Ways of Working and Learning in AMR surveillance systems in LMICs: Findings from the scoping phase

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Ways of Working and Learning in AMR surveillance systems in LMICs: Findings from the scoping phase

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This report has been prepared for Mott MacDonald and the DHSC
to inform the approach of the Open University within the Fleming Fund

Contents

List of Acronyms

AMR	Antimicrobial Resistance
AMRCC	Antimicrobial Resistance Coordinating Committee
AST	Antimicrobial sensitivity testing
BMJ	British Medical Journal
BSAC	British Society for Antimicrobial Chemotherapy
CME	Continuing medical education
CPD	Continuing professional development
DHSC	Department of Health and Social Care
EQA	External Quality Assurance
FAO	Food and Agriculture
GLASS	Global AMR Surveillance System
HEE	Health Education England
LMIC	Low and Middle Income Country
MOOC	Massive Open online Course
NAP	National Action Plan
OU	The Open University
OIE	World Organisation for Animal Health
QA	Quality Assurance
QC	Quality Control
SOP	Standard Operating Procedure
PALM	Pathology and laboratory medicine
PHE	Public Health England
UK	United Kingdom
WHO	World Health Organisation

Executive summary

Scope of the report

Our ability to treat life-threatening conditions is threatened by the rise of antimicrobial resistance (AMR). Tackling the effects of AMR requires international collaboration, political commitment and partnership to ensure that robust AMR surveillance can provide health intelligence data to inform evidence-based interventions at local, national and international levels. Strengthening AMR surveillance, particularly in low-and-middle income countries (LMICs) where the impact of infectious diseases is highest and the ability to respond to AMR may be limited, is a global health priority. This report contributes to this priority by recommending specific interventions that build capacity in AMR surveillance.

The work detailed in this report contributes to the Fleming Fund programme led by the Department of Health and Social Care (DHSC), specifically the objective overseen by Mott MacDonald to improve capacity in AMR surveillance in LMICs. This programme has been established to support LMICs in developing AMR surveillance systems. This work is aligned with the World Health Organization's Global AMR Surveillance System (GLASS) to support the Global Action Plan on AMR.

The scoping period began in April 2018 and is set out in two phases. Phase 1 (April – June 2018) was global scoping study involving desk research and interviews with AMR experts around the world to identify changes needed to build capacity in AMR surveillance. Phase 2 (July – December 2018) involved detailed analysis of the work practices of AMR surveillance policy specialists and laboratory professionals located within a number of animal, agricultural and human health sites in 3 LMICs: Bhutan, Tanzania and Ghana. Through site visits we identified the skills and knowledge needed by people in different job roles and how these skills could best be learned in ways that would have a durable impact on work practice.

In this report, we draw on the evidence from Phases 1 and 2 in order to identify what knowledge and skills are needed, who needs to learn these skills and how learning might be facilitated through pilot learning events in the next phase of work, Phase 3 (January – June 2019). This report will also inform a longer-term approach to build AMR surveillance capacity in LMICs over the period 2019-2022.
This report forms the basis of the final Year 1 deliverable: The AMR Learning Events Roadmap.

Key findings from the scoping phase

1 Sustained professional development is limited: We found evidence of a number of issues that impede LMICs from delivering sustained, well-resourced, high quality AMR professional development programmes. We found examples of good practice in professional development, usually through individuals being funded to study abroad, through mentoring schemes, train the trainer programmes or, in some of the reference laboratories, through international collaboration. However, professional development opportunities were patchy, not always open to all and there were limited examples of sustained capacity development.

The triggers for professional development implementation were usually to tackle problems of under-resourcing. For example, people might be trained to operate in particular ways because equipment is not functioning properly. Another issue is the high turnover of staff as many leave poorly paid laboratory roles, hence there are too few staff with skills and knowledge needed for high-quality AMR surveillance. Furthermore, governments and ministries do not always appreciate or value the skills needed for high- quality AMR surveillance, and consequently resourcing and quality training is less likely to be prioritised.

2. Nine areas of knowledge and skills take priority. We carried out a thorough analysis of the knowledge and skills needed of professionals working at all levels in different animal and human health sites. We gathered data through the Phase 1 interviews with AMR experts and Phase 2 visits to the country sites, talking and questioning more than 80 individuals spread across these phases and sites. We identified nine key categories of knowledge and skills needed to enable well-functioning AMR surveillance systems. Knowledge and skills given the highest priority include: a) Communication, Collaboration & Advocacy, b) Good Laboratory practice, c) Foundations in Microbiology and d) Data Use for Diagnosis in Clinical & Vet Services (Table 3). These priority areas need to be addressed in the forthcoming phases of work.

3. Laboratory professionals at all levels require capacity building. Professionals at all levels, whether Assistants, Technicians, Lab Scientists or Lab Managers, need opportunity to expand their knowledge. However, the particular AMR knowledge and skills they need to focus on depend, to some extent, on the job role of each individual. We have mapped the nine priority areas to specific job roles to help prioritise particular forms of learning towards specific groups.

4. Within existing AMR (or health system) structures in LMICs analysis systems are failing to routinely deliver or offer opportunities for professionals to engage with one another. This impedes multi-sectoral and interdisciplinary collaboration within and across settings (e.g. reference labs and sentinel sites are not always in a functional form). Siloed working appears to the norm for the majority of professionals to the detriment of cooperative and collaborative forms of engagement and knowledge exchange. There is little evidence of enabling management and supportive supervision or mentorship taking place within the surveillance system.

5. It is unclear what constitutes 'surveillance practice'. AMR surveillance activity is often in addition to and on top of other work that lab professionals carry out. These professionals are continually adapting their current practice, which increases their workload. They are often not clear about the whole surveillance system for pathogens, how their work fits within the system and what value they contribute. In the current system it is unclear who has ownership of specific tasks that need to be performed and which roles support these tasks. The novelty of AMR and its emergence as a global challenge provides a reason for this lack of clarity. 'Surveillance practice' needs to be defined and well communicated. It further requires re-organisation of roles and introduction of new positions. Capacity building could ensure that professionals at all levels and in all roles should understand how their work fits within the AMR system.

6. The introduction of AMR surveillance practice requires a restructuring of work. We found many examples where existing forms of laboratory work were at odds with good AMR surveillance. For example, in animal health, monitoring should be restructured to be proactive, rather than passive. Also, procurement processes often require the least expensive medium to be purchased, which often means it is not possible to detect pathogens at a sufficient level. Without a restructure of these procurement practices, it is unlikely that capacity building programmes will bring about the desired changes.

7. There are a range of existing AMR resources that could be used in learning events. The Phase 1 scoping study tracked a rich and diverse range of resources and guidance documents aimed at AMR that could be potentially used for learning. There is limited evidence of the impact of the use of these resources in changing AMR surveillance practice. The review of learning resources showed that not many resources have been developed specifically for laboratory staff, so although resources can be reused within learning events, these are likely to require a high degree of contextualisation or alternatively the development of new learning resources.

8. There is extensive use of digital and online technologies, usually mobile phones used for communication purposes. We found email was not the best form of digital communication and, in at least one country, WhatsApp was the most effective way to connect with others. Some professionals at senior levels were familiar with MOOCs and had participated in these, though they did not report a corresponding change in their practice. Although digital technologies were used extensively, people were less clear about how to 'learn' with the use of technology. Where people perceive they are learning via technology, there appears to be little value attributed to this way of learning, beyond fulfilling an immediate need.

Recommendations

Key recommendations have been identified around each of these findings. These recommendations have implications for the work that the OU is conducting within the Fleming Fund. Following the consultation process with Mott MacDonald and DHSC we will prioritise and select recommendations that are of high priority. We will aim to address these in the remaining of Year 1 and subsequent phases of work in Years 2-4.

1. **Opportunities to enhance the training of professionals within AMR systems by increasing and improving education provision must be explored and implemented**. Professional Development programmes, targeting AMR surveillance, should become an on-going provision and embedded within existing structures. Pedagogic leadership should be also included in such programmes for laboratories and other sites, especially for professionals in senior levels.

2. **Build capacity around the nine priority areas for AMR surveillance (Table 3).** The four main areas are 1) Foundations in Microbiology, 2) Communication, Collaboration & Advocacy, 3) Good Laboratory Practice and 4) Data Use & interpretation for diagnosis in Clinical and Vet Services. It is noted that Data Use & Interpretation for diagnosis in Clinical and Vet Services was considered important by the AMR Community / Experts but regarded as less of a priority for professionals in the country sites, possibly because this practice has not yet been established in all

country sites or it is not clear what it constitutes (see Finding 5). Five other areas are Molecular Advanced Microbiology; Surveillance System Planning & Implementation; One Health Multisectoral; Diagnostics Stewardship and Data Use & Interpretation for Public Health Policy.

3. **Target learning events for groups of people with specific job roles.** Learning events need to focus, to some extent, on the needs and job role of each individual and particular forms of learning should be prioritised towards specific groups.

4. **Design learning events that encourage collaborative work.** There is a need for improved collaboration and cooperation across and amongst key groups of professionals to foster a stronger interdependence across professional groups. For example, for patient-centred diagnostics, the patient becomes central to the surveillance and their treatment/care is supported by a range of professionals working as a team. There is a need to create opportunities for inter-professional work and also to enable multi-sectoral and interdisciplinary collaboration to take place within and across settings (including lab professionals, clinicians, nurses in human health sites and lab professionals and in animal health settings).

5. **Expand beyond traditional ways of working, where clinicians and labs are disconnected and not engaging in direct, two-way communication.** There is a need to consider new roles that bridge between the lab and the clinical and vet services, where microbiology labs bring in other professionals (eg biostatisticians or epidemiologists who alter their work to collaborate with lab professionals to support AMR surveillance) to support the surveillance work. Also new surveillance roles could be introduced within the system to act as brokers between various groups (Clinical/Vet Surveillance Officer, One Health Officer).

6. **Learning and capacity building has to maintain focus on new practices and be accompanied by a restructuring of work.** In the context of strengthening capacity, learning events could be designed in ways that allow policymakers, senior laboratory professionals and lab professionals to reflect upon and reimagine how work is structured and how new practices (e.g. data use and interpretation) can be built and sustained.

7. **Existing AMR learning and guidance resources should be reused whenever possible** to avoid unnecessary duplication and offer better value for money. Though existing resources will have to be contextualised for learning in specific contexts.

8. **Draw on social uses of mobile and online technology to create opportunities for workplace learning** and ensure that the impact of these activities is rigorously measured and reported consistently. As far as possible, the learning events should use draw on the digital tools and ways of communicating that are familiar to lab professionals.

Suggested options for learning events

Based on these recommendations, the following are several options to choose from as activities for The Open University (January to June 2019). For each of the proposed topics we have identified content areas (Table B4), who these learning events should be targeted towards (table 5, 6, 9 & 11) and potential resources that could be adapted (appendix C) we have also identified potential approaches to the learning (see below). All options contain multiple learning events and would feature a period of co-design with the target audience, DHSC and Mott MacDonald. Further detail is provided in section 7.

1 Category: Good laboratory practice

Working with lab professionals from across sectors and geographies to support the development of and understanding in 'Good laboratory practice'. This would be a multiple methods approach with a strong focus on the contextualisation of existing resources and building of communities of practice in order for participants to:

- Develop a shared understanding of good practice
- Understand what this looks like across sectors and countries
- Identify what changes in practice are needed in their context
- Develop skills related to good laboratory practice
- Develop a plan to implement change in practice

2 Category: Data use & interpretation for diagnosis in Clinical & Vet Services

Working with lab professionals, Senior Lab Professionals, Clinical Services Professionals, Vet Services Professionals to develop an understanding of 'Data use & interpretation'. Learning would be focussed around an existing MOOC on data use and interpretation course with additional learning and assessment developed in order to provide a more contextualised response. Participants would:

- Understand basic interpretation / analysis
- Identify how to apply this to your needs
- How data can be used to support your work
- Develop a plan to implement data use in practice
- Engage in knowledge sharing to support change in practice, challenges / successes.

3 Category: Foundations in Microbiology

Working with Lab Professionals, Senior Lab Professionals, Clinical Services, Professionals, Vet Services Professionals to develop a core understanding of AMR, within the subject category Foundations in Microbiology. This would be based on existing course (the OU OpenLearn course 'Understanding antibiotic resistance' is suggested). We would seek to run the course in its current state but with a closed cohort, depending on the outcome of the co design phase contextualisation of the course may need to be developed both with a view to geography and content level. Participants in this course would:

- appreciate the issues surrounding antibiotic resistance
- know about the challenges in developing new antibiotics
- know about alternative approaches to tackling infectious diseases.

1. Tackling AMR: background to the Fleming Fund

The rise of antimicrobial resistance (AMR) poses a threat to our ability to treat common and life-threatening infections on a global scale. Effective antimicrobials are prerequisites for both preventive and curative measures, protecting patients from potentially fatal diseases and ensuring that common or complex clinical procedures, such as giving birth or a surgery, can be provided at low risk. Yet misuse and overuse of these drugs in agriculture / food production and human health have put every nation at risk, hence harmonised and immediate global action is needed to minimise the impact of AMR.

Alert to this crisis, the May 2015 World Health Assembly adopted a Global Action Plan on antimicrobial resistance, which reflects a global consensus that antimicrobial resistance poses a profound threat to human health. The Global Action Plan outlines five objectives:

1. to improve awareness and understanding of antimicrobial resistance through effective communication, education and training;
2. to strengthen the knowledge and evidence base through surveillance and research;
3. to reduce the incidence of infection through effective sanitation, hygiene and infection prevention measures;
4. to optimize the use of antimicrobial medicines in human and animal health;
5. to develop the economic case for sustainable investment that takes account of the needs of all countries and to increase investment in new medicines, diagnostic tools, vaccines and other interventions.

In parallel to these developments, in 2014 the then UK Prime Minister asked the economist Jim O'Neill to analyse the global problem of rising drug resistance and propose concrete actions to tackle it internationally. The Review on AMR, jointly supported by the UK Government and Wellcome Trust, engaged widely with international stakeholders to understand and propose solutions to the problem of drug-resistant infections from an economic and social perspective. The final report and recommendations 'Tackling drug-resistant infections globally' was published in 2016. Recommendations expand beyond the need for the development of new forms of antibiotics and restricting the use of drugs to developing better detection methods that can instantly diagnose and recommend treatments and encouraging behavioural changes that will reduce instances of infection. In response to this review and aligned with the Global Antibiotic Resistance Surveillance System (GLASS), the UK government initiated The Fleming Fund, a UK Aid programme to help low-and-middle income countries tackle AMR and improve disease surveillance focused on drug-resistant infections. The Fleming Fund recognises that a key challenge in meeting the requirements of the Global Action Plan is the lack of surveillance data on resistance and antimicrobial prescription and use, therefore an investment of 260 million GBP is made, demonstrating the importance of taking a One Health approach and working towards achieving truly effective global disease surveillance to make sure that health systems are better prepared. The capacity for AMR surveillance in LMICs is relatively limited and fragmented, despite evidence that, as with the rest of the world, AMR in LMICs is

increasing. Strengthening AMR surveillance, particularly in LMICs where the burden of infectious diseases is highest and ability to respond may be limited, is a high priority.

2. Background and objectives to the OU grant

The Open University (OU) is a grantee of the Fleming Fund and is working with Mott MacDonald and the Department of Health & Social Care (DHSC) to identify capacity development needs for AMR surveillance in LMICs. The aim is to a) identify the skills and knowledge needed by different groups professionals working in AMR surveillance systems in LMICs, and then b) to design, implement and test a series of learning events using different pedagogical approaches to support capacity building. At the outset of our work is a recognition that a key component of the Global Action Plan focuses on making AMR a core component of professional education, training, certification, continuing education and development in the health and veterinary sectors and agricultural practice to ensure proper understanding and development of appropriate professional development.

To achieve this aim, over the project duration, The OU will:

- Develop learning resources and run learning events to meet the identified pedagogic and subject needs.
- Develop a longer-term approach to identify topics, methods and modes of delivery of online blended learning for AMR in LMICs.

Due to the complexity of this large-scale and long-term programme, an early learning needs analysis was carried out to support a clearer understanding of the AMR ecosystem and the wider capacity building needs, both subject based and pedagogic. This report marks the first output from this first phase of work (i.e. 'Scoping Phase'). This report was initially reviewed internally by Mott Macdonald staff, and comments were provided to the research team to establish how the process could be improved and how this analysis informs activities of the following phase. Once defined, a number of learning events will be co-designed with individuals/teams based at microbiology labs at the three target countries using the latest know-how in blended professional learning while, at the same time, paying attention to accessibility issues within low resource settings, learners with varying levels of digital literacy, and contexts where online learning can be viewed as low value.

Our work focuses on the AMR workforce as we recognise that an effective workforce is critical to an effective surveillance system. Our work is underpinned by a firm belief that strengthening surveillance systems needs to have all professionals working together to create sustainable health systems, with particular attention to the crucial role laboratories provide. We recognise that there are other critical actors, such as clinicians, nurses, vets, farmers, pharmacists prescribing and selling antibiotics and the general public. Their knowledge and approach to antibiotic use is critical to reducing AMR but is out of scope of this work for year 1, which focuses on laboratory professionals.

