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# POLICY PAPER ON AMR SURVEILLANCE AND MONITORING FRAMEWORK IN THE LIVESTOCK SECTOR

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## Policy Paper on AMR Surveillance and Monitoring Framework in the Livestock Sector

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Develop policy paper for an integrated AMR surveillance and monitoring framework, focusing on possible synergies


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# DISCLAIMER

# Abbreviations and Acronyms

| | |
|---|---|
| AMR | Antimicrobial Resistance |
| AMU | Antimicrobial Use |
| AST | Antimicrobial Susceptibility Testing |
| BAHIS | Bangladesh Animal Health Intelligence System |
| BLRI | Bangladesh Livestock Research Institute |
| BPW | Buffered Peptone Water |
| CDIL | Central Disease Investigation Laboratory |
| CLSI | Clinical and Laboratory Standards Institute |
| DLS | Department of Livestock Services |
| DOF | Department of Fisheries |
| DVH | District Veterinary Hospital |
| EQA | External Quality Assurance |
| EUCAST | European Committee on Antimicrobial Susceptibility Testing |
| FAO | Food and Agriculture Organization of the United Nations |
| FDIL | Field Disease Investigation Laboratory |
| ISO | International Standard Organizations |
| LDDP | Livestock and Dairy Development Project |
| LIMS | Laboratory Information Management System |
| MIC | Minimum Inhibitory Concentration |
| MRSA | Methicillin-Resistant Staphylococcus aureus |
| MoFL | Ministry of Fisheries and Livestock |
| MRL | Maximum Residue Limit |
| NAP | National Action Plan |
| NCC | National Coordination Centre |
| NCL | National Control Laboratory |
| NGS | Next-Generation Sequencing |
| NRL | National Reference Laboratory |
| OHS | One Health Secretariat |
| OTC | Over the Counter |
| PT | Proficiency esting |
| QA | Quality Assurance |
| QC | Quality Control |
| SOPs | Standard Operating Procedures |
| UCAST | European Committee on Antimicrobial Susceptibility Testing |
| UNEP | United Nations Environmental Programme |

| | |
|---|---|
| WGS | Whole Genome Sequencing |
| WHO | World Health Organisation |
| WOAH | World Organisation for Animal Health |

# CONTENTS

# INTRODUCTION AND BACKGROUND

The discovery of antibiotics in the previous century lead to a decrease in mortality and morbidity due to infectious diseases but their inappropriate and irrational use has resulted in the emergence of resistant microbial populations. Antimicrobial resistance (AMR) in humans and animals has reached alarming levels in most parts of the world. It has now been recognized as a significant emerging threat to global public health, food security, and safety. Overuse and improper use of antimicrobials in many parts of the world are recognized as key drivers of the emergence and spread of AMR. Antimicrobials are used in food animals for therapeutic purposes including treatment of infectious diseases, and non-therapeutic purposes including growth promotion and disease prevention. At present, there is large evidence that veterinary use of antimicrobials for non-therapeutic purposes is inappropriate and may negatively affect human health. Over the last decade, global livestock production has been growing rapidly and has moved increasingly towards an industrialized system in which antimicrobial use (AMU) is an integral part of production systems often replacing good farm management practices.

AMR occurs when bacteria, viruses, fungi, and parasites change over time and no longer respond to medicines making infections harder or even impossible to treat and increasing the risk of disease spread, severe illness, and death. AMR delays treatment, rendering patients infectious for a longer time and increasing the risk of spreading resistant microorganisms to others. From the public health perspective, the patient acts as a reservoir of infection for a longer period thus putting at risk more members of the community and healthcare workers. Bangladesh is a densely populated country in relation to both humans and animals and the problem of AMR is even more important here.

AMR affects the economy through either direct or indirect costs with an increase in human mortality and morbidity, and an increase in livestock mortality and morbidity. Direct costs of AMR include health care expenditures and resources used to treat the disease, AMR leading to higher medical costs, prolonged treatment time, production loss, engagement of health workers, and increased mortality. The world immediately needs to change the way it prescribes and uses antibiotics. According to World Health Organization (WHO), even if new medicines are developed, without behavior change, AMR will remain a major threat to the world.

Surveillance and monitoring are essential instruments to assess the occurrence and trends of AMR, and provide crucial information for infection prevention and control responses. Furthermore, surveillance and monitoring allow measuring the spread of AMR and informing the impact of local, national, and global strategies to limit AMR. Surveillance systems also provide data that enhance our understanding of the complex epidemiology of AMR.

Currently, there are a number of AMR surveillance activities carried out in the animal health sector across the country for academic and research purposes. But there is no coordination among the surveillance activities. There is a lack of harmonization in standard operating procedures (SOPs) from sampling to antimicrobial susceptibility testing methods, which makes it difficult to compare data across programmes and sectors. As AMR surveillance is being initiated progressively in Bangladesh, it is important that efforts are made to ensure data portability over time to maximize the potential value of the cumulative findings. A standardized and harmonized protocol for AMR monitoring is essential to formulate a universal and quality AMR surveillance

database. The harmonized protocol for AMR testing and monitoring must provide science-based technical methodologies from sample collection to data analysis and data reporting adapted to the national setting. It is essential to make a quantitative analysis of trends in the occurrence and spread of AMR and allow the identification of emerging or specific resistance patterns.

The key objectives of AMR surveillance are: i) to assess the occurrence and distribution of AMR in bacteria; ii) to describe the trends and sources of AMR in bacteria; iii) to detect the emergence of new AMR mechanisms; iv) to provide the data necessary for conducting risk analyses as relevant to animal and human health; v) to provide a basis for policy recommendations for animal and human health; vi) to provide information for evaluating antimicrobial prescribing practices for prudent use recommendations; and vii) to assess and determine the efficacy of actions to combat AMR. The information derived from AMR surveillance, is essential to formulate evidence-based guidelines for the treatment and prevention of infections and prevention of AMR transmission in animals and humans.

