Antimicrobial Resistance (AMR)

Mapping and Gap Analysis

“Cambodia, Lao P.D.R and Myanmar”

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EXECUTIVE SUMMARY

Existing National Action Plan on AMR (NAP-AMR) was in line with Global Action on AMR (GAP-AMR) and for national AMR surveillance system also has been established by involving multi-sectoral working groups, supported by AMR data management system, and routinely carried out (even until at the healthcare setting level) in coordination with the national reference laboratory. National AMR surveillance activities in most countries have in place for common bacterial pathogens that link patient information with susceptibility testing, with a national reference laboratory that participates in external quality assurance. Those existing guideline will be followed for AMR detected. However; existing AST, bacterial isolation, and identification protocols still not relevant or specific to national AMR surveillance objectives. Most countries still didn't have standardized and harmonized national AST guidelines are in place and few laboratories follow the same AST guidelines. Therefore, those countries have tried to modify the existing protocols and guidelines for adoption to the updated national AMR surveillance system. *(See Annex A for AMR NAP from Cambodia, Lao P.D.R and Myanmar).*

Most of hospitals have their own clinical microbiologists and culture and sensitivity tests. The national laboratory assessment determined availability of diagnostic capacity at the national level for virology, bacteriology, parasitology, microbiology, and AST. However, laboratory capacity for water and food testing need to be strengthened. Although AMR surveillance in human and animal sectors have been followed by existing standard, but not all AST laboratories are linked to national network coordinated by the National Reference Laboratory. On the other hand, there is limited coordination among ministries, vertical programs, partners, and institutions regarding laboratories and AMR surveillance systems. Therefore, it is important to strengthen the role of the national AMR laboratory network in the integrated national AMR surveillance system. It was also necessary to strengthen links and coordination between national AMR surveillance with local surveillance and response systems.

Data management for national AMR surveillance in some laboratory network has been computer-based, but still don't have data validation protocol. Most countries have capacity to generate data (antibiotic susceptibility testing and accompanying clinical and epidemiological data) and reporting on antibiotic resistance; but data collection in some countries still not used standardized approach and lacks national coordination and/ or quality management. There are gaps in information on antibiotic use data; challenge in collecting these data surrounds the differing needs of each region; and issues of confidentiality for data sharing. Therefore; multi-stakeholder collaboration to strengthen capacity and tools in data collection, data storage, data analysis, and data sharing are expected to support the development of standardized and integrated national AMR surveillance system.

According to Tricycle Antimicrobial Country Self-Assessment (TrACSS), Cambodia, Lao P.D.R and Myanmar have multi-sectoral working groups for One Health collaboration that are not only functional but also with defined clear activities. On the other hand, countries also have multi-sectoral coordination committee in charge of availability and access of AMR data to support national AMR monitoring and surveillance system. Multi-sectoral working groups/ or coordination committee in charge of national AMR strategy reviews data to amend national strategy and/ or information decision making (at least annually). Guidelines for appropriate use of antimicrobials also available and national antimicrobial stewardship program has been implemented in healthcare facilities. However, national AMR monitoring

and surveillance results have not been used to inform action and to update treatment guidelines and essential medicines lists. Therefore, harmonization between national and global surveillance systems need to be made to standardize methodology data to embrace a broader One Health and multi-sectoral approach on addressing AMR.

Some cross-sector ministries and working groups are involved not only in the development and implementation of NAP-AMR, but also in the AMR country self-assessment survey with related multi stakeholders across sectors as well. Given the need to coordinate action among these sectors, government engagement is imperative. Dedicated units should analyze AMR data and share the information with relevant stakeholders. Therefore, the result of AMR surveillance will be disseminated not only with/ and for multi-sectors involved in data collection and analysis, but also across other related sectors. However, the GAP-AMR has identified research and innovation as a key strategic objective so that evidence can be generated to guide current and future containment efforts. In order to support sustainable operation, government should led research outputs related to AMR global and national research agenda. Most countries were yet to put together a strategic research agenda that is relevant to current policies and programs, and address implementation challenges facing AMR containment efforts. Therefore, it was necessary to prioritize AMR strategic research agendas that can strengthen AMR containment program, including evaluating the primary drivers of AMR. On the other hand, national AMR surveillance system should not be limited to the following bacteria-antimicrobial drug combinations in compliance with the Global AMR Surveillance System (GLASS) manual, depending on the context of each country.

Country legislations on antimicrobial use that have been developed include prescription and sale of antimicrobials for human use, on prohibits the use of antibiotics for growth promotion in the absence of risk analysis, and on marketing of pesticides including antimicrobial pesticides in plant production. Even though animal health sector is actively involved in developing and implementing NAP-AMR, however country legislations on prescriptions and sales of antimicrobials for animal use have not yet been developed. On the other hand; countries are in the process of strengthening the integration of research to support evidence-based policy decisions, so every country needs to have well-established infrastructure, equipment, skilled manpower and sustainable financial support for Research & Development.

Strategies that can be considered to address challenges on AMR program implementation, such as: improve national multi-sectoral coordination/ collaboration and capacity (especially involving national reference laboratories); set up and use a standardized AMR surveillance guideline and protocol; continue submitting of GLASS data; develop One Health tools and training materials supported by mobile health application system; strengthening local investigation and response networks; strengthen quality assurance processes that in line with intergovernmental standards; and promote research and development to address AMR. Sustainable operation of the national laboratory network strengthening is through an established laboratory network, EQA measures in place, and demonstrated capacity of reference lab for research. On the other hand; integrated, harmonized, and standardized protocols need to be developed by taking into account the domain of effectiveness and efficiency of the AMR surveillance system, especially for low-to-middle-income country (LMIC) settings.

INTRODUCTION

A. Why Conduct National and Regional AMR Mapping and Gap Analyses?

Antimicrobial resistance (AMR) is the development of resistance in microorganisms- bacteria, viruses, fungi and parasites to an antimicrobial medicine to which it was previously sensitive. AMR in a wide range of infectious agents is a growing public health threat of huge concern to countries and to many sectors. Especially alarming is the rapid global spread of multi-resistant bacteria that cause common infections and that resist treatment with existing antimicrobial medicines. AMR is a grave threat to human health and economic development [1]. Estimated around 10 million deaths may be attributed to AMR by 2050 at the global level and nine million in developing countries, with 4.7 million in Asia, 4.2 million in Africa and 392,000 in Latin America [2]. On the animal side, the World Bank has projected significant decreases in international trade due to AMR as a result of decreases in the trade of livestock and livestock products; while on the human side, AMR could derail the Sustainable Development Goals, driving an estimated 24 million people into extreme poverty [3] and potentially resulting in tens of millions of deaths [1]. Therefore, it is important to start with AMR mapping and gap analysis into a framework linked to the Global Action Plan (GAP) objectives and the Sustainable Development Goals (SDGs), in order to support the work by assisting an understanding of what activities are already underway, what data are already being collected, and where there may be gaps in the efforts initiated to date. It was also discussed that this initial mapping could support efforts to develop a broader framework for monitoring and surveillance activities, their progress and impact under the GAP-AMR objectives.

B. What is The Value in Developing Common Protocols for AMR Surveillance?

Antimicrobial effectiveness is a global public good and must be protected by public authorities. Yet, two of the biggest risks to containing AMR are: 1) AMR policies that may not be feasible over decades, and 2) historic divisions between human health and other related sectors will hinder efforts to contain resistance [3]. Long-term commitments are needed in monitoring, surveillance, stewardship, and training to bring the substantial change in patterns of antimicrobial use [4] and in how waste and effluents are managed [5]. Therefore, surveillance and monitoring are widely acknowledged as critical components of the response to AMR and are one of the five strategic priorities of the GAP-AMR. Through surveillance, countries can detect the emergence of AMR and collect the data on AMR prevalence and antimicrobial use necessary to guide patient treatment, identify populations at risk, inform policy development and assess the impact of interventions. Putting resources into AMR containment now – including surveillance – is one of the highest-yield investments a country can make to mitigate the impact of AMR [6]. The development of protocols for the AMR surveillance system is very important as a guide to gathered and analyzed information about antimicrobial resistance incidence, prevalence, and trends for better understand and respond to antimicrobial resistance patterns and key drivers. Stronger networks of information sharing and a global strategic research agenda would improve global and national understanding of antimicrobial resistance.

METHODOLOGY FOR MAPPING AND GAP ANALYSIS

A. Literature Review

Objective:

- Mapping and gap analysis for current AMR surveillance practices in Cambodia, Lao P.D.R, Myanmar (in addition to China, Viet Nam, Thailand)

Resource Database:

- Medline/ Pubmed, CINAHL/ EBSCO, Web of Science, ProQuest, ScienceDirect, Google Scholar
- WHO website

Date: until January, 2020

PCC: Population = AMR monitoring and surveillance system
Concept = baseline & metada set, model & mechanism, capacity strengthening & training, gap of need
Context = One-Health approach and Trycycle program

Keyword:

antimicrobial resistance, one health, trycycle program
action plan, national plan, protocol, guideline, report,
framework, tool, method, model, system
implementation, surveillance, monitoring
challenge, problem, strategy, lesson learned
Cambodia, China, Lao P.D.R, Myanmar, Thailand and Viet Nam

Ms. Excel → reference management, data charting and extraction

B. Interviews

1) Involvement of Multi-Sectoral National Focal Points based on annual TrACSS

Country	Sector	2016-17	2017-18	2018-19	2019-20
Lao P.D.R	Human Health	N/ A	✓	✓	✓
	Animal Health	N/ A	✓	✓	✓
	Plant Health	N/ A	N/A	N/A	✓
	Food Production	N/ A	N/A	✓	✓
	Food Safety	N/ A	✓	✓	✓
	Environment	N/ A	N/A	N/A	N/A
Cambodia	Human Health	N/ A	✓	✓	✓
	Animal Health	N/ A	✓	✓	✓
	Plant Health	N/ A	✓	N/A	✓
	Food Production	N/ A	✓	N/A	✓

Country	Sector	2016-17	2017-18	2018-19	2019-20
	Food Safety	N/ A	✓	N/A	✓
	Environment	N/ A	✓	N/A	✓
Myanmar	Human Health	N/ A	✓	✓	✓
	Animal Health	N/ A	✓	✓	✓
	Plant Health	N/ A	✓	✓	✓
	Food Production	N/ A	✓	✓	✓
	Food Safety	N/ A	✓	✓	✓
	Environment	N/ A	✓	✓	✓
China	Human Health	N/ A	✓	✓	N/A
	Animal Health	N/ A	✓	✓	N/A
	Plant Health	N/ A	✓	✓	N/A
	Food Production	N/ A	✓	✓	N/A
	Food Safety	N/ A	✓	✓	N/A
	Environment	N/ A	✓	✓	N/A
Viet Nam	Human Health	N/ A	✓	✓	N/A
	Animal Health	N/ A	✓	✓	N/A
	Plant Health	N/ A	✓	✓	N/A
	Food Production	N/ A	✓	✓	N/A
	Food Safety	N/ A	✓	✓	N/A
	Environment	N/ A	✓	✓	N/A
Thailand	Human Health	N/ A	✓	✓	N/A
	Animal Health	N/ A	✓	✓	N/A
	Plant Health	N/ A	N/A	N/A	N/A
	Food Production	N/ A	N/A	N/A	N/A
	Food Safety	N/ A	N/A	N/A	N/A
	Environment	N/ A	N/A	N/A	N/A

Sectors are actively involved in developing and implementing the AMR National Action Plan

2) Involvement of Multi-Sectoral Regional Focal Points according to WHO, FAO and OIE Regions

Country	Sector	2016-17	2017-18	2018-19	2019-20
Lao P.D.R	WHO	WHO/ WPRO	WHO/ WPRO	WHO/ WPRO	WHO/ WPRO
	FAO	FAO/RAP	FAO/RAP	FAO/RAP	FAO/RAP
	OIE	(OIE/ AFEO)	(OIE/ AFEO)	(OIE/ AFEO)	(OIE/ AFEO)
Cambodia	WHO	WHO/ WPRO	WHO/ WPRO	WHO/ WPRO	WHO/ WPRO
	FAO	FAO/RAP	FAO/RAP	FAO/RAP	FAO/RAP
	OIE	(OIE/ AFEO)	(OIE/ AFEO)	(OIE/ AFEO)	(OIE/ AFEO)
Myanmar	WHO	WHO/ SEARO	WHO/ SEARO	WHO/ SEARO	WHO/ SEARO
	FAO	FAO/RAP	FAO/RAP	FAO/RAP	FAO/RAP
	OIE	(OIE/ AFEO)	(OIE/ AFEO)	(OIE/ AFEO)	(OIE/ AFEO)

Country	Sector	2016-17	2017-18	2018-19	2019-20
China	WHO	WHO/ WPRO	WHO/ WPRO	WHO/ WPRO	WHO/ WPRO
	FAO	FAO/RAP	FAO/RAP	FAO/RAP	FAO/RAP
	OIE	(OIE/ AFEO)	(OIE/ AFEO)	(OIE/ AFEO)	(OIE/ AFEO)
Viet Nam	WHO	WHO/ WPRO	WHO/ WPRO	WHO/ WPRO	WHO/ WPRO
	FAO	FAO/RAP	FAO/RAP	FAO/RAP	FAO/RAP
	OIE	(OIE/ AFEO)	(OIE/ AFEO)	(OIE/ AFEO)	(OIE/ AFEO)
Thailand	WHO	WHO/ SEARO	WHO/ SEARO	WHO/ SEARO	WHO/ SEARO
	FAO	FAO/RAP	FAO/RAP	FAO/RAP	FAO/RAP
	OIE	(OIE/ AFEO)	(OIE/ AFEO)	(OIE/ AFEO)	(OIE/ AFEO)

* World Health Organization, Western Pacific Regional Office (WHO/WPRO), World Health Organization, South-East Asia Regional Office (WHO/SEARO), Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific (FAO/RAP), World Organization for Animal Health Regional Commission For Asia, The Far East And Oceania (OIE/ AFEO)

C. Primary Data Collection [Attach Tool(s) as Appendices]

This activity conducted primary data collection based on the TrACCS questionnaire 2016-17, 2017-18, 2018-19, 2019-20 in Lao PDR, Cambodia, Myanmar, China, Viet Nam, and Thailand. Team analyzed and compared countries' responses to the first (2016-17), second (2017-18), third (2018-19), and fourth (2019-20) wave of the tripartite survey and describe the trend and current level of national progress (based on self-assessment) on AMR. Team conveyed progress achieved towards the goals of the GAP across regional level among countries. Finally, team explored progress in relation to progress made towards Multi-Sectoral and One-Health approach objectives. It is also important to note that although the survey did allow countries to report separately on animal health, plant health, food safety, food production and the environment for some questions, many countries chose just to report on the non-human sectors collectively. For this reason, in some cases comparison is made between the human health sector and the non-human health sectors collectively. On the other hand, primary qualitative data also had been collected from the focal point of each participating countries.

D. Other Data Sources

In addition to the literature review, interview, and primary data collection; several other data sources include policy and strategy documents (especially NAP-AMR from Lao P.D.R, Cambodia, and Myanmar):

1. National Strategy for Antimicrobial Resistance: Lao P.D.R 2019 – 2023
2. National Policy to Combat Antimicrobial Resistance: Cambodia 2014 and National Strategy to Combat Antimicrobial Resistance: Cambodia 2015-2017
3. National Action Plan for Containment of Antimicrobial Resistance: Myanmar 2017-2022

Including AMR surveillance guidelines, AMR multi-sectoral action plans, guideline on laboratory-based AMR surveillance system, and other related guidelines and protocol.

