcare settings) as well as locations that act as sinks for waste from point sources, such as river and lakes. The key elements for carrying out antimicrobial resistance surveillance from environment are required to be determined. The laboratory and human resource capacity for such surveillance need to be assessed as well. Surveillance will be phased and progressive.

Table 4.3-1: Framework for the surveillance of antibiotic resistance in the environment

Sites and types of samples	▪ Healthcare settings (human and veterinary): Sewage and effluent ▪ Farms (poultry, cattle, pig, fish): Effluent, farm litter/manure, drinking water (for animals), and pond water/sediment (for fish farms) ▪ Crop farms: Soils, including those where animal farm manure is applied ▪ Factory (feed mills, slaughterhouses, processing plants, pharmaceutical units, and sewage treatment plants(STPs) and effluent treatment plants (ETPs) ▪ Community settings (STPs and drinking water treatment plants): Effluent (inlet, mid-point, outlet) and drinking water ▪ Others (open wells, rivers, lakes, drug disposal sites): Groundwater, river/lakes, surface water, river sediments and soil
Bacteria for AST	**For the human health, food animal, and crop sectors** ▪ *Escherichia coli* ▪ *Enterococcus* spp. **Human-health sector** ▪ *Klebsiella pneumonia* **Food-animal sector** ▪ *Salmonella* spp. ▪ *Escherichia coli* **Crop sector** ▪ *Aspergillus* spp. (fungus)

4.4 Phased approach to expand surveillance capacity

Bangladesh will build and expand surveillance capacity using a phased approach.

For the human health sector, the phases include:

1. **Phase 1 (core level):** Case-finding based on priority specimens sent routinely to laboratories for clinical purposes, with core epidemiological information.

2. **Phase 2 (extended level):** Case-based surveillance of clinical syndromes, with extended-level epidemiological information.
3. **Phase 3 (advanced level):** Case-based surveillance of clinical syndromes, with advanced-level epidemiological information and activities.

In the animal health sector, the concept of core, extended, and advanced levels of capacity buildings will be considered in terms of both laboratory capacity and surveillance settings.

Plan for expansion of the surveillance network

The strategy emphasises capacity building in the selected sentinel sites, starting from basic or core level and progressing gradually to higher levels- to the extended and advanced levels. This approach of capacity development at smaller number of facilities, also known as vertical expansion, is preferable to the geographical expansion, which refers to increase in number of facilities under surveillance to have wider geographical representation. If resources are limited, vertical expansion should be prioritised. If resources are available, both expansions should be considered.

Plan for geographical or horizontal expansion

If sufficient resources are available, the programme may consider horizontal expansion after adequate capacity building and vertical expansion in Phase 1 surveillance sites. The following table summarises the proposed geographical expansion.

Table 4.4-1: Plan for geographical (horizontal expansion)

Phase	SL	Surveillance sites		
		Human health	Animal health	Aquatic animal health
1	01	Dhaka Medical College	Central Disease Investigation Laboratory	Quality Control Lab, Savar -
	02	Mymensingh Medical College	Bangladesh Livestock Research Institute	
	03	Chittagong Medical College	Field Disease Investigation Laboratory, Feni	
	04	Rangpur Medical College	Field Disease Investigation Laboratory, Jaipurhut	
	05	Khulna Medical College		
2	01	Sher E Bangla Medical College, Barisal	Animal health laboratories, public university teaching hospitals	Aquatic animal health-related laboratories of public universities
	02	Sylhet MAG Osmani Medical College		
	03	Rajshahi Medical College		
	04	Cox's Bazar Medical College		
	05	Six other sites to be proposed by the government		
3	01	Functioning public and private microbiology laboratories	Animal health-related private laboratories and hospitals	Aquatic animal health-related private laboratories
	02	District Level Laboratories		

4.5 Capacity building of the laboratories

4.5.1 Animal health laboratories

Table 4.5.1-1: Expected antimicrobial susceptibility testing capacity building for animal health laboratories

Period	Species	Organism	Test method	
			FDILs	CDIL (and BLRI)
Year 1, Quarter 1	Poultry/livestock/ pet animals	*E. coli*	Disk diffusion	Disk diffusion & broth dilution
Year 1, Quarter 2	Poultry/livestock/ pet animals	*Salmonella enterica*	Disk diffusion	Disk diffusion & broth dilution
Year 1, Quarter 3	Poultry	*Campylobacter* spp. *Enterococcus* spp.	Disk diffusion	Disk diffusion & broth dilution
	Livestock/pet animals	*Staphylococcus aureus*	Disk diffusion	Disk diffusion & broth dilution
Year 1, Quarter 4	Poultry/livestock/ pet animals	All organisms	Disk diffusion & broth dilution	Disk diffusion & broth dilution
Year 2	Poultry/livestock/ pet animals	All organisms	Disk diffusion & broth dilution	Disk diffusion & broth dilution Molecular methods and automated AST

4.5.2 Aquatic animal health laboratory

Table 4.5.2-1: Expected AST capacity building for aquatic animal health laboratory

Period	Species	Organism	Test method
Year 1, Quarter 1	Fish (species to be determined)	*E. coli, Salmonella enterica*	Disk diffusion
Year 1, Quarter 2	Fish (species to be determined)	*Vibrio* spp.	Disk diffusion
Year 1, Quarter 3	Fish (species to be determined)	*Listeria* spp.	Disk diffusion
Year 2	Fish (species to be determined)	All organisms	Disk diffusion & broth dilution