## VISION OF AMR SURVEILLANCE AND MONITORING

Reduce the burden of AMR by providing surveillance data for evidence-based policy making

## GOAL OF AMR SURVEILLANCE AND MONITORING

Development of a comprehensive and robust national surveillance database for effective prevention and control of AMR in animals and food of animal origin

## OBJECTIVES

Development of a robust national AMR surveillance and monitoring network in animals and food of animal origin in Bangladesh

## SCOPE

This document aims to provide a strategic overview for the implementation of a national AMR surveillance and monitoring programme in animals and food of animal origin. The potential national laboratory networks, with possible synergies between stakeholders have been

identified for conducting nationwide surveillance. This document also focuses laboratory capacities, workforce, resources and institutionalization with governance for a sustainable surveillance framework in the country.

# GLOSSARY/ DEFINITIONS

**Antimicrobial agent**: An antimicrobial agent is defined as a semi-synthetic or synthetic substance that kills or inhibits the growth of microorganisms such as bacteria, fungi, and algae.

**Antimicrobial Resistance (AMR)**: Antimicrobial resistance is the ability of bacteria and fungi to survive the drugs designed to kill them. That means the microorganisms are not killed and can multiply.

**Antimicrobial Use (AMU)**: Usage of antimicrobial (AMU) in livestock for therapeutic, prophylactic, metaphylactic and growth promotion purposes.

**Food chain**: Production to consumption continuum including, primary production (food-producing animals, plants/crops, feed), harvest/slaughter, packing, processing, storage, transport, and retail distribution to the point of consumption.

**Foodborne pathogens**: Foodborne pathogens (e.g. viruses, bacteria, parasites) are biological agents that can cause a foodborne illness event. A foodborne disease outbreak is defined as the occurrence of two or more cases of a similar illness resulting from the ingestion of a common food.

**Food production environment**: Food production is responsible for one-quarter of the world's greenhouse gas emissions. When it comes to tackling climate change, the focus tends to be on 'clean energy' solutions – the deployment of renewable or nuclear energy; improvements in energy efficiency; or transition to low-carbon transport.

**Hazard**: A hazard is a source or a situation with the potential for harm in terms of human injury or ill health, damage to property, damage to the environment, or a combination of these.

**Risk**: Risk management is the process of identifying, assessing, and controlling financial, legal, strategic, and security risks to an organization's capital and earnings.

**One heath approach**: One Health is a collaborative, multisectoral, and transdisciplinary approach at the local, regional, national, and global levels, with the goal of achieving optimal health outcomes by recognizing the interconnection between human, animals, plants, and their shared environment.

# KEY ELEMENTS FOR MONITORING AND SURVEILLANCE ACTIVITIES

When designing the monitoring and surveillance programme(s), the following elements should be considered:

## AMR:

- The highest priority microorganisms, panels of antimicrobials and sample sources to be targeted;
- Sampling points in the food chain and frequency of sampling;
- Representative sampling methods, sampling plans, laboratory analysis and reporting protocols; and
- Standardized and/or harmonized methodologies for sampling, testing and reporting.

## AMU:

- Antimicrobial distribution chains from manufacturing or import to end-user including sales/use data providers;
- Identification of the appropriate points of data collection and the stakeholders that can provide the data;
- An assessment of the need to establish a legal framework before initiating collection and reporting of antimicrobial sales and use data in food producing animals may be useful; and
- The collection of AMU data may be started on a voluntary basis in agreement with stakeholders who have these data.

# REGULATORY FRAMEWORK, POLICY AND ROLES

The Department of Livestock Services (DLS) should have good governance for AMR monitoring and surveillance programme(s). As a part of national action plans (NAPs) for AMR containment in Bangladesh, DLS is responsible for the monitoring and surveillance activities along the food chain, including the food production environment. DLS should ensure collaboration with human health, plant/crop health, environment and other relevant authorities.

Activities related to monitoring and surveillance programme(s) should involve a wide range

of relevant stakeholders, both public and private who may contribute to the development, implementation and evaluation of AMR monitoring and surveillance.

DLS should develop AMR surveillance and monitoring framework in consultation with relevant organizations from research, academia and private sectors. Based on the surveillance framework, shared responsibilities should be given to the different organizations/ laboratories in sampling, and data sharing. But overall management and monitoring should be sought by DLS.

# SAMPLING STRATEGIES

AMR in food-producing animals is a major public health concern, and many countries worldwide have been implementing AMR monitoring systems in animals and animal derived foods at a national level. When designing a sampling framework for AMR monitoring, it is necessary to consider both cost-effectiveness and statistical reliability. Sensitivity and specificity can vary with the number of animals sampled from each farm, while keeping the overall sample size constant to avoid additional sampling costs.

**a) Sampling should be conducted on a statistical basis. The sampling strategy should ensure that:**

- The sample is representative of the population of interest;
- The sampling method is robust;
- The sampling design should consider temporal and geographical coverage of data collection.

**b) The following criteria should be considered during sampling for AMR surveillance:**

- Sample source such as food-producing animal, food of animal origin, and animal feed;
- Food animal species, i.e., poultry, cattle, buffalo, sheep and goat, etc.;
- Category of animals within species such as age group, production type;
- Health status of the animals such as healthy and diseased;
- Sample selection such as targeted, and systematic random;
- Type of sample, based on value chain (e.g. faecal, carcass, meat, milk, and egg).

## Sample size

The sampling frame is a list of sampling units within the target population from which samples can be collected. This can be a list of farms, slaughterhouses, or other sources suitable for sampling. Where feasible, in a planned AMR surveillance programme, **it is ideal to have at least 80 percent of the total target population included in the sampling frame from**

which the actual samples will be drawn.