Lab professionals are central to the AMR workforce and motivated and a highly skilful workforce is essential to well-functioning laboratory services. And yet, even in high-income countries, the role of pathology and laboratory medicine (PALM) is not well understood by the public (Kleinert & Horton, 2018). This is highlighted in a recent Lancet series on PALM in

LMICs (Wilson et al, 2018) which outlines the crucial and central roles of PALM services in the accurate diagnosis and detection of disease, informing disease prognosis and guiding treatment, contributes to disease screening, public health surveillance and disease archives. Yet there are multiple challenges that have to be overcome: in many LMICs, laboratory work is neither an attractive nor a valued career choice; a considerable number of trained laboratory professionals leave the public health sector to work in the private sector where pay and conditions are better; new diseases and the rising demands for new lab diagnostics require continued development of workforce with specialist knowledge and skills. Wilson and colleagues (2018) provide a comprehensive analysis of the challenges and gaps that limit access to PALM services, including insufficient human resources or workforce capacity, inadequate education and training, inadequate infrastructure, and insufficient quality, standards, and accreditation.

Whilst the OU, through its work within the Fleming Fund, does not aim to provide answers to all these challenges, we place close attention on the challenge of inadequate education and training. From our earlier research on how professionals learn, we know that access to learning resources alone is unlikely to result in a change in work practice (see for example Littlejohn, Lukic & Margaryan, 2011). Practices tend to be passed down through generations. They become systemic and associated with 'being' a practitioner. When newcomers come into a workplace they try to fit in and become 'enculturated' into systemic practices and ways of doing things associated with expertise (Williams, 2013, p.147). Known 'ways of doing' are engendered in generations of practice and, whether good or bad, tend to endure as a template of 'how it is to be' a practitioner. It can be very difficult to change these practices, even when they become so outdated that they no longer work well. Any challenge to entrenched practices not only has to be sound and well argued, but also has to be aligned with or change the work culture.

Entrenched poor practice by clinicians, vets and lab professionals is seen as contributing to the increase of AMR. This can be in terms of misuse of antibiotics in agriculture, unregulated medicines, poor prescribing, poor manufacturing and also in terms of poor quality (or non-existent) analysis in laboratories, with no data to allow the right treatment for the right antibiotic at the right dosage for the right amount of time. There is poor awareness of AMR in LMICs at all levels of society. The focus of the Fleming Fund is on professional practice of a wide range of individuals with a variety of skills, backgrounds and interests, including surveillance staff, public health professionals, policy makers, clinicians, vets, and pharmacists. Hence the urgent need for professionals to learn about best practices associated with AMR on a mass scale with accessible materials to change professional practice.

There are a number of learning tools and resources that have already been developed which can be used to support the design and implementation of new learning solutions to meet the challenges of changing curricula, uncertain environments, professionals' training to support capacity development in AMR surveillance. At the same time adaptive digital tools can be used to support the personal learning needs of professionals. Use of such tools and resources can support and expand what lab professionals need to know and do in their lab and in their work with other staff. Use of these tools and resources can amplify and expand

the impact of effective professional-centred practices, leading to capacity building that is specific for the specialist roles emerging in clinical settings.

In the context of strengthening lab capacity to address the rise of drug-resistant infections, a lens on workforce prompts us to reconsider roles within the health-care/AMR workforce (Organisation of work) as well as new practices, to build and sustain a strong, professional, motivated and effective workforce (Workforce strengthening). Although it is anticipated that the OU work will have an impact on certain elements within a wider range of workforce issues, this report aims to highlight problems that will have to be considered long-term since it is clear that maintaining focus on and making investment in both is required to provide a workforce equipped with the capacity, skills to deliver the goals of AMR Global Action Plan and address the global threat of AMR. The purpose of this initial scoping phase is to offer evidenced possibilities in the key area of lab-based capacity building and identify key needs as expressed by professionals themselves.

3. Methodology

The scoping phase consisted of two linked pieces of research: Phase 1 - an examination of a range of issues related to AMR surveillance and lab capacity building in LMICs through in-depth interviews with world experts in AMR and analysis of their views with respect to the rules, community, tools and objectives of the surveillance activity; and Phase 2 - an investigation of the roles and the learning needs of laboratory professionals in LMICs, namely types of knowledge and skills professionals need in performing surveillance activity and specifically how they best learn about AMR surveillance through training as well as learning on-the-job at specific sites in three focus countries: Tanzania, Bhutan and Ghana. Three themes, informed by Phase 1, were guiding the activity in the three countries: i. AMR Governance and Leadership; ii. Knowledge, Attitudes, Practice on AMR and iii. Education, Training and Continuing Professional Development on AMR, hence the second phase also involved engagement with people leading policy activity on AMR in the countries. The specific country focus was directed by Mott MacDonald due to the country level of readiness within the Fleming Fund grant process. The overall purpose of the visits was to inform the design of Learning Events (i.e. topics, methods, format and modes of delivery) that will be delivered through the Open University UK within the focus countries as part of the Fleming Fund Activities.

These two linked phases were supplemented by desk-based research, including review of learning resources, whereas in preparation for the observations in laboratories within the focus countries two visits within the UK were planned in order to provide a baseline by which to understand what good AMR surveillance / stewardship looks like. The visits were to the main UK Reference Laboratory at Colindale and a sentinel site at the Stoke Mandeville Hospital.

This methodological approach was important since it enabled investigation of the work context and greater validity for the overall approach that the OU will take in the following months, especially around the design, facilitation and evaluation of learning events aiming to change the practice of laboratory professionals. Data collection were undertaken between April 2018 and October 2018. The scoping phase was monitored by Mott

MacDonald, while we engaged in consultations with the DHSC through regular meetings with the researchers throughout this period to monitor progress and, as required, update forward planning.

The research team engaged with a range of professionals (i.e. lab professionals, policy makers, clinical staff) and a number of target groups within the AMR system were identified through analysis of the data gathered through the interviews. The groups / professional roles are illustrated in Table 1. These job role categories are used throughout the report. Some limitations are noted, for example some professionals had more than one roles within the AMR system, whilst some roles are duplicated within clinical and vet services (e.g. pharmacist, epidemiologist).

Phase 1: Interviews with AMR Community / Experts

Data was gathered between April and June 2018 during a series of face-to-face and online interviews with experts in AMR (total n=23). Purposive sampling was performed as these experts are:

i. members of the Technical Advisory Group of the Fleming Fund / DHSC (TAG) (n=3)
ii. Members of staff at a research institution in LMIC, leading a capacity programme on AMR (n=2)
iii. members of the Experts Advisory Group (EAG) of the Management Agency leading the implementation of the Fleming Fund (n=7);
iv. Members of staff of the Management Agency; (n=8) and
v. secondees from the UK DHSC in organisations such as World Health Organisation, World Organisation for Animal Health (OIE) and Food and Agriculture Organisation (FAO) (n=3)

For the purposes of the analysis, this group of experts is included in the category 'AMR Community/Experts', apart from the fifth category which we view as 'Policy-Makers' (Table 1). Data were gathered through interviews (30min to 1hour; average duration 50min), that were audio recorded and transcribed verbatim. Interviews were guided by a semi-structured instrument previously validated during studies of self-regulated, professional learning (see Appendix A). It is noted that these experts had expertise on health systems research and AMR in multiple countries across the world, including: Vietnam, Malawi, Cambodia, Philippines, Pakistan, Mali, Tanzania, Ghana, Uganda, Nepal, India, Laos, Kenya, Bhutan, New Zealand, Myanmar, Zimbabwe, UK. It is acknowledged though that the majority of the experts had experience in human health systems (due to the nature of the provided contacts) and this might be reflected in their views.

In parallel to this activity, Phase 1 further included a review of learning resources on AMR, including but not limited to online courses, videos, frameworks and reports. The main objective was to gain a better understanding of the AMR landscape and document the range of existing resources in order to map these resources against the identified needs that would emerged from the interviews with experts and professionals in countries. The method is described below:

Table 1 Categories / Professional Roles

Category	Description

Lab Professionals	Lab technician, assistant, technologists, lab scientist (across sectors)
Senior Lab Professionals	Head/Manager of Lab, Head of Unit (across sectors)
Clinical Services Professionals	Clinicians, nurses, pharmacists, epidemiologists, superintended, clinical officers
Vet Services Professionals	Veterinarians, para-vets, Livestock professionals, field/vet officers, vet pharmacist
(Senior) Management staff in Clinical services	Head of Hospital, Chair of IPC committees / Drugs & Therapeutics / Resources
(Senior) Management in Vet Services	Director / Deputy of Vet Services
Policy makers	AMR Secretariat, Ministry Health, Ministry of Agriculture, Livestock, Fisheries, WHO, FAO, OIE
AMR Community / Experts	Academics, donors, Fleming Fund professionals, members of EAG, members of TAG, PhD students, FF fellows
Clinical and Veterinary services clients	Farmers/farm managers, patients, community pharmacies
The public	Members of the public

Phase 2: Country visits and fieldwork activity in laboratory settings

Data was gathered between July and October 2018 with an aim to identify work practice in laboratories in three target countries. We visited a number of AMR surveillance settings (animal health, human health, food production). We used quasi-ethnographic methods including observation and interviews with professionals in labs and AMR leaders and policy makers. These data were supplemented by desk-based research to identify country priorities and key stakeholders (e.g. AMR Committees, donors, individuals / organisations responsible for health information systems, local education / training institutions) who could collaborate with us. Figure 1 shows the engagement in AMR Surveillance sites per country.

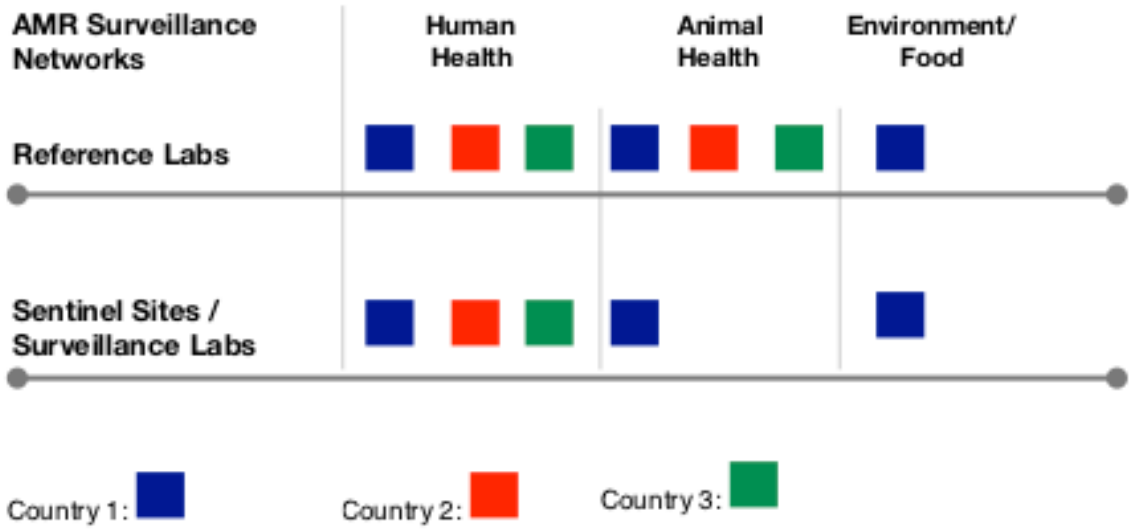

Figure 1: Site visits in Country 1, Country 2 and Country 3

Data were gathered through face-to-face and online interviews and site observations. Interviews were guided by a semi-structured instrument previously validated during studies of self-regulated, professional learning (see Appendix A / A2, A3). In total 60 interviews were conducted across the three countries. Semi-structured interviews (lasting from 30 minutes to 1 hour) were audio-recorded and transcribed verbatim. Table 2 shows the number of interviews per country and per professional role.

Further to the interviews, a short survey tool was developed with an aim to understand the extent to which the target audience within the target countries uses and access online and digital resources. The survey was distributed (either in hard copy or online) to interview participants in the three countries and their colleagues within the institutions they worked. Surveys within Country 1 were all delivered online, surveys within Country 2 were only completed in the print version and Country 3 had a mixture of both online and print. The number targeted was fifty-six (n=56), based on an estimated average of 4 people per site. The final number of responses to the survey are thirty-nine (n=39), as following: Country 1: n= 21, Country 2 n=12, Country 3 n= 6. The survey tool is included in Appendix A.

We acknowledge that interviews and survey were conducted in English, which is not the mother-tongue of the participants and this may have been a limitation to the study. Furthermore, the study reflects the views of a number of professionals in specific contexts, therefore any generalisation to wider professional communities should be performed carefully.

Table 2 Number of interviews conducted per country / per professional roles

Professional Roles	Country 1	Country 2	Country 3
Laboratory Professionals	9	10	5
Senior Laboratory Professionals	10	4	2

Clinical Services Professionals	1	-	-
Senior Management Staff in Clinical Services	1	-	1
Policymaker	3	6	4
AMR Community / Expert	1	1	2
Total	**25**	**21**	**14**

The data were analysed by means of thematic categorisation (Tuomi & Sarajärvi, 2009) using qualitative analysis software NVivo 11. Nine main themes were identified in the interviews indicating skills gaps, knowledge gaps and need to develop practices and are shown on Table 3. The first six categories are specific to AMR surveillance activity and can also be viewed as specific to roles within the system, whereas the last three cut across sectors and roles. It is noted that some areas align with one or more categories (e.g. Communication, Collaboration & Advocacy and One Health Multisectoral) but these have been separated due to the analytic interest of the scoping phase. These categories and groups are used throughout the report.

Table 3 Categories of knowledge and skills gaps

Ref	Category name	Description
1	**Diagnostics Stewardship**	refers to the appropriate use of laboratory testing to guide patient treatment, in order to optimize clinical outcomes and limit the spread of AMR (incl. clinical case definition, demand for appropriate tests, sampling selection - sample & test, Sample-in-transport, and diagnostic information translated into appropriate management of patient)
2	**Good Laboratory Practice**	Refers to a quality system of management controls for laboratories to ensure the consistency, quality, and integrity of lab tests. Incl. resources management (re-agents, supplies, media), biosecurity & biosafety, Quality Control (internal process) SOPs and Quality Assurance (external scheme).
3	**Foundations in Microbiology**	Refers to core knowledge of concepts of microbiology and development of skills around microbiological use of various equipment like microscopes and various dyes and stains and performing many microbiological techniques, e.g. AST, agar diffusion test, bacterial inhibition, microbiological culture. More applicable to the sites/sentinel sites
4	**Molecular Advanced Microbiology**	Refers to core knowledge of biological activities at the molecular level and development of skills around the use of specific techniques unique to molecular biology and genetics or biochemistry e.g. Polymerase chain reaction (PCR). More applicable to the Reference Labs
5	**Data Use & Interpretation for diagnosis in Clinical and Vet Services**	Refers to the activity where individual case-level anonymised data are collected as local health facility data (i.e. sentinel site data) These could include the total number of patient episodes and the total number of samples processed in the laboratory. It also refers

		to activity where lab diagnostics support treatment of individual patients.
6	**Data Use & interpretation for Public Health Policy**	Refers to the activity where local health facility data (from sentinel sites or surveillance labs) are submitted regularly to national co-ordinators, healthcare / public health administration, clinical and laboratory staff, to support continued engagement with AMR surveillance. Aggregated data in district level; aggregated data at the national level; aggregated data at the global level to inform public health policy.
7	**Communication, Collaboration & Advocacy**	Effective advocacy and communication, education and training, and empowerment and networking can lead to improved data use and sharing, awareness and understanding of antibiotic resistance and can facilitate behaviour change. Could also include report writing.
8	**Surveillance System Planning & Implementation**	Refers to developing surveillance strategy (local, district and national level), surveillance workforce organisation, surveillance management, project management, Fleming grants
9	**One Health Multisectoral**	Refers to the One Health perspective and operationalisation; all sectors, collaboration in the human, and the animal, livestock, fisheries, and other sectors collaborating to achieve a common outcome.

4. Analysing the AMR Ecosystem in LMICs: opinions of AMR Community/Experts

The analysis of the data generated through the interviews with AMR Community / Experts (n=23), supports identification of tensions between elements of the AMR system, either at the global level or at the country level. The aim of the analysis is to trace the challenges and reveal the tensions that may emerge as laboratory professionals experience change in their professional practice. The analysis also surfaces potential future dilemmas associated with implementing a capacity strengthening programme. The following section highlights key tensions that emerged through the Phase 1 interviews.

4.1 Nature of challenge

4.1.1 AMR is an emerging global challenge

During the interviews the experts referred to AMR as a new, emerging, complex issue that requires attention. The recent emergence of AMR as a known concept is perceived as the main reason that the general public lack awareness of the problem of AMR. This is also the reason why professionals working in public health facilities have limited knowledge about AMR and is considered by some as the reason why there has been limited mobilisation of resources to tackle AMR within health systems and to the lack of regulation around the use of antibiotics in LMICs.

Given that AMR is an emerging global challenge, it generates enhanced interest by many stakeholders and donors in this field, but it also creates an environment that is 'dynamic' and 'fluid':

> *"there's quite a lot of other donors involved in this area. And it's an up and coming subject. So people are investing, and taking up, and taking up the resources of a very limited number of people. So you have to be careful to pitch programmes at the right level for each country because the absorptive capacity of the countries…has been limited…" [AMR Community / Expert, P3)*

This quote highlights specific vested interests and competing concerns / priorities. Within, for example, Ministries / departments / donors that influence the resources available (e.g. funding). The above quote also signals that a likely outcome is a sense of fatigue among the various groups that these stakeholders are targeting.