Chapter 5: Data management

Objectives

Objectives of Data Management System Development in Antimicrobial Resistance Surveillance

Antimicrobial resistance (AMR) surveillance aims to obtain national and local data from relevant sectors to inform the decision-making of the National AMR Containment Programme. As such, data generated by the surveillance programme should be of the highest quality. The overarching objectives of establishing a strong data management system for AMR surveillance are as follows:

- Support data management capacity building at all levels across all sectors.
- Establish standards for data management that improve data quality and facilitate the flow of data between sentinel sites, national reference laboratories (NRLs), and the National Coordination Centre (NCC) at the Office of Communicable Disease Control (CDC) at the Directorate General of Health Services (DGHS).
- Integrate the AMR surveillance data into DGHS's health information system, DHIS2, and the Bangladesh Animal Health Intelligence System (BAHIS).
- Establish standards of use and analysis for national AMR data through a national AMR data dashboard with access to all sectors and sentinel sites.

Data management system

This strategy provides an outline of a proposed data management system. This design, however, will be detailed and refined once Bangladesh has developed a data management improvement plan based on a comprehensive assessment of the surveillance, laboratory, and data management capacity of the AMR surveillance network. The final design should reflect assessment findings and enable the storing of a large volume of complex data for an indeterminate period.

Data sets from the human health, animal health, and aquaculture sectors will differ due to differences in surveillance settings and reporting levels. However, at the apex level, data from all the sectors will be collated and the correlations of the data from different sectors analysed.

5.1 Data from the human health sector

To facilitate effective, efficient data collection, AMR surveillance facilities are required to use laboratory information management system (LIMS) to capture the clinical bacterial culture and antimicrobial susceptibility testing (AST) results. Site LIMS should collect the minimum required AMR surveillance data elements, which are:

- The unique patient identifier.
- The date of specimen collection.
- Clinical/syndromic diagnosis.
- The date of laboratory processing.
- The specimen type.
- Pathogen identification.
- AST results (i.e., the zone of inhibition, minimum inhibitory concentration (MIC), sensitivity classification).
- The following patient data must be included in AMR surveillance system:
    - Date of admission
    - Gender
    - Age
    - Hospital ward/unit

- The origin of the infection (hospital-acquired, community-acquired) must be evaluated through a simple question, as per the WHO GLASS lab-based surveillance proforma.

Data generated from sentinel sites will be shared with the Coordination Centre for Human Health at the Institute of Epidemiology Disease Control and Research (IEDCR), where the national reference laboratory (NRL) for human health is situated. Human health data compiled by the NRL will be shared by IEDCR with the One Health Secretariat and NCC. The NCC will submit data to GLASS. In addition, AMR surveillance data will be integrated into other health systems of DGHS and DHIS 2, using the optimal pathway identified by a panel of experts. This step will be important as AMR surveillance expands to the district and *upazila* levels in the future.

5.2 Data from animal health and aquaculture sector

The World Organisation for Animal Health's (OIE) Terrestrial Animal Health Code, Chapter 6.8, Article 6.8.8 (OIE, 2018), recommends the following guidelines on recording and storing AMR data:

- Ensure the storage of raw (primary, non-interpreted) data, as storage allows evaluation in response to various questions, including those that arise in the future.
- Consider the technical requirements of computer systems when planning a system to facilitate the exchange of data (comparability or compatibility of automatic recording of laboratory data and transfer of these data between and within resistance surveillance and monitoring programs). Results should be collected in a suitable national database and recorded quantitatively as:
    - Distributions of MICs in micrograms per millilitre.
    - Inhibition zone diameters in millimetres.
- Include the following aspects in recorded information:
    - Sampling programme.
    - Sampling date.
    - Animal species and production type.
    - Type of sample.
    - Purpose of sampling.
    - Type of antimicrobial susceptibility testing method used.
    - Geographical origin (geographical information system data, where available) of the herd, flock, or animal.
    - Animal factors such as age, condition, health status, identification, sex, breed.
    - Exposure of animals to antimicrobial agents.
    - Bacterial isolation rate.
- Include the following information when reporting laboratory data:
    - Identity of the laboratory.
    - Isolation date.
    - Reporting date.
    - Bacterial species, and, as relevant, other typing characteristics (e.g., serotype, serovar).
    - Phage-type, wherever applicable.
    - Antimicrobial susceptibility result or resistance phenotype and genotype.
- Include the following information in discussions of the interpretation of AMR results:
    - Trends.
    - Emerging resistance.
    - Difficulties encountered.

- Inherent biases.
- Relevance of findings.
- Comparison of the situation along the food chain.

5.3 Data management and analysis

Data will be in electronic formats and stored in a structured data management system (e.g., an Excel file, LIMS, or WHONET) for ease of sharing and further data analysis. Data will be collected and analysed at the levels recommended by the NTC/CWG and at the national level. Data will be presented in a consistent format.