LITERATURE REVIEW FINDINGS

A. What Guidance Exists for AMR Surveillance?

In some sectors, such as plants, food processing and the environment sectors, there are few, if any, international guidelines and standards for surveillance AMR and AMU, whereas there are generally well-established guidelines for surveying AMR and AMU in humans, animals and food of animal origin [6]. Some existing guidelines for AMR surveillance systems that can be considered, such as:

1. Global Antimicrobial Resistance Surveillance System (GLASS) [6,7]
2. Integrated Surveillance of Antimicrobial Resistance [6,8]
3. Harmonization of National Antimicrobial Resistance Surveillance and Monitoring Programs [6,9]
4. Integrated Surveillance of Antimicrobial Resistance in Foodborne Bacteria: Application of a One Health Approach [6,10]
5. Guidelines For Risk Analysis of Foodborne Antimicrobial Resistance [6,11]
6. Monitoring of The Quantities And Usage Patterns of Antimicrobial Agents Used in Aquatic Animals [6,12]
7. Development and Harmonization of National Antimicrobial Resistance Surveillance and Monitoring Programs for Aquatic Animals [6,13]
8. Monitoring of The Quantities and Usage Patterns of Antimicrobial Agents Used in Food-Producing Animals [6,14]

The first step in establishing AMR surveillance is the development of a National Action Plan for AMR (NAP-AMR), as set out by the WHO Global Action Plan on AMR [15]. A further barrier may be difficulty in implementing international guidelines at the national level. Other obstacles include a lack of robust legal and regulatory frameworks, limited professional services, and poor coordination among the human, animal and other sectors [6]. However, there is proposed steps in setting up a national AMR surveillance system as follow [7]:

1. Establish a national surveillance coordinating body with a focal point and a data management structure.
2. Define the surveillance objectives: (a) to assist the planning and monitoring of the national strategies to control AMR and (b) to inform global efforts to control AMR.
3. Define a strategy for gradual implementation of national surveillance system and participation in Global Antimicrobial Surveillance System (GLASS).
4. Establish at least one national reference laboratory that participates in an external quality assurance scheme.
5. Identify AMR surveillance sites, that have access to epidemiological support and a microbiology laboratory, and promote diagnostic stewardship
6. Develop or adapt national protocols for data collection, laboratory protocols, diagnostic stewardship, and data flow.
7. Disseminate protocols and tools, and train staff in their use.
8. Start collecting data on progress or status of implementation and on AMR

9. Report information on the AMR situation to inform the national strategy, and report aggregated data to GLASS to inform global strategies.
10. Ensure that monitoring and evaluation include pilot-testing of any new surveillance approach, a review of steps, and adjustment of processes as necessary.

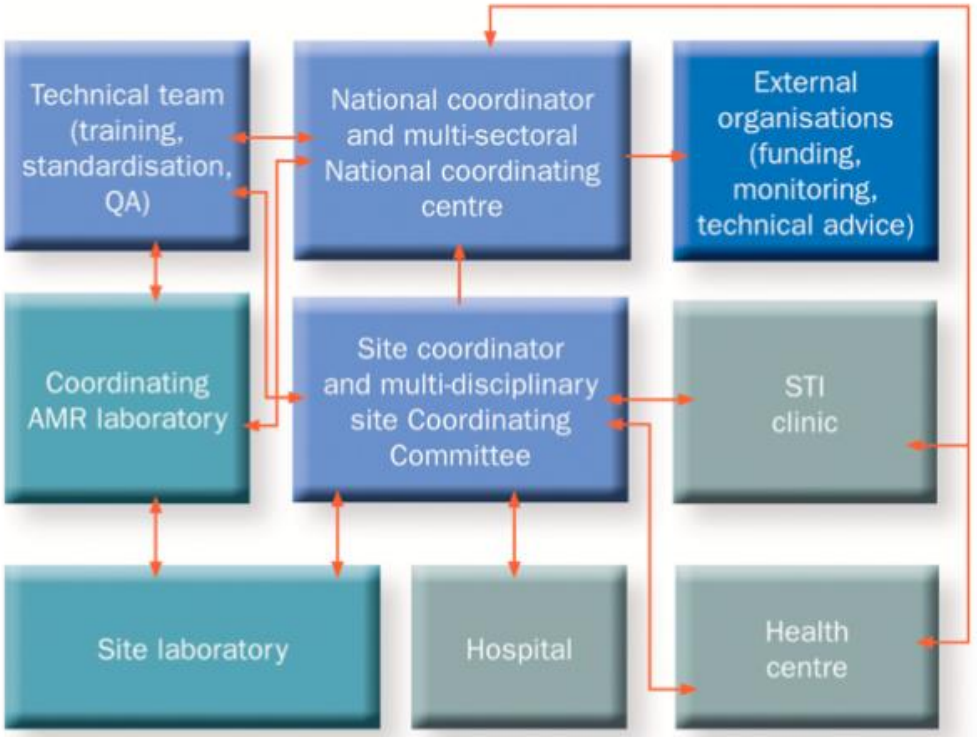

Figure 1: Organizational structure for AMR Surveillance in low resources setting (Source: Seale et al, 2019)

Each country should develop its own organizational structures, and define terms of reference. While the governance structure may vary, important factors include identification of a National Coordinating Centre (NCC), convening a technical team, and strong engagement with the Ministry of Health, reflecting the national importance of AMR surveillance in health systems. The NCC should include a committee of multi-sectoral stakeholders to support a One Health approach both at national and international levels. The figure above is example of an organizational structure for AMR Surveillance in low resource settings [15].

B. What Are The Characteristics of an Effective and Efficient AMR Surveillance System?

Figure 2: Components of an effective AMR surveillance system (Source: Interagency Coordination Group on AMR, 2018)

Effective surveillance systems should be both coordinated and complementary among sectors and levels. Five components of an effective coordinated, complementary surveillance system [6], such as:

1. Integration
   Integrated (multiple dimensions, within and among sectors and levels) with other existing One Health and multi-sectoral surveillance systems, including vertical alignment (within public health initiatives) and horizontal coordination (among strategies for human and animal health, food production, plants and environment sectors).

2. Prioritization
   Prioritized what to monitor, when and how it is important to ensure the best use of resources. Sample sources, microorganisms and antimicrobial classes should all be prioritized. Prioritization may be based on international standards and guidelines but should also be tailored to local and national contexts, national priorities, resources (affordability) and the availability of data (feasibility).

3. Comparability
   Multi-sectoral data should be harmonized, be aggregated, and be compared to identify trends across sectors. National surveillance systems should follow international data models to ensure broader assessments and analysis techniques of AMR and AMU.

4. Availability
   Surveillance data should be easy to obtain and easy to use for designing actionable strategies. Data should be available in public reports, distributed through existing global systems, translating into useful information, knowledge sharing, and then AMR policy development.

5. Investment
   Resources are required to build and sustain surveillance of AMR and AMU with adequate coverage and quality. The costs include not only those for data collection but also for information technology, data analysis, personnel time and training and software at facilities and national level. AMR surveillance also includes the cost of establishing and running laboratories.

Integrated surveillance systems that connect and build on existing systems maximize the efficiency of resource use and provide more complete data. To be most effective, surveillance systems should cover human and animal populations and food as well as, when supported by scientific evidence and risk assessment, plant production and relevant aspects of the environment. Surveillance system should also, as far as possible, provide harmonized – or equivalent – data that can be easily compared, exchanged, used or aggregated locally, nationally and globally.

Surveillance data are most effectively used to study trends and inform policies when they are of high quality and easily transferable and comparable among systems. Participating surveillance sites that do not yet have suitable software for efficient data management and reporting can use the free WHONET software, which can be used on stand-alone computers or linked to through existing information systems [6][7]. On the other hand, to allow full and informative interpretation of data, effective AMR surveillance requires well-functioning health-systems that serve a defined population. Standard laboratory methods for pathogen identification and antimicrobial susceptibility testing are vital in order to understand the emergence of AMR and inform policy, but so too are population descriptors, healthcare utilization patterns, and the systematic assessment and investigation of patients [15]. Some other components related to collaboration for effective surveillance systems, include [16]:

1. Increase laboratory capacity and associated QA systems, particularly in LMIC; one challenge is the current low capacity for provision of training;
2. Improve effectiveness of communication within networks; the gaps and challenges are to overcome limited resources and differences in technology, and to encourage a “reporting” form of surveillance;
3. Improve effectiveness of communication, particularly of risk, among networks at regional and global levels; the challenge is to address issues relating to governance and to ownership of data, and to determine roles and responsibilities in terms of coordination;
4. Make more effective use of data; and close the gaps between the laboratory data and data required for expressing burden of disease, economic impact and treatment guidelines; gaps include a lack of relevant incidence and prevalence data, and a lack of the standardized reporting that is required for data comparability;

5. Improve coordination between the human, animal and environmental sectors, to counter the lack of appropriate coordination mechanisms and political will;
6. Have consensus on data sharing; this requires political support and functional national systems;
7. Convince policy-makers to prioritize the problem and to allocate resources.

To promote effectiveness and economic efficiency, interventions need to be designed from sound evidence gained from surveillance. A broad One Health approach to the evidence-gathering surveillance, data analysis, intervention design and evaluation is proposed. Given the scale of the problem and the expected socioeconomic costs, the additional monetary, social and time investments are likely to be recovered by the resulting benefits, which include quantifiable financial efficiencies and improved human and animal health outcomes. In addition, if one looks broadly and includes the less tangible benefits to society (open trade and travel), animal welfare, ecosystem health and environmental resilience, then the business case for a One Health approach to AMR surveillance is strengthened [17]. Therefore, the approach to implementing effective surveillance for AMR in LMIC settings need to be 3-pronged: a) strengthening microbiology diagnostic services at all tiers of both private and Government run health care services; b) use of laboratory data to guide and restrict antibiotic use; and c) creating effective and sustainable AMR surveillance [15]. Kindly see table 1 for costs and benefits of One Health Antimicrobial Resistance (AMR) Surveillance and Resultant Interventions

Integrating AMR surveillance to a One Health level	
Costs	**Benefits**
• Costs of design and setup, including time to agree on common goals, new roles and duties, dispersal of funding and resolving issues of conflict. • Costs of training staff in interdisciplinary work. • Costs of additional staff, expert consultants, joint consultations and meetings. • Costs of collating additional data, and joint analysis and communication of results. • Additional costs for extending the breadth and depth of coverage of surveillance.	• Improved service delivery. • Improved efficiency by sharing scarce resources or better use of underutilized resources. • Social capital gains through sharing skillsets and networking. • Improved synergies between empirical, social, environmental and ecological sciences. • Enriched and more efficient research outcomes. • More timely and accurate identification of risks through broader surveillance and integration. • Improved, more timely and efficient interventions based on improved risk assessments.
Integrated interventions arising from One Health surveillance	
Costs	**Benefits**
• Increased costs of wider interventions across human and animal health and the environmental sectors.	• Broader benefits across sectors arising from a systems approach versus narrow reactionary solutions.

• Potential increased costs of livestock production through use of improved biosecurity in contrast to prophylactic use of antibiotics.	• Improved and broader valuation of benefits by including intangible societal and environmental benefits. • Reduced healthcare costs (prevention of longer hospitalization, more expensive drugs, intensive infection control measures, etc.) • Decreased morbidity and mortality. • Prevention of reduced workforce productivity owing to prolonged recovery or caring for relatives. • Prevention of costs of litigation against hospital and staff. • Prevention of lost income through reduced cross-border travel and tourist income, and from reduced trade in live animals and food of animal origin. • Reduced cost of animal health care and infection control in food-producing animal systems. • Prevention of increased cost in food stuffs from animal origin. • Improved consumer confidence in food safety. • Improved ecosystem resilience.

Table 1. Costs and Benefits of One Health Antimicrobial Resistance (AMR) Surveillance and Resultant Interventions (source: Queenan et al, 2016)

C. What Sectors, Data Sources, and/ or Entities Must Be Included?

A One Health approach – incorporating humans, animals, plants and the broader environment – is needed to ensure adequate action. Given the need to coordinate action among these sectors, government engagement is imperative [5]. National AMR surveillance system should have multi-sectoral representation (including involvement from agriculture and veterinary medicine) in AMR surveillance bodies from the outset, in order to inform, monitor and control the threat to public health arising from AMR. Membership should include relevant technical experts and stakeholders, although individuals may fulfill the remit of more than one technical brief. A typical committee may include following representatives: technical team leader, Ministry of Health, Ministry of Agriculture, national public health institute, coordinating AMR laboratory, international stakeholders, clinical microbiologist, data manager, public health analyst, laboratory manager, hospital manager, adult physician, pediatrician, pharmacist, veterinarian, infection control manager [15].

The aims of AMR surveillance program include monitoring trends in infection and resistance to develop standard treatment guidelines that support best practice for patient care, but also recognize the importance of linking information on AMR from different sectors, such as human, animal, food, agriculture, environment, and data on antibiotic use in human and animal populations and

environmental antibiotic usage. AMR surveillance should also allow for assessment of interventions to reduce AMR, provide early alerts for emergence of novel resistant strains, and aid the rapid identification and control of outbreaks [15]. This is the following definition for multi-sector that had been included, both human and non-human sectors [18–21]:

1. Animal Health Sector
   In its simplest form, animal health is defined as the absence of disease. This sector includes systems or activities designed to optimize the physical and behavioral health and welfare of animals, including the prevention, treatment and control of diseases and conditions affecting the individual animal and herd or flock. The recording of illness, injuries, mortalities and medical treatments is an essential part of effective animal health measures where appropriate.
2. Plant Health Sector
   In its simplest form, plant health is defined as the absence of disease. This sector includes phytosanitary systems or measures that focus on preventing, controlling and mitigating the introduction, spread and establishment of diseases or pests of plants.
3. Food Production Sector
   This sector includes all processes procedures and infrastructure that aim to optimize productivity and efficiency of animal and plant production systems, over and above those relevant to maintain Animal/ Plant health and include aspects such as selective breeding, nutrition, housing systems, and other husbandry techniques.
4. Food Safety Sector
   Aspects of food production and processing which relate to safeguarding public health, whether pre or post slaughter or harvest. Food encompasses any substance, whether processed, semi-processed or raw, which is intended for human consumption.

Many low- and middle-income countries lack the basic capacity to establish and maintain surveillance systems to collect and use data on antimicrobial resistance and antimicrobial use [6]. Some multiple data types that need to be considered include: information on pathogen, determinants of resistance, the commodity, the classes of antimicrobials tested, the sampling design, laboratory methods, analysis and reporting. Even including data on sales or wholesale distribution, imports, production, clinical or prescribing data. Several priority of antimicrobials can be considered in the AMR surveillance system [7,9,22–24], such as :

a) Priority Pathogen and Specimen (WHO, 2015)
b) Critically Important Antimicrobial Agents (OIE, 2015)
c) Critically Important Antimicrobials (WHO, 2017)
d) Priority Pathogens List (WHO, 2017)
e) Priority Animal Pathogens (OIE, 2019)

Given the need to integrate data from different sources, including individual patient data, it is essential that there are data governance agreements and procedures in place. These should protect the confidentiality of individual patients, but also facilitate the sharing of AMR surveillance data to inform policy locally, nationally and internationally. To meet ethical obligations, technical, legal and/or political

barriers to data sharing must be overcome, and best practice for data collection ensured. For these reasons, a successful AMR surveillance program requires clear political support, and should engage accordingly with the relevant government bodies [15].

D. What Protocols Are Essential for AMR Surveillance According to The Literature and Stakeholders – in Humans, Animals (Terrestrial and Aquatic), Environment, Multi-Sectoral (One Health)?

Data quality on AMR can be improved by the use of standardized methods for determine susceptibility to antimicrobial agents. However, surveillance system should be dynamic and allow for development and inclusion of new monitoring and surveillance tools [6]. Some essential protocols that need to be developed or adopted from existing national protocols include: data collection, laboratory protocols, diagnostic stewardship, and data flow protocols [7]. Some of standardized methods for AMR and AMU [6,7,12,14,25–29] that can be considered as essential protocol, such as:

1. Surveillance Standards for Antimicrobial Resistance (WHO, 2002)
2. Manual for Antimicrobial Susceptibility Testing (WHO, 2003)
3. Standardized Epidemiological Methods (WHO, 2015)
4. Methodology for Surveillance of Antimicrobial Consumption (WHO, 2017)
5. Assessment Tool for Laboratories and Antimicrobial Surveillance Systems (FAO, 2018)
6. Manual of Diagnostic Tests and Vaccines (OIE, 2019)
7. Standardized Antimicrobial Monitoring System (OIE, 2019)

Some crucial things that need to be considered to support the implementation of standardized protocols, such as: multi-sectoral collaboration/ coordination, robust legal and regulatory framework, adequate resources and capacity (i.e. data collection, identification, reporting), laboratory and communication infrastructure, cooperation between national authorities and the private sector. In general, the process related to AMR surveillance system protocol, described as follows [15]:

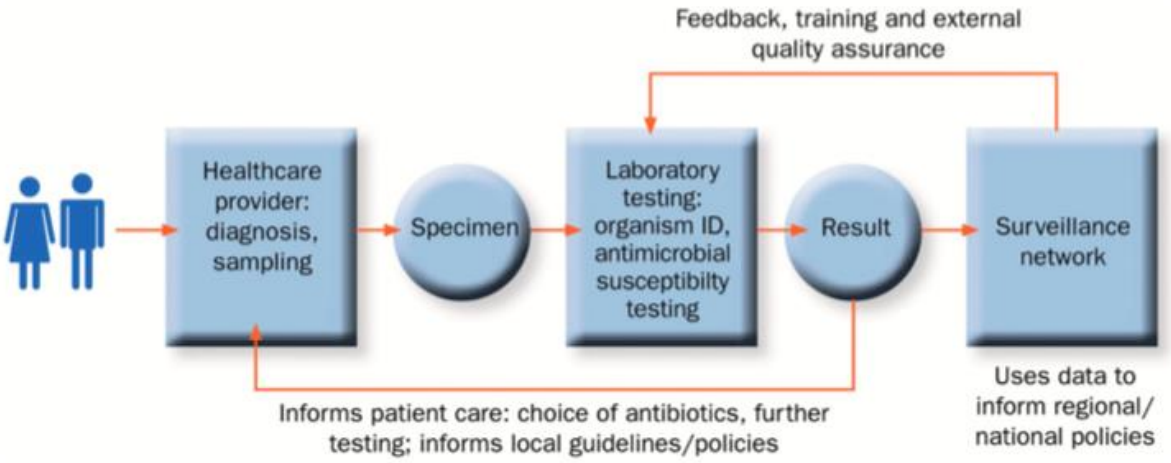

Figure 3 AMR Surveillance Process (Source: Seale et al, 2019)

Some technical components that are essential to consider, such as:

1. Population Catchment and Sampling Frame.
   Wherever possible, the catchment population of the health facilities included in surveillance should be defined and an assessment should be made of the patterns of healthcare utilization in that population

2. Integration of AMR Surveillance
   AMR surveillance data should be interpreted in the context of local clinical practice. This is particularly relevant for low-income country settings, which use syndromic management approaches where patients are diagnosed clinically and treated empirically.