Interviewees identified 'management of expectations' as a major challenge and proposed careful navigation of the environment and also - where possible - co-ordination and alignment with other stakeholders, especially with the policy-makers in each country. This is indicated by a comment raised by one of the interviewees, in response to a question about the challenges in their role: "[I need] to make sure that what I'm doing, what I'm creating, and what I'm spending funds on is in line with what the Ministry of Health wants" (P7). The experts further pointed to a risk of "duplicating initiatives" [AMR Community / Expert, P5), which the Fleming Fund is mindful of and which is a key principle of the Fund.

4.1.2 AMR is a multi-disease and multi-sectoral challenge

Interviewees perceived AMR as a multi-disease and multi-sectoral challenge that involves farming and agriculture, the environment, human health and animal health systems. Hence AMR must be dealt with through collaborative and multi-sectoral approaches, while maintaining a focus on the local, regional, national, and global levels. This challenge is an important one to highlight and to be addressed. Therefore, collaborative forms of work and learning across boundaries are required to ease this tension. A consequence is that different groups (acting as silos) that have been designed to work separately (e.g. Human Health systems, Animal Health systems) now have to work together. This requires a number of architectural or organisational changes, but it is not clear how these can be actuated.

An example is the One Health perspective that underpins the Fleming Fund. While the focus of AMR work is on protecting human health, this cannot be achieved without a strong One Health component with linkages between animal and human health disciplines at the country level. Many interviewees referred to this principle, alongside the other three principles of the Fleming Fund, to point to a 'design challenge'. The Fleming Fund has to work towards facilitating the One Health. However, this work takes place in an environment where there is limited awareness about the One Health perspective, which creates a tension in terms of how to operationalise this perspective. This tension is illustrated in the following quote:

> *"And that's [One Health] been a big thing, again for our own team [Fleming Fund / Management Agency] to understand, and then for countries to understand. Because everybody from WHO, and the tripartite, DH, Mott, and to some extent on the ground uses the words One Health, and understands that One Health is important for antibiotic resistance, but without really understanding how to achieve that" [AMR Community / Expert, P23]*

It is noted that the interviewees referred to specific mechanisms have already been put in place to facilitate the One Health perspective. The AMR Committees that have been established and are currently operating in each of the Fleming Fund countries with representatives from the various sectors is one example of an action towards One Health. The approach taken to implement One Health often focuses on facilitating the strengthening of each individual surveillance system (i.e. human, animal, environment), so that *"they are each producing quality results that can be relied on, that they've got some harmonised approaches…" [AMR Community / Expert, P23].*

4.2 Engagement strategy with the challenge

4.2.1 AMR Surveillance is an outcome of well-functioning lab networks

One of the key mandates of the Fleming Fund is to establish and support AMR surveillance networks within the countries, consisting of Reference Labs (human and animal health) and a number of sentinel sites. Depending on the country, a network may already be in place, or

may be developed as part of the capacity-building process. The main criteria that are considered are: current in-country capacity in clinical, laboratory and data handling areas, costs for starting and maintaining the proposed AMR surveillance system, as well as the sustainability of the proposed AMR surveillance system.

The interviews suggested that the speed and extent to which AMR surveillance can be strengthened depends on the functioning of these networks and the resources available, including funding and human resources. It heavily relies on policy commitment, as pointed in the following:

> *"Without engagement from the government, our [Fleming Fund] systems wouldn't really work, because they require the AMR committee to sign off on stuff and to request supports and for it all to be part of the national plan… Not having the government buy-in and a functional AMR committee is a bit of a problem for us" [P10]*

In most LMICs countries there is existing laboratory capacity, yet the scale varies substantially, not only across countries, but also within the country itself. For example, labs in rural settings differ from urban areas, the capacity and expertise in AMR reference labs is different from sentinel sites, only a few labs are accredited, whereas there was a consensus among interviewees that AMR surveillance for human health is better developed than for animal health.

Regarding the day-to-day operation of the laboratories, a number of systemic issues were raised during the interviews, such as the infrastructure (i.e. power supply, equipment, lack of capacity to use the equipment), quality (i.e. quality control, quality assurance) but also the procurement process within the public health system in LMICs. The issue of access to high quality re-agents was highlighted:

> *"most of the procurement agency in countries base their choice of reagent based on cost. And so, they will select re-agents that are unfit to provide good quality testing. And this is because there is a disconnection between the finance ministry and the technical people, even from the country. And so, these systemic issues like quality is not restricted to train lab technicians, to do good testing. They know that they need good reagents, but they don't have these reagents, because the national procurement agency is not supporting [purchase of] this reagent because they cost too much initially…And there is all this economic value chain that is not taken into consideration by the finance ministry" (P5)*

4.2.2 AMR Surveillance relies on Good Practice

During the interviews, the interviewees drew attention to extensive and often unnecessary use of antimicrobials by humans in human health, agriculture / food production and animal health. It is well known that AMR is driven by the evolutionary response in the microbial

world, but the phenomenon is usually made worse by ingrained professional practices. Several examples of entrenched practice were described, such as the pharmacist who sells antibiotics over-the-counter without a prescription, the farmer who uses antibiotics in agriculture in an indiscriminate way, the clinician who prescribes antibiotics without sufficient data or the lab technician who is not following quality control procedures. The practise of clinicians were most frequently used as examples of bad practice. Clinicians were perceived as not making use of lab-diagnostics to treat patients, and, instead, relying on empirical diagnosis. These examples of poor professional practice might be due to the patients having to pay for tests, hence the cost of treatment may have been increased. Alternatively, there may be *"no culture of reliance amongst clinicians for using laboratory services as part of their day to day clerical work" [P13].* Alternative interpretations of this phenomenon could be that the lab service is not available, reliable, or timely, or clinicians are not trained in interpreting the data and results. However, these possible explanations were not put forward by the interviewees.

Another interviewee viewed clinicians' prescription practices as an 'old practice' that is still endured despite changing circumstances:

> *"…you know, antibiotic prescribing was a very easy task when I was a young physician because we had a lot of antibiotics and every antibiotic was working on most bacteria. So, it was very easy. Now it's very, very complicated in many instances, because we have bacteria on which very few antibiotics which are working. And depending on the patient, you have strictly to use this one or this one, at that dose or this dose. And very often, it's a great help for the clinicians to have the advice of the microbiologist to choose the right antibiotic […]" [AMR Community / Experts, P18]*

Drawing on this evidence it seems that clinicians are a key group to include in capacity building. Though it is noted this group are out of scope within year 1.

4.2.3 AMR Surveillance requires data flow across local, national and global systems

In AMR surveillance readily available, good quality data from the labs is shared within a facility with clinicians or vets to support diagnosis, prophylaxis and treatment at an individual level. Data is also made available in aggregated forms beyond the local facility and is shared with district and national facilities to support treatment guidelines, SOPs and public health policy nationally. Three different visions of data use within a surveillance system were articulated:

> *"The first one is to report it to the clinician and tell him, well, you have to use antibiotic X or Y and not antibiotic zed to treat your patient…The second use is to tell a clinician every year, during the past year, we have isolated, I don't know, 564 bacteria of that type in your department…To give them the statistics. Which will help them to use this data in what we call an empiric manner… and so you can adapt your empirical treatment using the retrospective data…. And the third use of the data is to gather all the information from hospitals or health centres… and to have a global picture in the country of the susceptibility pattern of each type of bacteria.*

And so the leaders and the people that make the public health policy… will take specific measures against bacteria X" [P18]

In most LMICs there is no systematic way of collecting and reporting these data. There are few standardised procedures and standardisation of reporting systems and data sharing and comparability with other countries is not yet possible. Links between clinical data, samples and clinical outcomes are not usually made, while any data that is available often is generated by externally funded research projects.

4.2.4 AMR surveillance relies on motivated and skilful professionals

In response to the question about what the key challenges are in building capacity in AMR laboratories in LMICs (see Annex B), almost all the interviewees referred to the same issue: lab professionals do not have the technical expertise needed to perform bacterial susceptibility testing. There was a consensus about the difficulty lab professionals face to *"technically assess precisely the results of the susceptibility…It's extremely difficult technically to say bacteria X is susceptible to antibiotic Z, but not to antibiotics A and B"* [P18]. Interviewees pointed to inadequate and sometimes non-existent training as another factor contributing to the poor functioning of AMR surveillance systems.

There was a concern about low retention rates of laboratory professionals, low salaries and poor motivation. These are all viewed as major barriers in strengthening capacity - "it all comes back to resourcing: if you are a lab technician working in a poorly resourced lab…you will still feel undervalued and under-represented…" [P22]. Entrenched behaviours among members of staff appear to impact the quality of work and public health system appear to place constraints in making the sort of Human Resources changes that are necessary to improve the system. The fact that labs operate in low-resource environments, where often lab managers/heads of units cannot commit extra resources to AMR surveillance, was also viewed as detrimental:

"a lab may have three lab technicians/technologists. And three lab technicians would be one for malaria programme, one for tuberculosis, and maybe one for HIV/AIDS. And that's the expectation most of the host government have that if you are coming into a country for the lab strength, then you also need to keep funds to place a Lab Technologist or keep a microbiologist in the lab" [P1]

4.2.5 AMR surveillance requires trust and openness among professionals

There are specific 'norms' within AMR systems, one of which was expressed as 'lack of trust' of clinicians in terms of the results generated by the laboratories, as expressed in the following quote:

"The second major issue is about trust…If you go to a UK hospital with a suspicion of infection, immediately, you will be taking a number of samples depending on the type of infection. And these samples will go to the lab,

and the clinicians will use the result to treat you because they trust the results from the lab. In many, many places in developing countries, this does not happen because first, the clinician do not do the sampling. Very often, they do not do the sampling, because… they don't trust the result of the lab. And if they don't trust the results of the lab, they don't do the test because they know that they will not use the result…They don't send test, so the lab has very little tests to perform, and so they are not very good at performing tests and they are not very good at giving good results. And so it doesn't work" [P18]

This tension originates from the hierarchical structures within health systems. One interviewee noted that "the clinical staff and laboratory staff often don't talk to each other very much…" [P]. This lack of trust influences the ways in which the microbiology labs operate. One issue is that LMICs laboratories are usually run by people without a medical background, and this is sometimes perceived by clinicians as problematic. This problem is aggravated by the ways results are communicated, since lab professionals "cannot exert a bit of weight when giving advice on what antibiotics should be used" [P7]. Tensions between key groups of people is not limited to the clinician-laboratory staff relationship.

One interviewee expressed a *"deep sense of responsibility"* that clinicians share: *"if I'm a doctor in a malaria endemic area, and I miss a malaria case, then I'm no good at my job. So, I'd rather treat everybody for malaria in the absence of other…" [P16].* This feeling of responsibility might explain partially why clinicians follow entrenched prescription practices in LMICs, particularly when treating children, as highlighted by some of the interviewees.

4.3 Key knowledge and skills needs by the AMR Community/Experts

There are significant AMR knowledge and skills gaps that need to be addressed. Table 4, Table 5 and Table 6 summarise the key findings and Appendix B presents detailed analysis of these data (see Table B1).

Table 4 The number of experts expressing what needs to be learnt (N=23)

Categories / Who says?	DS	GLP	FM	MAM	DICV	DUP	CCA	SSPI	OH
Policy Makers (n=3)	1	1	1	-	1	-	2	-	-
AMR Community/ Experts (n=20)	4	8	11	1	12	6	13	7	3
Total	**5**	**9**	**12**	**1**	**13**	**6**	**15**	**7**	**3**

DS=Diagnostics Stewardship; GLP= Good Laboratory Practice; FM= Foundations in Microbiology; MAM=Molecular Advanced Microbiology; DUCV= Data Use & Interpretation for diagnosis in Clinical and Vet Services; DUPH=Data Use & interpretation for Public Health Policy, CCA=Communication, Collaboration & Advocacy; SSPI=Surveillance System Planning & Implementation; OH=One Health Multisectoral

Table 5 Who should learn per category?

Categories / Target groups	DS	GLP	FM	MAM	DICV	DUP	CCA	SSPI	OH
1. Lab Professionals	x	x	x	x	x	x	x	x	x
2. Senior Lab Professionals		x	x	x	x	x	x	x	x
3. Clinical Services Professionals	x		x		x	x	x	x	x
4. Vet Services Professionals	x		x		x		x		x
5. Senior Management staff in Clinical services	x				x	x	x	x	x
6. Senior Management in Vet Services						x	x	x	x
7. Policy maker					x	x	x	x	x
8. AMR Community / Experts					x	x	x	x	x
9. Clinical and Veterinary services clients							x		
10. The Public							x		

DS=Diagnostics Stewardship; GLP= Good Laboratory Practice; FM= Foundations in Microbiology; MAM=Molecular Advanced Microbiology; DUCV= Data Use & Interpretation for diagnosis in Clinical and Vet Services; DUPH=Data Use & interpretation for Public Health Policy, CCA=Communication, Collaboration & Advocacy; SSPI=Surveillance System Planning & Implementation; OH=One Health Multisectoral

Table 4 illustrates the number of experts who prioritised a specific AMR topic for future learning events. The top three categories are 'Communication, Collaboration & Advocacy' (n=15), 'Data Use & Interpretation for diagnosis in Clinical and Vet Services' (n=13) and 'Foundations in Microbiology (n=12) (see Categories in Table 3). Detailed descriptions of what the experts said that should be included within these categories is presented in Appendix B / Table B4.

This analysis highlights the importance of developing communication, collaboration and advocacy skills across roles in the surveillance system. This category does not look at subject specific skills, such as in the category 'Foundations in Microbiology' or "Good Laboratory Practice'. However, it acknowledges that surveillance activity involves numerous processes, interfaces and handoffs across different professional groups with varying levels of educational and professional training. Effective AMR surveillance involves many instances where critical information must be accurately communicated - across professionals, ranks, settings, teams and sectors. This means that working in specific siloed groups, without communicating with others, is no longer possible and communication and collaboration is critical. Where professionals are not communicating effectively, patient/public health safety is at risk and errors are likely to occur. The importance of communication, collaboration and advocacy skills is highlighted in Table 5, where it is evident that this is the only category that extends across all target groups. Experts often talked about specific target groups who need to work together. These groups are shown on Table 6, which highlights the importance of collaboration between lab professionals and clinical services professionals.

Table 6. Roles / target groups who should be working together per identified categories

Roles / Categories	Lab Professionals	Senior Lab Professionals	Clinical Services Professionals	Vet Services Professionals	Senior Management staff in Clinical services	Senior Management in Vet Services	Policy makers	AMR Community / Experts	Clinical and Vet services clients	The Public
FM	x	x								
DUPH	x	x								
					x		x			
					x	x	x	x		
CCA	x	x								
	x	x								x
	x		x	x						
	x	x	x		x					
		x			x					
			x		x					
				x					x	
					x		x			
							x	x	x	
SSPI		x			x					
OH	x	x								

DS=Diagnostics Stewardship; GLP= Good Laboratory Practice; FM= Foundations in Microbiology; MAM=Molecular Advanced Microbiology; DUCV= Data Use & Interpretation for diagnosis in Clinical and Vet Services; DUPH=Data Use & interpretation for Public Health Policy, CCA=Communication, Collaboration & Advocacy; SSPI=Surveillance System Planning & Implementation; OH=One Health Multisectoral

A second critical category is 'Data Use & Interpretation for diagnosis in Clinical and Vet Services". This highlights the importance of data flow across local, national and global systems as a critical element of the surveillance activity. The experts are well aware that inability to interpret and use surveillance data on antimicrobial prescription and use and drug resistance, or the absence of these data, impedes diagnosis and effective treatment. This gap in knowledge on how to use data might be due to the fact that AMR surveillance systems are not yet mature in LMICs. It might be because no specific roles have been created to use and interpret data, or because professionals who have this role have not yet acquired specialised skills, do not feel ownership of specific tasks or are not sufficiently supported in the performance of this activity to break through and be visible within the system and there is no data to act upon. These gaps cannot be dealt with in isolation and any approach to reducing them should consider hierarchical and organisational structures at the local facility level. The roles of professionals who are close to the patient or animal should be reviewed/created to ensure their practice enables effective sampling and data use. But there is also a need to clarify what knowledge and competencies are required for data use and interpretation to be performed adequately at the local level.

Some categories are arguably well established within the field, such as 'Foundations in Microbiology' and 'Laboratory Good Practice'. As a result, knowledge and skills needs that are revealed within these categories (e.g. knowledge on Quality Control – see Appendix B / Table B4), might be easier to address given existing strong expertise in the sector. However, categories such as 'Surveillance System Planning & Implementation', 'Data use &

Interpretation for diagnosis in Clinical and Vet Services' and 'One Health Multisectoral' are not yet well established, and these might be critical in establishing an effective AMR surveillance system. This finding means that we have to reconsider roles within the health-care/AMR workforce, as well as the knowledge, skills and practices that are appropriate for workforce strengthening programmes.