To harmonise and integrating Bangladesh's AMR surveillance system with those of other countries and the region, the strategy recommends the following:

- Interpretive criteria used for MIC determination, if deviating from the recommended susceptibility testing methods.
- A description of quality assurance systems.
- The AST results (MIC value).
- The AST results will be in table form for every animal population, broken out by bacterial species.
- Qualitative tables to report the result for each antimicrobial tested, including:
    - Number of isolates tested.
    - Number of resistant isolates.
    - Number of fully-susceptible isolates and number of isolates resistant to 1, 2, 3, 4, 5 or >5 antimicrobials of different classes.
- Prevalence measures for each organism and antimicrobial combination, preferably as a time series, if there is enough data, including confidence intervals.
- Quantitative tables to report MIC distributions for each animal in each bacterial species.
- MIC50 and MIC90 for each antibiotic should be calculated.
- Prevalence of resistant isolates in the target population and reported for the appropriate epidemiological unit, i.e., animals, flocks, food samples.
- Confidence intervals of the prevalence values expressing the precision of the estimates.

5.4 AMR surveillance data flow

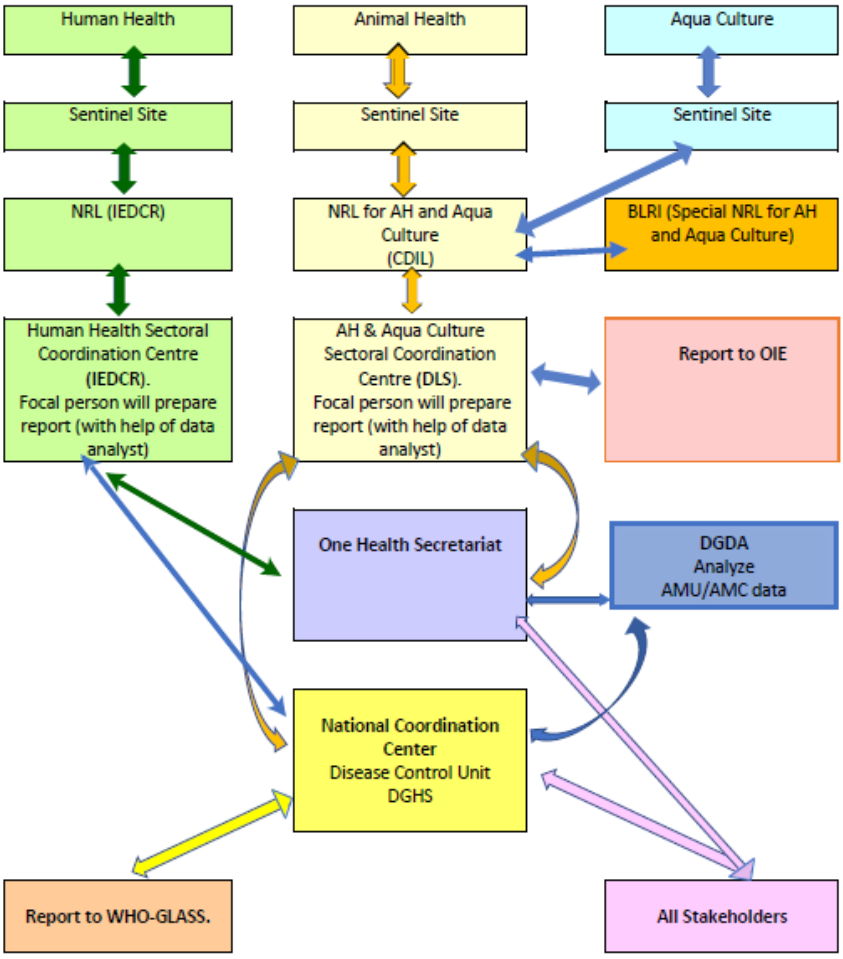
Data collected at the surveillance sites will be shared with the NRLs (CDIL/BLRI for animal health and IEDCR for human health), which will analyse all data obtained from the human health, animal health, and aquaculture sectors. The data will then be transmitted to the One Health Secretariat and the NCC, which will explore and analyse surveillance data from all three sectors. The overall data will be stored at the national data repository.

Both the One Health Secretariat and NCC will establish a data dashboard. These dashboards, which will eventually connect with DHIS 2, will be accessible to a wide range of stakeholders, including hospitals, clinicians, laboratories and sentinel sites, scientists, the Directorate General of Drug Administration (DGDA), relevant ministries and departments, development partners, and non-governmental organisations (NGOs).

The NCC at DGHS is responsible for sharing AMR data from the human health sector with WHO GLASS. The Department of Livestock will report data on the animal health and aquaculture sectors to OIE. Both the NCC and Department of Livestock will draw data from the same source, the national AMR data dashboard.

Figure 5.4-1 presents an overall schematic of the flow of AMR surveillance data in Bangladesh. Data generated at the surveillance sites are fed into the respective NRLs (IEDCR for the human health sector and CDIL for the animal health and aquaculture sectors; the Bangladesh Livestock Research Institute (BLRI) will perform molecular testing and genome sequencing for samples from the animal health sector and have data flow to and from CDIL, the other NRL for animal health). Data from NRLs will be transmitted to the sectoral coordination centres. For animal health and aquaculture, the sectoral coordination centre is the Department of Livestock (DLS). For human health, the NRL and sectoral coordination centre are situated in the same institute, IEDCR. After analysing the sectoral data, the sectoral coordination centres will transmit the data to the One Health Secretariat, which will collate national data from all sectors, then submit it to the National Coordination Centre. The NCC is also responsible for reporting data to WHO GLASS; for the animal sector, the DLS will report BAHIS data to OIE.