## Sample sources

### Sampling frame for farms

The epidemiological unit for broilers/ layers is the flock. As it is often not possible to obtain an exhaustive list of flocks or farms covering the entire population of interest, the sampling frame should include flocks or farms representing at least 80 percent of the population targeted.

### Sampling frame for slaughterhouses

The sampling frame should include slaughter facilities that account for at least 80 percent of the slaughter population of the food animal species prioritized. A complete list of all slaughter places including the number of animals per animal species slaughtered at each setting per year should be made. The list should be made from the latest updated annual data.

### When a suitable sampling frame is not available

In this case proxy (or indirect) sampling may be used, e.g. if there is no sampling frame of farms/slaughter points, a list of villages/ Upazilas may be used as a proxy. A random sample of villages/ Upazilas is selected, and animals are sampled from one of the farms/ slaughter points found in the village/ Upazila. If no farms/slaughter point is found in the selected village, the next randomly selected village is used.

## Site of the sample collection

Sample for AMR surveillance and monitoring can be collected at a variety of sites. Ideally, to enhance use of available resources, sampling for AMR surveillance could be done concomitantly to sampling for other food safety purposes, if feasible. All possible sampling places and sampling types that could be considered in an AMR surveillance programme in animals and foods of animal origin are listed below:

### Sampling at farms

Samples from poultry farms include cloacal swabs, fresh faeces, and boot swabs. Similarly, rectal swabs, feces, and milk, etc. can be selected for sampling from small and large ruminants.

### Sampling at abattoir/ slaughtering point

This is the point where livestock are closest to consumer exposure. It is usually also the most convenient and cost-effective point for collecting animal samples. It is generally preferable to collect caecal samples from slaughterhouses as it is believed that caecal samples generally provided a higher recovery of isolates than carcass sampling, and better reflect farm level exposure in individual animals. Poultry samples from abattoir/ slaughtering point

includes, caeca, intestinal contents and whole carcass, etc. Likewise, ruminant samples from abattoir/ slaughterhouses can be preferred intestinal contents, and fresh meat etc.

# TARGET PATHOGENS/ BACTERIAL ISOLATES

## Commensal bacteria

E. coli and Enterococci (Enterococcus faecium and E. faecalis) may be sampled from animal feed, food-producing animals and products of animal origin intended for human consumption. These bacteria are commonly used in surveillance and monitoring programmes as indicators, providing information on the potential reservoir of antimicrobial resistance genes, which may be transferred to pathogenic bacteria. Furthermore, these bacteria may become pathogenic once colonizing the consumers' digestive tract. It is considered that these bacteria should be isolated from healthy animals, preferably at the abattoir, and be monitored for antimicrobial resistance.

## Zoonotic bacteria

**Salmonella**

Salmonella should be sampled from animal feed, food-producing animals and animal derived food products. For the purpose of consistency and harmonization, samples for AMR surveillance in animals should be preferably taken at the abattoir. Isolation and identification of bacteria and bacterial strains should follow nationally or internationally standardized procedures. Serovars of public health importance such as S. Typhimurium and S. Enteritidis should be included. The inclusion of other relevant serovars will depend on the epidemiological situation of the country. All Salmonella isolates can be serotyped and, where appropriate, phage-typed in accordance with standard methods used at the nationally designated laboratories. Further, representative number of Salmonella isolates could be genotyped using next generation sequencing/ whole genome sequencing methods.

**Campylobacter**

Campylobacter should be isolated from food-producing animals and associated food products (primarily from poultry). Isolation and identification of these bacteria should follow nationally or internationally standardized procedures. Campylobacter isolates should be identified to the species level, i.e. Campylobacter jejuni and C. coli.

**Other emerging bacterial pathogens**

Other emerging bacterial pathogens such as methicillin-resistant Staphylococcus aureus (MRSA), Listeria monocytogenes or others, which are pathogenic to humans, may be included in surveillance and monitoring programmes.

# NATIONAL LABORATORY NETWORKING FOR AMR SURVEILLANCE AND MONITORING

Accurate, reliable and timely laboratory testing is an essential component of AMR surveillance and monitoring. High quality AMR testing is essential for veterinarians to formulate treatment plans and subsequently monitor the effects of treatment. It is also important to guide national policies and treatment guidelines according to the national AMR patterns. Improving laboratory-based surveillance of AMR is a key component to strengthen animal health systems. Laboratory-based surveillance of AMR has been recognized as a fundamental priority for the development of strategies to contain AMR and for assessment of the impact of interventions.

### Laboratory-based surveillance has several requirements:

- **Prioritisation of organisms** that should be monitored, taking into account the burden of the disease in the country;
- **Selection of antimicrobials** to be tested for each isolate, taking into account the list of essential medicines and treatment guidelines;
- **Development or updating of standard operating procedures (SOPs)** for the isolation, identification and antimicrobial susceptibility testing of the selected pathogens using standard methods;
- **Establishment or strengthening** of laboratory capacity and quality systems;
- **Setting up a database** based on surveillance results.

**AMR surveillance data** would help to monitor the susceptibility patterns of microorganisms to antimicrobial agents. Regular dissemination of data can help veterinary professionals to provide the best treatment in animal health care settings. In addition, such information can be used for sensitizing clinicians, regulators, pharmacists and the general public.

**The laboratory network** will provide accurate and timely laboratory confirmation of infections, an essential component of disease surveillance systems. The laboratory network provides high-quality surveillance data which will help to develop guidelines for disease eradication, elimination, and develop control programmes.