4.4 Recommendations

This section summarises key findings and recommendations from the interviews with experts, as follows:

Table 7 Key findings and recommendations from interviews with experts in Phase 1

	Finding	Recommendation
1	The environment within which the AMR surveillance networks fit suffers from systemic complexities in funding, poor coordination of surveillance planning and delivery, and system inadequacies, including workforce shortages and infrastructure.	1.1 A strengthening capacity programme should consider the ecosystem within the AMR surveillance systems in each country exist and recognise that systemic issues cannot not be addressed in the short-term. 1.2 AMR capacity programmes should aim to create enabling/inclusive environments for lab diagnostics and surveillance to take place and make best use of the workforce, existing infrastructure and technologies.
2	Lack of trust among key professional groups, namely clinicians and lab professionals, emerged as a key issue that affects AMR surveillance system in LMICs.	2.1 A capacity strengthening programme that only looks at achieving advancement of knowledge and skills will not bring desirable change.
3	Professionals tend to work in silos.	3.1 AMR strengthening capacity programmes require multi-sectoral and trans-disciplinary collaborative approaches e.g. human health and animal health, lab professionals with clinicians, lab professionals in urban and rural sites. 3.2 Development of Communication, Collaboration and Advocacy skills are essential within capacity programmes.
4	Lack of technical skills among lab professionals to perform core microbiology tests (e.g. susceptibility test) is identified as a key gap.	4.AMR strengthening capacity programmes should address the need for 'Foundations in Microbiology' and target development of practical skills.
5	Lack of surveillance data on resistance and no flow of data between local, district and national levels	5.1AMR strengthening capacity programmes should address key needs in 'Data use and Interpretation for diagnosis in Clinical and Vet Services'. 5.2 Clarify / Review what knowledge and competencies are required for data use and

		interpretation to be performed adequately at the local level. 5.3 Review / Create roles at the local level for this activity to take place in an effective way and professionals to feel supported.
6	Lack of clarity about categories such as ‘Surveillance System Planning & Implementation’, ‘Data use & Interpretation for diagnosis in Clinical and Vet Services’ and ‘One Health Multisectoral’.	6.1 AMR strengthening capacity programmes should include these topics. 6.2 Clarify what knowledge, skills and practices are appropriate for workforce strengthening programmes on AMR surveillance to address those topics.

5. Sourcing AMR Resources that can be used in learning events

This section presents the approach followed for sourcing existing learning resources on AMR (Appendix C) and the key findings that emerged from this review. The aim of this activity was to identify resources that can be used in learning events. As this list is not intended to be definitive (due to the ever-expanding range of content) it is envisioned that this would be developed, over the course of the current and any future grant from the Fleming Fund, with more expert and user evaluation of content to provide value to those seeking to deliver learning. In forthcoming months, we aim to carry out a systematic review of available resources.

5.1 Approach

The process had six discreet steps:

1. A review of current literature was conducted through keyword search in English language within Google Scholar and Google search; keywords identified as frequently used within the AMR literature were used, including AMR education; AMR learning; AMR training; Antimicrobial Resistance education; Antimicrobial Resistance learning; Antimicrobial Resistance training.
2. Online search for resources through keyword search in English via Google search using keywords: AMR; AMR education; AMR learning; AMR training; Antimicrobial Resistance; Antimicrobial Resistance education; Antimicrobial Resistance learning; Antimicrobial Resistance training.
3. Keyword search through popular MOOC platforms, namely edX, Coursera and FutureLearn.
4. Following-up on suggestions provided through expert interviews and in-country interviews with various professionals.
5. A meeting with UK based industry AMR learning providers; BMJ Learning and BSAC
6. Monitoring of the WHO AMR NAP discussion forum

The information gathered was recorded into a spreadsheet and categorised under the following headings:

- Type: Online Course / MOOC, Video, Webinar, repot etc;
- Name: the title of the resource
- Subject area: on the basis of the nine categories identified in the analysis, (see table 3)
- Audience role: who is the learning aimed at (see table 1.).
- Format: online, face to face;
- Duration: time it takes to complete (where relevant)
- Status/Development stage: is it available now, in development, no longer available
- Who has developed/delivered it: organisation / individual responsible for production / delivery
- Country: which country it is from
- Language: languages it is available in
- Licence: the licence applied to the resource

- Key contact: who is the key contact
- Link: where you can find the resource
- Use/Impact report: any data / info related to use of the resource
- Numbers engaged: how many people have already used the resource)
- Formal / informal: whether it is part of formal or informal education
- Accreditation: what credit is available, if any. Formal credit would be categorised as university credit or CPD credit, informal credit would be categorised as a certificate of achievement or participation.
- Notes/Description: any additional information

5.2 Key Findings

An initial fifty-eight (58) resources were identified and catalogued with a further forty (40) resources catalogued from the HEE (2017) training resources guide. Resources from reports by Dacombe et al. (2016), Ashley et al. (2016) and Rogers Van Katwyk et al. (2018) were also noted and work to incorporate the relevant resources into the catalogue is ongoing. The following analysis is based on the 58 resources identified by OU as the HEE resources had a UK Health focus given the nature of the guide but will be included in further analysis.

Resources were mainly focussed at a generic audience with 61% having three or more defined target audience groups. Of those audience groups the emphasis was predominantly on health professionals (Clinical Services Professionals, (Senior) Management staff in Clinical services) with 71% of the categorisation recognising clinical services at some level. It is noted that lab professionals are targeted only in 4% of the identified resources. This finding is backed-up by the literature where clinical microbiologists are under-represented (Rogers Van Katwyk et al, 2018) although this may represent a more senior role description based on our categories.

In terms of the subject focus the predominant area was ‘Foundations in / Core microbiology’ which represented 37% of the sample. The next most prominent subject area in the resources was ‘Diagnostics Stewardship’ with 20% of the identified resources. It is recognised that a possible limitation of the review is the identification of more non-specialised resources, which could be a result of the search that was implemented. At the same time this might reflect a growing interest over the recent years for general information on AMR as a subject area.

Resources found were predominantly delivered in English language (93%) while the remainder were offered in English with an additional language option (7%) although these were mainly within the ‘Communication, Collaboration & Advocacy’ category, and similar to the point raised in the previous paragraph it can be viewed as a result of an increased interest in raising awareness on AMR globally. The finding regarding predominant use of English language is not surprising and reflects the nature of the search and the focus on Global North results.

33% of the found resources did offer some type of informal or formal credit, however this review did not recognise any potential institutionally based CPD credit that may utilise these courses as part of internal programs of development. The extent to which credit is offered is

not an indicator of value to the audience as a number of the resources catalogued were publications, guides, toolkits etc; so did not lend themselves to assessment structures but could feature as resources within formal / informal credit systems. Finally, one significant finding around the resources identified is the lack of data on their impact, namely how the resource has been used and what the outcomes have been. Limited data around use is available, data that is available often focuses on the more general and advocacy focused content and is related to access rather than use specifically. This might be a limitation of the approach followed in reviewing the resources, as it is recognised that data on impact might have been published in academic journals, not linked directly from the resources themselves or appeared within the search results.

5.3 Recommendations

This section summarises key findings and recommendations, as following:

Table 8 Key findings and recommendations from the review of learning resources

	Finding	Recommendation
1	The review reveals an extensive range of resources and resource type on AMR.	Re-use resources both as is and where licence allows adapt for local context. Resources can be used to enhance 'new' learning events as supporting material.
2	Lack of resources aimed at lab professionals.	There is a gap in terms of resources targeting lab professionals at all levels, as a core target group for AMR surveillance. It may be that the approach above could go some way to fulfilling this but a more in-depth look at the specific needs would be required.
3	Lack of discipline specific resources, particularly content aimed at veterinary practitioners.	Given the One Health approach needed any approach needs to take account of this in-balance.
4.	Human health has been more strongly observed in the review of the learning resources.	
5.	Lack of local language content, predominant use of English Language.	English language delivery of learning events is a year 1 requirement, but it is clear that local language interaction will be key in progressing learning further. Current resources could be translated, but equally this could be addressed by through further information that is provided as wraparound material.
6	Lack of country-specific learning content.	As above this would help to deliver a more contextualised approach which would enable a greater uptake.

6. Understanding the national perspective: examining surveillance systems in two LMICs

This section examines data generated during Phase 2 of the Scoping study, namely the fieldwork activity in three LMICs. The country activity aimed at understanding the roles within the surveillance system and the learning needs of laboratory professionals such as types of knowledge and skills professionals need in performing surveillance activity and specifically how they best learn about AMR surveillance through training as well as learning on-the-job. The analysis of this data (see Figure 1 and Table 2 for fieldwork activity) supports identification of tensions between elements of the AMR system at the country level.

The following section highlights key findings that emerge in data from Country 1 and Country 2. Country 3 data is not included because data collection was immediately before the due date for this report, which did not allow time for analysis. Although this limits the dataset in this interim report, the analysis of qualitative data from Country 3 will be completed by January 2019 to inform development of the learning events in 2019.

6.1 Findings from Country 1

6.1.1 Key knowledge and skills needs by professionals in Country 1

Findings from the analysis of nineteen (19) individual interviews and one group interview (3 professionals) are presented in this section (total n=22). The main target group was Laboratory Professionals, though interviews were conducted with policy-makers within the AMR system and professionals in clinical services (see Table 2). The analysis of the interviews revealed two key issues around skills and knowledge gaps, with direct implications on AMR strengthening capacity programmes, as following:

AMR strengthening capacity programmes should focus on

I. developing/upgrading practical skills in laboratory work, and
II. advancing theoretical knowledge about microbiology and AMR.

Communication, collaboration and advocacy both in developing (surveillance) work practice and raising awareness about AMR is needed.

Specifically, the examples provided during the interviews shed light on a number of practical issues lab professionals face when engaged in regular lab or surveillance activity, such as: specialised knowledge on AMR; interpreting results from antimicrobial susceptibility test; understanding the Minimum Inhibitor Concentration (MIC) value; gram negative/positive bacteria; what antibiotics to put for ASD profiling; understanding how to use the range of resistance and which drugs to test; what techniques are available; general knowledge of bacteriology, virology and new diseases; and identifying organisms/pathogens at species level. What this shows is that capacity building programmes need to account for and consider practical day-to-day laboratory work, address a wide range of regular laboratory tasks, but also integrate tasks that are specific to surveillance.

The importance of understanding sample management from the point of view of quality control as well as following quality guidelines were emphasised in the interviews. The need to update the existing guidelines for ensuring quality control in microbiology laboratories was raised. Furthermore, interviewees identified gaps around 'Surveillance System Planning and Implementation'. Whereas these were seen as mainly targeting policymakers, there is certainly a need for senior lab professionals to understand how to design surveillance strategy and operationalise surveillance within the local facility (see Table 9).

A category that is prominently featured in the interviews is 'Communication, Collaboration and Advocacy' related needs, skills and knowledge gaps, This category mainly encompassed issues around: communication and collaboration between Clinical Services Professionals and Laboratory Professionals; establishing links and collaborating/learning from other laboratories and hospitals either at a national level or internationally; raising AMR awareness by collaborating across teams, disciplines, organisations and sectors. In other words, the interviewees emphasised the importance cross-sectoral collaboration. Further to this, the need for behavioural change, especially directed towards both the Public and professionals at the facility level, was highlighted in the interviews. Raising AMR awareness for tackling AMR emerges as a key priority activity at the national level, especially targeting Policymakers.

Two groups that appear to have a challenging relationship are lab professionals and clinical services professionals. A specific issue around their professional communication and collaboration were associated with sharing patients' information when sending samples to the laboratory (i.e. linking clinical with lab data and clinical outcomes), whereas nurses' central role in receiving and communicating laboratory results was raised, though their role seems not to be acknowledged within the surveillance system.

Table 8 below shows the overall number of individuals by each professional group indicating what are the needs and skills and knowledge gaps in the current activity in Country 1. Table 9 that follows presents the number of people expressing which group to target that should learn the identified issues.

In Appendix B, Table B2 includes detailed information of the identified nine themes, professional groups and target groups is provided.

6.1.2 Ways of learning by professionals in Country 1

The interviewees expressed a range of views regarding the best ways in supporting AMR strengthening capacity programmes. Many seemed to consider formal training around AMR as an essential way to increase professional capabilities. This includes trainers delivering training on-site. Learning in the laboratory itself ('on-the-bench' training) was viewed highly beneficial because it is seen as being supported by using the equipment and materials available in the setting, but also that lab professionals are developing knowledge and skills that can be directly applied in their own work environment.

Overall, the interviewees viewed on-the-job learning as an important way to build capacity. This includes visiting laboratories in other countries, and indeed many interviewees referred to their experience of learning whilst visiting other laboratories either within their country

or abroad. Visiting the field and engaging in research activities was brought up as a beneficial way of learning on-the-job.

Many of the laboratory professionals, but also other professional groups had experience on both online and face-to-face learning, as well as theory-based training and on-the-job learning. A few interviewees expressed their ideal ratio within training courses, namely 30% theory and 70% on-the-job learning, as well as 50% theory and 50% on-the-job learning.

Table 8 The number of interviewees in Country 1 expressing what needs to be learnt (N=22)

Categories / Who says what needs to be learnt	DS	GLP	FM	MAM	DICV	DUP	CCA	SSPI	OH
Laboratory Professionals	1	2	6	1			1	1	
Senior Laboratory Professionals	2	1	7				2		
Senior Management Staff in Clinical Services	1	1	1	1			2		
Policymaker		1	2				2		1
Total	4	5	16	2			7	1	1

DS=Diagnostics Stewardship; GLP= Good Laboratory Practice; FM= Foundations in Microbiology; MAM=Molecular Advanced Microbiology; DUCV= Data Use & Interpretation for diagnosis in Clinical and Vet Services; DUPH=Data Use & interpretation for Public Health Policy, CCA=Communication, Collaboration & Advocacy; SSPI=Surveillance System Planning & Implementation; OH=One Health Multisectoral

Table 9 The number of people expressing who should learn the identified issues (Country 1) (N=22)

Category/ Who should learn and what	DS	GLP	FM	MAM	DICV	DUPH	CCA	SSPI	OH
Laboratory Professionals	1	2	10	2			3	2	
Senior Laboratory Professionals			1						
Clinical Services Professionals			1				3		
Veterinary Services Professionals			1				1		
Clinical and Veterinary Services Clients	1								
Policymakers		2	1				3	2	

The Public							2		1
Total	2	4	14	2			12	4	1

DS=Diagnostics Stewardship; GLP= Good Laboratory Practice; FM= Foundations in Microbiology; MAM=Molecular Advanced Microbiology; DUCV= Data Use & Interpretation for diagnosis in Clinical and Vet Services; DUPH=Data Use & interpretation for Public Health Policy, CCA=Communication, Collaboration & Advocacy; SSPI=Surveillance System Planning & Implementation; OH=One Health Multisectoral

Online learning was viewed as another possibility in terms of learning, having one main benefit, namely saving time, though one challenge that was raised from learning from online resources was the language of delivery, as the majority of the resources are in English. Online learning, however, is not officially recognised within this country. This emerged even though online learning was valued by some professionals as a way to advance skills and knowledge on AMR informally, at the same time it was perceived as not having 'value' within the formal country system as it is not currently recognised as a valid method of learning.

Within the animal health system, for the field workers in the animal health online learning was considered as having limitations because these professionals have limited access to the Internet while working. Finally, informal workshops to share knowledge and experiences was brought up by one laboratory professional as an efficient way of learning, whilst also recognising that a challenge in arranging these type of workshops is lack of time and available resources.

6.2 Findings from Country 2

6.2.1 Key knowledge and skills needs by professionals in Country 2

Findings from the analysis of nineteen (19) individual interviews are presented in this section (total n=19). The main target group was Laboratory Professionals, though interviews were also conducted with policy-makers within the AMR system (see Table 2). The analysis of the interviews in Country 2 are well aligned with the findings from Country 1. Two similar issues around skills and knowledge gaps were identified and have direct implications on AMR strengthening capacity programmes, as following:

1. AMR strengthening capacity programmes should focus on
    a. developing/upgrading practical skills in laboratory work as well as good laboratory practice; and
    b. advancing theoretical knowledge about microbiology and AMR.

2. Communication, collaboration and advocacy both in terms of developing (surveillance) work practice and raising awareness about AMR is needed.

The identified skills and knowledge needs for capacity building were centred on a range of regular/routine laboratory tasks but also understanding what consists Good Laboratory practice (see Table 10). Within these categories, the main target group identified in the interviews was Laboratory/Senior Laboratory Professionals (see Table 11), but targeting Clinical Services Professionals, especially around understanding the sample process, sample

collection and Standard Operating Procedures, was also deemed important. Specific examples regarding capacity building in this particular area were provided, such as advancing AMR knowledge; how to perform culture; knowledge of new technology in diagnostics; knowledge and understanding of bio security and biosafety; knowledge on how to handle transboundary animal diseases; how to collect and manage samples; how to make selection of drugs to use in lab tests; how to perform isolation of bacteria; how to perform AST; knowledge of alternative ways when quality control fails.

Further to this, another need identified is with regards to developing guidelines for antibiotic prescribing and consumption, as well as developing national AMR database within the surveillance system, the target group being policymakers.

'Communication, collaboration and Advocacy' related needs and skills and knowledge gaps mainly refer to collaboration and information sharing between Laboratory Professionals and Clinical Services Professionals; multi-sectoral collaboration; skills to communicate information about AMR to the Public; raising AMR awareness, and learning how people change their behaviour.