3. Identification sentinel sites
   Specimen culture and testing for antimicrobial susceptibility should be done by sentinel site laboratories. Isolates with unusual susceptibility profiles, or of uncertain identification, should be referred to the coordinating AMR laboratory, as well as a proportion of all isolates for quality control purposes. All isolates from blood or CSF specimens should be sent to the coordinating AMR laboratory for storage.

4. Antimicrobial Susceptibility Testing
   AMR surveillance programs should include, but should not be limited to, the following bacteria-antimicrobial drug combinations in compliance with the GLASS manual

5. Data Management
   Reporting results requires efficient data management at both sentinel site and national levels. Quality control should be incorporated at every stage, with automated data validity checks and rules, as well as audit to check data consistency, completeness and accuracy. Confidentiality should be protected and data security measures should be in place.

6. Use of Innovative Technologies and Mobile Communications
   In high-income settings, innovative technologies for diagnostics, therapeutics and data management are integrated into most health systems, with funding streams for research and executive bodies to evaluate and approve new technologies

As part of monitoring, evaluation, and development; quality assurance (QA) should be led by national coordinator and technical team in country, in conjunction with external organizations as appropriate. At a core level, all site procedures should be undertaken according to SOPs, adapted from national SOPs, and based on these guidelines. Alongside these, quality control (QC) and QA procedures should be established to ensure that the data produced are accurate and reliable. On the other hand, key performance indicators (KPIs) are used to monitor progress and identify sentinel sites where problems are arising and more detailed investigation is needed to understand why the indicators are not being met. The purpose of this investigation is to support sentinel sites to achieve the KPIs [15].

Development of AMR surveillance is essential to address the global challenge of drug resistant infections (DRI). It is expected that, in line with GLASS, AMR surveillance systems will develop in low-income countries to extend AMR surveillance progressively, to include agriculture (including animal health) and the environment in a One Health approach. Standardized guideline or protocol should intended to provide a roadmap for improving laboratory capacity, data collection and surveillance for AMR with an effective One Health approach, through multi-sectoral involvement across the interface between humans, animals and their various environments. Therefore, outputs of AMR surveillance must be used to underpin public health policy, locally, nationally and internationally. In addition, where possible, surveillance systems should provide a platform to answer research questions with local, national and international collaborations, which will inform our understanding of the emergence and evolution of AMR and, in the long term, support development of urgently-needed intervention strategies.

MAPPING, GAP ANALYSIS, AND DISCUSSION

Regional Level

Mapping and Gap Analysis

A. Existing Regional-Level Guidance and Protocols on AMR Surveillance

Existing NAP-AMR was in line with GAP-AMR and AMR surveillance was routinely undertaken among countries that have progress on national surveillance systems for AMR in animal and food sectors. However; existing antimicrobial susceptibility testing (AST), the bacterial isolation and identification protocols still not relevant or specific to the national AMR surveillance objectives. Most countries did not have standardized and harmonized national AST guidelines are in place or only less than 30% laboratories follow the same AST guidelines. Few countries have modifications in the AST, bacterial isolation and identification protocols used are required to improve their adaptation to national AMR surveillance objectives. On the other hand, data management for AMR surveillance system in some laboratory network has been computer-based but still don't have data validation protocol. See table 2 for Progress on National AMR Laboratory Network in AMR Surveillance System (2018-19, 2019-20)

Country	Laboratory Integration		Standardization and Harmonization of Procedures		Relevance of Diagnostic Techniques		Data Management	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Lao P.D.R	A	B	A	A	A	A	E	B
Cambodia	D	C	C	C	C	C	C	C
Myanmar	B	B	A	B	B	B	B	B
China	C	B	E	A	E	A	D	B
Thailand	C	C	D	C	D	C	C	C
Viet Nam	C	B	A	B	B	B	A	B

Table 2. Progress on National AMR Laboratory Network in AMR Surveillance System (2018-19, 2019-20)

Laboratory Integration

A = Information not available.

B = Laboratories perform antimicrobial susceptibility testing (AST) for own purposes and are not included in the national AMR surveillance system.

C = Some laboratories performing AST are integrated in the national AMR surveillance system.

D = All laboratories performing AST are integrated in the AMR surveillance system but the role should be better formalized and the network better and developed.

E = All laboratories performing AST are integrated in the national AMR surveillance system, have a clear position, and are linked to a national network coordinated by a National Reference Laboratory.

Standardization and Harmonization of Procedures

A = Information not available.

B = No standardized national AST guidelines are in place or less than 30% laboratories follow the same AST guidelines.

C = Between 30% to 79% of laboratories follow the same AST guidelines.

D = Over 80% of laboratories use the same AST guidelines.

E = 100% of laboratories use the same AST guidelines.

Relevance of Diagnostic Techniques

A = Information not available.

B = AST, bacterial isolation and identification protocols are not relevant or specific to the national AMR surveillance objectives.

C = Major modifications in the AST, bacterial isolation and identification protocols used are required to improve their adaptation to national AMR surveillance objectives.

D = Minor modifications in the AST, bacterial isolation and identification protocols used would improve their adaptation to the national AMR surveillance objectives.

E = AST, bacterial isolation and identification protocols are perfectly suited to the national AMR surveillance objectives.

Data Management

A = Information not available.

B = AST data are handled manually, or AST data management is not computerized in all laboratories of the network and/or there are problems in the recording of the samples and their traceability along the analysis chain.

C = Most laboratories of the network use computers to manage part of their data but major improvements in the system are required.

D = Some minor improvements may be made in some laboratories of the network for the computerized management of laboratory data (computerized transmission of data, input procedures, sample storage information, etc.).

E = All laboratories use optimal data management (e.g. samples and test results are identified using a complete computerized management system covering each step in the analysis chain, including the storage of epidemiological information, data validation protocol and the computerized transmission of results, conforming perfectly to the requirements of the national AMR surveillance system).

Although the guidelines for appropriate use of antimicrobials are available and national antimicrobial stewardship program has been implemented in some healthcare facilities (especially in human and animal health sectors), but monitoring and surveillance results have not been used to inform action and to update treatment guidelines and essential medicines lists. Therefore, some of strategies that will be done to address or overcome these challenges, such as: improve national multi-sectoral coordination, collaboration, and capacity (especially involving national reference laboratories); set up and use a standardized approach and protocol; develop One Health tools and training materials supported by mobile health application system; strengthen quality assurance processes in line with intergovernmental standards; promote research and development to address AMR. See table 3 for Progress on Antimicrobial Use and Stewardship (2016-17, 2017-18, 2018-19, 2019-20)

Country	Human Health				Animal and Crop Production	Plant Health	Animal Health			Plant Production
	2016-17	2017-18	2018-19	2019-20	2016-17	2017-18	2017-18	2018-19	2019-20	2019-20
Lao P.D.R	A	C	A	B	A	A	A	A	B	A
Cambodia	N/A	A	A	C	N/A	A	A	B	C	C
Myanmar	A	B	C	C	A	B	B	B	B	B
China	E	D	E	N/A	D	N/A	N/A	C	N/A	N/A
Thailand	B	C	D	N/A	C	B	C	C	N/A	N/A
Viet Nam	D	C	C	N/A	B	C	C	C	N/A	N/A

Table 3. Progress on Antimicrobial Use and Stewardship (2016-17, 2017-18, 2018-19, 2019-20)

2016-17

A = No/weak national policy & regulations for antimicrobial stewardship

B = National policy and regulations for antimicrobial stewardship developed & approved, that address use, availability and quality of antibiotics in the community and in health care settings.

C = National antimicrobial stewardship program is being implemented in some healthcare facilities. Planned legal/regulatory changes are being introduced to regulate access to antibiotics for human use.

D = Antimicrobial stewardship program is implemented in health care facilities nationwide. Legal/regulatory changes approved and publicized to regulate sales and products for human use, but not fully enforced. Antibiotic quality testing program operational.

E = Antimicrobial stewardship program is implemented in most health care facilities and in community. Regulations

are enforced on access to antibiotics and use in human health.
Monitoring and surveillance results are used to inform action and update treatment guidelines and essential medicines lists.

2017-18, 2018-19, 2019-20

A = No/weak national policies for appropriate use.

B = National policies for antimicrobial governance developed for the community and health care settings.

C = Practices to assure appropriate antimicrobial use being implemented in some healthcare facilities and guidelines for appropriate use of antimicrobials available.

D = Guidelines and other practices to enable appropriate use are implemented in most health facilities nationwide. Monitoring and surveillance results are used to inform action and to update treatment guidelines and essential medicines lists.

E = Guidelines on optimizing antibiotic use are implemented for all major syndromes and data on use is systematically fed back to prescriber

B. Existing Regional AMR Surveillance Systems

1. What is The Existing Capacity to Monitor AMR?

Most countries have the capacity to generate data (antibiotic susceptibility testing and accompanying clinical and epidemiological data) and reporting on antibiotic resistance; especially in human, animal, and food sectors). However, data collection in some countries still not used standardized approach and lacks national coordination and/ or quality management. Laboratory capacity and reporting AMR data for plant and environment sectors were still lacking in most countries. As part of the AMR surveillance system, the sustainable operation of the national laboratory network strengthening is through an established laboratory network, EQA measures in place, and demonstrated capacity of reference lab for research. Kindly see table 4 for progress on National Surveillance System for AMR (2016-17, 2017-18, 2018-19, 2019-20).

Country	Human				Animal and Food	Animal			Food			Plant	Environ-ment
	2016-17	2017-18	2018-19	2019-20	2016-17	2017-18	2018-19	2019-20	2017-18	2018-19	2019-20	2017-18	2017-18
Lao P.D.R	B	C	B	D	A	N/A	E	B	N/A	A	A	N/A	N/A
Cambodia	B	C	C	C	N/A	C	D	D	A	D	D	A	A
Myanmar	B	C	D	D	B	C	C	C	A	B	B	A	A
China	D	D	E	N/A	D	N/A	E	N/A	N/A	E	N/A	N/A	N/A
Thailand	D	C	D	N/A	B	C	C	N/A	C	C	N/A	B	B
Viet Nam	B	A	B	N/A	B	B	D	N/A	B	D	N/A	B	B

Table 4. Progress on National Surveillance System for AMR (2016-17, 2017-18, 2018-19, 2019-20)

Human Sector

(2016-17, 2017-18)

A = No capacity for generating data (antibiotic susceptibility testing and accompanying clinical and epidemiological data) and reporting on antibiotic resistance.

B = AMR data is collated locally for common bacteria, but data collection may not use a standardized approach and lacks national coordination and/or quality management.

C = National AMR surveillance activities are in place for common bacterial pathogens that link patient information with susceptibility testing, with a national reference laboratory that participates in external quality assurance.

D = There is a functioning national AMR surveillance system covering antibiotics in hospitals and outpatient clinics, with external quality assurance, and a national coordinating center producing reports on resistance levels.

E = The national AMR surveillance system integrates surveillance of AMR across sectors, and generates regular reports. The national surveillance system contributes data on AMR to the Global AMR Surveillance System (GLASS).

(2018-19, 2019-20)

A = No capacity for generating data (antibiotic susceptibility testing and accompanying clinical and epidemiological data) and reporting on antibiotic resistance.

B = AMR data is collated locally for common bacteria, but data collection may not use a standardized approach and lacks national coordination and/or quality management.

C = National AMR surveillance activities for common bacterial infections follow national standards, and a national reference laboratory that participates in external quality assurance.

D = There is a functioning national AMR surveillance system covering common bacterial infections in hospitalized and community patients, with external quality assurance, and a national coordinating center producing reports on AMR.

E = The national AMR surveillance system integrates surveillance of AMR across sectors, and generates regular reports covering at least one common indicator.

Non-Human Sector

(2016-17)

A = No national plan or system for monitoring AMR in animals, food and agricultural production.

B = AMR data is collected locally but may not use a standardized approach and lacks national coordination and/or quality assurance. Priority pathogens have been identified for surveillance.

C = Studies available on levels of resistance in at least 2 pathogens relevant for animals.

D = National system of surveillance of AMR established for relevant animal pathogens which follows quality assurance processes in line with intergovernmental standards. Laboratories that report for AMR surveillance follow quality assurance processes.

E = Data collected and reported on a regular basis on AMR in relevant pathogens for animals and in food.

(2017-18)

A = No national plan for a system of monitoring of AMR is available.

B = National plan for monitoring AMR but capacity (including laboratory) for surveillance and reporting data on AMR is lacking.

C = Some AMR data is collected locally but may not use a standardized approach and lacks national coordination and/or quality management.

D = Priority pathogenic/ commensal bacterial species have been identified for surveillance. Data systematically collected and reported on levels of resistance in at least 2 of those bacterial species, involving a laboratory that follows quality management processes, e.g. proficiency testing.

E = National system of surveillance of AMR established for priority pathogens and for relevant commensal bacteria which follows quality assurance processes in line with intergovernmental standards. Laboratories that report for AMR surveillance follow quality assurance processes.

(2018-19, 2019-20)

A = No national plan for a system of surveillance of AMR is available.

B = National plan for surveillance of AMR but capacity (including laboratory and for reporting data on AMR) is lacking.

C = Some AMR data is collected locally but may not use a standardized approach and lacks national coordination and/or quality management.

D = Priority pathogenic/ commensal bacterial (in animal) or priority food borne pathogenic/ indicator bacterial species (in food), which have been identified for surveillance. Data systematically collected and reported on levels of resistance in at least 1 of those bacterial species, involving a laboratory that follows quality management processes, e.g. proficiency testing.

E = National system of surveillance of AMR established for priority animal pathogens, zoonotic and commensal bacterial isolates (in animal), priority foodborne pathogens (in food), and/or relevant indicator bacteria which follows quality assurance processes in line with intergovernmental standards. Laboratories that report for AMR surveillance follow quality assurance processes

Coordination among organizations on AMR issues and budget support is still not optimal and strengthening the national AMR surveillance system with local investigation and response networks is needed. On the other hand; lack of awareness, capacity, and practice on AMR has not been followed by regular training on AMU and AMR. Even there is a lack of AMR pharmaceutical manufacturer for animals. Some capacity in AMR technical areas that need to be improved, such as: antimicrobial resistance detection, surveillance of infections caused by antimicrobial-resistant pathogens, health care-associated infection prevention and control programs, and antimicrobial stewardship activities. Because of lack of capacity, insufficiency resources in AMR program, and many people do multi-tasking; so there is still no national monitoring system for antimicrobial (sales / use) in human health, even less

progress on AMR program implementation. Only a few countries have systems designed for surveillance of antimicrobial use for human health, that includes monitoring national level sales or consumption of antibiotics in health services.

Therefore, strategies to improve national multi-sectoral coordination, collaboration, and capacity (especially involving national reference laboratories); set up and use a standardized approach and protocol is part of the proposed strategy needed to overcome challenges related to AMR monitoring capacity. On the other hand, one of the lessons learned that needs to be maintained is that countries not only conducted multi-stakeholder meetings, but also capacity building for data collection and analysis to support the guidelines for improvement and implementation of the national AMR surveillance system and strengthen collaboration within it. Multi-stakeholder collaboration to strengthen capacity and tools in data collection, storage, and analysis also supported the development of standardized AMR surveillance system guidelines. See table 5 for progress on National Monitoring for Antimicrobial Use (2016-17, 2017-18, 2018-19, 2019-20)

Country	Human Health				Animal and Crop Production	Animal			Plant Production		
	2016-17	2017-18	2018-19	2019-20	2016-17	2017-18	2018-19	2019-20	2017-18	2018-19	2019-20
Lao P.D.R	A	A	A	B	A	A	A	A	N/A	A	A
Cambodia	A	A	A	A	N/A	A	B	C	A	A	B
Myanmar	A	A	A	A	A	B	C	C	B	C	A
China	E	E	E	N/A	A	N/A	C	N/A	N/A	N/A	N/A
Thailand	B	B	C	N/A	B	B	C	N/A	C	B	N/A
Viet Nam	C	B	B	N/A	B	A	B	N/A	A	N/A	N/A

Table 5. Progress on National Monitoring for Antimicrobial Use (2016-17, 2017-18, 2018-19, 2019-20)

Human Health

A = No national plan or system for monitoring use of antimicrobials.