**The national laboratory network** should be established across the country to conduct regular real time AMR surveillance. The national laboratory network should encompass, a central/ national referral AMR laboratory in addition to several sentinel laboratories. Currently, Central Disease Investigation Laboratory (CDIL) has been designated as the National Reference Laboratory (NRL) for AMR surveillance while, two Field Disease Investigation Laboratory (FDIL) located at Feni and Joypurhat has been designated as the sentinel laboratories for AMR surveillance in the animal health sector. Furthermore, AMR laboratory of Bangladesh Livestock Research Institute have been designated as the National Reference Laboratory (NRL) for AMR Research. At present there are 10 FDILs and 64 District Veterinary Hospitals (DVHs) are operational across the country under the framework of Department of Livestock Services (DLS). It is demand of time to strengthen and expand AMR surveillance capacity to all FDILs in

the first phase of planning, and gradually it can be extended and expanded to the all DVHs to foster the evidence based treatment of infectious diseases. CDIL can take led to coordinate with the sentinel laboratories, i.e. FDILs to perform AMR surveillance effectively. FDILs can share representative number of AMR isolates with CDIL for molecular characterization. The laboratory mapping for AMR surveillance at the Department of Livestock Services is presented in Table 1.

**Table 1: AMR laboratory networks within the Department of Livestock Services**

| Laboratories | Antimicrobial Resistance Determination | | Area of interest |
|---|---|---|---|
| | Phenotypic | Genotypic | |
| Central Disease Investigation Laboratory (CDIL), Dhaka | DD, MIC | PCR and NGS | All over the country |
| Field Disease Investigation Laboratory at Joypurhat | DD | - | Rajshahi division |
| Field Disease Investigation Laboratory at Feni | DD | - | Chattogram division |
| Field Disease Investigation Laboratory at at Manikganj | DD | - | Dhaka division |
| Field Disease Investigation Laboratory at Gaibandha | DD | - | Rangpur division |
| Field Disease Investigation Laboratory at at Sirajganj | DD | - | Rajshahi Division |
| Field Disease Investigation Laboratory at Barishal | DD | - | Barishal division |
| Field Disease Investigation Laboratory at Jashore | DD | - | Khulna division |
| Field Disease Investigation Laboratory at Sylhet | DD | - | Sylhet division |
| Field Disease Investigation Laboratory at Chattogram | DD | - | Chattogram division |
| Field Disease investigation Laboratory at Gopalganj | DD | - | Dhaka division |
| DD: Disk Diffusion; MIC: Minimum Inhibitory Concentration; PCR: Polymerase Chain Reaction; NGS: Next Generation Sequencing | | | |

There are some other laboratories also have been engaged with AMR surveillance and research under the ownership of academic, research and private organizations. These laboratories are also need to be connected and linked with the national laboratory network for AMR surveillance. DLS as a national regulatory authority to coordinate AMR surveillance in animal health, can come forward and make a strong coordination and networking among the AMR laboratories

owned by the research, academic and private organizations.

The DLS should make a strong network with the microbiology/AMR laboratories at the Bangladesh Livestock Research Institute (BLRI), veterinary schools, public universities, and private leading diagnostic laboratories those have been involved with AMR surveillance and research activities across the country. The veterinary schools that could be included in the networks, Bangladesh Agricultural University (BAU), Chattogram Veterinary and Animal Sciences University (CVASU), Sylhet Agricultural University (SAU), Shere-e-Bangla Agricultural University (SAU), Haji Mohammad Danesh Science and Technology University (HSTU), Patuakhali Science and Technology University (PSTU), Rajshahi University (RU), Khulna Agricultural University (KAU), Sirajganj Government Veterinary College (SGVC), and Jhenidah Government Veterinary College (JGVC). The proposed national AMR laboratory networks in the animal health sectors would be as follows;