Figure 5.4-1: National AMR surveillance system data flow



Information technology (IT) experts working with surveillance programme leads from the sectoral working groups will finalise the details of the system, including data collection tools and the design of the database and dashboard. The IT experts will also identify the tools and software needed to incorporate data from different sectors into a single AMR surveillance system that can show correlations between sectoral data while also recognising the diversity of source data. The National Technical Committee (NTC) will approve the final design of the surveillance data system, after receiving a recommendation from the Core Working Group (CWG).

Chapter 6: Monitoring and evaluation

Monitoring and evaluation (M&E) is a continuous process of collecting and analysing data to assess how well an intervention is being implemented and whether it is delivering expected results (i.e. achievement of outputs and progress towards outcomes). Monitoring is the routine tracking of services and programme achievements against targets to find out 'What is happening?' Evaluation is the periodic assessment of effectiveness that answers the question 'Was the goal or objective achieved, and why or why not?'

The M&E plan proposed for the AMR surveillance programme is designed to identify progress and challenges. Specifically, the monitoring and evaluation of the system aims to ensure effective, efficient data collection, analysis, and interpretation so that the AMR situation is well understood. M&E will surveillance data is used effectively to inform policy decisions on the rational use of antibiotics, monitor the prevalence of strains of multidrug-resistant microbes, enforce antimicrobial use and consumption control measures, and guide further research on AMR.

Monitoring and evaluation processes will begin soon after surveillance activities begin. The country will establish an M&E team with representations from the National Coordination Centre (NCC), national reference laboratories (NRL), sectoral surveillance committees, One Health Secretariat, and international partners. The M&E team will collaboratively design a programme evaluation strategy that will describe the performance and determine the overall effectiveness of the programme.

Routine monitoring of the surveillance programme will produce data on inputs, processes, and outputs. A formal evaluation of the surveillance system, on the other hand, will analyse outcomes and impacts. This evaluation, which would be based on an established framework, can be designed after a period of programme implementation. Monitoring and evaluation reports should be made available to stakeholders to guide system improvements and ensure success moving forward. Ideally, monitoring and evaluation is a continuous process leading to changes required for programme improvement, as illustrated in the figure below.

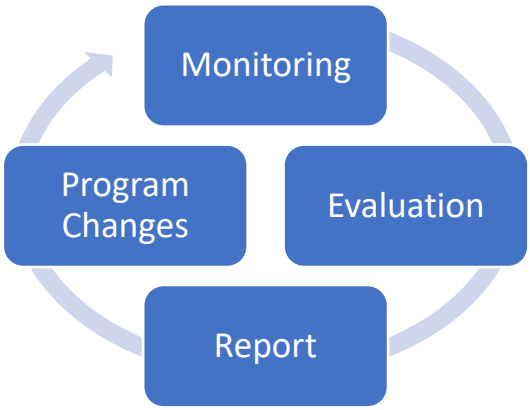


Figure 6-1: M&E and programme improvement cycle

The rationale for collecting M&E data

Monitoring and evaluation data are required to:

- Guide the planning, coordination, and implementation of the interventions.
- Assess the effectiveness of interventions.
- Identify areas for programme improvement.
- Ensure accountability.

Monitoring and evaluation are important to ensure that the following steps of the surveillance system done properly:

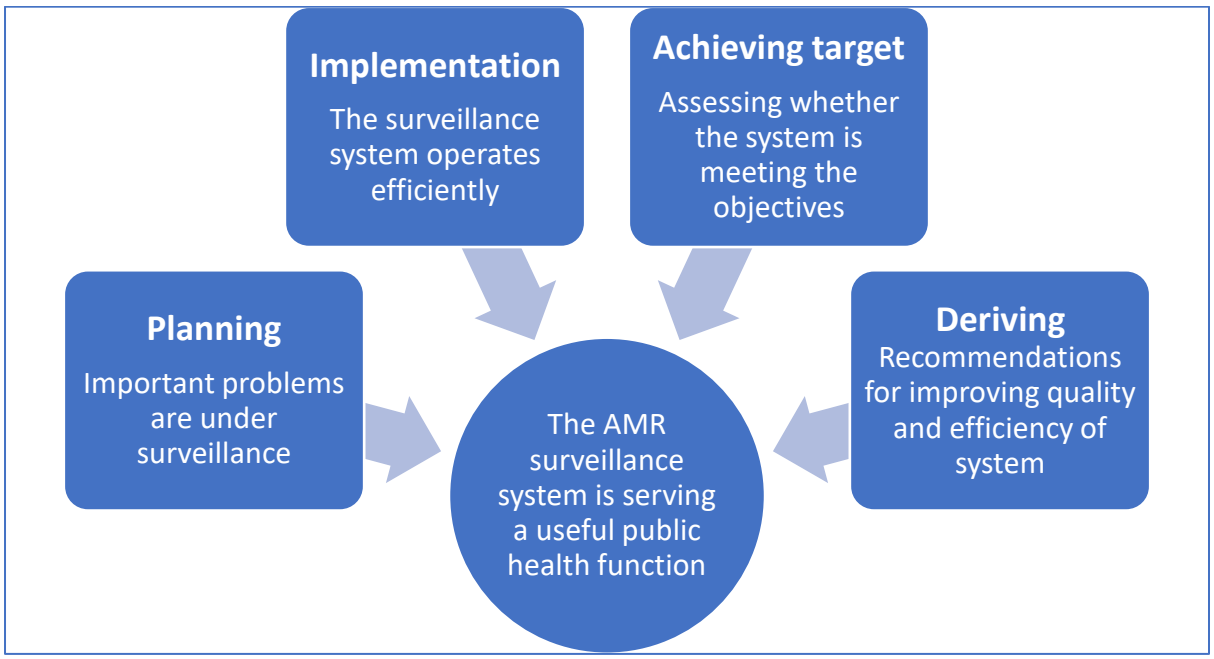


Figure 6-2: Steps of surveillance system that should be ensured by monitoring

6.1 Quality indicators

Quality indicators are objective measures of surveillance and laboratory practices. For example, indicators can measure timeliness, patient refusals, lost or delayed laboratory reports, and sample rejection, among other things.

Types of indicators

Any programme monitoring and evaluation plan should include the following types of indicators (with examples tailored to AMR surveillance):

1. **Inputs** – The level of resources put into programmes (e.g., the number of laboratories provided with equipment, logistic, and HR capacity building support).
2. **Processes** – Activities and milestones that enable services to be implemented as planned (e.g., number of labs that have completed upgrades, number of labs enrolled for accreditation, number of labs provided with the lab protocols and standard operating procedures (SOPs), etc.).
3. **Outputs** – E.g., labs with trained staff, labs following established protocols, etc.
4. **Outcomes** – E.g., AST profile available for all target microbes, number of multidrug-resistant strains identified, data available for use by the target audience (doctors, the drug regulation authority, therapeutic guidelines modified based on AMR data, etc.).
5. **Impact –** Evidence that the programme resulted in lowering the circulation of multi-drug resistant strains, lowering the duration of illness caused by certain bacteria, etc.

The NCC and the Core Working Group (CWG) will review the logical framework and progress against the indicators listed in Tables 6.1-1 and 6.1-2 annually to evaluate AMR surveillance and decide on appropriate actions. Such monitoring and evaluation will aim to improve the surveillance system in the long term.

Table 6.1-1: Monitoring and evaluation logical framework

Input (Resources)	Process (Activities)	Output (Results)	Outcome
1. Funding for personnel, equipment, consumables 2. Local guidelines and SOPs 3. Staff with expertise in the field of AMR surveillance including epidemiology and laboratory expertise 4. Communication protocols and facilities	1. Mobilisation and management of funds 2. Development or adaptation of SOPs 3. Development and implementation of training materials 4. Agreed means and frequency of communication between clinical laboratory and surveillance staff 5. Implementation of network mentorship and quality assurance	1. Sustainable financing and resources available on a regular basis 2. Common understanding of protocols 3. Trained staff with relevant competencies at surveillance sites 4. Quality-controlled implementation of AMR surveillance methods 5. Reliable information on defined AMR public health priorities available	Therapeutic guidelines modified based on national AMR surveillance data

Table 6.1-2: Monitoring indicators for AMR surveillance in Bangladesh

Type	Indicator	Definition
Input	Number of AMR surveillance sites (Epi data collected: Core to expanded to advanced)	# of surveillance sites fulfilling requirements to collect and report data on patients and AST that can be fed into the national system
	National reference laboratory	At least one NRL is designated with agreed terms of reference to support the national AMR surveillance system
	National plan for AMR surveillance	Presence of a strategic and operational plan for implementing and strengthening AMR surveillance, including participation in GLASS
Process	Existence of documented roles & responsibilities	# of surveillance sites with well-documented roles and responsibilities # of surveillance sites with an AMR focal person or committee
	Routine validation of surveillance data	% of surveillance sites with established monthly feedback provided following validation of surveillance data **or** % of surveillance sites visited at least once in a year for validation of surveillance data
	Internal QA at sentinel sites	% of laboratories with an internal quality control plan % of laboratories with active internal quality control programs
	Participation of sentinel sites in external quality assurance programmes (EQAP)	% of laboratories participating in an EQAP
	External quality assurance (EQA) performance of	% of sites passing EQA proficiency testing

Type	Indicator	Definition
	laboratories contributing data to the national system	
	Staff trained in AMR	# of scheduled training sessions in AMR surveillance including GLASS methodology conducted % of staff with appropriate training in AMR surveillance including GLASS methodology % of staff participating in a laboratory mentorship programme
Output	Priority specimen types included in the AMR surveillance	% of national target specimens reported through AMR surveillance
	Priority pathogens	% of surveillance sites reporting all pathogens listed as priority pathogens
	Completeness of data reported	% of surveillance sites submitting reports to the surveillance system every month
	Timeliness of submission of surveillance reports	% of surveillance sites submitting reports to national level every month
Outcome	National strategy informed by AMR surveillance	Treatment guidelines and drug policy documents revised based on AMR surveillance data

M&E framework needs to assess the following aspects

- The surveillance system includes microbes important to public health.
- Sample collection (number and procedure) follows standard operating procedures.
- Laboratories follow SOPs.
- Lab technicians and the concerned health workforce are competent.
- Data collection, entry, and compilation are flawless.
- Reporting is timely and regular.
- Challenges and gaps are identified and addressed.
- Policy decisions are guided by evidence generated by the surveillance system.