B = System designed for surveillance of antimicrobial use, that includes monitoring national level sales or consumption of antibiotics in health services.

C = Total sales of antimicrobials are monitored at national level and/or some monitoring of antibiotic use at sub-national level.

D = Prescribing practices and appropriate antibiotic use are monitored in a national sample of healthcare settings.

E = On a regular basis (every year/two years) data is collected and reported on:

a) Antimicrobial sales or consumption at national level for human use; and

b) Antibiotic prescribing and appropriate/rational use, in a representative sample of health facilities, public and private

Animal Health and Crop Production

A = No national plan or system for monitoring use of antimicrobials in animal or crop production.

B = Plan agreed for monitoring quantities of antimicrobials used in animals, based on OIE standards.

C = Implementation of plans to monitor sales, consumption and type of use (therapeutic or growth promotion).

D = Data collected and reported on national sales or consumption of antimicrobials for animal production.

E = On a regular basis, data is collected and reported

Animal Health

A = No national plan or system for monitoring sales/ use of antimicrobials in animals.

B = Plan agreed for monitoring quantities of antimicrobials sold for/ used in animals, based on OIE standards5.

C = Data collected and reported on total quantity of antimicrobials sold for/used in animals and their intended type of use (therapeutic or growth promotion).

D = On a regular basis, data is collected and reported to the OIE on the total quantity of antimicrobials sold for/used in animals nationally, by antimicrobial class, by species (aquatic or terrestrial), method of administration, & by type of use (therapeutic/ growth promotion).

E = Data on antimicrobials used under veterinary supervision in animals are available at farm level, for individual animal species.

Plant Production

A = No national plan or system for monitoring use of pesticides used for the purpose of controlling bacteria or fungal diseases.

B = Plan agreed for monitoring quantities of pesticides used for the purpose of controlling bacteria or fungal diseases.

(C to E on 2017-18)

C = Data collected and reported on quantity of AM used in some subsectors of plant production.

D = Data collected and reported on total quantity of AM used nationally in plant production.

E = On a regular basis, data is collected and reported on total quantity of AM use in crop production, by AM class.

(C to D on 2018-19, 2019-20)

C = Data collected and reported on total quantity of pesticides including antimicrobial pesticides such as bactericides and fungicides sold/ used nationally for the purpose of controlling bacteria or fungal diseases.

D = On a regular basis, data is collected and reported on quantity of pesticides including antimicrobial pesticides such as bactericides and fungicides sold/used in plant production for the purpose of controlling bacteria or fungal diseases, disaggregated by class of active ingredient and plant type/species.

2. What does data management and sharing look like?

Cambodia, Lao P.D.R and Myanmar have multi-sectoral coordination committee in charge of availability and access of AMR data to support national monitoring and surveillance system. Countries also more likely to have multi-sectoral working groups/ or coordination committee in charge of national AMR strategy reviews data to amend national strategy and/ or information decision making (at least annually) for human health, animal health, and food production sectors. National AMR surveillance system has been established by involving multi-sectoral working groups, supported by a AMR data management system, and routinely carried out (even until at the healthcare setting level) in coordination with the national reference laboratory. Those progresses reflect the maturity and level of investment in AMR programs. Kindly see table 6 for progress on National AMR Strategy Data Reviews (2018-19, 2019-20)

Country	Human Health		Animal Health		Plant Health	Food Production	Food Safety	Environment
	2018-19	2019-20	2018-19	2019-20	2019-20	2019-20	2019-20	2019-20
Lao P.D.R	No	Yes	No	Yes	No	No	No	No
Cambodia	No	No	No	Yes	No	Yes	Yes	No
Myanmar	No	Yes	No	Yes	No	Yes	No	No
China	Yes	N/A	Yes	N/A	N/A	N/A	N/A	N/A
Thailand	Yes	N/A	Yes	N/A	N/A	N/A	N/A	N/A
Viet Nam	No	N/A	No	N/A	N/A	N/A	N/A	N/A

Table 6. Progress on National AMR Strategy Data Reviews (2018-19, 2019-20)

Monitoring and data collection has been developed for plant production (including antimicrobial pesticides i.e. bactericides and fungicides) and animals (by type of use i.e. therapeutic or growth promotion). Progress for data collection systems on animal health, plant health, food production, food safety, and environment were required to support existing monitoring and surveillance systems,

although steady progress was being achieved on antimicrobial use data intended for use in human and animal health. On the other hand; data management for AMR surveillance system in some laboratory network has been computer-based, but systems still don't have data validation protocol.

Multi-sectoral strategy is needed that not only can strengthen links and coordination between national AMR surveillance with local surveillance and response systems, but also can strengthen integrated AMR surveillance and monitoring systems with robust and reliable data to improve AMR programs/ interventions. Understanding and utilization of AMR data needs to be improved (i.e. through capacity building in generating AMR data, piloting AMR surveillance, standardized guidelines, software development, reporting system) to support further policy engagement and resource allocation for AMR intervention. Multi-stakeholder collaboration to strengthen capacity and tools in data collection, storage, and analysis actually also can supported the development of standardized AMR surveillance system guidelines. See table 7 for progress on Relevance of Diagnostic and Data Management in AMR Surveillance System (2018-19, 2019-20).

Country	Relevance of Diagnostic Techniques		Data Management	
	2018-19	2019-20	2018-19	2019-20
Lao P.D.R	A	A	E	B
Cambodia	C	C	C	C
Myanmar	B	B	B	B
China	E	A	D	B
Thailand	D	C	C	C
Viet Nam	B	B	A	B

Table 7. Progress on Relevance of Diagnostic and Data Management in AMR Surveillance System (2018-19, 2019-20)

Relevance of Diagnostic Techniques

A = Information not available.

B = AST, bacterial isolation and identification protocols are not relevant or specific to the national AMR surveillance objectives.

C = Major modifications in the AST, bacterial isolation and identification protocols used are required to improve their adaptation to national AMR surveillance objectives.

D = Minor modifications in the AST, bacterial isolation and identification protocols used would improve their adaptation to the national AMR surveillance objectives.

E = AST, bacterial isolation and identification protocols are perfectly suited to the national AMR surveillance objectives.

Data Management

A = Information not available.

B = AST data are handled manually, or AST data management is not computerized in all laboratories of the network and/or there are problems in the recording of the samples and their traceability along the analysis chain.

C = Most laboratories of the network use computers to manage part of their data but major improvements in the system are required.

D = Some minor improvements may be made in some laboratories of the network for the computerized management of laboratory data (computerized transmission of data, input procedures, sample storage information, etc.).

E = All laboratories use optimal data management (e.g. samples and test results are identified using a complete computerized management system covering each step in the analysis chain, including the storage of epidemiological information, data validation protocol and the computerized transmission of results, conforming perfectly to the requirements of the national AMR surveillance system).

3. How are Results of AMR Surveillance Shared? Between Sectors? Across Sectors and With Public?

Progress on NAP-AMR implementation indicators from national monitoring and surveillance data (including TrACSS and pilot results) will be compared and consistently evaluated by the national committee in coordination with joint external evaluations (JEE) to improve AMR intervention/ program and standardized treatment. Dedicated units will analyze the data and share the information with relevant stakeholders is one of the steps in improving the use of surveillance data in decision-making [16]. Therefore, sustainability of knowledge sharing from AMR surveillance data can't be separated from strengthening efforts to drive multi-sectoral and One Health agendas through investments and engagement across sectors.

Some cross-sector ministries and working groups are involved not only in the development and implementation of NAP-AMR, but also in the AMR country self-assessment survey with all related multi stakeholders across sectors as well. Prescribing practices and appropriate antibiotic use are monitored not only at the national or sub-national level but also in healthcare settings both public and private. Countries also more likely to have multi-sectoral working groups/ or coordination committee in charge of national AMR strategy reviews data to amend national strategy and/ or information decision making (at least annually) for human health, animal health, and food production sectors.

As a component of AMR surveillance system, data review is closely related to data use, data linkage, and data governance. Sentinel site functions for AMR surveillance systems vary depending on the level based on their respective capacities, as follows [15]: Kindly see table 8 for Sentinel Site Functions for Data Review on Antimicrobial Resistance Surveillance

Overall Aim	Requirements and Standards For Core Level	Extended Level Activities	Advanced Level Activities
Data Usage	Anonymised individual data submitted to national coordinating centre and shared regionally and internationally	-	Automated real time submission of data to national network
Data Linkage	Clinical and laboratory data linked by recording them on same lab request form	Automated linkage between clinical request data and laboratory data	Automated linkage between clinical and laboratory databases
Data Governance	Data sharing policy and agreements in place in collaboration with the Ministry of Health and/or national public health institute	-	-

Table 9: Sentinel Site Functions for Data Review on Antimicrobial Resistance Surveillance (Core, Extended, Advanced)

Epidemiological and statistical validity and quality assurance are needed, so that the data can be used, shared and combined to provide reliable evidence of AMR prevalence and to evaluate effectiveness of

interventions [15]. Therefore, the result of AMR surveillance will be disseminated not only with/ and for multi-sectors involved in data collection and analysis, but also across other related sectors. Those results of the AMR surveillance system have contributed to development of multi-sectoral NAP-AMR and its guidelines through several workshops and consultative meetings across sectors. Development of multi-sectoral NAP-AMR and its guidelines is followed by identifying national surveillance system progress and the adoption of "AWaRe" tools. Some AST performing laboratories are integrated in the national AMR surveillance system as well. Engagement in large multi-sectoral and One Health working groups was associated with greater progress in implementation across all sectors and reported to have more advanced systems for taking action to address AMR.

4. What are the Protocols for Response when AMR is Detected?

Existing standardized, harmonized, and integrated AMR surveillance system guideline and protocol will be followed for AMR detected. Those AMR data will be used for the multi-sectoral NAP-AMR development in national level and for programs / interventions development in the community and health facility levels. However; coordination among organizations on AMR issues and budget support, play an important role in the sustainability of national AMR surveillance systems both in human and non-human sectors. As part of protocol, strengthening the national AMR surveillance system with local investigation and response networks still needs to be improved. AMR's national surveillance system has been established accompanied by the development of laboratory capacity and AMR data management system.

5. Is There a Regional One-Health Approach to AMR Surveillance?

A One Health approach – incorporating humans, animals, plants and the broader environment – is needed to ensure adequate action. Given the need to coordinate action among these sectors, government engagement is imperative. Some cross-sector ministries and working groups are involved not only in the development and implementation of NAP-AMR, but also in the AMR country self-assessment survey with all related multi stakeholders across sectors as well. This is showed the commitment in strengthening multi-sectoral and One Health collaboration/ coordination.

Country	2016-17	2017-18	2018-19	2019-20
Lao PDR	B	B	B	B
Cambodia	C	C	C	C
Myanmar	A	B	D	D
China	E	E	E	N/A
Viet Nam	B	E	E	N/A
Thailand	B	B	B	N/A

Table 10. Progress on Multi-sectoral and One Health Collaboration/ Coordination (2016-17, 2017-18, 2018-19, 2019-20)

A = No formal multi-sectoral governance or coordination mechanism on AMR exists.
B = Multi-sectoral working group(s) or coordination committee on AMR established with Government leadership.
C = Multi-sectoral working group(s) is (are) functional, with clear terms of reference; regular meetings, and funding for working group(s). Activities and reporting/accountability arrangements are defined.
D = Joint working on issues including agreement on common objectives.

E = Integrated approaches used to implement the national AMR action plan with relevant data and lessons learned from all sectors used to adapt implementation of the action plan.

Countries have large multi-sectoral working groups for One Health collaboration that are not only functional but also funded and defined clear activities. On the other hand, all sectors (i.e. human health, animal health, plant health, food production, food safety, and environment) are actively involved in developing and implementing NAP-AMR. Those NAP-AMR are also linked to any other existing action plans, strategies or targets related to HIV, Tuberculosis, Malaria, sexually transmitted diseases; but still less on neglected tropical diseases.

In order to optimize antimicrobial use and antimicrobial stewardship; national policies and guidelines for appropriate use have been developed and implemented for human health, animal health, and plant production. Guidelines and operational plans for infection prevention and control programs are also available and implemented. Country legations on antimicrobial use that have been developed include regulation on prescription and sale of antimicrobials for human use, on prohibits the use of antibiotics for growth promotion in the absence of risk analysis, and on marketing of pesticides including antimicrobial pesticides in plant production. Therefore, harmonization between national and global surveillance systems need to be made to standardize methodology data to embrace a broader One Health approach.

Country	Human Health			Animal Health			Plant Health			Food Production			Food Safety			Environment		
	2017-18	2018-19	2019-20	2017-18	2018-19	2019-20	2017-18	2018-19	2019-20	2017-18	2018-19	2019-20	2017-18	2018-19	2019-20	2017-18	2018-19	2019-20
Lao P.D.R	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	N/A
Cambodia	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes
Myanmar	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
China	Yes	Yes	N/A	Yes	Yes	N/A	Yes	Yes	N/A	Yes	Yes	N/A	Yes	Yes	N/A	Yes	Yes	N/A
Viet Nam	Yes	Yes	N/A	Yes	Yes	N/A	Yes	Yes	N/A	Yes	Yes	N/A	Yes	Yes	N/A	Yes	Yes	N/A
Thailand	Yes	Yes	N/A	Yes	Yes	N/A	No	No	N/A	No	No	N/A	No	No	N/A	No	No	N/A

Table 11. Progress to Involved Sectors in Developing and Implementing NAP-AMR (2016-17, 2017-18, 2018-19, 2019-20)

All TrACSS related questionnaires are can be seen in Annex B.

C. Regional Detection and Lab Capacity

1. Access to Microbiology Laboratory Services

The AMR national surveillance system has been established accompanied by the development of laboratory capacity and the AMR data management system. Most of the hospitals have their own clinical microbiologists and culture & sensitivity tests. The national laboratory assessment determined the availability of diagnostic capacity at the national level for virology, bacteriology, parasitology, microbiology, and antimicrobial susceptibility (AST). Laboratory capacity for water and food testing need to be strengthened. Although national AMR surveillance activities in the human and animal sectors have been followed by national standards, but not all AST laboratories are linked to a national network

coordinated by the National Reference Laboratory. On the other hand, there is limited coordination among ministries, vertical programs, partners, and institutions regarding laboratories and surveillance systems. Therefore, it is important to strengthen the role of the national AMR laboratory network in the integrated national AMR surveillance system. It is also necessary to strengthen links and coordination between national AMR surveillance with local surveillance and response systems.

2. Quality Assurance Dx tests, ID and Susceptibility

Quality assurance should be led by national coordinator and country technical team in country, in conjunction with external organizations as appropriate. At a core level, all site procedures should be undertaken according to SOPs, adapted from national SOPs, and based on these guidelines. Alongside these, quality control (QC) and QA procedures should be established to ensure that the data produced are accurate and reliable [15]. Sustainable operation of the national laboratory network strengthening is through an established laboratory network, EQA measures in place, and demonstrated capacity of reference lab for research.

Based on TrACSS data (point B); national AMR surveillance activities in most countries have in place for common bacterial pathogens that link patient information with susceptibility testing, with a national reference laboratory (NRL) that participates in external quality assurance. However, existing antimicrobial susceptibility testing (AST), bacterial isolation and identification protocols still not relevant or specific to the national AMR surveillance objectives. Other areas of the laboratory which impact the quality of diagnostic, such as:, training and supervision, supplies, quality management, and laboratory biosafety require significant improvements. Therefore, some training related to standard methodology for identification, sampling, isolation, testing bacteria/ pathogens; update of AMR and AMU issue and best practice; and laboratory quality management system had been conducted. Several efforts that are currently being developed to overcome AMR issues are not only related to improving national multi-sectoral coordination, collaboration, and capacity (especially involving national reference laboratories); but also strengthen the quality assurance processes in line with intergovernmental standards and promote research and development.

3. Regulatory Issues

Country legislations on antimicrobial use that have been developed include regulations on prescription and sale of antimicrobials for human use, on prohibits the use of antibiotics for growth promotion in the absence of risk analysis, and on marketing of pesticides including antimicrobial pesticides in plant production. Even though animal health sector is actively involved in developing and implementing NAP-AMR, however country legislations on prescriptions and sales of antimicrobials for animal use have not yet been developed.