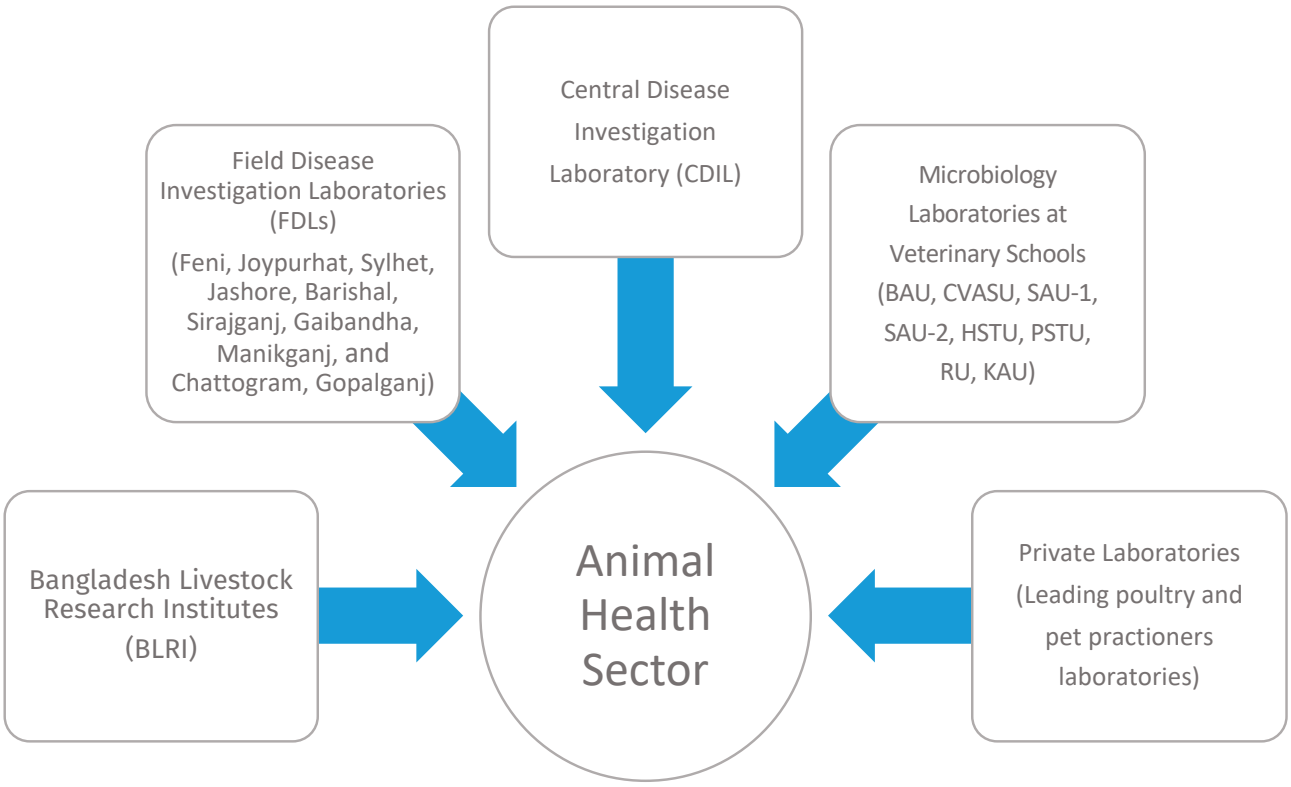



Fig 1: National AMR laboratory networks in animal health sector

# NATIONAL LABORATORY NETWORKING FOR AMR SURVEILLANCE AND MONITORING

As per given responsibility by the AMR National Action Plan (NAP), **DLS is the national**

**coordination centre for planning and executing AMR surveillance** in the animal health sector. Several laboratories from extension, research, and academic institutions are currently performing AMR surveillance in animal health.

**Three laboratories of DLS have been designated for AMR surveillance** (CDIL and two FDILs). CDIL has been equipped with modern techniques and technologies to conduct AMR surveillance both at phenotypic and genotypic level. Rather, FDILs at Joypurhat and Feni are getting support for infrastructure, equipment, chemical & reagents and capacity building for AMR surveillance. The current laboratory capacity strengthening and AMR surveillance costing support of CDIL and FDILs are mostly donor-driven. The AMR laboratory of BLRI has been equipped with state of the art facilities. The financial support of BLRI is also mostly donor-driven with limited regular support from the Government. Several laboratories at the public universities and veterinary schools are capable to conduct AMR surveillance. **Funding for AMR surveillance and research** in these laboratories are mostly from university (Government) research grants, with limited internal or external competitive research grants.

**The capacity of all FDIL's** should be strengthened in terms of infrastructure, equipments, and logistics to conduct AMR surveillance gradually in a phased manner. Further, DLS should strengthen the capacities for its DVHs for AMR surveillance to provide evidence based treatment to the animal farm owners. Dedicated and regular government funding is essential for secured and sustainable AMR surveillance activities.

# LABORATORY METHODOLOGIES FOR ANTIMICROBIAL SUSCEPTIBILITY TESTING (AST)

Methods that are standardized and validated by nationally or internationally recognized organizations should be used where available. The selection of an AST methodology may be based on the following factors:

i. ease of performance;

ii. flexibility;

iii. adaptability to automated or semi-automated systems;

iv. cost;

v. reproducibility;

vi. reliability;

vii. accuracy;

viii. the organisms and the antimicrobials of interest;

ix. availability of suitable validation data for the range of organisms to be susceptibility tested.

There are three gold standard methods have been used globally for antimicrobial susceptibility testing according to recognized standard guidelines such as CLSI and EUCAST:

I. disk diffusion,

II. broth dilution,

iii. agar dilution.

Furthermore, Next Generation Sequencing (NGS) combined with bioinformatics tools is now being used to monitor genomic resistance. NGS will most likely replace conventional laboratory methodologies for surveillance of AMR in foodborne bacteria in the future.

# DATA MANAGEMENT, VALIDATION, ANALYSIS AND REPORTING

Careful consideration should be given to database design in order to store and keep the complex and voluminous information for an undetermined period of time. The information should be included, where possible, the following aspects:

- 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 herd, flock or animal;
- animal factors such as age, condition, health status, identification, sex, breed;
- exposure of animals to antimicrobial agents; and
- bacterial isolation rate.

**Data management and data analysis**

Data should be kept in electronic format and stored in a structured data management system (example: excel file, LIMS, or any available data management software, such as WHONET or national customized data management software, such as BAHIS) for ease of sharing and further data analysis. The data should be collected and analysed at local, subnational, and national level and presented in a consistent format grouped by target bacteria as follows:

- *E. coli*
- *Enterococcus spp.*
- *E. faecalis*
- *E. faecium*
- *Salmonella spp.*
- *S. Enteritidis*
- *S. Typhimurium*
- *Campylobacter spp.*
- *C. coli*
- *C. jejuni*

During data management and analysis some additional information should be included such as the microbiological methods used for culture, identification and susceptibility testing; the interpretative criteria used for reporting; quality control and quality assurance measures; a glossary of terms; statistical methods; and any changes made in the methodology over time. Centralized databases should be designed in a way that allows data to be extracted appropriately and uniformly. For ease of analysis and reporting, data should focus on individual isolate identifiers with links to metadata, including denominator data. The database needs to be centrally managed. Also, data should remain confidential when shared with analysts. Where possible, surveillance data should be analysed in conjunction with other available datasets, such as information on antimicrobial use, pulsed-field gel electrophoresis (PFGE), MLST, PCR/ sequencing of resistance genes, NGS, plasmid typing data (or other strain typing data), as well as outbreak investigations involving isolates recovered in surveillance. Once data integrity and confidentiality have been ensured, data should be made freely available for independent analysis and reporting as close as possible to real time. The following key suggestions can be considered for AMR data management, validation, analysis and reporting:

- Harmonized standard operating procedures (SOPs) for antimicrobial sensitivity testing of the AMR pathogens should be adopted among all laboratories in the national AMR laboratory network in the animal health;

- The panel of antimicrobials or disk for phenotypic susceptibility testing should be harmonised within national monitoring and surveillance programme(s) as to ensure uniformity and comparability of data;

- Similar standards (either UCAST or CLSI or others) for the interpretation of AMR results should be adopted in all laboratories in the national network;