M&E items to be considered in the animal health sector and aquaculture

The following items are covered in the OIE Code:

- The number of isolates regarded as resistant should be reported as a proportion of the number of isolates tested, including the defined interpretive criteria used such as epidemiologic cut-off values (ECOFFs) in case of AMR monitoring and surveillance.
- In the clinical setting, breakpoints are used to categorise bacterial strains as susceptible, intermediate, or resistant. These clinical breakpoints may be elaborated on a national basis and may vary between OIE countries.
- For surveillance and monitoring purposes, the use of ECOFFs is preferred. This is based on the distribution of MICs or inhibition zone diameters of the specific bacterial species tested.
- When using ECOFFs, only the bacterial population with acquired resistance that deviates from the distribution of the normal susceptible population will be designated as resistant.
- Ideally, data should be collected at the individual isolate level. This will allow antimicrobial resistance patterns to be recorded over time, along with relevant data on the usage of antimicrobial agents and management practices, when available.

Annex 1: Terms of Reference of the National Steering Committee (NSC) and the present structure and membership of the NSC, National Technical Committee (NTC), and Core Working Group (CWG) on Antimicrobial Resistance Containment in Bangladesh

National Steering Committee

Terms of reference

1. The National Steering Committee (NSC) will be responsible for approving the National Strategy and Action Plans and any other guidance on antimicrobial resistance control that have a wide range of policy implications, based on the recommendations provided by National Technical Committee (NTC).
2. The NSC will supervise and guide activities of the NTC and will review the annual report on the progress of the National Antimicrobial Resistance Control (NARC) Programme submitted by NTC.
3. The NSC will review the advocacy and policy recommendations by NTC based on generated AMR surveillance data and take necessary actions based on the evidence.
4. The NSC will review the proposed budget for activities outlined in Action Plans and recommend what the concerned line ministries to include in their respective budgets.
5. The NSC will meet every at least once in every six months and at shorter intervals when required.

Membership structure

The NSC currently has the following membership structure:

- ***Chairperson***: Honourable Minister, Ministry of Health and Family Welfare
- ***Co-chairperson***: Honourable Minister, Ministry Fisheries and Livestock
- ***Member-Secretary***: Secretary, Ministry of Health and Family Welfare
- ***Members*** (not according to a warrant of precedence):
    1. Attorney General of Bangladesh
    2. Director-General, Directorate General of Health Services
    3. Director-General, Directorate General of Drug Administration
    4. Director-General, Directorate General of Armed Forces Medical Services
    5. Director-General, Department of Livestock Services (DLS)
    6. Director-General, Department of Fisheries
    7. Director-General, Department of Environment
    8. Director-General, Press Institute of Bangladesh
    9. Principal Information Officer, Press Information Department
    10. Director-3/Representative, Prime Minister Office
    11. Director, Bangladesh Livestock Research Institute (BLRI)
    12. Director / PSO (Quality control), Directorate General Fisheries
    13. Country Representative, World Health Organization (WHO)
    14. Country Representative, Food and Agriculture Organization (FAO)
    15. Country Representative, UNICEF
    16. Country Representative, United Kingdom Department for International Development (DFID)
    17. Executive Director, International Centre for Diarrheal Disease & Research (icddr,b)
    18. President/Secretary General, Bangladesh Medical Association

19. President/Secretary, Bangladesh Veterinary Association
20. President/Secretary, Bangladesh Association of Pharmaceutical Industries
21. President/Secretary, Bangladesh Bar Council
22. President/Secretary, Consumers Association of Bangladesh (CAB)

National Technical Committee

Terms of reference

1. Act as a technical advisory body to the National Steering Committee on the Antimicrobial Resistance Control (NARC) Programme.
2. Develop the Strategy, Action Plans, and Guidelines for the Prevention and Control of Antimicrobial Resistance and other policy documents for submission to the NSC for final approval.
3. Periodically review the above-mentioned policy documents and submit to NSC for necessary decisions.
4. Prepare budgets for the different activities outlined in the Action Plan.
5. Monitor and evaluate the implementation of the NARC programme and submit an annual report on progress to the NSC.
6. Work based on feedback from the Core Working Group (CWG) and different Sectoral Working Groups.
7. Meet at least quarterly, and additionally, if the situation requires.