Based on the risk for AMR transmissions, legislation and / or regulations to prevent contamination of the environment with antimicrobials have already addressed specifically for AMR in all risk for AMR transmissions, except wastewater discharges from manufacturing sites for antimicrobial agents (either as Active Pharmaceutical Ingredient (API) or finished products). Most legislation and / or regulations to prevent contamination of the environment with antimicrobials also have an impact on AMR in all risks

for AMR transmission. Those legislation and/ or regulations also have functioning systems for monitoring compliance and enforcement in all risk for AMR transmission, except wastewater discharges from manufacturing sites for antimicrobial agents (either as Active Pharmaceutical Ingredient (API) or finished products).

Based on the situational analysis report, the existing policies and structures in most countries have supported activities related to research on the prevention and containment of AMR, while still in the process of strengthening the integration of research to supporting evidence-based policy decisions. To prepare for this, every countries need to have well-established infrastructure, equipment, skilled manpower and funds for R&D both from domestic and international donors.

D. AMR in This Region

1. What do we know about AMR currently?

Cambodia, Lao P.D.R and Myanmar already have national surveillance system for AMR as part of NAP-AMR that has been developed. Those systems are followed by the development of policy strategies, national multi-sectoral steering committee, and AMR surveillance system guidelines. Most countries already have a national surveillance system for AMR; while progress in human and animal sectors are faster than food, plant and environment sectors. This could be due to lack of national coordination, standardized approach, and quality management. National AMR surveillance activities in the human and animal sector have been followed by national standards and involve national reference laboratories (NRL). Therefore, prescribing practices and appropriate antibiotic use are monitored not only at the national or sub-national level but also in healthcare settings.

AMR surveillance is routinely undertaken among countries that have progress on national surveillance systems for AMR in animal and food sectors. However, existing antimicrobial susceptibility testing (AST), bacterial isolation and identification protocols still not relevant or specific to the national AMR surveillance objectives. On the other hand, data management for AMR surveillance system in some laboratory network has been computer-based but still don't have data validation protocol. As part of AMR surveillance system, the sustainable operation of the national laboratory network strengthening is through an established laboratory network, EQA measures in place, and demonstrated capacity of reference lab for research.

2. What are the primary drivers of AMR? How do we know?

Routine culture and sensitivity tests from sentinel were sent to their laboratory where AMR data were put into WHO-net system. All staffs and professionals involved in AMR surveillance had already been trained how to use WHO-net software and how to analyze data. After data collection, those data were sent to National AMR Coordination Center (NCC) quarterly. Some primary drivers of AMR that can be considered, such as:

a) Over-prescription of antibiotics
b) Patients not finishing the entire antibiotic course
c) Overuse of antibiotics in livestock and fish farming

d) Poor infection control in health care settings
e) Poor hygiene and sanitation.

Some activities for updates related to primary drivers of AMR are done through literature review, national and international meeting and conferences, discussion and knowledge sharing, and research. The GAP-AMR has identified research and innovation as a key strategic objective so that evidence can be generated to guide current and future containment efforts. In order to support sustainable operation, government should led research outputs related to AMR global and national research agenda. Most countries are yet to put together a strategic research agenda that is relevant to current policies and programs, and address implementation challenges facing AMR containment efforts. Therefore, it is necessary to prioritize AMR strategic research agendas that can strengthen AMR containment program delivery.

3. What are the organisms causing disease, driving AMR and AMU, and serving as reservoirs?

Coordinating AMR laboratories should be accredited, or be working towards laboratory accreditation. Some of the functions of the coordinating AMR laboratory are: a) participation in internal and external quality assurance; b) provision of a reference service for core organism / antimicrobial combinations as a minimum, for borderline isolates or isolates with unexpected or unusual resistance profiles, and collaboration with international centers to monitor emerging resistance patterns; c) assisting sentinel site laboratories to procure equipment and reagents, in collaboration with the NCC; d) maintaining a biorepository for bacterial isolates [15].

Coordinating AMR laboratory with NCC monitored and analyzed all pathogens, particularly WHO high priority pathogens such as: Acinetobacter species, Pseudomonas species, Enterobacteriaceae, Enterococcus species, Staphylococcus aureus, Neisseria gonorrhoeae. In addition, national data of 8 GLASS priority pathogens including Acinetobacter species, E. coli, K. pneumonia, Samonella spp., S. aureus, S. pneumonia, Shigella spp., and N. gonorrhoea were uploaded to GLASS. Some type of resistance based on those bacteria, such as: Carbapenem-resistant, ESBL producing, Vancomycin-resistant, Methicillin-resistant, Cephalosporin-resistant, fluoroquinolone-resistant. The metada set of invasive pathogen [30,31] which mostly available, including:

Invasive Pathogen	Antimicrobial
GLASS pathogen	
Gram-negative	
Acinetobacter baumannii	3GC, Carbapenem, Multidrug
Escherichia coli	AMP–GEN, AMP, GEN, 3GC, Carbapenem, Multidrug
Klebsiella pneumoniae	AMP–GEN†, 3GC, Carbapenem, Multidrug
Non-Typhoid Salmonellae	FQ, CRO, MDR, FQ and multidrug
Salmonella Paratyphi A	FQ, CRO, MDR, FQ and multidrug
Salmonella Typhi	FQ, CRO, MDR, FQ and multidrug
Gram-positive	
Staphylococcus aureus	MET, VAN
Streptococcus pneumoniae	Penicillin, MAC/LIN, MDR

Invasive Pathogen	Antimicrobial
Non-GLASS pathogen	
Burkholderia pseudomallei	CAZ, TMP/SXT
Enterobacter cloacae	AMP–GEN, 3GC, Carbapenem, Multidrug
Group A Streptococcus	MAC/LIN
Haemophilus influenzae	AMP, CRO, Multidrug
Neisseria meningitidis	CRO
Pseudomonas aeruginosa	CAZ, Carbapenem, Multidrug

Table 12. Common Invasive Pathogen on Surveillance System of AMR and AMU

3GC, third-generation cephalosporin; AMP–GEN, resistance to both ampicillin and gentamicin; CAZ, ceftazidime; CRO, ceftriaxone; FQ, fluoroquinolone; MDR, multidrug resistant; MAC/LIN, resistance to macrolides and/or lincosamides; MET, methicillin; TMP/SXT, trimethoprim/sulfamethoxazole; VAN, vancomycin. †K. pneumoniae is intrinsically resistant to AMP, and thus AMP–GEN resistance in K. pneumoniae isolates is equivalent to GEN resistance

National AMR surveillance programs should not be limited to the following bacteria-antimicrobial drug combinations in compliance with the GLASS manual [7,15], such as:

a) Escherichia coli vs. 3rd generation cephalosporins and fluoroquinolones;
b) Klebsiella pneumoniae vs. 3rd generation cephalosporins and carbapenems;
c) Staphylococcus aureus vs. oxacillin or cefoxitin;
d) Streptococcus pneumoniae vs. penicillin or oxacillin;
e) Salmonella species vs. fluoroquinolones;
f) Shigella species vs. fluoroquinolones;
g) Neisseria gonorrhoeae vs. 3rd generation cephalosporins

Ideally, antimicrobial susceptibility testing for priority pathogens should be carried out in line with international standards [15]. However, the information collected still could not explain whether participating countries had considered the European Committee on Antimicrobial Susceptibility Testing (EUCAST) methodology and guidance (www.eucast.org); and whether participating countries have implemented the Clinical and Laboratory Standards Institute (CLSI) guidelines. Unless automated systems are already in place, antimicrobial susceptibility testing at the core level should be performed using the disc diffusion method.

4. What interventions exist to address AMR at the regional level?

Cambodia, Lao P.D.R and Myanmar are at different stages in responding to the growing threat posed by AMR. GAP-AMR was adopted in 2015 by all countries through decisions in the World Health Assembly, The Food and Agriculture Organization of The United Nations (FAO) Governing Conference Governing Conference and The World Organization for Animal Health (OIE) [32–34]. All countries approved the GAP-AMR and agreed to develop and implement NAP-AMR by 2017. The UN General Assembly also called upon WHO, FAO, OIE, regional and multilateral development banks, UN agencies, and civil society

to support the development and implementation of national action plans and AMR activities at the national, regional, and global levels [35]. This has been done through the development of One Health tools and training materials [36].

The World Health Assembly has also called on the WHO, FAO, OIE and other relevant partners to develop a framework for monitoring and evaluation to assist with the achievement of GAP Principle. As part of their response, WHO, OIE and FAO created a national self-assessment survey containing questions structured around the objectives of the GAP. Those survey database are available at http://www.who.int/antimicrobial-resistance/global-action-plan/database/en/ . Going forward, the momentum thus achieved will be sustained through stronger multi-sectoral collaboration, including the creation of platforms that can enable joint planning, exchange of surveillance information and sharing of resources [2].

The tripartite (WHO, FAO and OIE) has developed a draft approach for monitoring and evaluation of the GAP-AMR. The purpose of this global monitoring is to review and summarize country progress in implementing key actions to address AMR, for reporting annually at global and regional level. The Regional Office has established baseline data for national AMR control programs to measure progress [37]. It is also intended to encourage national-level review of country progress and help identify priorities for next steps. The country responses will also be used to guide follow-up actions and identify areas where assistance and support is required. This will help to provide a picture of the stage the country has reached in building an effective and sustainable multi-sectoral response to AMR. It may also stimulate discussion at country level on how to increase progress [18–21].

In the regional level; not only stakeholder mapping on antimicrobial use and updating the NAP-AMR, but also several activities to strengthen AMR campaigns and resilience among smallholder farmers have been carried out. Some investments in supporting vaccination and M&E (Global Fund, ADB, GAVI), engaging the food and agriculture sectors to combat AMR using a One Health approach (FAO-FF AMR Project), and technical assistance for monitoring on antimicrobial consumption/ usage have also been conducted. There has been an increasing involvement, investment and contribution from the private sector and non-conventional donors that need harmonization. Donor-funded projects and NGOs have kept service delivery at fair levels, however integration with district-level planning and coordination could be further improved that followed by knowledge-sharing improvement.

Coordination on programs and interventions that have been conducted by AMR team in each country were developing national AMR strategic plan, strengthening the relevance of diagnostic (bacteriology) techniques used by laboratories included in AMR surveillance system, capacity building and piloting national assessment of risks for AMR transmission in the environment and pollution control, and improved progress on adoption of "AWaRe" classification of antibiotics in National Essential Medicines List so be able to be monitored and incorporated into antimicrobial stewardship strategies. Some activities and donor collaboration also has been coordinated by the national AMR focal in member countries. On the other hand; training related to standard methodology for identification, sampling, isolation, testing bacteria/ pathogens; update of AMR and AMU issue and related best practice; and laboratory quality management system had been conducted as well.

Discussion on Identified Gaps

1. What Protocols Were Identified as Needed (According to the Literature Review and Key Stakeholders), But Do Not Exist or Are Not of Good Quality?

The Following Figure shows the interconnected and integrated One Health surveillance framework that puts at its center antimicrobial resistance and antimicrobial consumption [17]. The integrated, harmonized, and standardized protocols need to be developed by taking into account the domain of effectiveness and efficiency of the AMR surveillance system. Guidelines related to the implementation of the tricycle program, laboratory-based AMR surveillance system, antimicrobial stewardship and AMR data management (data collection and usage) can also be encouraged. On the other hand, data on treatment outcomes also important to better inform prescription practice and guidelines. Develop evidence-based guidance on effective interventions at clinical, health systems and policy levels which priorities are to: review treatment guidelines and essential medicines lists and measure the need to access essential medicines.

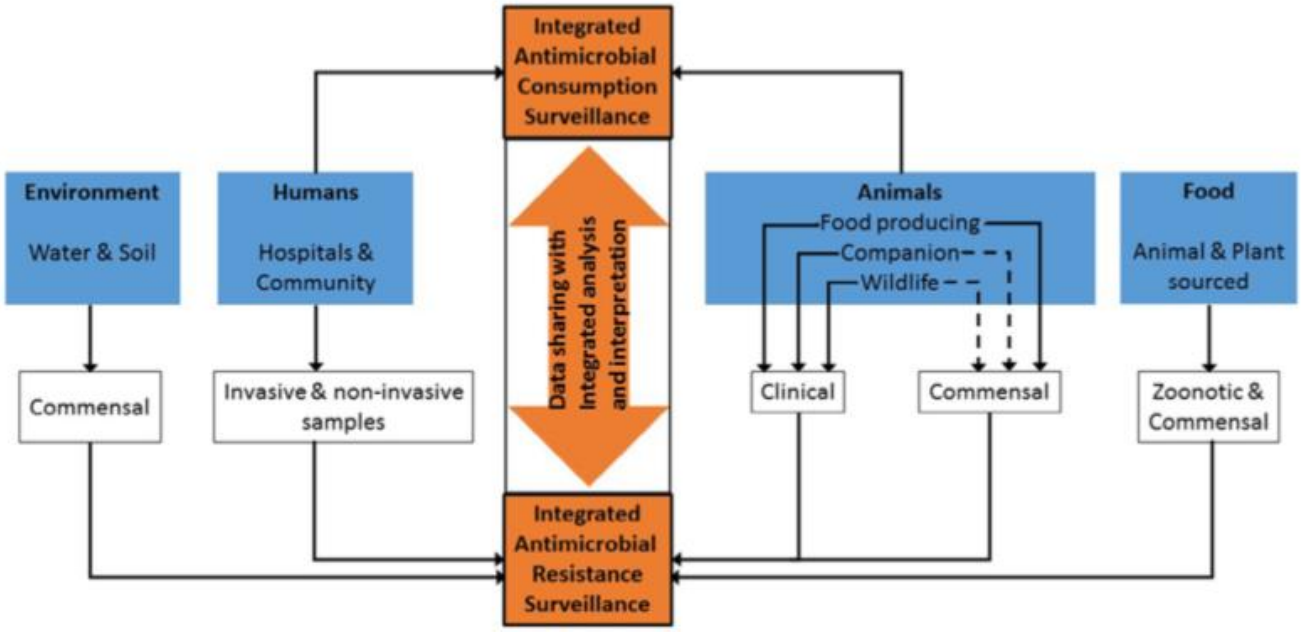

Figure 4: Interconnected and integrated One Health Surveillance Framework (Source: Queenan et al, 2016)

2. Detection and Lab Capacity to Implement Needed Protocols

Strengthening surveillance and laboratory capacity is one of the six points in the WHO policy package launched on World Health Day 2011. Key challenges identified in package included poor infrastructure and data management, low coverage of surveillance, lack of intersectoral cooperation and inadequate international collaboration [16]. The development of an integrated AMR surveillance system should also explain technically how to integrate and synchronize multi-sectoral detection and laboratory capacity that takes into account the One Health approach. Independent training guidelines for local capacity development will also support the implementation of the integrated AMR surveillance system. Protocol

to evaluate and quality check microbiological and epidemiological results, and establish an alert system in surveillance systems also need to be considered.

3. Data Sharing Agreements Needed

The challenges in persuading countries and networks to share data were discussed briefly. It was important to clearly explain to data providers the benefits of contributing to a wider WHO data-collection exercise. Providing incentives might be considered by offering something in return (e.g. assistance with the use of WHONET). The ANSORP experience was also noted, where the benefits for data sharers can be scientific (e.g. co- authorship of a paper), financial (for certain projects) or professional (e.g. ability to use data for their own purposes, slides and lectures). Generally, there is a willingness to share data, but establishing a clearly defined and open relationship between the data managers and the data providers is critical for the development of any global system [16].

There are gaps in information on antibiotic use data; such data are necessary for appropriate action. The challenge in collecting these data surrounds the differing needs of each region, and issues of confidentiality for data sharing. Existing agreements on data sharing need to be strengthened by involving cross sectors, especially those involved in the development and implementation of NAP-AMR. A platform that integrates data sources and data references from all sectors will also support a commitment to strengthening data sharing to address AMR. Have consensus on data sharing is one component of and collaboration for effective surveillance systems; and this requires political support and functional national systems.

Country Level

Cambodia – National Level

A. Existing national level guidance and protocols on AMR surveillance (including the National AMR Action Plan) and stakeholders
   - National Policy to Combat AMR 2015-2017
   - National Strategy to Combat AMR 2015-2017
   - National Standard Operation Procedure (SOP) for Laboratory-Based Antimicrobial Surveillance November 2017
   - Multi-Sectoral Action Plan on AMR 2019-2023
   - Stakeholders:
     - Cambodian Department of Communicable Disease Control (CCDC), Department of Hospital Services(DHS), National Institute of Public Health (NIPH), Ministry of Health
     - Partners: WHO, US CDC, KOICA, DMDP, Pasteur, Sentinel Sites.