Table 10 The number of interviewees in Country 2 expressing what needs to be learnt (N=19)

Categories / Who says what needs to be learnt	DS	GLP	FM	MAM	DICV	DUPH	CCA	SSPI	OHM
Laboratory Professionals		3	3			1	2		
Senior Laboratory Professionals	3	5	6				4	1	
Policymakers	2	1	5		1	1	6	4	3
Total	**5**	**9**	**14**		**1**	**2**	**12**	**5**	**3**

DS=Diagnostics Stewardship; GLP= Good Laboratory Practice; FM= Foundations in Microbiology; MAM=Molecular Advanced Microbiology; DUCV= Data Use & Interpretation for diagnosis in Clinical and Vet Services; DUPHP=Data Use & interpretation for Public Health Policy, CCA=Communication, Collaboration & Advocacy; SSPI=Surveillance System Planning & Implementation; OHM=One Health Multisectoral

Table 11 The number of people expressing who should learn the identified issues (Country 2) (N=19)

Categories / Who should learn and what	DS	GLP	FM	MAM	DICV	DUPH	CCA	SSPI	OHM
Laboratory Professionals	1	6	13				3	1	
Clinical Services Professionals	1	2	1		1		4		
Veterinary Services Professionals	1		3				1		

Clinical and Veterinary Services Clients	1						3		
Policymakers						1	2	3	3
The Public							5		
Total	4	8	16		1	1	18	4	3

DS=Diagnostics Stewardship; GLP= Good Laboratory Practice; FM= Foundations in Microbiology; MAM=Molecular Advanced Microbiology; DUCV= Data Use & Interpretation for diagnosis in Clinical and Vet Services; DUPHP=Data Use & interpretation for Public Health Policy, CCA=Communication, Collaboration & Advocacy; SSPI=Surveillance System Planning & Implementation; OHM=One Health Multisectoral

Table 10 below shows the overall number of individuals by each professional group indicating what are the needs and skills and knowledge gaps in the current activity in Country 2. Table 11 above presents the number of people expressing which group to target that should learn the identified issues.

In Appendix B, Table B3 includes detailed information of the identified nine themes, professional groups and target groups is provided.

6.2.2 Ways of learning by professionals in Country 2

Similar to Country 1, the interviewees in Country 2 also emphasised the importance of on-the-job learning as well as learning by visiting other laboratories. Importantly, workshops, mentoring and supportive – supervision as a form of on-site training were perceived an effective way of building capacity. Regarding the latter, the main challenge expressed is lack of resources but also limited time available within existing structures to train others.

Many interviewees seemed to consider formal training on AMR as a good way of learning when combined with on-the-job learning. An example by an interviewee of an ideal ratio within training was 20% theory learning and 80% on-the-job learning.

Online learning was considered as a possible method of learning, also seen as providing an easy access to learning and necessary credits that professionals need for renewing professional licence to practice.

Finally, during the interviews farmers were brought up as a target group that should learn about AMR (see Table 11). Due to structural changes, it is no longer necessary for animal health professionals to visit farms. An approach currently followed within the animal health reference lab is for lab professionals to educate the farmers when they visit the laboratory and expecting that these farmers will share this knowledge with other farmers.

6.3 Access to digital and online technologies in the three target LMICs

This section summarises the results from the digital survey that was distributed to professionals in the sites we visited in the three countries (see Figure 1). A total of thirty-nine responses were collected (either paper-based or online). The results of the survey can

be found in Appendix D, but notable results in respect to this report are briefly described below.

In general, the findings were in line with current global trends that show increased online access and access through mobile (We are social, 2018. IWS (a), 2018). Although there is increased access globally, access across the continents in which the focus countries are is still generally low with Africa showing 11% of population using the internet (IWS (a), 2018) and Asia showing 49% of population using the internet (IWS (a), 2018). However, within the surveyed sample there is 100% use of and access to the internet. Respondents used the internet for work related information searches and backed this up with further activity beyond searching 52% (n=29) reported downloading content for use at work and 28% (n=29) reported some type of sharing activity. Although there is no evidence of using technology for work based professional development (this was not a feature of the survey) it is evident that a work-based approach to learning has the scope to utilise both digital and online digital methods of access. In terms of use specifically for an identified learning activity ("Have you ever used the internet to take a course?") 56% (n=36) answered positively further enforcing the use of online access as a viable solution as part of a blended approach. In terms of access platform both laptop and desktop access were recorded by most but by far the highest positive response at 97% (n=38) was access via mobile phone. All 3 countries have a similar profile in terms of digital use and access with Ghana showing slightly more variety in types of use but given the smaller sample size within Ghana this may not be significant but warrants further investigation. Overall, we have a picture of a connected workforce that uses the internet for work related activities and is becoming familiar with online learning; this is not unfamiliar globally. The additional information gathered within the interviews does skew this with access to the internet intermittent due to inconsistent power supply and expense. Economic barriers are compounded when this is a personal expense both in access to the internet and the devices by which this is facilitated.

6.4 Recommendations

This section summarises key findings and recommendations from the analysis of the data collected in the target LMICs. We acknowledge that the number of interviewees is not particularly high, however the study shows a tendency, across both countries, of needs, skills and knowledge gaps being around key thematic areas such as 'Good Laboratory Practice', 'Foundations in Microbiology' and 'Communication, Collaboration and Advocacy'. The tendency is similar from both the perspective of who, within each interviewed group, expresses the specific needs in skills and knowledge but also in terms of which group should be targeted for the skills and knowledge gaps.

Table 12 Key findings and recommendations from the analysis of the data collected in target LMICs

Finding	Recommendation

1	Lab professionals lack knowledge of core microbiology	To strengthen laboratories' capacity at individual level a focus on specific skills is needed. However, there is evidence that learning specific skills and focusing on individuals is not enough in contemporary complex environments. Capacity building needs to be expanded to encompass general skills applicable in various contexts and go beyond an individual.
2	Lab professionals lack understanding of the surveillance system and others' contribution to the system AMR is viewed as new and complex Work in silos is observed	Promote understanding of the whole ecosystem and collaboration between teams, disciplines, organisations, sectors and countries is essential. Laboratory Professionals at different levels need to have a holistic view of AMR, knowledge about laboratories and other professionals' roles in tackling AMR. Developing practical tools to create continuous collaborative learning opportunities in a sustainable way is essential. This must not be restricted to policymakers and senior management professionals.
3	Lack of awareness about AMR	3.1 Recognise that policymakers have a central role to play about raising awareness on AMR. The importance of collaboration between different professions at the facility level in raising awareness was expressed.
4	Lack of awareness about the significance / value of microbiology labs in health care	4.1 The profiles and perceived value of microbiology laboratories need to be enhanced by capacity building, while their significance should be communicated appropriately. 4.2 Development of guidelines that focus on microbiology are needed.
5	Limited context-specific capacity building for Laboratory Professionals	5.1The expressed needs and skills and knowledge gaps were similar in both countries, but variations were observed in the laboratory activity contexts. Learning resources need to be contextualised in the specific environment.
6	Valuing 'on-the-job learning'. Limited views on online learning.	6.1 Explore and develop/offer online resources as they can offer great opportunities for professionals to learn in LMICs. 6.2. Develop blended/mixed-method learning for Laboratory Professionals. 6.3 Co-design learning events with the practitioners is needed to balance between on-the-job and online learning as well as contextualise them.
7	Professionals have access to and use of digital/mobile technologies. Professionals appeared positive in attending learning events related	7.1 Digital delivery is an appropriate element as part of a blended approach. 7.2 Develop learning events with a focus on utilisation of mobile technology and systematically evaluate the tools through which the learning events are delivered.

	to microbiology which were online and utilising technology	7.3 Consideration needs to be given to the amount of time spent online, in terms of being able to maintain access.
8	Lack of evidence on the impact of digital resources or courses within professional development in LMICs	8.1 Embed an understanding of the impact of digital within the M&E of the learning events.

7. Capacity building approach: Recommendations and Guidelines

In this report we presented evidence from the scoping phase (April – December 2018) in order to identify the what knowledge and skills are needed, who needs to learn these skills and how learning might be facilitated through pilot learning events in the next phase of work, Phase 3 (January – June 2019). This report also informs a longer-term approach to build AMR surveillance capacity in LMICs over the period 2019-2022.

Key findings from the scoping phase

1 Sustained professional development is limited: We found evidence of a number of issues that impede LMICs from delivering sustained, well-resourced, high quality AMR professional development programmes. We found examples of good practice in professional development, usually through individuals being funded to study abroad, through mentoring schemes, train the trainer programmes or, in some of the reference laboratories, through international collaboration. However, professional development opportunities were patchy, not always open to all and there were limited examples of sustained capacity development. The triggers for professional development implementation were usually to tackle problems of under-resourcing. For example, people might be trained to operate in particular ways because equipment is not functioning properly. Another issue is the high turnover of staff as many leave poorly paid laboratory roles, hence there are too few staff with skills and knowledge needed for high-quality AMR surveillance. Furthermore, governments and ministries do not always appreciate or value the skills needed for high- quality AMR surveillance, and consequently resourcing and quality training is less likely to be prioritised.

2. Nine areas of knowledge and skills take priority. We carried out a thorough analysis of the knowledge and skills needed of professionals working at all levels in different animal and human health sites. We gathered data through the Phase 1 interviews with AMR experts and Phase 2 visits to the country sites, talking and questioning more than 80 individuals spread across these phases and sites. We identified nine key categories of knowledge and skills needed to enable well-functioning AMR surveillance systems. Knowledge and skills given the highest priority include: a) Communication, Collaboration & Advocacy, b) Good Laboratory practice, c) Foundations in Microbiology and d) Data Use for Diagnosis in Clinical & Vet Services (Table 3). These priority areas need to be addressed in the forthcoming phases of work.

3. Laboratory professionals at all levels require capacity building. Professionals at all levels, whether Assistants, Technicians, Lab Scientists or Lab Managers, need opportunity to expand their knowledge. However, the particular AMR knowledge and skills they need to focus on depend, to some extent, on the job role of each individual. We have mapped the nine priority areas to specific job roles to help prioritise particular forms of learning towards specific groups.

4. Within existing AMR (or health system) structures in LMICs analysis systems are failing to routinely deliver or offer opportunities for professionals to engage with one another. This impedes multi-sectoral and interdisciplinary collaboration within and across settings (e.g. reference labs and sentinel sites are not always in a functional form). Siloed working appears to the norm for the majority of professionals to the detriment of cooperative and collaborative forms of engagement and knowledge exchange. There is little evidence of enabling management and supportive supervision or mentorship taking place within the surveillance system.

5. It is unclear what constitutes 'surveillance practice'. AMR surveillance activity is often in addition to and on top of other work that lab professionals carry out. 'These professionals are continually adapting their current practice, which increases their workload. They are often not clear about the whole surveillance system for pathogens, how their work fits within the system and what value they contribute. In the current system it is unclear who has ownership of specific tasks that need to be performed and which roles support these tasks. The novelty of AMR and its emergence as a global challenge provides a reason for this lack of clarity. 'Surveillance practice' needs to be defined and well communicated. It further requires re-organisation of roles and introduction of new positions. Capacity building could ensure that professionals at all levels and in all roles should understand how their work fits within the AMR system.

6. The introduction of AMR surveillance practice requires a restructuring of work. We found many examples where existing forms of laboratory work were at odds with good AMR surveillance. For example, in animal health, monitoring should be restructured to be proactive, rather than passive. Also, procurement processes often require the least expensive medium to be purchased, which often means it is not possible to detect pathogens at a sufficient level. Without a restructure of these procurement practices, it is unlikely that capacity building programmes will bring about the desired changes.

7. There are a range of existing AMR resources that could be used in learning events. The Phase 1 scoping study tracked a rich and diverse range of resources and guidance documents aimed at AMR that could be potentially used for learning. There is limited evidence of the impact of the use of these resources in changing AMR surveillance practice. The review of learning resources showed that not many resources have been developed specifically for laboratory staff, so although resources can be reused within learning events, these are likely to require a high degree of contextualisation or alternatively the development of new learning resources.

8. There is extensive use of digital and online technologies, usually mobile phones used for communication purposes. We found email was not the best form of digital communication and, in at least one country, WhatsApp was the most effective way to connect with others. Some professionals at senior levels were familiar with MOOCs and had participated in these, though they did not report a corresponding change in their practice. Although digital technologies were used extensively, people were less clear about how to 'learn' with the use of technology. Where people perceive they are learning via technology, there appears to be little value attributed to this way of learning, beyond fulfilling an immediate need.

Suggested options for learning events

Based on these recommendations, the following options are descriptions of the potential learning events that could be run between January and June 2019. In understanding the capacity to deliver within the given timeframe option 1 and 2 may be considered a combination of multiple learning events so will require a much heavier resource allocation. Each option would be preceded by a co-design phase which would involve in country learners / partners, DHSC and Mott MacDonald. This would enable a clearer specification including the resource requirements. The following is an indication of resource and approach to help reach a decision on the suitability of the options.

Option 1 Good laboratory practice

Outline	
Discipline category	**Lab professionals** (see description Table 1]) from across sectors and geographies who will either already be Fleming Fellows or will be selected through a selection process supported by the in-country grantee or AMR committee.
Subject category:	What makes **good laboratory practice**
Learning objectives: *These draft objectives will be discussed and refined during the co-design phase (Dec 2018 – Jan 2019)*	By the end of this learning event, participants will be able to: 1. Describe current and developing best AMR laboratory practice (as defined by a Subject Matter Expert from Mott); 2. Describe actual laboratory practices from their own work context; 3. Map how real-world practice from their own lab context aligns with or differs from good laboratory practice; 4. Develop an action plan to implement practice change in their own work context. It is expected that this action plan, developed as an output of the training, will be implemented after the learning event, and a progress report will be submitted 3 months after the event.

Approach to learning design

Objective 1:	• Introductory webinar / video to contextualise the approach for Fleming. • Identify existing online course (guidance / framework) which all participants take as a single cohort. This course (or artefact) will act as foundational material to inform work-based collaborative activities. For example, knowledge around barriers to practice (why the laboratory door should be closed) would be applied to real-world, practical situations. • Examples of resources that could be used in this learning event include: *https://www.futurelearn.com/courses/infection-control-antimicrobial-resistance* *http://www.bsac.org.uk/antimicrobialstewardshipebook/BSAC-AntimicrobialStewardship-FromPrinciplestoPractice-eBook.pdf* *https://www.slideshare.net/shettyuc/who-good-practices-for-microbiology-labs* *https://www.researchgate.net/publication/295504396_GOOD_LABORATORY_PRACTICE* *http://www.oecd.org/chemicalsafety/testing/good-laboratory-practiceglp.htm* *http://www.who.int/tdr/publications/documents/glp-handbook.pdf* • In country face to face support at a central location, run by in-country fellow / grantee / beneficiary institution to support the learning though the provision of additional activities, providing context and opportunity to engage in local language. One 3 hr session run during the course and one after the course is complete. Activities to focus on understanding best practice with emphasis on course activities. • Complimentary content will be provided in addition to the course to both extend the learning and to contextualise for the learners. • Online demonstrations / webinars from subject matter experts (provided by Mott / OU or International Reference Centre for AMR).
Objective 2:	• In country face to face support at a central location, run by in country fellow / grantee / beneficiary institution to support the learning though the provision of additional activities, providing context and opportunity to engage in local language. This is likely to be run twice (2 / 3 hrs at a time). One 3 hr session run during the course (as part of the objective 1 session). Activities to focus on understanding current practice. • Complimentary content will be provided in addition to the course to both extend the learning and to contextualise for the learners. • Online discussion forums to compliment face to face sessions to introduce and extend discussion on current practice.
Objective 3:	• Complimentary content will be provided in addition to the course to both extend the learning and to contextualise for the learners. This will include mapping practice. • Online discussion forums to share mapping activity results • In person practical session (at a central location, run by in country fellow / grantee / beneficiary institution) where learners follow identified best practice to support mapping to current practice support the identification of gaps.

Objective 4:	• As an extension to the practical session (objective 3) face to face support at a central location, run by in country fellow / grantee / beneficiary institution to support the learning though the provision of additional activities, providing context and opportunity to engage in local language. 3-hour session with activities which focus on developing and agreeing an action plan. • Online discussion forums to introduce and extend discussion on current practice.

Operational needs

Timing	These timings are indicative and would need further discussion during co-design phase. • January co-design phase • February design and build • April 2019, course / focussed learning event would run for three weeks (To be agreed; but likely to be part time, in the region of 6 hrs a week, with 3 additional days committed to face to face activities). Collaborative activities as part of objectives 3 & 4 would run for a further 2 weeks. • Additional review activity would run for a week, 3 months after the 5 weeks above.
Learning event development	• Lab professionals during the co-design phase • Supporting organisations / institutions in country to promote learning event • Subject matter expertise (provided by Mott potential to fund by OU) to assess found course and content • Subject matter expertise to develop content and approve activities.
Learning event running	• 1 person in each country to lead face to face sessions (could be a fellow or grantee or some type of supporting organisation / institution). If in countries where this is not possible this could be provided through Mott connections. • This person will also act as a focal point for the learning within country, advocating for the course, generating interest and support from participants and relevant institutions. If not a fellow, then it might be a dual role for a tutor (see next bullet) • 2 individuals to monitor forums / act as tutors. One would need to be a subject matter expert (potentially provided by Mott) the other would have more learning facilitation expertise and would be provided by the OU. • Location needed for face to face sessions this could be provided by grantee or beneficiary institution. Would be ideal if one central location could be found that also has access to lab space for practical sessions • Logistical support for setting up face to face sessions and M&E work provided by either Mott country rep, grantee or beneficiary institution.
Recognition / Assessment / accreditation	• Subject matter expertise to develop / approve assessment in addition to any assessment within the found course. • Assessment could be run by host institution or potentially peer led?