Membership structure

- ***Chairperson:*** Director General of Health Services
- ***Co-chairperson:*** Additional Director General (Admin) of Health Services
- ***Member-Secretary****:* Director (Disease Control), DGHS and National Focal Point, NARC Programme
- ***Members*** *(not according to a warrant of precedence)*:

1. Director (Quality Control, P. marketing, Surveillance & C. Drug Testing Lab), DGDA
2. Director (Veterinary), Directorate General of Drug Administration
3. Director (Hospitals), Directorate General of Health Services (DGHS)
4. Director, Institute of Epidemiology, Disease Control, and Research (IEDCR)
5. Director, Institute of Public Health (IPH)
6. Representative from Director General of Armed Forces Medical Services
7. Director, Livestock Research Institute (LRI), Department of Livestock Services (DLS)
8. Director, Quality control, Directorate General Fisheries
9. Professor of Microbiology, Bangabandhu Sheikh Mujib Medical University
10. Professor of Pharmacology, Bangabandhu Sheikh Mujib Medical University
11. Head of the Department of Microbiology, Dhaka Medical College
12. Head of the Department of Pharmacology, Dhaka Medical College
13. President/Secretary, Bangladesh Society of Medicine
14. President/Secretary, Bangladesh Association of Physicians
15. President/Secretary, Bangladesh Society of Surgeons
16. President/Secretary, Bangladesh Paediatric Association
17. President/Secretary, Obstructive and Gynaecological Society of Bangladesh

18. President/Secretary, Bangladesh Pharmacological Society
19. President/Secretary, Bangladesh Society of Medical Microbiologists
20. President/Secretary, Bangladesh Pharmaceutical Society
21. President/Secretary, Bangladesh Pharmacy Council
22. President/Secretary, Bangladesh Veterinary Association
23. Representative from the World Health Organization (WHO)
24. Representative from the Food and Agriculture Organization (FAO)
25. Representative from International Centre for Diarrheal Disease & Research (icddr,b)
26. Prof. M. A. Faiz, Prof. of Medicine and Former Director-General of DGHS
27. Prof. Quazi Tarikul Islam, Ex Prof. of Medicine, Popular Medical College
28. Prof. J U Ashraful Hoq, Professor of Microbiology
29. Prof. Md. Zahurul Hoque, Former Director, Drug Administration
30. Dean, Faculty of Pharmacy, University of Dhaka
31. Dr Salauddin Khan, Former Director-General, DLS
32. Coordinator, Core Working Group

Core Working Group

Terms of reference

The Core Working Group (CWG) is a smaller group of technical experts, typically representatives from the relevant sectors involved in AMR surveillance. The main functions of the CWG include:

1. Develop draft policy documents, including guidelines and strategic action plans, in response to NTC requests.
2. Monitor and evaluate of implementation of different components of the National Action Plan.
3. Prepare and submit to NTC a quarterly report on the status of the National AMR Control Programme.
4. Act as the coordinating body, liaising among sectoral working groups and with national reference laboratories, the National Coordination Centre, and the One Health Secretariat.
5. Support and monitor the activities of the surveillance network and laboratories within it to ensure the quality of AMR surveillance data generation, reporting, analysis, and sharing at all levels.
6. Meet at least monthly and more often, if required.
7. Provide secretarial support to the NTC.

Membership structure

- ***Chief Coordinator:*** Director (Disease Control), DGHS & National Focal Point
- ***Coordinator:*** One Designated Officer of CDC, Directorate General of Health Services (DGHS)
- **Members:**
    1. Prof. of Pharmacology, Bangabandhu Sheikh Mujib Medical University (BSMMU) /Competent representative
    2. Head, Dept. of Virology, Institute of Epidemiology, Disease Control, and Research
    3. PSO, Dept. of Microbiology, Institute of Epidemiology, Disease Control, and Research
    4. Deputy Director, Drug Administration
    5. DPM/ Representative from Hospital Management Service, DGHS
    6. DPM, Emerging & Re-emerging Diseases, CDC, DGHS

7. Head, Epidemiology wing, Department of Livestock Services (DLS)
8. Associate Professor of Medicine
9. Lecturer, Dept. of Microbiology, Dhaka Medical College
10. Associate Professor of Microbiology, BSMMU/Representative
11. NPO (Epid), WHO/ Representative
12. Representative from Dept. of Environment
13. Regional Consultant, Bangladesh Livestock Research Institute (BLRI), DLS
14. Asst. Scientist, Microbiology Lab., International Centre for Diarrheal Disease and Research (icddr,b)
15. Lab personnel from FAO Food Safety Lab.

Sectoral Working Groups

1. Each Sectoral Working Group (SWG) will work as a forum of the surveillance sites, laboratory networks, and reference laboratories within the sector.
2. Work experiences, surveillance findings, aid issues will be shared within the SWG to facilitate joint learning and problem-solving.
3. The SWG will report on progress and challenges faced to the Core Working Group (CWG) and the National Technical Committee (NTC).
4. The SWG, along with the appropriate national reference laboratory (NRL) of the sector, will ensure high safety and quality standards through established protocols for laboratory quality and participation in a national quality assurance programme.
5. SWG members will participate in supportive supervisory visits to the sentinel sites (each site should be visited at an interval of every two months).
6. SWG will convene monthly meetings and prepare quarterly progress reports for submission to CWG/NTC.
7. Membership of each SWG will be decided by NTC with a recommendation from CWG.

Antimicrobial Resistance Containment (ARC) at the local level

Structure and membership to be decided at the local level. At a minimum, entities should include different stakeholders from all the relevant sectors (human and animal health, agriculture, fisheries, technical experts, One Health activists, etc.).