- Unique template or protocol should be developed and adopted in all laboratories under the national network for collection, collation or storage of the AMR surveillance metadata in an electronic format. The data can be stored in a structured data management system (e.g., an excel file, customize software, BAHIS, LIMS, or WHONET) for ease of sharing and further data analysis;

- Sentinel/ peripheral laboratories have to send the surveillance metadata to the national reference laboratory/ national surveillance coordination centre at a regular interval;

- Data should be stored in a secured centralized database that permits simple data entry and retrieval, as well as flexible reporting of standard and ad hoc analysis results;

- Data analysis should be included isolate listings and summaries, percentage of resistance, test measurement statistics, multidrug resistance profiles, and statistical and microbiological alerts to possible outbreaks and important or unusual laboratory findings;

- DLS periodically analyze surveillance data and will be shared with the scientific community as well as to be reported to the competent authority;

- DLS should share the surveillance data/ result with one health secretariat or National Coordination Centre (NCC) for AMR surveillance, i.e. Directorate General of Health Services;

- DLS should take initiatives to translate AMR data into information in the local language that can be understood by non-specialists. It is helpful to prepare narrative summaries, written in plain language, to accompany the data, in order to help consumers and other stakeholders understand the risks, hazards, and meaning of significant or notable trends.

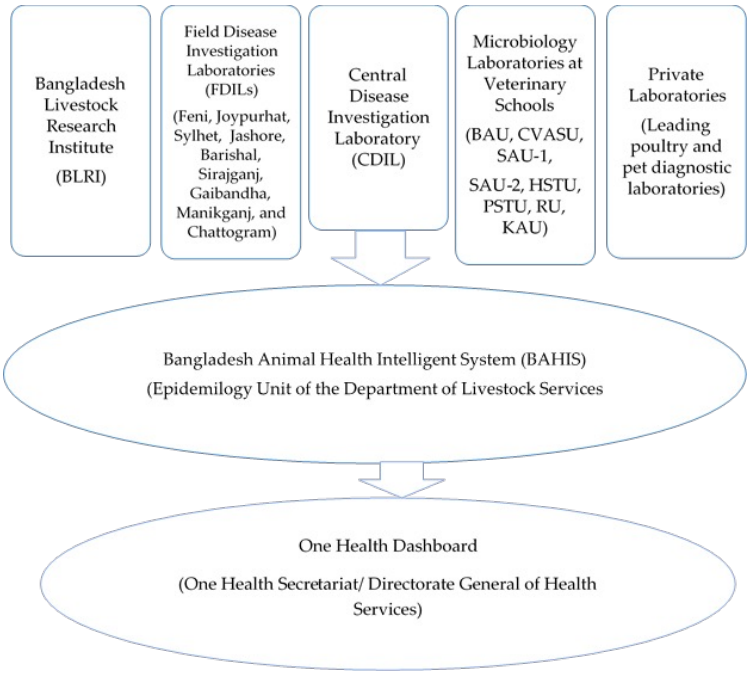



Fig 2: National AMR surveillance data management in a One Health approach

# QUALITY CONTROL, AND INTERPRETATIVE CRITERIA

Quality control strains of bacteria should be included and used according to international standards where available to support the validation of results and data harmonization. Interpretation of results for minimum inhibitory concentration (MICs) or disk diffusion, should be undertaken consistently according to European Committee on Antimicrobial Susceptibility Testing (EUCAST) or the Clinical and Laboratory Standards Institute (CLSI) standards, and should include quantitative results (i.e. inhibition zone diameters including the disk content or MIC values).

Categorization of the isolate and reporting of results may be undertaken based on the epidemiological cut-off values (ECOFFs) which should be reported according to the interpretive category. The use of ECOFFs as interpretive criteria will allow for optimum sensitivity for detection of acquired resistance, temporal analysis of trends and comparability between isolates from different origins. Clinical breakpoints may differ between animal species.

Proficiency testing (PT), sometimes referred to as external quality assurance or EQA, is the determination of a laboratory's performance by testing specimens of undisclosed content. Ideally, PT schemes should be run by an external independent provider. Participation in proficiency testing enables the laboratory to assess and demonstrate the reliability of results by comparison with those from other participating laboratories. All laboratories should, where possible, participate in external proficiency testing schemes appropriate to their testing. Participation in such schemes is a requirement for accredited laboratories. This provides an independent assessment of the testing methods used and the level of staff competence. CDIL and BLRI as the NRL for AMR should go under PT by external resources (FAO, WOAH, etc.).

**CDIL as the National Reference Laboratory (NRL)** for AMR surveillance should be designated with responsibility for:

i. Monitoring the quality assurance programmes of sentinel laboratories (FDILs) participating in surveillance and monitoring of antimicrobial resistance;

ii. Characterizing and supplying to a set of reference microorganisms to the sentinel laboratories;

iii. Creating, managing, and distributing samples/ panels to be used in external proficienc testing;

iv. Creating a central database available on the internet that contains the different susceptibility/resistance profi es for each bacterial species under surveillance.

# TRAINING AND CAPACITY-BUILDING

To deliver quality service, the laboratories in the network (reference and sentinel laboratories) require quality workforce development with necessary technical skills in bacteriology, AST and data management. Training is indispensable in improving the quality and excellence of the laboratory services. It would be advisable to organize regular AST workshops at the national level within the laboratory network.

**There is a scarcity of skilled human resources to perform AMR surveillance** in livestock and food in Bangladesh. Skilled and dedicated human resources are basic and fundamental resources to conduct standard surveillance and produce quality data. It is recommended to conduct **several trainings** on different cross-cutting issues for AMR surveillance and monitoring:

- Sample collection, preservation, shipment, and processing;
- Isolation & identifi ation of WOAH and WHO priority AMR pathogens;
- Phenotypic characterisation of AMR pathogens, i.e. DD, MIC, etc.
- Genotypic characterisation of AMR pathogens, i.e. conventional and real time PCR methods;
- AMR surveillance automation system, Vitek-2, MALDI-TOF etc.;
- Dedicated training on interpretation of AMR results in accordance with CLSI and EUCAST guidelines.;
- Laboratory bioinformatics to analyze NGS data;
- Training on AMR surveillance data collection, storage, interpretation, and sharing;
- Training on laboratory management, biosafety, biosecurity and good laboratory practices.