B. Existing national AMR surveillance system(s)

   1. What is the existing capacity to monitor AMR?
      a. Pathogens monitored and how
         - Blood: *E.colik K.pneumoniae, Acinetobacter* spp., *S.aureus, S.pneumoniae, Salmonella* spp., *B.pseudomallei*
         - CSF: Any bacteria.

      b. Frequency of reporting and to whom
         - Frequency of reporting: Monthly
         - To whom: Local users (IPC/AMS), National WG for AMR, and GLASS and relevant stakeholders.

   2. What is the structure of the database for AMR surveillance data?
      a. Who has access to the information?
         - AMR Sentinel Sites
         - National AMR Working Group.

      b. How is it used?
         - Local use of the AMR data to strengthen the Hospital Therapeutic Committee and Hospital's Infection Prevention and Control Committee
         - National use of the AMR data to design the national policy and strategy to combat AMR
         - Sharing the AMR data with the international community (GLASS).

3. How are results of AMR surveillance shared? Between sectors? Across sectors and with public?
    - The results have been shared locally between the microbiology lab staff and the IPC/AMS committee and between the microbiology lab staff and the National AMR Surveillance Team/National AMR Working Group
    - The AMR Data was shared during different forums including the mid-year, annual, 2-years findings workshops and national conferences as well as during the international conferences
    - The 2018 national AMR data was also shared between Cambodia and GLASS for the first time. The 2019 national data also was also shared
    - The annual antibiotic awareness was held every year to raise awareness about the AMR targeting the public and other relevant stakeholders.

4. What are the protocols for response when AMR is detected?
    - The MOH made the national policy and strategy to combat AMR and a national Multi-Sectoral Action Plan on AMR 2019 -2023
    - At the hospital level, the AMS and IPC committee made use of the AMR data to strengthen the rational use of the antibiotics and the IPC practices.

5. Is there a One Health approach to AMR surveillance?
    - There is a tentative agenda to enhance the implementation of the One Health Approach in the AMR surveillance as highlighted in the National Multi-Sectoral Action Plan, BUT not yet elaborated and implemented on the ground.

C. JEE and or GLASS country results, as applicable

Antimicrobial resistance	P3.1 Antimicrobial resistance detection	3
	P3.2 Surveillance of infections caused by antimicrobial-resistant pathogens	2
	P3.3 Health care associated infection prevention and control programmes	2
	P3.4 Antimicrobial stewardship activities	2

D. National detection and lab capacity

1. Access to microbiology laboratory services

In addition to their traditional role supporting disease diagnosis and patient treatment, laboratories also play an essential role in disease surveillance, preparedness, prevention and outbreak response. In the assessment of the national laboratory system performed in 2013, public health functions received the lowest average score (30%) among 22 laboratories assessed. This indicates that most laboratories are focused on diagnosis to support patient treatment and do not actively participate in public health activities such as surveillance,

notification and reporting of events of public health importance, and outbreak response. The National Institute of Public Health (NIPH) and Institute Pasteur du Cambodge (IPC) have been officially designated as reference laboratories and actively participate in surveillance and outbreak response. An extensive list of laboratory tests is available in the national reference laboratories, which allows for most diagnostic tests to be performed in the country.

The national laboratory assessment determined the availability of diagnostic capacity at the national level for virology (90%), bacteriology (83%), parasitology (75%), microbiology (58%), and antimicrobial susceptibility (50%). Laboratory capacity for water (25%) and food (25%) testing need to be strengthened. Likewise, there is limited capacity for the diagnosis of Leptospira, Chikungunya, and Rotavirus.

There is limited coordination among ministries, vertical programs, partners, and institutions regarding laboratories and surveillance systems. The national referral system and specimen transportation are not standardized and several parallel transportation systems exist (e.g., SARI/ILI, TB, HIV (CD4)).

Planned activities to strengthen public health functions of the laboratory including microbiology are:

- Strengthen laboratory support for disease surveillance, preparedness, prevention and outbreak response:
- Develop and publish a national flowchart outlining the integrated public health functions of reference and referral laboratories
- Develop guidelines stating the roles and responsibilities of laboratories during outbreaks and emergencies
- Formalize the roles, responsibilities, and activities included in the collaboration between CDC, NIPH, and partner organizations in the context of disease surveillance, preparedness, prevention, and outbreak response
- Ensure the minimum requirements for laboratory services comply with International Health Regulations (IHR)
- Review the overall requirements for detection, differentiation and confirmation of pathogens of public health importance in different tiers of the laboratory system and integrate the results into the CPA guidelines
- Strengthen laboratory capacity in referral hospitals for detection of pathogens of public health importance to support surveillance and outbreak response
- Establish a national specimen referral and transportation system by integrating specimens for TB, HIV/AIDS, Malaria, SARI/ILI, and other surveillance systems into a single system with regular schedules and pre-determined routes
- Develop disease notification guidelines for laboratories, covering all diseases of public health importance

- Integrate all referral laboratories into a laboratory-based surveillance system
- Support development of a national laboratory surveillance system that integrates human, animal, foodborne, waterborne, and environment surveillance data.

2. Quality Assurance Diagnostic tests, ID and susceptibility

The national assessment of 22 laboratory facilities performed in 2013 showed that clinical (68%) and microbiology (78%) diagnostics are available in most facilities assessed. However, other areas of the laboratory which impact the quality of diagnostics – namely, training and supervision (45%), supplies (47%), quality management (47%) – and laboratory biosafety (48%) require significant improvements.

Planned activities for this area are as follows:

- Establish a system to regularly assess the status of laboratories:
- Use a rotation schedule to perform a national assessment of half of all laboratories in national and provincial referral (CPA3) hospitals every year using an existing laboratory assessment tool adapted to Cambodia and disseminate the results. Include CPA2 facilities as soon as possible
- Develop a standard assessment checklist that can be used by laboratories and supervisors for internal audits in order to monitor laboratory status and prepare for national assessments
- Document regular biorisk assessments in laboratories and ensure compliance with minimum laboratory biosafety standards
- Require proof of participation of laboratories in the public and private sectors in External Quality Assurance (EQA) programs as a condition to issue new licenses or renew their licenses
- Strengthen, and expand as needed, microbiology laboratory capacity and ensure capacity for Antibiotic Sensitivity Testing (AST)
- Ensure laboratory equipment calibration as well as preventive and curative maintenance
- Ensure the timely provision of quality-assured laboratory supplies, reagents, and controls to laboratories
- Support implementation of a Laboratory Quality Management System (LQMS) in reference laboratories as well as laboratories in all national and provincial referral hospitals
- Establish compliance of minimum national laboratory quality standards in CPA2 and CPA1 facilities
- Ensure internet connectivity in all public laboratories and install an electronic Laboratory Information System in public and private laboratories.

3. Regulatory issues

Several factors have contributed to slow and inadequate implementation of the National Policy and Strategic Plan for Medical Laboratory Services (2010-2015). These include limited participation in the development and limited commitment in implementation by

stakeholders, limited dissemination to the broader laboratory community, limited political commitment and the consequent lack of resources, and an inadequate regulatory and legal framework. Together, these barriers weaken the overall laboratory system.

The assessment of the national laboratory system in 2013 revealed that laboratory governance (36%) needs to be strengthened to support sustainable development of the laboratory system and planned activities for the National Laboratory Strategic Plan 2015-2020 to establish and enforce regulatory mechanisms are as follows:

- Strengthen the technical regulatory body responsible for licensing of laboratories and laboratory professionals
- Establish national laboratory standards for medical laboratories
- Establish new licensing criteria for both public and private laboratories based on compliance with national laboratory standards
- Establish a mechanism for inspection of laboratories to assess compliance with national laboratory standards
- Establish licensing criteria for laboratory professionals based on a theoretical and practical competency evaluation
- Establish a system for taking disciplinary action against laboratories and professionals who operate without a license or with expired licenses
- Promote the establishment of an accreditation system for public and private laboratories
- Develop regulations outlining the public health obligations of public and private laboratories under IHR
- Establish national regulations on management of infectious agents, laboratory biosafety and quality of diagnostics.

E. AMR status in Cambodia

1. What do we know about AMR currently?

Before drafting the Multi-Sectorial Action Plan (MSAP), the Technical Working Group on Antimicrobial Resistance of the Ministry of Health and the Ministry of Agriculture, Forestry and Fisheries, and Ministry of Environment with support from FAO, OIE and WHO, conducted a situation analysis in October to December 2017 to assess AMR efforts by the agriculture, human health and environment sectors. Published articles, documents, presentations and other reports were reviewed. Key informant interviews and site visits were conducted among government agencies, hospitals, partners and experts. Results of the situation analysis were presented during a consultation of stakeholders on 29–30 November 2017 in Phnom Penh. The participants (government officials, experts and technical officials, and representatives from partner organizations) validated the results, confirmed the gaps and endorsed seven strategic areas where actions should be focused over the next five years.

1. Building human capacity for antimicrobial resistance
2. Containing AMR through good practices
3. Evidence generation through surveillance and laboratories

4. Governance and coordination to reduce antimicrobial resistance
5. Increasing public awareness
6. Rational use of antimicrobial medicines
7. Research and innovation for antimicrobial resistance.

2. What are the primary drivers of AMR? How do we know?

Based on the prevailing conditions in the country and even with no specific supporting data in Cambodia, the primary drivers of AMR are:

- Over-prescription of antibiotics
- Patients not finishing the entire antibiotic course
- Overuse of antibiotics in livestock and fish farming
- Poor infection control in health care settings
- Poor hygiene and sanitation.

3. What are the organisms causing disease, driving AMR and AMU, and serving as reservoirs?

The following are priority pathogens isolated from blood:

- *E.coli*
- *K. pneumonia*
- *Acinetobacter spp.*
- *S aureus*
- *S. pneumonia*
- *Salmonella spp.*
- *B. pseudomallei*

Any bacterial pathogen from cerebro-spinal fluid (CSF) but mostly:

- *S. agalactiae*
- *H. influenza*
- *S. pneumonia*
- *S. suis*
- *N. meningitides*
- *Listeria monocytogenes.*

4. What interventions exist to address AMR at the national level?

Implementing AMR interventions activity with National Action Plan's objectives.

5. Tricycle program implementation
   a. If it was implemented – how did it go?
   b. If it was not implemented – is there any national interest in the concept?

   Dialog with other partners including WHO, FAO and OIE for their interest and support for Tricycle program in Cambodia.

F. Ethical clearance – would ethical clearance be needed to conduct a pilot in country?

While AMR surveillance system is a public health surveillance activity and individual patient consent is therefore not required, a pilot in the country will need approval of the National Ethic Committee for Health Research (NCHR) in Cambodia.

Cambodia - Discussion on Identified Gaps

A. At the national level – Cambodia

1. What protocols were identified as needed (according to the literature review and key stakeholders), but do not exist or are not of good quality?

   There is no provision of the Standard Operation Procedure for Cambodia Laboratory-based AMR Surveillance System in November 2017 to tackle the regional aspect of cross-border collaboration and AMR should be one of the ongoing disease list or part of an event-based surveillance to be shared among participating countries.

2. Detection and Lab capacity to implement needed protocols

   There is an issue of completeness as only a limited number of laboratories with microbiology capability are part of the AMR surveillance and this is compounded by the fact that the data from more capable laboratories serving cross-border population may not be accessible to the country of origin for timely action as deemed appropriate.

3. Data sharing agreements needed

   Any existing agreement on data sharing needs to revised to incorporate AMR as part of cross-border collaboration, especially in the area of rapid response to a potential outbreak situation. It is expected that there will be any hurdle for moving to this direction as each participating country will benefit from an effective public health response for the same of their own population health.

B. Addressing Gaps – Protocols and SOPs needed

1. What protocols are the priority for this network at this time and why?

   Cross-border disease surveillance protocol needs to incorporate AMR in the list of diseases or part of an event-based surveillance as AMR could be linked to the need for immediate actions in the context of an outbreak response currently under the framework of MBDS cooperation.

2. What are the criteria used for prioritizing needed protocols – list and justify criteria

   Criteria used for prioritizing needed protocols include the volume of cross-border movement of the population (migrants) and the completeness of AMR surveillance in each participating country.

3. Describe the feasibility and acceptability of developing the prioritized protocol(s)

   a. Is it possible to develop them and use them practically and cost-wise? Is it possible to do in the time allotted for this project? (feasibility)
      It is expected that there is no major technical and financial barriers for the practical implementation of the revised protocol as there is an existing framework for information sharing across borders.

   b. Will key stakeholders adopt and use them (acceptability)?
      As the aforementioned criteria for prioritization prevail in MBDS countries, this mutually beneficial move will be acceptable to each participating country.

   c. Is this protocol it needed? Is anyone else doing it?
      As lead MBDS country for ICT, Cambodia will take the lead in strengthening national and this regional event-based surveillance.

   d. Does it address a main driver of antimicrobial use?
      There is an indirect impact on the main drivers as country and region specific responses to AMR-related public health events could be used to show case on each of the five major drivers elaborated above. This is quite important to tackle the paradox linked to the immediacy of these main drivers.

   e. What is the current impact of this driver of AMR? (Health or economic or something else)
      The adoption of this new protocol will have an overall impact on all the 5 drivers in both health and economic aspects. After action reports of any AMR public health response will be used to advocate for the adoption of each main driver.

   f. One Health – What stakeholders will need to be engaged in order to implement this protocol? How will the One Health approach be promoted through protocol implementation?
      We have the precedence of the participation of the Ministry of Agriculture, Forestry and Fisheries (MAFF) in avian influenza response and for AMR surveillance and response, the health and economic cost could be linked to the potential overuse of antibiotic for growth promotion for instance and the health impact will not discriminate this group of people practicing this in non-health sector.

   g. What would change if we had the AMR surveillance data this protocol would collect?
      Immediate impact of AMR will be used to contextualize the visibility to advocate for the strengthening of each of the main drivers, especially on the immediacy for action taking in complement to the overall bigger picture to address AMR at highest level.

Lao P.D.R - National Level

A. Existing national level guidance and protocols on AMR surveillance (including the National AMR Action Plan) and stakeholders

Since 2016, Lao PDR agreed to have a national action plan to prevent, control and Monitor AMR, the National AMR surveillance protocol have been developed and endorsed in 25 Oct 2019, The "Protocol for an Antimicrobial Resistance (AMR) Surveillance System in Lao PDR" is a companion document for the "Strategy for an Antimicrobial Resistance (AMR) Surveillance System in Lao PDR" that includes the technical procedures that will be used at the AMR surveillance sites. This protocol describes the clinical definitions to be included in the surveillance system, the prioritized organisms and antimicrobials for surveillance, sample collection and transport methods and the recommended techniques for culture of specimens, bacterial isolation and identification and bacterial susceptibility testing

To monitoring the progress in implementation of National action plan, the Ministry of Health has been jointly with Fleming Fund and The Ministry agriculture to developed National multi steering committee, AMR surveillance system, policy and strategy. National Action Plan on AMR (2017-2020) first draft was prepared in December 2016 with Joint effort by both the Ministry of Health and the Ministry of Agriculture and Forestry, in 2019 National Strategic Plan on AMR (2019-2023) have been developed, It has recently been endorsed by both the Ministry of Health and the Ministry of Agriculture and Forestry, This has replaced the National Action Plan on AMR (2017-2020).

Key stakeholders are Ministry of health, Fleming fund, KOICA, LOMWRU, JICA, CIRAD, IDRC, Merieux, Pasteur, CHAI, FAO, OIE)

B. Existing national AMR surveillance system(s)

Lao PDR initial develop plan for AMR surveillance system in January 2018, the Ministry of Health with collaboration with Ministry of Agriculture and Fishery conducted TWG meeting with related ministries and development partner to discussed and develop AMR surveillance system

April 2018, Ministry of health established focal point of AMR surveillance, the Department of Communicable Disease control and National Centre for Laboratory and Epidemiology (NCLE) have been nominated as an AMR focal point. Moreover, NCLE was assigned as national reference laboratory in order to supervise surveillance sites. From 2019 to present, a pilot AMR surveillance has been implementing in 3 provinces: Vientiane Capital (Mahosot hospitaland Setthathirath hospital), Khammuan province and Luangprabang province, AMR surveillance network supported from Fleming fund are: Luangnamtha, Xiengkhoung and Saravanh province. There is a functioning national AMR surveillance system covering common bacterial infections in hospitalized and community patients with external quality assurance, and a national coordinating centre producing reports on AMR

1. What is the existing capacity to monitor AMR?

a. Pathogens monitored and how

AMR surveillance cases will be found among routine clinical samples using the provided clinical definitions in the document. Data collection at surveillance sites will be performed

using a standard request form and the WHONET software is using for database entry and report. The listed substances are priorities for surveillance of resistance in each pathogen, the essential combination of antibiotics, bacterial species and specimens that must be reported to the national surveillance system (NCLE) monthly; however, the rare or unusual resistance isolates will be sent to NCLE for confirmation. In addition, any other specimen, species or antibiotic that is already being routinely tested at the surveillance sites for clinical diagnosis can be registered in the local hospital WHONET database

b. Frequency of reporting and to whom?