	• There may also be an assessment component as part of the found / re-used course. • Supporting organisation / institution in country could offer credit / recognition, either informally or through more formal CME/ CPD systems.
Participants	• Supporting organisations / institutions in country across disciplines to support the attendance of employees (support would be nomination, time and whatever is standard in terms of per diem / expense as advised by UK Gov) • Lab professionals across all three geographies (potentially 50 given sites visited)

Option 2 Data use & interpretation for diagnosis in Clinical & Vet Services

Outline	
Discipline category	**Senior Lab Professionals** **(Senior) Management staff in Clinical services** **(Senior) Management in Vet Services** (see category description Table 1) from across geographies who will either already be Fleming Fellows or will be selected through a selection process supported by the in-country grantee or AMR committee.
Subject category:	**Data use & interpretation for diagnosis in Clinical & Vet Services**
Learning objectives: *These draft objectives will be discussed and refined during the co-design phase (Dec 2018 – Jan 2019)*	By the end of this learning event, participants will be able to: 1. Describe forms of AMR data, how they are generated and their purpose; 2. Analyse and interpret data at a basic level; 3. Identify how data interpretation can support the participant's everyday work practice; 4. Develop a plan to implement data use in practice (taking into consideration the data available); 5. Identify the challenges in implementing this plan.

Approach to learning design	
Objective 1:	• Introductory webinar / video to contextualise the approach for Fleming.
Objective 1 & 2:	• Identify existing open online course (potentially a MOOC) which all participants participate in.
Objective 2:	• In country face to face support at a central location, run by in country fellow / grantee / beneficiary institution to support the learning though the provision of additional activities, providing context and opportunity to engage in local language. One 3 hr session run during the course and one after the course is complete. Activities to focus on Analyse and interpret data at a basic level. Participants would bring their own data. If no data is available in their own work context, participants use existing data sets / examples eg; https://resistancemap.cddep.org/AntibioticResistance.php

	• Complimentary content will be provided in addition to the course to both extend the learning and to contextualise for the learners. • Online demonstrations / webinars from subject matter experts (provided by Mott / OU).
Objective 3:	• In country face to face support at a central location, run by in country fellow / grantee / beneficiary institution to support the learning though the provision of additional activities, providing context and opportunity to engage in local language. One 3 hr session run during the course (as part of the objective 2 session). Activities to focus on how data interpretation can support everyday work practice. • Complimentary content will be provided in addition to the course to both extend the learning and to contextualise for the learners. • Online discussion forums to compliment face to face sessions to introduce and extend discussion on current practice. Participants divided into groups, according to demographics (job role, location). In an online, group forum session (1-2 hours) each participant presents how data can support their role.
Objective 4:	• Online activity developed (or found) to support the development of a data plan. • Discussion forums to support collaboration and check understanding of plan development. Following the initial discussion forum activity aligned to objective 3 (two weeks later) each participant draws up and posts an action plan within the forum. • In country face to face support at a central location, run by in country fellow / grantee / beneficiary institution to support the learning though the provision of additional activities, providing context and opportunity to engage in local language. One 3 hr session run after course is complete (combined with session for objective 5). Activities to review data plans.
Objective 5:	• In country face to face support at a central location, run by in country fellow / grantee / beneficiary institution to support the learning though the provision of additional activities, providing context and opportunity to engage in local language. One 3 hr session run after course is complete. Activities to focus on Identifying the challenges in implementing your data plan. • Online activity developed (or found) to support the identification of challenges of data plan. • Discussion forums to support collaboration and share potential challenges. Two weeks after objective 4 activities, moderated forum session (moderated by a subject matter expert) to support identification of problems and ways to overcome these issues, this would then feed into the face to face session for discussion of plans. • Submit final plans for peer review within online forum.

Operational needs

Timing	These timings are indicative and would need further discussion during co-design phase. • January co-design phase • February design and build

	• April 2019, course / focussed learning event would run for one - two weeks. (TBA but likely to be part time IRO 6 hrs a week, with 3 additional days committed to face to face activities). Collaborative activities as part of objectives 3 & 4 would run for a further 2 weeks. • Action plan follow up as part of objective 5 would be May / June.
Learning event development	• Senior Lab Professionals, (Senior) Management staff in Clinical services, (Senior) Management in Vet Services, Policy makers during the codesign phase. • Supporting organisations / institutions in country to promote learning event • Subject matter expertise (provided by Mott potential to fund by OU) to assess found course and content • Subject matter expertise to develop (or support development of) any additional content and approve activities.
Learning event running	• 1 person in each country to lead face to face sessions (could be a fellow or grantee or some type of supporting organisation / institution). If in countries where this is not possible this could be provided through Mott connections. • This person will also act as a focal point for the learning within country, advocating for the course, generating interest and support from participants and relevant institutions. If not a fellow then it might be a dual role for a tutor (see below)/ • Location needed for face to face sessions this could be provided by grantee or beneficiary institution. Would be ideal if one central location could be found that also has access to lab space for practical sessions • 2 individuals to monitor forums / act as tutors. One would need to be a subject matter expert (potentially provided by Mott) the other would have more learning facilitation expertise and would be provided by the OU. • Logistical support for setting up face to face sessions and M&E work provided by either Mott country rep, grantee or beneficiary institution.
Assessment / accreditation	• Subject matter expertise to develop / approve assessment in addition to any assessment within the found course. • Assessment could be run by host institution or potentially peer led? • There may also be an assessment component as part of the found / re-used course. • Supporting organisation / institution in country could offer credit / recognition.
Participants	• Supporting organisations / institutions in country across disciplines to support the attendance of employees (support would be nomination, time and whatever is standard in terms of per diem / expense as advised by UK Gov)

	• Senior Lab Professionals, (Senior) Management staff in Clinical services, (Senior) Management in Vet Services, Policy makers across all three geographies (potentially 50 given sites visited)

Option 3 Foundations in Microbiology

Outline	
Discipline category	**Lab Professionals, Senior Lab Professionals, Clinical Services Professionals, Vet Services Professionals** (see category description [Table 1]) from across geographies who will either already be Fleming Fellows or will be selected through a selection process supported by the in-country grantee or AMR committee.
Subject category:	**Foundations in Microbiology**
Learning objectives: *These draft objectives will be discussed and refined during the co-design phase (Dec 2018 – Jan 2019)*	By the end of this learning event, participants will be able to: 1. Outline the basic principles of AMR 2. Understand what antibiotics are and how they work 3. Understand how bacteria become resistant to antibiotics 4. Appreciate the issues surrounding antibiotic resistance 5. Describe approaches to AMR in a range of different countries. 6. Describe actions related to AMR in within the lead country participants country and place of work. 7. Reflect on how global and local approaches to AMR can be applied to his or her own work practice.

Approach to learning design	
Objective 1, 2, 3, 4:	• Introductory webinar / video to contextualise the approach for Fleming. • Participants would register for and take the OU OpenLearn course 'Understanding antibiotic resistance' as a closed course (ie a course open only to specific participants). https://www.open.edu/openlearn/science-maths-technology/understanding-antibiotic-resistance/content-section-overview?active-tab=description-tab
Objective 5:	• Content will be contextualised for 3 Fleming Fund focus country. • Video content found or produced outlining approach from professionals within 3 Fleming Fund countries.
Objective 6:	• Content will be contextualised for the lead focus country.
Objective 7:	• Through online activity participants will reflect on and describe whether and how AMR practice aligns with their work.

Operational needs	
Timing	These timings are indicative and would need further discussion during co-design phase. • January co-design phase

	• February – March, contextualisation, design and build • April run course over 3 – 4 weeks (8 – 6 hrs per week) There is the potential to run the course with no contextualisation so timings could be more flexible but this would be decided after co-design phase
Learning event development	• Lab Professionals, Senior Lab Professionals, Clinical Services Professionals, Vet Services Professionals during the co-design phase. • Supporting organisations / institutions in country to promote learning event • Subject matter expertise (provided by Mott potential to fund by OU) to assess course and content • Subject matter expertise to develop (or support development of) any additional content and approve activities.
Learning event running	• 2 individuals to monitor forums / act as tutors. One would need to be a subject matter expert (provided by Mott or OU) the other would have more learning facilitation expertise and would be provided by the OU. • Logistical support for M&E work provided by either Mott country rep, grantee or beneficiary institution.
Assessment / accreditation	• Subject matter expertise to support development of / approve assessment. • Supporting organisation / institution in country could offer additional credit / recognition.
Participants	• Supporting organisations / institutions in country across disciplines to support the attendance of employees (support would be nomination, time and whatever is standard in terms of per diem / expense as advised by UK Gov) • Lab Professionals, Senior Lab Professionals, Clinical Services Professionals, Vet Services Professionals across all three geographies (potentially 50 given sites visited)

Conclusion / Next steps

Over the following 6 months January – June 2019 we will pilot learning events. Based on the current options we believe that we could run option 3 plus either option 1 or 2. In delivering these learning events there are several principles / guidelines which we believe should be adhered to:

Guidelines / Design Principles

Co-Design: Each learning event developed should begin with a co-design phase. Working in collaboration with the learner (plus other supporting organisations where relevant) to finalise parameters and validate ways/methods of the development and delivery.

Blended learning: The delivery methodology should be focussed on a blended learning approach which broadly aims to take into account both physical and virtual interactivity.

Digital design: All digital development will adhere to the Open University QA standards as well as the 'Principles for Digital Development' (https://digitalprinciples.org/principles/) both of which are closely aligned.
Access: Reducing barriers to access should be a key principle within delivery of learning events, taking into account the contextual needs of the end user. This ranges from openly accessible materials to accessible forms of interaction.
Recognition: Learning events should have some form of recognition built in from informal peer lead systems to more formal international and national providers embedded into local CME / CPD systems.
Local context - Learning events should take account of local context.
Support: Support systems should take into account the relevant value of systems that are lead from peers, colleagues, facilitators, educators and organisations.
On-the-job training for target groups: Learning events should be targeted at all levels of professionals, but need to focus, to some extent, on the needs and job role of each individual and particular forms of learning should be prioritised towards specific groups

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Appendix A: Methodology

Research Instruments

A1 Interview Protocol: AMR Community / Experts (Phase 1)

A. About you

1. **Can you please explain to me in a few sentences what's your role and what does it involve?** (e.g. in Mott MacDonald)

1.1 Can you take me through what does your role involve at a practical, day-to-day basis?

[prompt: What tools, practices, processes are you using in this role?]

2. **What would you say are the difficulties in this role?**

2.1 How do you go about addressing these difficulties? (draw on an example)

[prompt: Do you think current structures enable you to meet these challenges? If not, why?]

B. Context - Needs analysis

3. **What are the key issues in building laboratory capabilities and strengthening surveillance within country systems in low resource countries?**
(draw on a country s/he knows well, clarify: human health/animal health, public health system Vs private system)

Follow-up: You chose to speak about e.g. transport, data management, misuse of antibiotics… (pick-up one)

3.1 How can we/you improve this specific area you have identified in the next few months?

[prompt: Have you seen any changes showing that direction? What would you say are the threats facing future developments?]

3.2 What types of opportunities are there for people to develop new skills/change behavior/do things differently? (e.g. training)

C. Learning Landscape of AMR resistance

Insights from their experience

Encourage them to think of learning in broad terms, as an everyday situation and not just through formal opportunities e.g. training, but learning from other people, learning at the workplace

4. **Can you describe a scenario/situation, where you've seen people change/develop new knowledge/skills/?** (based on previous experience, draw on an example)

    4.1 What did they do, what worked, what didn't work?

    Prompt: What roles, tools, practices, rules, processes were in place?

5. **Can you describe a scenario/situation where you believe it'll be important for people to change the way they do things and do things differently?** (within AMR context)

    5.1 What kind of change would that bring? Why is this an important one?

D. Stakeholders

We are planning visits to Uganda, Ghana and Nepal soon.

6. Who else do we need to speak to?

Stakeholders, organisations, partners, other stakeholders we need to be aware of in the surveillance system, visits we should do in the country

A2 Interview Protocol: Lab professionals (Phase 2)

About you

Can you please explain to me what's your role in this lab and what does it involve? (e.g. in reference lab, surveillance site)

2. Tell us about the people you are in direct contact with in everyday tasks.
How does your role link to them?

3. In this role, can you describe two typical tasks? (AMR tasks)(if in the lab, show us)

What tools are you using; what processes do you follow, who do you work with?
4. What are the difficulties in this task?

How do you go about addressing these difficulties? What helps you overcome these challenges?

5. Can you give us an example when you had to do something in a new way at work? What allowed you to make this change? What changed?

What did you do, what worked, what didn't work?

What roles, tools, practices, rules, processes were in place?

6. What is good practice in AMR? What does it look like?

7. Is there anything that might improve the way you are doing things in AMR/in the lab?

What change would that bring?

8. Have you seen any changes in your lab showing change in this area?

What made this happen?

9. What types of opportunities are there for you to develop new knowledge and skills about AMR?

How did you go about developing knowledge/skills on AMR surveillance?

Things/subjects that you'd like to see?

10. What do you like about your job? What motivates you?

(to lab managers) **How does the lab fit within the overall AMR surveillance system?**

11. Is there anything else that you'd like to tell me that might be useful?

A3 Interview Protocol: Country Officials (Phase 2)

A. About you and your role in the AMR landscape

1. **What's your role in the [ministry, AMR committee, WHO, FAO)? What are the main responsibilities within this role?**

2. In this role, please describe 2-3 tasks you do on a daily basis that relate to AMR surveillance?

What tools/equipment do you use, what processes do you follow, who do you work with, objective?

3. (pick-up one task from previous) **What are the difficulties, if any?**

How do you go about addressing these difficulties? (draw on the same task)

What worked? What didn't? What enabled you to meet these challenges? If not yet, why?

4. Can you help us understand the surveillance system in the country?

Describe

B. Context: Work on antimicrobial resistance and surveillance processes

5. What are the key issues in building capacity within surveillance laboratories within your country [Bhutan, Tanzania]?

6. What types of opportunities are there for people involved in AMR surveillance to develop new skills and knowledge?

Are there any specific programmes, courses, university provision, in-service training, government initiatives, internships, learning-at-work?
Use of technology in these programmes/schemes?

7. What types of opportunities are in the pipeline for education and training ? (give an example)

8. How can we improve capacity building in AMR?
What are your concerns? What are the threats facing future developments? Any indications showing towards positive change?

9. What are subject priority areas needed for learning about AMR?

A4 Survey tool: Fleming Fund digital access survey (Phase 2)

This survey is being conducted by The Open University UK as part of our research to understand the context of building laboratory capabilities and strengthening antimicrobial resistance surveillance within country systems in low resource settings. The work is funded by the Fleming Fund form the Department of Health and Social Care in the UK, it will focus particularly on the learning landscape and subject needs around surveillance and control in Low Middle Income Countries, especially within public health labs.

The data from this survey will be used to support our research and to tailor the learning we plan to deliver through understanding the context in which we are working and our ability to evaluate its impact.

The survey should take around 15 minutes to complete. All questions are optional and you can stop at any time by closing your browser. By taking part in this questionnaire you agree to us using your data in contributing to research and delivery of the project outputs. All data used will be anonymised.

All data will be stored securely at The Open University and will only be accessed by the research team. The data will be stored for 7 years, after which it will be destroyed.

Completion of the questions in the survey that follows indicates that you have read and understood the above and consent to participate in this research.

If you have any questions or require more information you may contact the project manager Tim Seal Tim.Seal@open.ac.uk

1. **What is your age?**

- ☐ under 20
- ☐ 21 - 33
- ☐ 34 - 46
- ☐ 47 - 59
- ☐ 60 and over

2. **What is your gender?**

- ☐ Female
- ☐ Male

3. **What is your first language?**

4. What is your level of English?

	(1) None	(2)	3)	(4)	(5) Fluent
stand spoken English	☐	☐	☐	☐	☐
English	☐	☐	☐	☐	☐
English	☐	☐	☐	☐	☐
:nglish	☐	☐	☐	☐	☐

5. What is your job title?

6. What is the name of your workplace?

7. Do you own any of the following devices?

	I own it	Work provides it
e phone	☐	☐
	☐	☐
op computer	☐	☐
o	☐	☐

8. How often do you use the following devices?

	y day	times a week	3 times a week	a week	2 weeks	a month	an once a month	ever
e phone	☐	☐	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐	☐	☐
op computer	☐	☐	☐	☐	☐	☐	☐	☐

)	☐	☐	☐	☐	☐	☐	☐	☐

9. Do you have connectivity to the internet?

	1.	2. Yes	3. No
ne		☐	☐
k		☐	☐

10. Where do you access the internet? (select all that apply)

	Home	Work	side of work & home	ot applicable
e phone	☐	☐	☐	☐
	☐	☐	☐	☐
op computer	☐	☐	☐	☐
)	☐	☐	☐	☐

11. How often do you use any of the following applications?

	ay	times a week	times a week	week	weeks	month	an once a month	
soft word (or other word processing application)	☐	☐	☐	☐	☐	☐	☐	☐
Point	☐	☐	☐	☐	☐	☐	☐	☐
et browser	☐	☐	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐	☐	☐
ook	☐	☐	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐	☐	☐
App	☐	☐	☐	☐	☐	☐	☐	☐
r	☐	☐	☐	☐	☐	☐	☐	☐

Are there any applications / websites that you use regularly (at least once a week) that are not on the list above?