Terms of reference

1. Ensure rational use of antimicrobial drugs through advocacy and the monitoring of adherence to protocols on the rational use of antibiotics
2. Support the microbiology laboratory to reproduce standard culture and susceptibility reports.
3. Monitor AMR using a microbiological assay pattern situation in the catchment area.
4. Ensure the supply and use of proper antibiotics in line with national guidelines.
5. Enforce infection control measures, including waste management.
6. Monitor antimicrobial use (AMU) and antimicrobial consumption (AMC) through a market surveillance system.
7. Share information on AMC, AMU, and AMR patterns among implementers in different sectors.
8. Oversee risk communication on AMR in the community.

Annex 2: Prevalence estimates and important resistance determinants

Table 1: Prevalence estimates of *Campylobacter*, *Salmonella* and *E. coli* in Bangladesh

	Pathogen	Host	Type	Prevalence (%)	Reference
	Campylobacter	Humans	Individual	1) 14% diarrhoea patients; less in rural area, 5% 2) *C. coli* – 2.7; *C. jejuni* -9.5 (in diarrhoea patients)	1) Glass *et al.,* 1983 2) Ahmed *et al.,* 2011
		Chickens	Individual	40.5% in broiler and chickens	
			Farm litter	No valid data	Hasan et al., 2020
	Salmonella	Humans	Individual	1) 16% from human stool 2) 6.4%	1) Nesa *et al.,* 2011 2) Ahmed *et al.,* 2011
		Chickens	Individual	Variable prevalence estimates reported: 1) 21.1% (can include the serovars Pullorum and Gallinarum, two poultry specific but non-motile serovars 2) 6.8% in backyard chickens when sampled liver, heart, spleen, and bone marrow of dead birds 3) 14% in Sonali chickens (a crossbreed of Fayoami and Rhode Island Red) under semi-scavenging (when sampled dead birds) 4) 12% in broody hen chicks (chicks hatched and reared by hens in villages) (when sampled dead birds) 5) 65.5% in frozen chicken meat	1) Mahmud *et al.,* 2011 2) Biswas *et al.,* 2005 3) Biswas *et al.,* 2006 4) Biswas *et al.,* 2008 5) Parvin et al., 2020
			Farm litter	1) Layer farm: 18%; The only one serotype detected in layer birds was *S.* Kentucky 2) Broiler farm: 11%. *S.* Virchow and *S.* Kentucky were the two predominant serovars	1) Barua *et al.,* 2012 2) *Barua et al.,* 2013

Pathogen	Host	Type	Prevalence (%)	Reference
Serovar Typhimurium	Humans	Individual	33.3 % among the motile serovars isolated from humans	Barua *et al.,* 2014
	Chickens	Individual	No published data available	
		Farm litter	No published data available	
Serovar Enteritidis	Humans	Individual	10.5% among the motile serovars isolated from humans	Barua *et al.* 2014
	Chickens	Individual		
		Farm litter	100% (2 out of 2) Breeder farms (not detected in broiler or layer farms)	Barua *et al.,* 2014
E. coli	Humans	Individual	1) 18.0% for ETEC in diarrhoea patients (flood-affected) 2) 46% (stool samples from clinically sick people, unpublished data)	1) Qadri *et al.,* 2005
	Chickens	Individual	1) 7%: When dead backyard chickens were sampled (from liver, heart, spleen. and bone marrow) 2) 58% Cloacal swabs/Intestinal swabs 3) 53 – 59 % (unpublished data) 4) 76.1% in frozen chicken meat	1) Biswas *et al.,* 2005 2) Akond *et al.,* 2009 4) Parvin *et al.,* 2020
		Farm litter	38 – 53 % (unpublished data)	

Table 2: List of some important resistance determinants

Resistance determinant	Antibiotics	Reference	Remarks
mecA gene	β-lactam antibiotics	Ubukata *et al.,* 1989	Major AMR determinant used for screening methicillin-resistant *Staphylococcus aureus* (MRSA)
bla gene and *Amp*C gene	β-lactam antibiotics (including Cephalosporin)	Logan *et al.,* 2016	Major AMR determinant used for screening extender-spectrum beta lactamases (ESBLs) producing Enterobacteriaceae
mcr gene (*mcr1, mcr2, mcr3, mcr4, mcr5, mcr6, mcr7, mcr8, mcr9 , mcr10*)	Colistin	Aghapour *et al.,* 2019	Major AMR determinant used for screening colistin-resistant Enterobacteriaceae
van gene (*van*A, *van*B, *van*C, *van*D)	Vancomycin	Chang *et al.,* 2003	Major AMR determinant used for screening vancomycin-resistant *Staphylococcus aureus* and *Enterococcus* spp.

	Resistance determinant	Antibiotics	Reference	Remarks
	aac(6')-Ib-cr gene and *qnr* gene (*qnr*A, *qnr*B, *qnr*D, *qnr*S)	Fluoroquinolone	Osinska *et al.,* 2016	Major AMR determinant used for screening fluoroquinolone-resistant bacteria
	tet gene (*tet*A, *tet*B, *tet*D, *tet*E, *tet*G, *tet*K *tet*L, *tet*M, *tet*O, *tet*S)	Tetracycline	Hedayatianfard *et al.,* 2014	The *tet*A, *tet*B, *tet*D, *tet*E and *tet*G are reported in Gram-negative bacteria. Whereas, the *tet*K, *tet*L, *tet*M, *tet*O, and *tet*S are significantly found in the Gram-positive bacteria.

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