Data generated by surveillance sites is submitted to NCLE on a monthly basis shared with DCDC used for policymaking at the national level and data submitted to GLASS yearly.

2. What is the structure of the database for AMR surveillance data?

Lao PDR using WHONET database to collect AMR surveillance data from surveillance sites

a. Who has access to the information? Stakholder National department AMR
Chair of AMR committee (AMR Focal point DCDC, NCLE), WHO CO.

b. How is it used? To reduce AMR
Data used for policymaking at the national level to enforcement of legislation to manage antimicrobial importation, prescribing and supply

3. How are results of AMR surveillance shared? Between sectors? Across sectors and with public? Meeting

- Data generated by surveillance sites is submitted to NCLE on a monthly basis shared with DCDC used for policymaking at the national level and data submitted to GLASS
- Data from 2017-2018 (Mahosot Hospital) submitted to GLASS during the 2019 data
- Some KAP survey and scientific writing have been public
- National AMR annual meeting have been conducted once a year to share information among doctors and the pharmacy and laboratory including development partners and stakeholders.

4. What are the protocols for response when AMR is detected? AMR action plan and cacity building education support budget, surveillance mechanism, strengthening Lab

- Develop new guideline for antibiotic use and Capacity building for doctor and Pharmacy for diagnostic stewardship
- Education and training of pharmacists in clinical pharmacy
- education and advocacy about AMR in the general population to reduce patient demands for antibiotics

5. Is there a One Health approach to AMR surveillance?
    - MoU between MoH and MAF
    - Coordination and cooperation for management of emergency disease outbreaks
    - Zoonotic disease committee involving DCDC, NAHL, DVS
    - Formation of the National Antimicrobial Resistance Surveillance and Control Committee (meets ad hoc only)
    - Development and endorsement of the National Strategic Plan on AMR 2019-2023
    - Join Annual One Health Symposium
    - Joint celebration of World Rabies Day
    - Twice-yearly laboratory coordination meetings
    - Joint simulation exercises from multiple sectors
    - Joint training between NAHL and NCLE

C. JEE and or GLASS country results, as applicable

- Lao PDR has been Joint External Evaluation: Antimicrobial Resistance (AMR) in February 2017,
- Enrolled in Global AMR Surveillance System (GLASS) since 2018

D. National detection and lab capacity

1. Access to microbiology laboratory services

The country has capacity to test for all AMR priority pathogens in both animal and human sector, including at the National level (National Centre for Laboratory and Epidemiology, National Animal Health Laboratory), Centre for Malaria, Parasitology and Entomology, Institute Pasteur Lao, TB-National Referral laboratory , central hospitals (Setthathirath, Mittaphab and Lao-Oxford-Mahosot Hospital-Wellcome Trust Research Unit), Meriux, and 6 provincial hospital laboratories

2. Quality Assurance Diagnostic tests, ID and susceptibility

All national laboratories participated in relevant international EQA (National Centre for Laboratory and Epidemiology, Institute Pasteur Lao, Lao-Oxford-Mahosot Hospital-Wellcome Trust Research Unit, Meriux : ISO 20000)

3. Regulatory issues

CDCD Law and Lab policy for Lao P.D.R

E. AMR status in Lao PDR

1. What do we know about AMR currently?

Lao P.D.R has monthly report, public literature, scientific annual report and quarterly

2. What are the primary drivers of AMR? How do we know? Establish
   - AMR committee established
   - NAP on AMR developed and approval
   - AMR national surveillance protocol
   - Funding currently available from donors (e.g. KOICA, Fleming Fund)
   - GLASS focal points nominated for AMR, AMC and AMU

3. What are the organisms causing disease, driving AMR and AMU, and serving as reservoirs?
   - Susceptibility patterns suggest high prevalence of ESBLs in blood isolates of E. coli and K. pneumoniae
   - Ongoing development of mutational resistance of Salmonella spp. and Shigella spp. to fluoroquinolones
   - All N. gonorrhoea isolates in 2017-2018 (n=154) were non-susceptible to penicillin, ciprofloxacin and tetracycline
   - B. pseudomallei is an important pathogen in Laos; isolates remain susceptible
   - Low rates of MRSA (11%, n=56)

4. What interventions exist to address AMR at the national level?
   - Law enforcement for sales of antibiotics with prescription
   - A regulation on veterinary medicine was developed
   - Conducted GMP workshop for the pharmaceutical factories
   - Conducted quality testing of small samples of antimicrobials
   - Post marketing surveillance for GPP, GWP, GDP (public & private)
   - PV guideline and ADR forms for reporting for overall medicines including antibiotics but not a separate guideline for antibiotics including conduct training for this guideline at central and subnational level
   - AMC implementation at the hospital level
   - Country has laws or regulations on prescription and sale of antimicrobials, for human use
   - Law on Drugs and Medical Products revised 2011 (MoH)

5. Tricycle program implementation
   a. If it was implemented – how did it go?
      Lao PDR Tripartite AMR country self-assessment survey (TrACSS) have been conducted since 2018 and update annual

   b. If it was not implemented – is there any national interest in the concept?
      Lao PDR is in very first step of implementing tricycle program. The concept has been presented to all concerned sector and waiting for the agreement to implement this program.

F. Ethical clearance – would ethical clearance be needed to conduct a pilot in country?

Ethical clearance be needed conduct a pilot in Lao P.D.R

Lao PDR - Discussion on Identified Gaps

A. At the national level – Lao PDR

1. What protocols were identified as needed (according to the literature review and key stakeholders), but do not exist or are not of good quality?
   - Limited or small-scale antimicrobial resistance awareness campaign targeting some but not all relevant stakeholders
   - No national survey for Antimicrobial consumption in human and animal sectors in Lao PDR
   - Law enforcement for sales of antibiotics with prescription not fully implemented
   - There is no national guideline and the AMS program has not been implemented in the Lao hospitals
   - Low awareness among communities for AMU and consequences of AMR
   - Limited information on Antibiotic consumption /Rational use
   - Limited data and evidence on AMR patterns in Health and Animal
   - DTC committee is still not well-functional

2. Detection and Lab capacity to implement needed protocols
   - Limited HR capacity especially for Bacteriology lab
   - SOP for sample collection and testing limited among health care worker

3. Data sharing agreements needed
   - Online publication
   - Access to national database and public

B. Addressing Gaps – Protocols and SOPs needed

1. What protocols are the priority for this network at this time and why?
   - Development of antibiotic guideline is needed to be a guide for empirical treatment. The issues are the misused or over use of antibiotic in both human and animal sector.
   - Integration of AMR surveillance data and AMC data to have comprehensive knowledge on antimicrobial use and resistance pattern in Lao PDR.
   - Development of laboratory technique for AST testing is needed to be a guide at provincial hospital.
   - Development of diagnostic guideline and tool are very important to increase the number of sample with good quality and utilized laboratory result to improve patient care

- Enforcement of selling the antibiotics with prescription.
- Expand national AMR surveillance network to have the representative data of AMR trend in Lao PDR

2. What are the criteria used for prioritizing needed protocols – list and justify criteria
   - The feasibility to apply in Lao context is important to consider because there are low resource setting country.
   - Political and interest of government are important. If this is in one agenda of country, the work will go smoothly and a lot of support to achieve the target
   - Sustainably is another criteria to consider that how country to continue the program without interruption

3. Describe the feasibility and acceptability of developing the prioritized protocol(s)
   a. Is it possible to develop them and use them practically and cost-wise? Is it possible to do in the time allotted for this project? (feasibility)
      - It's possible to develop and apply in Laos but should consider on the Laos context particularly for existing human resource-capacity and skills, infrastructure and equipment
      - The antibiotic and dashboard for AMR and AMC are development process. These can be finalized during the project time frame.

   b. Will key stakeholders adopt and use them (acceptability)?
      - These will be national standard documents where key stakeholders can apply or use as reference

   c. Is this protocol it needed? Is anyone else doing it?
      - Yes, there are needed. However, some organizations are supporting this

   d. Does it address a main driver of antimicrobial use?
      - All listed documents will be addressed the main driver of antimicrobial use particularly the antibiotic guideline

   e. What is the current impact of this driver of AMR? (Health or economic or something else)
      - Currently, there are ESBL resistance and Carbapenem resistance which cause for mortality and high cost of treatment. Moreover, we could observe a lot of misuse and over use of antibiotic in both human, animal and food chain.

f. One Health – What stakeholders will need to be engaged in order to implement this protocol? How will the One Health approach be promoted through protocol implementation?
   - The one health approach is very useful to bring other stakeholders to work together on AMR such as animal health sector and environmental sector. The stakeholders should share information and their activities to collaborate and integrate some activities.

g. What would change if we had the AMR surveillance data this protocol would collect?
   - The AMR surveillance data is very useful to understand the important pathogens and resistance pattern of that pathogen to specific medicine. This data can guide policy maker on
     - Hospital management:
       - Develop strategies in antimicrobial stewardship and IPC
       - Develop or revise antimicrobial prescribing guidelines
       - Education/awareness campaigns
     - Clinicians: support more effective prescribing

Myanmar – National Level

A. Existing national level guidance and protocols on AMR surveillance (including the National AMR Action Plan) and stakeholders

Stakeholder meeting was held on NAP AMR in 27 Feb 2017, where all participants reviewed the existing proposals on governance mechanisms and propose a multi-sectoral governance mechanism in line with WHO NAP guidelines. Strategic interventions, objectives, situation analysis and any subsequent in country developments related to AMR control were discussed. There are five strategic objectives in NAP AMR.

Objective 1: Improve awareness and understanding of antimicrobial resistance through effective communication, education and training

Objective 2: Strengthen the knowledge and evidence base through surveillance and research

Objective 3: Reduce the incidence of infection through effective sanitation, hygiene and infection prevention measures

Objective 4: Optimize the use of antimicrobial medicines in human and animal health

Objective 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.

NAP, NCC and International Implementation partners

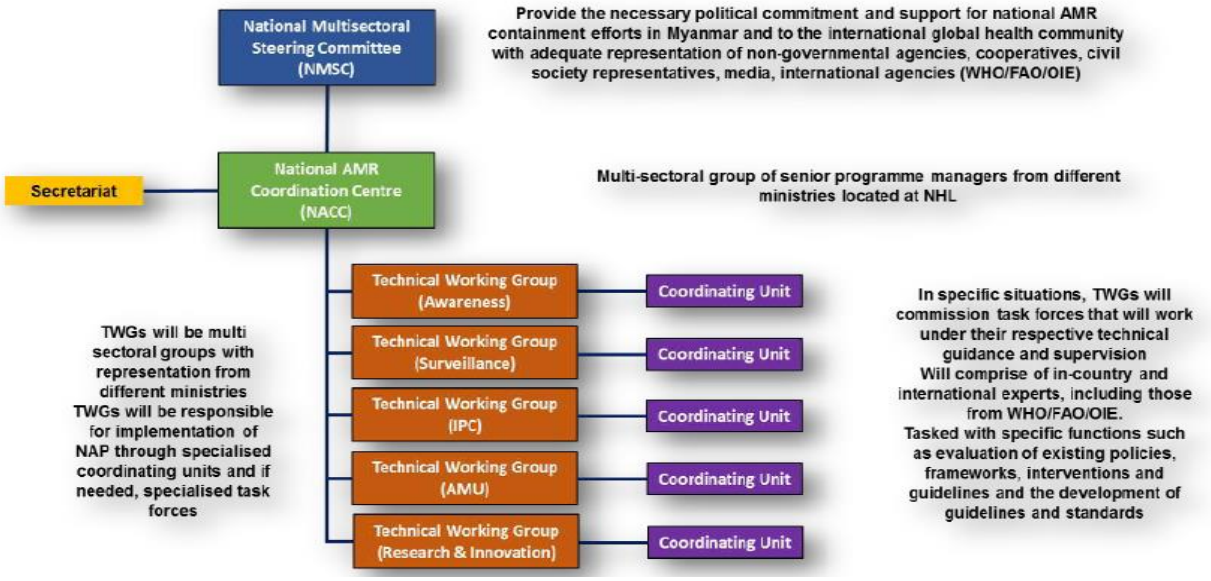

Figure 1: NAP Governance Structure in Myanmar, 2017-2022

National multi-sectoral steering committee (NMSC) combating Myanmar was endorsed in 22nd January 2018, consisting of 19 members in multi-sectoral and one health approach. Chairman is Union Mister of Health and Sports. Members include Ministry of Health and Sports (Med. Care, National Health Laboratory, Food and Drug Administration), Ministry of Agriculture, Livestock and Irrigation (LVBD Lab, Agri. Lab), Education, Commerce, Home Affairs, Defense, Myanmar Pharmaceutical Association, Myanmar Medical Association, Myanmar Private Hospital Association. First meeting of NMSC was held on 18th April 2018 at NayPyiTaw Township, Myanmar. NMSC provides the necessary political commitment and set the guidelines for NAP AMR containment effort in Myanmar. In addition, NMSC also collaborates with other non-governmental agencies, civil society representatives, media and other international organizations such as WHO, FAO, OIE. Furthermore, WHO listed National Coordinating Centre (NCC), located in Yangon, was established in June 2018 and it was supervised by NMSC. First meeting of NCC was held on 1st August 2018. The NCC is composed of five strategic technical working groups matching with strategic areas of GAP. NCC governance structure covered the counterpart ministries such as Ministry of Defense, Ministry of Home Affairs. Followings are roles and responsibilities of NCC.

1. Planning, implementation and monitoring & evaluation of different strategic interventions and activities of NAP AMR
2. Monitoring and evaluation on implementation different strategic interventions and activities of NAP AMR
3. Reporting implementation status to NMSC, national agencies and international partners
4. Constitute technical working groups and commission task forces for tasks that include providing technical input for program support and decision-making
5. Facilitating collaborations with internal and external agencies and organizations, is essential for many countries especially in the field of surveillance and innovations
6. Advocate for prevention and containment of AMR

Under the supervision of NCC there are Five Technical Working Groups (TWGs) who are responsible for implementation of NAP AMR through specialized coordinating units including Awareness, Surveillance, Infection Prevention and Control, Antimicrobial Usage and Research and Innovation.

At the same time, National action plan on AMR (NAP AMR) version 01 was launched in 2017. There is national plan for AMR control and also trying to update the NAP AMR version 01 into version 02 in 2020 [38].