# INTEGRATED AMR SURVEILLANCE

A programme of integrated surveillance of AMR in foodborne bacteria must provide data for public health decision making. The sustainability of a surveillance programme is directly associated with the ability of this programme to provide accurate data needed for public health decision making in a timely manner. The active participation and commitment of different sectors and disciplines is particularly helpful in sustaining the programme of integrated surveillance of AMR in foodborne bacteria. Scientists and professionals from different disciplines (e.g. physicians, veterinarians, microbiologists, epidemiologists and environmental scientists), and representatives from food production industries, as well as government agencies responsible for risk assessment, risk management and research, have a role in supporting

and sustaining a programme of integrated surveillance of AMR among foodborne bacteria. In addition to a sound surveillance infrastructure, including an appropriate sampling design and adequate microbiological, epidemiological, and data management capacities, a sustainable programme of integrated surveillance of AMR in foodborne bacteria is commonly accompanied by: 1) continued policy and financial support arising from a recognition of the public health importance of AMR and AMU surveillance; 2) cooperation and good communication between the human health, animal health, fisheries, environment and agriculture sectors, and between microbiologists, clinicians, epidemiologists, veterinarians, food scientists, environmental scientists, food producers and public health officials.

For integrated AMR surveillance, multiple disciplines of Bangladesh such as Directorate General of Health Services (DGHS), Department of Livestock Services (DLS), Department of Fisheries (DoF), Department of Agriculture Extension (DAE), Department of Environment (DoE) should have strong and functional coordination and commitment to work together for potential synergies. DGDA is the national regulatory/ apex organization to coordinate and promote integrated surveillance and research for AMR. Following suggestions should be undertaken for sustainable and effective integrated AMR surveillance:

- Identifications of potential departments/ partner organizations to promote integrated AMR surveillance;
- Formal bilateral or multilateral agreements (Memorandum of Understanding-MoU or Letter of Agreement-LoA) should be made among the organization's;
- Roles and responsibilities of the different sectors (DGDA, DLS, DOF, DAE and DOE) should be made;
- Formation of multisectoral core working group with well-defined ToR should be in place;
- Formation of multisectoral technical committee with well-defined ToR should be in place;
- Formation of multisectoral steering committee with well-defined ToR should be in place;
- Regular meeting, seating and streamlining of the different multisectoral committees should be in place.

# GOVERNANCE AND RESOURCE MOBILIZATIONS

AMR surveillance and monitoring require good governance by the competent authorities. It is mandate of DLS to conduct and coordinate AMR surveillance in the animal production settings, foods of animal origin, including the food production environment. There is a lack of earmark Directorate or functional unit with committed workforce at the DLS headquarter dedicated to the internal and external coordination, oversight and direction of AMR management functions at the fie d operation levels throughout the country (i.e., Division, District, Upazila and Union

Council). But, at the current organizational structure of DLS, there is a "Veterinary Public Health" section led by a Principal Scientific Officer at the Livestock Research Institute and there is a Deputy Director, Veterinary Public Health at the divisional livestock offices. Therefore, Veterinary Public Health section can be assigned ad hoc basis to oversee and coordinate AMR containment issues. Currently at the DLS headquarter, Deputy Director (Animal Health) and Epidemiology unit has been temporarily assigned to look after AMR surveillance in the animal health sector.

The current resources to conduct AMR surveillance activities are not secured and sustainable, mostly donor-driven with limited Government support. The following suggestions can be considered to strengthen and sustain governance and secure resources to implement AMR surveillance:

- A revised structural organization of the DLS to enable the creation of a clear chain of command for implementing AMR management regulatory function from headquarters to the field level;

- The capacity of DLS staff at all levels needs to be strengthened to ensure their ability to effectively implement AMR regulatory functions;

- Sufficient technical, logistical, and financial resources must be made available to implement legal mandates for containment of AMR in foods of animal origin;

- Formation of a sectoral core working group with roles and responsibilities to provide technical and operational inputs;

- Formation of a technical committee with a defined ToR to review approaches and initiatives to combat AMR and make recommendations on technical issues;

- Formation of a steering committee to oversee and endorse the policy decisions made by the technical committee;

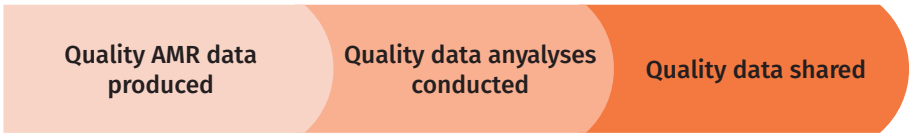
- Establish adequate regular funding provisions from the revenue budget to conduct AMR surveillance;

# THEORY OF CHANGE

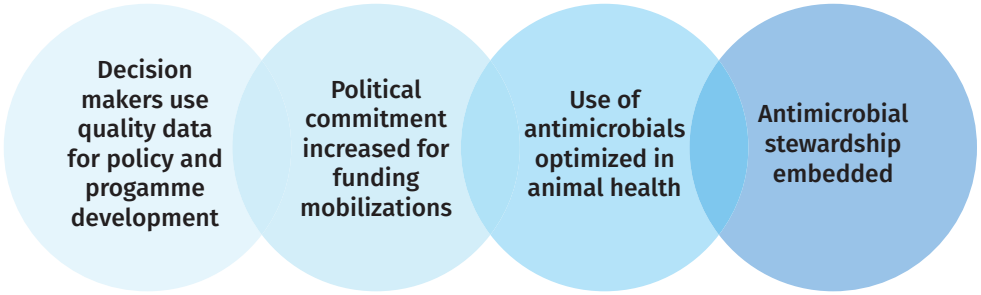
The AMR surveillance and monitoring policy framework aims to strengthen AMR surveillance systems and the generation of quality surveillance data for evidence based decision making to encounter the impact of AMR.