12. Which of these things have you done in the last year? (Select all that apply)

- ☐ n email
- ☐ n a document using word processing software (e.g. Word)
- ☐ presentation software (e.g. PowerPoint)
- ☐ med calculations with spreadsheet software (e.g. Excel)
- ☐ buted to a wiki (e.g. Wikipedia)
- ☐ n a blog post (e.g. Wordpress, Blogger)
- ☐ d an image online (e.g. Flickr, Instagram, Pinterest)
- ☐ d on a microblogging platform (e.g. Twitter, Tumblr)
- ☐ part in a videochat (e.g. Skype, Viber)
- ☐ buted to an internet forum
- ☐ buted to a social network (e.g. Facebook, Google+, MySpace, Beebo)
- ☐ cloud-based storage (e.g. Dropbox, Google Drive)
- ☐ ed online (e.g. eBay, Amazon)
- ☐ loaded a podcast (e.g. iTunes)
- ☐ loaded a file using a torrent client (e.g. Bittorrent, UTorrent)
- ☐ d and uploaded video content
- ☐ a virtual learning environment to study or teach (e.g. Moodle, Blackboard)
- ☐ ded and uploaded a podcast
- ☐ text
- ☐ n instant message (e.g. Viber, WhatsApp)

13. Have you ever used the internet to search for information to use at work?

- ☐ Yes
- ☐ No

If yes could you provide an example?

14. If you find information for work on the internet what do you do with it?

- ☐ nline only
- ☐ load it to my computer

☐ t as a bookmark in my browser
☐ t
☐ via social media
☐ via email
☐ s it with colleagues
☐ (please specify)

15. Have you ever used the internet to take a course?

☐ Yes
☐ No

If yes are you able to provide an example of a course or courses you took?

Thank you for completing the survey

Appendix B – Analysis

Results from Phase 1 – Interviews with experts

Table B1: Learning & Subject Needs by the experts / AMR Community

Who says?	What to learn? Topics / Themes		Who needs to learn? Who to target?	Target sector
	Category		**Roles**	
Policy makers (n=3)	1. Diagnostics Stewardship	1	• Vet Services Professionals	Animal Health
	2. Good Laboratory Practice	1	• Lab Professionals	Animal health
	3. Foundations in Microbiology	1	• Vet Services Professionals	Animal health
	4. Molecular Advanced Microbiology			
	5. Data Use & Interpretation for diagnosis in Clinical and Vet Services	1	• Clinical Services Professionals • Vet Services Professionals	Human / Animal Health
	6. Data Use & interpretation for Public Health Policy	-		
	7. Communication, Collaboration & Advocacy	2	• AMR Community / Experts • Vet Services Professionals - Clinical and Vet services clients; • Lab Professionals – Clinical Services Professionals - The Public	Human/ Animal Health
	8. Surveillance System Planning & Implementation	-	-	-
	9. One Health Multisectoral	-	-	-
AMR Community/ Experts (n=20)	1. Diagnostics Stewardship	4	• Lab Professionals • Clinical Services Professionals • Vet Services Professionals • Senior Management staff in Clinical services	Human Health
	2. Good Laboratory Practice	8	• Lab Professionals • Senior Lab Professionals	Human/ Animal Health
	3. Foundations in Microbiology	11	• Lab Professionals • Clinical Services Professionals • Vet Services Professionals • Lab Professionals – Senior Lab Professionals	Human/Animal health
	4. Molecular Advanced Microbiology	1	• Lab Professionals • Senior Lab Professionals	Human Health

	5. Data Use & Interpretation for diagnosis in Clinical and Vet Services	12	• Lab Professionals • Senior Lab Professionals • Clinical Services Professionals • Vet Services Professionals • Senior Management staff in Clinical services • AMR Community / Experts	Human Health
			• Lab Professionals – Senior Lab Professionals	
	6. Data Use & interpretation for Public Health Policy	6	• Clinical Services Professionals • Senior Management staff in Clinical services • Senior Management in Vet Services	Human/ Animal Health
			• Senior Management staff in Clinical services - Policy makers • Senior Management staff in Clinical services - Senior Management in Vet Services - Policy makers - AMR Community / Experts	
	7. Communication, Collaboration & Advocacy	13	• Clinical Services Professionals • Clinical and Veterinary services clients • AMR Community / Experts	Human/Animal health
			• Lab Professionals-Clinical Services Professionals; • Lab Professionals- Clinical Services Professionals- Vet services professionals; • Lab Professionals- Senior Lab Professionals - Clinical Services Professionals - Senior Management staff in Clinical services; • Clinical Services Professionals - Senior Management staff in Clinical services; • Senior Lab Professionals - Senior Management staff in Clinical services; • Policy makers - AMR Community / Experts - Clinical and Veterinary services clients; • Senior Management staff in Clinical services - Policy makers;	
	8. Surveillance System Planning & Implementation	7	• Lab Professionals • Senior Lab Professionals • Clinical Services Professionals • Senior Management staff in Clinical services • Senior Management in Vet Services • Policy makers • AMR Community experts	Human/ Animal health
			• Senior Lab Professionals - Senior Management staff in Clinical services;	
	9. One Health Multi-sectoral	3	• Lab Professionals • Clinical Services Professionals • Vet Services Professionals • Senior Management staff in Clinical services • Senior Management in Vet Services • Policy makers • AMR Community / Experts	Human/Animal Health
			• Lab Professionals - Senior Lab Professionals;	

Results from Phase 2 – Interviews with professionals in target LMICs

Table B2: Learning & Subject Needs by professionals in Country

Country 1				
Who says?	**What to learn? Topics / Themes**		**Who needs to learn? Who to target?**	**Target sector**
	Category			**Roles**
Laboratory Professionals	Diagnostics Stewardship	1	Laboratory professionals Clinical and Veterinary Services Clients	Human Health
	Good Laboratory Practice	2	Laboratory Professionals	Animal health
	Foundations in Microbiology	6	Laboratory Professionals	Animal health Human health
	Molecular Advanced Microbiology	1	Laboratory Professionals and Laboratory Professionals who have an advanced certificate in microbiology	Human health
	Data Use & Interpretation for diagnosis in Clinical and Vet Services	-		
	Data Use & interpretation for Public Health Policy	-		
	Communication, Collaboration & Advocacy	1	Laboratory Professionals	Human health
	Surveillance System Planning & Implementation	1	Policymakers	Human health
	One Health Multisectoral	-		
Senior Laboratory Professionals	Diagnostics Stewardship	2	Laboratory Professionals	Animal health
	Good Laboratory Practice	1	Laboratory professionals	Human health
	Foundations in Microbiology	7	Clinical Services Professionals Laboratory Professionals Senior Laboratory Professionals	Human health Animal health
	Molecular Advanced Microbiology	-		
	Data Use & Interpretation for diagnosis in Clinical and Vet Services	-		

	Data Use & interpretation for Public Health Policy	-		
	Communication, Collaboration & Advocacy	2	Laboratory professionals Policymakers The Public	Human health Animal health
	Surveillance System Planning & Implementation	-		
	One Health Multisectoral	-		
Clinical Services Professionals	Diagnostics Stewardship	-		
	Good Laboratory Practice	-		
	Foundations in Microbiology	-		
	Molecular Advanced Microbiology	-		
	Data Use & Interpretation for diagnosis in Clinical and Vet Services	-		
	Data Use & interpretation for Public Health Policy	-		
	Communication, Collaboration & Advocacy	-		
	Surveillance System Planning & Implementation	-		
	One Health Multisectoral	-		
Veterinary Services Professionals	Diagnostics Stewardship			
	Good Laboratory Practice			
	Foundations in Microbiology			
	Molecular Advanced Microbiology	-		
	Data Use & Interpretation for diagnosis in Clinical and Vet Services	-		
	Data Use & interpretation for Public Health Policy	-		
	Communication, Collaboration & Advocacy	-		
	Surveillance System Planning & Implementation	-		

	One Health Multisectoral	-		
Senior Management Staff in Clinical Services	Diagnostics Stewardship	1	Clinical Services Professionals Laboratory Professionals	Human health
	Good Laboratory Practice	1	Clinical Services Professionals Laboratory Professionals	Human health
	Foundations in Microbiology	1		Human health
	Molecular Advanced Microbiology	1	Laboratory Professionals	Human health
	Data Use & Interpretation for diagnosis in Clinical and Vet Services	-		
	Data Use & interpretation for Public Health Policy	-		
	Communication, Collaboration & Advocacy	2	Clinical Services Professionals Recently graduated professionals	Human health
	Surveillance System Planning & Implementation	-		
	One Health Multisectoral	-		
Senior Management Staff in Veterinary Services	Diagnostics Stewardship	-		
	Good Laboratory Practice	-		
	Foundations in Microbiology	-		
	Molecular Advanced Microbiology	-		
	Data Use & Interpretation for diagnosis in Clinical and Vet Services	-		
	Data Use & interpretation for Public Health Policy	-		
	Communication, Collaboration & Advocacy	-		
	Surveillance System Planning & Implementation	-		
	One Health Multisectoral	-		
Policymakers	Foundations in Microbiology	1	Veterinary Services Professionals Laboratory Professionals	Animal health

	Good Laboratory Practice	1	Policymakers	Human health
	Foundations in Microbiology	2	Policymakers	Human health
	Molecular Advanced Microbiology	-		
	Data Use & Interpretation for diagnosis in Clinical and Vet Services	-		
	Data Use & interpretation for Public Health Policy	-		
	Communication, Collaboration & Advocacy	2	Clinical Services Professionals Policymakers The public	Human health
	Surveillance System Planning & Implementation	2	Policymakers	Human health
	One Health Multisectoral	1	Policymakers The Public	Human health

Table B3 Learning & Subject Needs by professionals in Country 2				
Who says?	**What to learn? Topics / Themes**		**Who needs to learn? Who to target?**	**Target sector**
	Category			**Roles**
Laboratory Professionals	Diagnostics Stewardship	-	Laboratory Professionals	Human health
	Good Laboratory Practice	3	Laboratory Professionals	Human health Animal health
	Foundations in Microbiology	3	Laboratory Professionals	Human health
	Molecular Advanced Microbiology	-		
	Data Use & Interpretation for diagnosis in Clinical and Vet Services	-		
	Data Use & interpretation for Public Health Policy	1		Human health
	Communication, Collaboration & Advocacy	2	Laboratory Professionals Clinical Services Professionals Policymakers The public	Human health
	Surveillance System Planning & Implementation	-		
	One Health Multisectoral	-		
Senior Laboratory Professionals	Diagnostics Stewardship	3	Laboratory Professionals; Recent graduates who have theoretical knowledge Clinical services professionals	Animal health Human health
	Good Laboratory Practice	5	Laboratory professionals	Animal health
	Foundations in Microbiology	6	Veterinarians Services Professionals Laboratory Professionals Clinical and Veterinary Services clients	Animal health
	Molecular Advanced Microbiology	-		
	Data Use & Interpretation for diagnosis in Clinical and Vet Services	-		

	Data Use & interpretation for Public Health Policy	-		
	Communication, Collaboration & Advocacy	4	Clinical and Veterinary Services Clients	Animal health
	Surveillance System Planning & Implementation	1	Policymakers	Human health
	One Health Multisectoral	-		
Clinical Services Professionals	Diagnostics Stewardship	-		
	Good Laboratory Practice	-		
	Foundations in Microbiology	-		
	Molecular Advanced Microbiology	-		
	Data Use & Interpretation for diagnosis in Clinical and Vet Services	-		
	Data Use & interpretation for Public Health Policy	-		
	Communication, Collaboration & Advocacy	-		
	Surveillance System Planning & Implementation	-		
	One Health Multisectoral	-		
Veterinary Services Professionals	Diagnostics Stewardship	-		
	Good Laboratory Practice	-		
	Foundations in Microbiology	-		
	Molecular Advanced Microbiology	-		
	Data Use & Interpretation for diagnosis in Clinical and Vet Services	--		
	Data Use & interpretation for Public Health Policy	-		
	Communication, Collaboration & Advocacy	-		
	Surveillance System Planning & Implementation	-		
	One Health Multisectoral	-		

Senior Management Staff in Clinical Services	Diagnostics Stewardship		Clinical Services Professionals Laboratory Professionals	Human health
	Good Laboratory Practice		Clinical Services Professionals Laboratory Professionals	Human health
	Foundations in Microbiology		Laboratory Professionals	Human health
	Molecular Advanced Microbiology	-		
	Data Use & Interpretation for diagnosis in Clinical and Vet Services		Clinical Services Professionals	Human health
	Data Use & interpretation for Public Health Policy	-		
	Communication, Collaboration & Advocacy		Laboratory Professionals Clinical Services Professionals	Human health
	Surveillance System Planning & Implementation		Policymakers	Human health
	One Health Multisectoral	-		
Senior Management Staff in Veterinary Services	Diagnostics Stewardship	-		
	Good Laboratory Practice	-		
	Foundations in Microbiology	-		
	Molecular Advanced Microbiology	-		
	Data Use & Interpretation for diagnosis in Clinical and Vet Services	-		
	Data Use & interpretation for Public Health Policy	-		
	Communication, Collaboration & Advocacy	-		
	Surveillance System Planning & Implementation	-		
	One Health Multisectoral	-		
Policymakers	Diagnostics Stewardship	2	Laboratory Professionals	Animal health Human health

			Veterinary services Professionals	
	Good Laboratory Practice	1		
	Foundations in Microbiology	5	Laboratory Professionals Clinical Services Professionals Veterinary Services Professionals	Human health Animal health
	Molecular Advanced Microbiology	-		
	Data Use & Interpretation for diagnosis in Clinical and Vet Services	1	Laboratory professionals and Clinical Services Professionals	Human health Animal health
	Data Use & interpretation for Public Health Policy	1	Policymakers	Human health
	Communication, Collaboration & Advocacy	6	Policymakers The public Clinical Services Professionals Veterinary Services Professionals Laboratory Professionals Multidisciplinary teams at the facility level	Human health Animal health Food
	Surveillance System Planning & Implementation	4	Policymakers Laboratory professionals	Human health Animal health
One Health Multisectoral		3	Policymakers Laboratory Professionals Veterinary Services Professionals Clinical Services Professionals	Human health Animal health All sectors, including the private sector/medicine manufacturers

Table B4: Descriptions of knowledge and skills needed per category as emerged from interviews

	Category	Capabilities and Skills	Knowledge
1	Diagnostics Stewardship	Decision-making skills about which new diagnostics are needed, how they will be used, and whether the patient/insurance are worth paying for. Demand of tests: right clinical specimens to be collected and in the right way, Transport of samples; Links to clinical data; Use the results appropriately for the care of the patient	Guidance on good practice; Knowledge of available lab diagnostics; Understand which specimens to take and how to handle these: practical protocols for the proper collection of the four groups of specimens (blood, urine, faeces and urethral/cervical swabs) needed for GLASS participation; Sample integrity and appropriate sample transport; Information processing and management; Understand diagnostics stewardship as involving the diagnostic pathway for infections and understand the ways to properly organize it; Knowledge of the WHO GLASS Guide to Implementation (http://www.who.int/glass/resources/publications/diagnostic-stewardship-guide/en/).
2.	Good Laboratory Practice	Operationalise an external Quality Assurance scheme; Operationalise and monitor internal Quality Control in lab diagnostics; Establish SOPs – monitor, evaluate, mentor, assess the adherence to standard operating procedures Samples: not contamination, proper documentation, storage of samples, information processing and privacy; Skills to perform lab tests properly: culture, isolation and identification, sensitivity tests, to grow right bugs, assess quality of agar, time needed in incubator, documentation and recording, good diagnostic outlines. Maintain equipment - technical skills to repair and maintain;	Knowledge on principles of Biosecurity & Biosafety; Knowledge on Quality Assurance schemes Understanding of Quality control and Quality Assurance processes, Knowledge on International Guidelines and standardised protocols Procurement processes: regulations, management of suppliers, reagents, and consumables Ethical Considerations Understanding on how to establish SOPs, monitor and evaluate performance of the lab
3.	Foundations in Microbiology	Core skills in microbiology: perform the AST reliably; Skills to perform other tests or use other techniques and methods to test resistance; Skills to use of the technology / equipment; Applying practical experience with theoretical knowledge: how to do good blood culture, how to read the results, what you do with the data.	Knowledge about bacteria and AMR - understand bacteria; a biological understanding of pathogen; resistance; links between environment/food, animal health and human health; Knowledge about available techniques – tests – methods; Fundamental knowledge of laboratory maths and biology. Understand bigger picture of surveillance system Know where to put limits: “limiting what you're doing-not trying to do everything”; Understanding internal Quality Control (also Category 2)