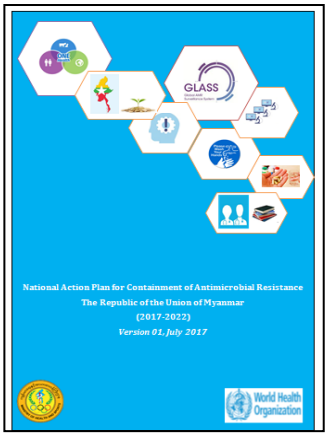

Figure 2: National action plan on AMR (2017-2022) version 01

B. Existing national AMR surveillance system(s)

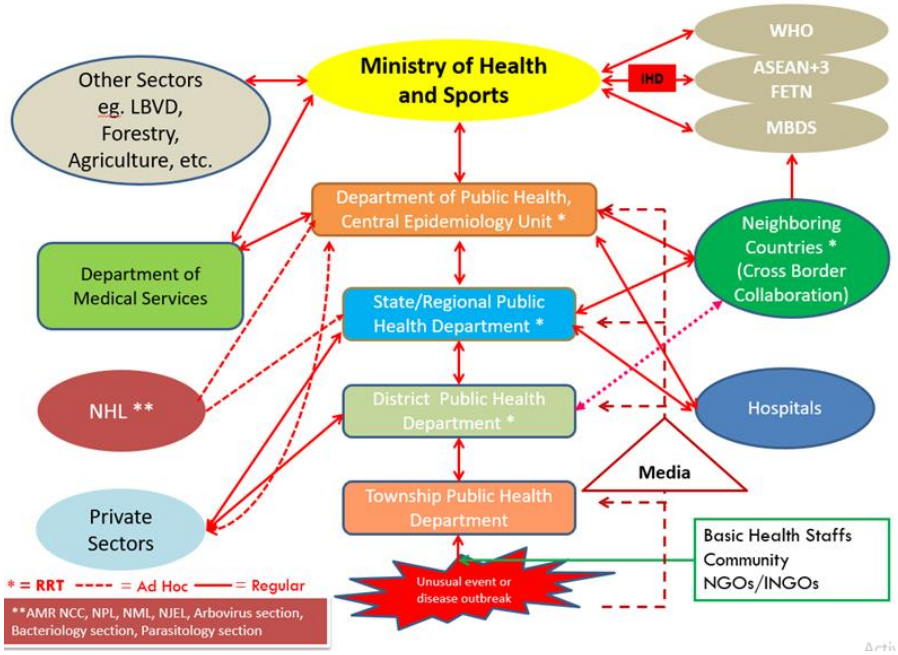

Figure 3: Info graphics of the surveillance system in Myanmar

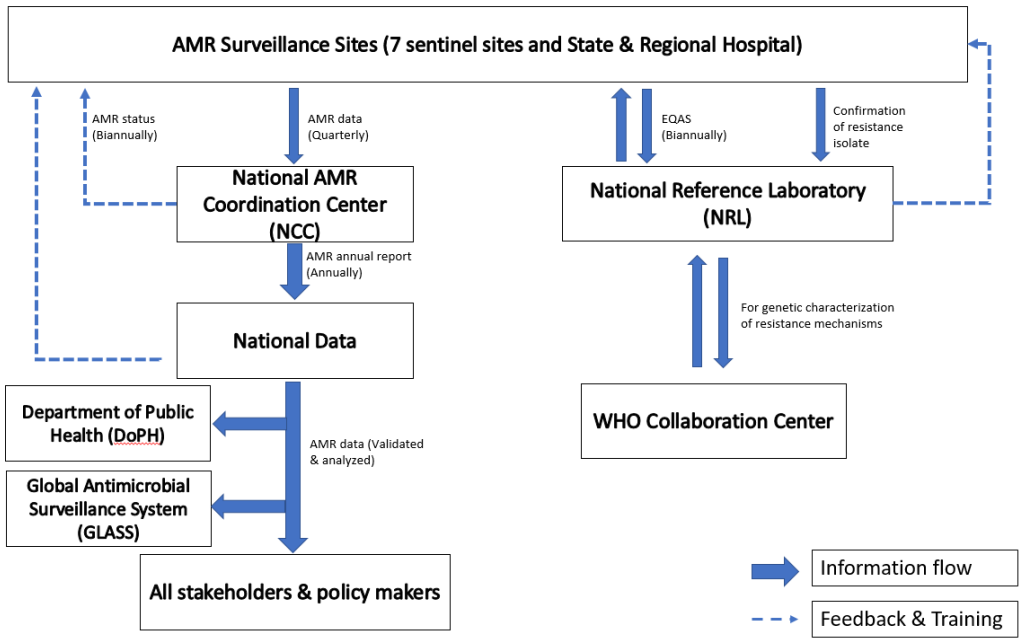

Figure 4: Workflow at National Health Laboratory for AMR control

1. What is the existing capacity to monitor AMR?

Firstly NCC established 7 sentinel sites as pilot areas for AMR surveillance. Those are Yangon General Hospital (YGH), New YGH, North Okkala General Hospital (NOGH), Central Women Hospital (CWH), Yangon Children Hospital (YCH), 1000-bedded Naypyitaw Hospital, Mandalay General Hospital.

a. Pathogens monitored and how

Routine culture and sensitivity tests from seven sentinel hospitals were sent to their own hospital based laboratory where AMR data were put into WHOnet system. All staffs and professionals involved in AMR surveillance had already been trained how to use WHOnet software and how to analyze data by WHO consultants and their teams before and during the AMR project. After data collection, those data were sent to NCC quarterly. NCC monitored and analyzed all pathogens, particularly WHO high priority pathogens such as *Acinetobacter* species, *Pseudomonas* species, Enterobacteriaceae, Enterococcus species, *Staphylococcus aureus, Neisseria gonorrhoeae.* Moreover, National Reference Laboratory (NRL) provides technical supports to all hospital based laboratories from seven sentinel sites. National External Quality Assessment Schemes (NEQAS) at NRL assess the culture and sensitivity testing capacities of sentinel sites. Furthermore, international EQAS for NHL was supported by National Institute of Health Thailand yearly. In the other hand, AMR surveillance guidelines are also preparing in order to standardize the AMR surveillance system in all laboratories in Myanmar.

Type of Resistance	Bacteria	Total Isolate	Number of resistance	Percentage
Carbapenem-resistant	*Acinetobacter* species	254	54	21%
	Pseudomonas species	1287	345	27%
	Enterobacteriaceae	7056	1002	14%
ESBL producing	Enterobacteriaceae	1095	512	47%
Vancomycin-resistant	*Enterococcus* species	178	53	30%
Methicillin-resistant	*Staphylococcus aureus*	1996	590	30%
Cephalosporin-resistant	*Neisseria gonorrhoeae*	3	1	33%
fluoroquinolone-resistant		3	3	100%

Table 1: WHO high priority pathogens in Myanmar 2018

b. Frequency of reporting and to whom

Seven sentinel sites collected AMR data and reported quarterly to NCC (located at NHL) where data analysis was done. After analysis, NCC sent back the results to sentinel sites and also reported those national data to Department of Public Health. In addition, we enrolled GLASS in 2018 and national data of **8 GLASS priority pathogens** including *Acinetobacter* species*, E. coli, K. pneumonia, Samonella* spp*., S. aureus, S. pneumonia, Shigella spp.,* and *N. gonorrhoea* were uploaded to GLASS in 2019. Furthermore those national data were shared to all stakeholders and policy makers and published annually.

2. What is the structure of the database for AMR surveillance data?

a. Who has access to the information?

NCC combines all AMR data from seven sentinel sites and publishes analysis report on hospitals antimicrobial resistance annually with the support of JICA organization, which is very fruitful. According to Infographics of AMR surveillance system in Myanmar, all departments under Ministry of Health and Sports can access the AMR database. Moreover, everyone can get the data officially.

Figure 5: Analysis Reports on Hospital Antimicrobial resistance in Myanmar

b. How is it used?

It can be applied in addressing Hospital Antibiotic usage Guideline, Infection Prevention and Control Guidelines, Optimization of Antibiotics usage, Antibiotic purchasing and so on.

3. How are results of AMR surveillance shared? Between sectors? Across sectors and with public?

The results of AMR surveillance are shared at national and regional meetings, regular meetings with other Ministries, AMR awareness week workshops, Myanmar Health Research Conferences, Poster presentations, Public talks and so on.

4. What are the protocols for response when AMR is detected?

AMR surveillance guideline will be followed when AMR is detected.

5. Is there a One Health approach to AMR surveillance?

Currently, joint working on multi-sector and One Health collaboration/coordination is drafted with including agreement.

Sectors involved in AMR National Action Plan are:

- Human health including WASH
- Animal Health (terrestrial and aquatic)
- Plant Health
- Food production
- Food safety
- Environment

C. JEE and or GLASS country results, as applicable

Technical areas	Indicators	Score
Antimicrobial resistance	Antimicrobial resistance detection	3
	Surveillance of infections caused by antimicrobial-resistant pathogens	3
	Health care-associated infection (HCAI) prevention and control programmes	1
	Antimicrobial stewardship activities	1

Table 2: JEE result for AMR in Myanmar, 2017

Scores: 1 = No capacity
2 = Limited capacity
3 = Developed capacity
4 = Demonstrated capacity
5 = Sustainable capacity

D. National detection and lab capacity

1. Access to microbiology laboratory services

Most of the hospitals have their own clinical microbiologists and Culture & Sensitivity tests are available.

2. Quality Assurance Diagnostic tests, ID and susceptibility

NEQAS from NRL covers 37 hospitals and identifies laboratory competency assessment biannually. If diagnostic quality do not reach the competency level, NRL arrange refresher trainings, provides monitoring and evacuation services and support technical resources.

3. Regulatory issues

To standardize the laboratory capacities at national level, there are SOP for sample collection and transportation, Guidelines on Biosafety and Biosecurity for Biomedical Laboratories, Instruction for Laboratory aspect of Infection and Prevention Control and Medical Laboratory Waste Management Instruction.

E. AMR status in Myanmar

1. What do we know about AMR currently?

Currently AMR is the implementation state in Myanmar. World Antibiotics awareness week are held annually. Knowledge of AMR were extended not only among communities but also among professionals of human and animal health, the food industry and agriculture. AMR and related topics will be incorporated in undergraduate and postgraduate curricula in human and animal health, the food industry and agriculture.

National Surveillance system have already set up for AMR under the leadership of National Coordinating Center (NCC). National Referral Laboratory (NRL) provides laboratory capacity building and supports surveillance activities.

Hospital Infection Prevention and Control were performing with separate projects and each hospital are preparing their own hospital antibiotic guideline. National antibiotic usage guidelines are also in the initiation phase. In addition, the Greater Mekong Health Security Project (GMS-HS), Myanmar, is a five-year regional project. The objective of the program is to strengthen and build the capacity in IPC to the healthcare staffs from 12 target hospitals of five states and regions located on the borders and economic corridors of Myanmar.

Furthermore, AWaRe tools were launched in October 2019 to build national capacity to optimize the use of antibiotics through the implementation of antimicrobial stewardship programs and regular monitoring of antimicrobial consumption.

Research prioritization workshop on AMR was also accomplished on 7-8 Nov 2019. They finally developed three priority groups of research questions such as first, second and third priority groups. First priority group covered the area of awareness of AMR, antimicrobial usage, AMR surveillance and infection prevention and control.

2. What are the primary drivers of AMR? How do we know?

The main driver of this resistance is antimicrobial usage. Antibiotics at subinhibitory concentrations may influence susceptibility of microbes to antibiotics. Prolonged antimicrobial treatment, failure to narrow antimicrobial therapy, prolonged prophylactic therapy, patient's poor adherence, self-medication, poor quality antimicrobial products, misuse by food industry in animal feed stocks, antibiotics residue in soil and water are contributing antibiotic resistance.

By reviewing literatures of AMR, attending national and international conferences, discussing and sharing of AMR contributive factors, doing more research about transmission of AMR for knowing the drivers of AMR.

3. What are the organisms causing disease, driving AMR and AMU, and serving as reservoirs?

Acinetobacter species, *E. coli*, *K. pneumonia*, *Samonella* spp., *S. aureus*, *S. pneumonia*, *Shigella* spp., and *N. gonorrhea* are the organisms causing AMR.

Farm animals e.g. chicken, pig are exposed to considerable quantities of antimicrobials and can act as an important reservoir of AMR genes, which could be transmitted to humans through the food chain, direct animal contact and the environment [39] [40].

4. What interventions exist to address AMR at the national level?
   National Action Plan version 01 was launched in 2017 for 5 year plan to develop version 2 in year 2020.

5. Tricycle program implementation
   a. If it was implemented – how did it go?
      Tricycle program was not implemented yet.

   b. If it was not implemented – is there any national interest in the concept?
      Myanmar is planning to implement Tricycle program soon. In NAP AMR Myanmar version 02, Tricycle program will be described more in details.

F. Ethical clearance – would ethical clearance be needed to conduct a pilot in country?
   Not required

Myanmar - Discussion on Identified Gaps

A. At the national level – Myanmar

1. What protocols were identified as needed (according to the literature review and key stakeholders), but do not exist or are not of good quality?
   Tricycle Program are remained to be implemented according to requirements.
   Antimicrobial stewardship Program have not started yet.

2. Detection and Lab capacity to implement needed protocols
   Currently laboratory services are growing in each human, animal and environmental health sector but there are still challenging to combine each other as one health approach.

   As technical assistance, the requirement to develop molecular method and gene sequencing method for addressing the resistant gene in various pathogens. In addition, support of reagents, primers, laboratory technique are also demanding. Human resources for data collection, data analysis and lab technicians are also desired.

3. Data sharing agreements needed
   Ministry of Agriculture, Livestock and irrigation (MoALi) – Joint Statement on Multi-stakeholder Engagement to combat AMR in Myanmar 2018
   Tripartite AMR Country Self-assessment Survey – TrACSS (4.0) 2019-2020 was done in January 2020 and data will be published by May 2020.
   https://www.who.int/southeastasia/activities/who-sear-tripartite-amr-country-self-assessment

B. Addressing Gaps – Protocols and SOPs needed

1. What protocols are the priority for this network at this time and why?
   The Tricycle program is the priority currently and it will focus on the frequency rates of ESBL-*E. coli,* measured yearly in strictly identical and controlled conditions in the three majors sectors that are the human, the food-chain and the environment. ESBL-*Ec* are diverse and essentially ubiquitous microorganisms that can readily cross barriers between humans, animals and the environment in a cyclic and reciprocating manner [41].

2. What are the criteria used for prioritizing needed protocols – list and justify criteria

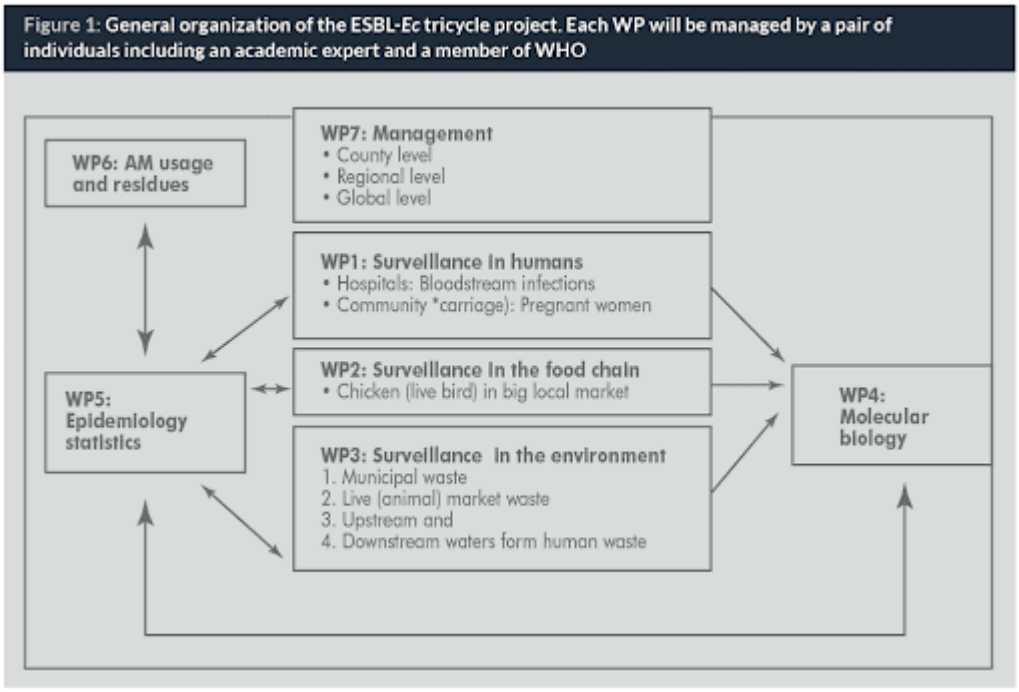

Figure 6: General Organization of the ESBL-Ec tricycle Project
WP = Workpackage

3. Describe the feasibility and acceptability of developing the prioritized protocol(s)
   a. Is it possible to develop them and use them practically and cost-wise? Is it possible to do in the time allotted for this project? (feasibility)
      Yes.

   b. Will key stakeholders adopt and use them (acceptability)?
      Yes.

   c. Is this protocol it needed? Is anyone else doing it?
      Yes.

   d. Does it address a main driver of antimicrobial use?
      Yes.

   e. What is the current impact of this driver of AMR? (Health or economic or something else)
      AMR have impact on treatment failure, prolonged illness, high mortality, increased cost due to prolonged hospital stays.

f. One Health – What stakeholders will need to be engaged in order to implement this protocol? How will the One Health approach be promoted through protocol implementation?

Multi-sectoral working groups are required to be functional with regular meetings, funding, activities and reporting. Members should actively participate with integrated approaches to implement this protocol.

g. What would change if we had the AMR surveillance data this protocol would collect?

If we had the AMR surveillance data from Tricycle program, we could know the burden of antimicrobial resistance gene and so we would detect the impact on human health. When we know the cause of resistance, we could prevent the AMR.

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B. National

Lao PDR

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2. National Strategic Plan on AMR (2019-2023)
   - List of people interviewed:
   - Chair of AMR national committee (AMR Focal point DCDC, FDD, NCLE), WHO CO.

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APPENDICES

Cambodia

1. Standard Operation Procedure for Cambodia Laboratory-based AMR Surveillance System (Ethical consideration)
2. National Policy to Combat AMR 2015-2017
3. National Strategy to Combat AMR 2015-2017
4. Multi-Sectoral Action Plan for AMR 2019-2023.

Myanmar

1. National Action Plan for Containment of Antimicrobial Resistance Myanmar (2017-2022)
2. AMR Surveillance Guideline Myanmar
3. AMR Surveillance at a glance in Myanmar