### Outputs

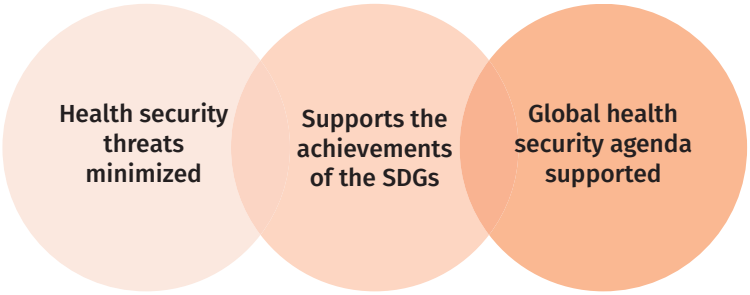

### Intermediate outcomes




### Long term outcomes




### Impact of the AMR surveillance




## MONITORING AND EVALUATION FRAMEWORK

Key performance indicators with measurable targets to support implementation of the activities as well as key responsible organizations that can lead the recommended implementation activities have been identified. The monitoring and evaluation framework is detailed in Table 2.

**Table 2: Monitoring and evaluation framework**

| Activities | Output Indicators | Mode of Verification | Responsibility |
|---|---|---|---|
| Designate National Reference Laboratory (NRL) for AMR surveillance in animal health | NRL has been designated | Office memorandum/ notification | Ministry of Fisheries and Livestock (MoFL)/ DLS |
| Designate sentinel laboratories for AMR surveillance | Sentinel laboratories has been designated/ identified | Office memorandum/ notification | DLS |
| Develop/ update/ revise AMR surveillance protocols and SOPs | Protocol/ SOPs has been updated/ revised | Endorsed and printed version of SOPs | DLS, BLRI, WOAH, FAO, Veterinary schools |
| Harmonization of AMR surveillance SOPs for consistent and quality data production | Number of laboratories adopted harmonized SOPs | Endorsed harmonized SOPs | DLS, BLRI, Veterinary schools, academic institutes |
| Strengthening network with (research and academic) laboratories to conduct quality AMR surveillance | Number of laboratories participated in national AMR surveillance | Surveillance report/ Laboratory assessment report | DLS, BLRI, Veterinary schools and academic institutes |
| Strengthening network with private laboratories to conduct quality AMR surveillance | Number of private laboratories participated in AMR surveillance | Surveillance report/ Laboratory assessment report | Private laboratory owner |
| Phenotypic and genotypic characterization of Salmonella spp. | Number of Salmonella spp. isolates identified and characterized | Periodic/ annual surveillance report/ journal publication | NRL/ sentinel laboratories |
| Serotyping with phenotypic and genotypic characterization of Salmonella enterica serovars | Number of Salmonella enterica serovars isolates (Typhimurium & Enteritidis) identified and characterized | Periodic/ annual surveillance report/ journal publication | NRL/ sentinel laboratories |
| Isolation with phenotypic and genotypic characterisation of E. coli | Number of E. coli isolates identified and characterized | Periodic/ annual surveillance report/ journal publication | NRL/ sentinel laboratories |

| | | | |
|---|---|---|---|
| Isolation with phenotypic and genotypic characterisation of Campylobacter spp. (C. coli and C. jejuni) | Number of Campylobacter spp. (C. coli and C. jejuni) isolates identified and characterized | Periodic/ annual surveillance report/ journal publication | NRL/ sentinel laboratories |
| Isolation and characterisation (phenotypic& genotypic) of Enterococcus spp. (E. faecium and E. faecalis) | Number of Enterococcus spp. (E. faecium and E. faecalis) isolates identified and characterised | Periodic/ annual surveillance report/ journal publication | NRL/ sentinel laboratories |
| Isolation and characterisation (phenotypic and genotypic) of Staphylococcus aureus | Number of Staphylococcus aureus identified and characterized | Periodic/ annual surveillance report/ journal publication | NRL/ sentinel laboratories |
| Strengthen surveillance based on molecular epidemiology using AMR genome database | Number of WGS/ NGS data of resistant pathogens submitted to gene bank | Publication/ Gene bank accession number | CDIL, BLRI |
| Strengthen surveillance of antimicrobial drug residues in foods of animal origin | Number of samples analysed to detect antimicrobial drug residues | Laboratory report/ Publications | DLS, BLRI, Veterinary schools and Academic institutes |
| Capacity building of the laboratory personnel | Number of training/ seminar/ workshop conducted with laboratory personnel | Training module/ certificate of participation | DLS, BLRI, FAO, WOAH, WHO, Veterinary schools |
| Establish proficiency testing in the national and sentinel/ regional laboratories at the regular interval | Number of laboratories participated in proficiency testing | Proficiency testing report | FAO, WOAH, Development partners |
| Establish a digital intelligence/ platform for AMR surveillance data collection, storage, information sharing and dissemination | BAHIS is developed | Technical report / Analytical report | DLS |

| | | | |
|---|---|---|---|
| Translate AMR surveillance data into information to inform policy makers and build awareness among veterinarian, regulators, pharmacists and the general public | Number of information materials / directives developed and distributed to the different stakeholders | Message/ Information note/ News bulletin | DLS |
| Strengthening AMR governance system | Designated desk, focal person and technical committees formed | Office memorandum/ memo | Ministry of Fisheries and Livestock (MoFL), DLS |
| Raise government commitment for funding to support surveillance on AMR. | Amount of dedicated funding committed/ allocated for AMR surveillance | Budget approval letter/ bank statement | MoFL, Ministry of Finance |

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