		Skills on interpreting results and communicate what they mean;	
4.	Molecular Advanced Microbiology	Skills to perform lab tests, such as whole genome sequencing Skills on interpreting results and communicate what they mean; Skills on using the equipment (e.g. PCR)	Knowledge about AMR genomics; Understanding of microbial diversity and evolutionary biology, and of how pathogenic bacteria and viruses interact with human, animal and plant hosts at the molecular level. Knowledge about available techniques in the fields of cellular and molecular biology;
5.	Data Use & Interpretation for diagnosis in Clinical/Vet Services	Establish and use systems to capture health-related data that will be practically used by lab professionals and clinical/vet settings. IT Technical Skills: use of database (e.g. Whonet); data entry; monitor the data that labs are generating and the number of samples that they're analysing; Collect data & store in a way that's accessible and useful for lab professionals and clinicians; Data management at lab level and establish links to clinical data; Analysis of data per individual and per aggregated data at local facility level; Skills for Quantitative and Qualitative data analysis and processing (e.g. biostatistics) Monitor cases where lab diagnostics resulted in change in therapy with a better outcome for patients and cost efficiency; Communication skills (surveillance Language skills): use of appropriate language for communicating results appropriately to the clinicians for patients to get treatment based on laboratory results;	Practical guidelines: how surveillance/lab-based diagnostics can serve the clinical/vet community? Knowledge on: what is the resistance level, what treatments to follow; how to use the data information; how to communicate the results appropriately; Understanding of basic epidemiology and how they apply to health-care associated infections at individual/local level for clinical care; Understanding of aggregated surveillance data at clinical setting; Practical protocols: what to do when you find a bug that is resistant; what to do when you find out that the facility has levels of resistance? Guidance on good practice: what makes a good prescriber; what antibiotics to give based on lab results; prescription guidelines How to connect clinical data and microbiology data, what the results may mean, what the effect of their results could be, clinically (i.e. the relevance of certain results;); understand links between lab data and clinical data (clinical outcomes); Understanding of the information the clinician needs: what's causing the patient to be sick? What's going to be effective to treat it? are these antibiotics resistant? Which antibiotics work, and which don't; Guidelines of good practice: how to use the results properly for the care of their patient;

6.	Data Use & interpretation for Public Health Policy	Advocacy, networking and collaboration skills; Appropriate use of the data to generate more support and advocacy from policymakers; Epidemiology and surveillance skills; Develop packages of both screening and implementation, investigation within local networks, and rapidly translate that into a much more regional picture; Public Health Policy: interpretation of health-related data for the planning, implementation, and evaluation of public health practice	Knowledge on epidemiology and surveillance: understand of basic epidemiology and how they apply to health-care associated infections at district/national level; Understanding of what disease factors affect the population and perform assessment of trends over time. Turning data into information and results and looking at the policy impact but also the impact back at the clinical/vet setting. Guidelines of strategy and response to the areas where there is resistance problem: policy implications; Regular updates about: what do we know about AMR in a country? What's known about AMR diseases and which ones have the biggest impact? Which ones should we be doing something about? What are the resistance patterns and which ones have the higher prevalence? What antibiotics are really at risk? Where are the links between, or possible links between animals and humans?
7.	Communication, Collaboration & Advocacy	Advocacy, networking and collaboration skills; Communication skills: facilitating communication between clinicians - lab professionals for knowledge sharing; Establish protocols to capture the contribution of appropriate lab diagnostics to health & wellbeing; Use of health-related data and translating it into economic terms for the Ministry of Finance; Advocacy skills: importance of AMR and why it's important to make changes at facility level/regional level; Communicating scientific evidence / new knowledge in an accessible / practical way Writing skills - writing protocols, scientific presentation skills, analyse grant applications; Networking skills, Assertive skills, Negotiation skills	Understand the processes in the lab: what are the limitations of the tests, the timelines of the tests to grow bacteria and do culture; Understand the roles (e.g. lab professionals) are playing within the surveillance system, what their work entails, and their contribution; Understand of laboratory and clinical practices; Understand chain of environment to animals to humans; Knowledge about AMR across sectors;
8.	Surveillance System Planning & Implementation	Skills to plan and develop a surveillance system at local facility/district level; Project management skills; Grant/financial management skills; Develop strategic planning on surveillance and consider roles;	Understand the surveillance processes and protocols; Practical guidelines on bringing everything together and the system to put in place; Knowledge on equipment; Understanding of internal quality control and external quality assurance; Knowledge & understanding about concepts, approaches, mechanisms, approaches on how to operationalize One Health and AMR and surveillance
9.	One Health Multisectoral		Understand bacteria in humans and animals; Understand about dealing with human and animal specimens;

			Understand Quality Control and Quality Assurance for One Health collaboration; Knowledge & understanding about concepts, approaches, mechanisms, approaches on how to operationalize One Health and AMR and surveillance

Appendix C Sourcing of Resources

01/05/2018

Found AMR Resources

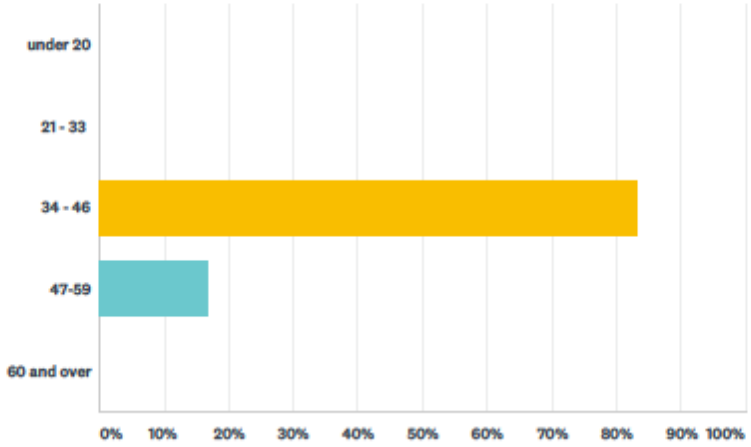
Type	Name	Subject area	Audience / Roles	Format	duration	development stage	Who has delivered	Countr	language	licence	key contact	link	impact report	numbers engag	Formal / infor	Acreditation	Notes/Description	Retrieved from report?
online course	Antimicrobial Stewardship: A competency-based approach	Diagnostics Stewardship	3	online	8h	available/currently runni	WHO	Global	English			https://openwho.org/courses/AMR-competen		12887		Gain a confirmation of particip	free and open for everyone	
MOOC	Antimicrobial Stewardship: Managing Antibiotic Resistance	Diagnostics Stewardship	1, 2, 3, 4, 5, 6, 7, 8	online	6 weeks/3h p	available / Next: 14 May	University of Dundee/B	UK	English/Spanish/Russian/		Tracey Guise	https://www.futurelearn.com/courses/antimicrobial-stewardship				Pay for a Certificate of Achieve	free	
Online course	ANTIMICROBIAL STEWARDSHIP: IMPROVING CLINICAL OUTCOMES BY OPTIMIZATION OF ANTIBIOTIC PRACT	Diagnostics Stewardship	3, 4	online	7h	available / Apr 18 - April	Stanford Centre for Con	USA	English			https://med.stanford.edu/cme/courses/online/AntimicrobialReboot.html				7 CME Credits Offered	free	
	BMJ Online course in Vietnam / CME Course					under development											mentioned by Rogier - OUCRU Vietnam	
f2f session, summer school	ANTIMICROBIAL RESISTANCE SPECIAL SESSION	Diagnostics Stewardship	1, 2, 3, 4, 5, 6, 7, 8	In person, ser	1 day	next session summer 201	McGill University, Summ	Canada	English		summerinstitute.m	http://mcgill-idgh.ca/courses/antimicrobial-resistance-special-session/				None	include these f they are offered for a fee but	
MOOC	One Health, One Medicine: A Global Health Approach	One Health Multisectoral	1, 2, 3, 4, 5, 6, 7, 8	online	8 weeks 2 - 3	completed, currently not	St Georges University	Grenada	English			https://online.sgu.edu/courses/SGUx/OHOM1/2014/about				University credit for a fee ($115)		
Article	The Hidden Link Between Farm Antibiotics and Human Illness	One Health Multisectoral	1, 3, 4, 7, 9, 10	online	n/a	Article available online	Maryn McKenna via WIR	USA	English		@marynmck	https://www.wired.com/story/farm-antibiotics-human-illness-hidden-link/				n/a		
Video	Promoting Pioneers – Colombia	Surveillance System Planning & Implen	4, 6, 7, 8, 9, 10	online	2 minutes 38	Video available online	Wellcome Trust	UK	English	CC-BY		https://www.youtube.com/watch?v=MPlfMUa		11415		n/a		
Working paper	Tackling antimicrobial resistance (AMR) together: Working Paper 5.0: Enhancing the focus on gender and e	Data use & interpretation for Public Heal	2, 5, 6, 7, 8	online	n/a	Working paper	WHO	Global	English	CC-BY-SA		http://www.who.int/antimicrobial-resistance/national-action-plans/workingpaper5e				n/a		
Video	Antimicrobial Resistance: The End of Modern Medicine? with Dame Sally Davies	Foundational/Core Microbiology - Comm	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	online	1hr	Video available online	The Royal Institution	UK	English			https://www.youtube.com/watch?v=2H_Ox1v		18595		n/a	accompnying Q&A video here https://www.	
video	Q&A - Antimicrobial Resistance: The End of Modern Medicine? with Dame Sally Davies	Foundational/Core Microbiology - Comm	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	online	15 minutes	Video available online	The Royal Institution	UK	English			https://www.youtube.com/watch?v=B5jSMZ8		3958		n/a		
Book	Antimicrobial Stewardship: From Principles to Practice	Foundational/Core Microbiology - Diagno	1, 2, 3, 4, 5, 6, 7, 8	online	n/a	Availble online, for down	British Society of Antimi	UK	English	Copyright b	Tracey Guise	http://bsac.org.uk/antimicrobial-stewardship-from-principles-to-practice-e-book/ebo				n/a	very extensive covers lots of areas	
Hackathon	Lab Hackathon: Zimbabwe	Good Laboratory Practice / Surveillance S	1, 2, 3, 4	in person, onl	n/a	Would need to be set up	University of Oxford, Na	n/a	English	n/a		https://labhackathon.wordpress.com/				n/a		
MOOC	Bacterial Genomes: Disease Outbreaks and Antimicrobial Resistance	Molecular Advanced Microbiology	1, 2, 3, 4, 8	online	3hrs per weel	available - timed starts	Wellcome Genome Cam	UK	English			https://www.futurelearn.com/courses/introduction-to-bacterial-genomics				RCPath and RCN has approved	Currently a free upgrade is being offered to a	
MOOC	Using Infection Control to Combat Antimicrobial Resistance	Good Laboratory Practice / Foundational,	3	online	3hrs per weel	currently running	University of East Anglia	UK	English			https://www.futurelearn.com/courses/infection-control-antimicrobial-resistance				Certificate of achievment for £52		
MOOC	Challenges in Antibiotic Resistance: Point Prevalence Surveys	Data Use & Interpretation for diagnosis ir	2, 3, 4, 5, 6, 7	online	2hrs per weel	currently running	British Society of Antimi	UK	English			https://www.futurelearn.com/courses/point-prevalence-surveys				Certificate of achievment for £52		
MOOC	Challenges in Antibiotic Resistance: Gram Negative Bacteria	Foundational/Core Microbiology	1	online	3hrs per weel	currently running	british Society of Antimi	UK	English			https://www.futurelearn.com/courses/gram-negative-bacteria				Certificate of achievment for £52		
MOOC	One Health: Connecting Humans, Animals and the Environment	One Health Multisectoral	1, 2, 3, 4, 5, 6, 7	online	5hrs per weel	currently running	University of Basel	Switzerla	English			https://www.futurelearn.com/courses/one-health				Certificate of achievment for £62		
MOOC	Antimicrobial Resistance in the Food Chain	Foundational/Core Microbiology	1, 2, 7, 9	online	3hrs per weel	not currently running	University of Nottinghar	UK	English			https://www.futurelearn.com/courses/antimicrobial-resistance-food-chain				Certificate of achievment for £62		
MOOC	Antibiotic Resistance: the Silent Tsunami	Foundational/Core Microbiology	1, 2, 3, 4, 5, 6, 7, 8, 9 10	online	3hrs per weel	not currently running	Uppsala University	Sweden	English			https://www.futurelearn.com/courses/antibiotic-resistance				Certificate of achievment for £42		
f2f course	Antimicrobial Resistance (AMR): a Multidisciplinary Approach	Foundational/Core Microbiology	1, 2, 3, 4, 5, 6, 7	in person	5 days	not currently running	London school of hygen	UK	English			https://www.lshtm.ac.uk/study/courses/short-courses/antimicrobial-resistance				£1,500 includes certificate of attendance		
MOOC	Antimicrobial resistance - theory and methods	Foundational/Core Microbiology	1, 2	online	2hrs per weel	currently running	Technical University of D	Denmark	English			https://www.coursera.org/learn/antimicrobial-resistance				certificate for a fee		
MOOC	Metagenomics applied to surveillance of pathogens and antimicrobial resistance	Molecular Advanced Microbiology / Data	1, 2, 8	online	3hrs per weel	currently running	Technical University of D	Denmark	English			https://www.coursera.org/learn/metagenomics				certificate for a fee		
MOOC	Antibiotic Stewardship	Diagnostics Stewardship	3, 4, 5	online	2hrs per weel	currently running	Stanford University	USA	English			https://www.coursera.org/learn/antibiotic-stewardship				certificate for a fee	The videos were produced as part of a free o	
Video	Global Action Plan on Antimicrobial Resistance - message from WHO Director-General	Communication, Collaboration & Advoca	1, 2, 3, 4, 5, 6, 7, 8	online	2 minutes	Video available online	WHO	Global	English			https://www.youtube.com/watch?v=QLCy3UFhYTQ				n/a		
course	Antimicrobial Resistance (Part 1)	Foundational/Core Microbiology	1, 2, 3, 4, 5, 6, 7	online	2 hrs	currently running	The Global Health eLear	USA	English			https://www.globalhealthlearning.org/course/antimicrobial-resistance-part-1-0				certificate of completion		
course	Antimicrobial Resistance (Part 2)	Foundational/Core Microbiology	1, 2, 3, 5, 7	online	3 hrs	currently running	The Global Health eLearning Cent		English			https://globalhealthlearning.org/course/antimicrobial-resistance-part-2				certificate of completion		
Video (animation)	Amala's story: how to prevent antimicrobial resistance	Foundational/Core Microbiology	10	online	1 minute 30	Video available online	WHO	Global	English			https://www.youtube.com/watch?v=Y9WEERS		1392		n/a		
video (animation)	WHO: Antibiotics -- handle with care	Communication, Collaboration & Advoca	10	online	1 minute 05	Video available online	WHO	Global	English			https://www.youtube.com/watch?v=-ZX97bIb		24907		n/a		
Video	Tackling AMR in Bangladesh – a One Health approach	Communication, Collaboration & Advoca	4, 6, 7, 8, 9	online	5 mminutes 3	Video available online	FAO	Global	English			https://www.youtube.com/watch?v=YmOey7		1106		n/a		
video (animation)	FAO and Antimicrobial Resistance	Communication, Collaboration & Advoca	4, 6, 7, 8, 9	online	2 minutes 23	Video available online	FAO	Global	English			https://www.youtube.com/watch?v=IiH400W-		4313		n/a		
framework	WHO Competency Framework for Health Workers' Education and Training on Antimicrobial Resistance	?	3	online	n/a	resource online	WHO	Global	English			http://www.who.int/hrh/resources/WHO-HIS-HWF-AMR-2018.1/en/				n/a		
Video	Antimicrobial Stewardship Videos	Molecular Advanced Microbiology	4, 6, 8	online	1 hr	Video available online	National Centre for Anti	Australlia	English			https://www.ncas-australia.org/home				n/a	Series of 6 video lectures	
Blog	World Bank by Uzo Chukwuma	Communication, Collaboration & Advoca	7, 9, 10	online	n/a	Article online	World Bank	Global	English			http://blogs.worldbank.org/health/how-antimicrobial-resistance-amr-stewardship-cr				n/a		
Publication	Antibiotic resistance in Vietnam: moving towards a One Health surveillance system	Surveillance System Planning & Impleme	7, 8	online	n/a	Publication online	BMC publication	Global	English			https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-018-6022-4				n/a		
Publication	Antimicrobial resistance: a threat to global health	One Health Multisectoral	1, 2, 3, 4, 5, 6, 7, 8	online	n/a	Publication online	The Lancet publication	Global	English			https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(18)30471-7/fulltext				n/a		
course	Optimizing Antimicrobial Therapy with Timeouts	Diagnostics Stewardship	3	online	2 hrs	currently running	Stanford Center for Con	USA	English			https://med.stanford.edu/cme/courses/online/optimizing-antimicrobial-therapy.htm				Physicians will be awarded 2 AMA PRA Category 1 Credits™. All other partic		
Publication	The Core Elements of Human Antibiotic Stewardship Programs in Resource-Limited Settings:National and H	Diagnostics Stewardship	5, 6, 7	online	n/a	Publication online	The National Center for Emerging		English			https://www.cdc.gov/antibiotic-use/healthcare/pdfs/18-295875-A-ASP-CE-Web-508.p				n/a		
promotional material	Tripartite AMR communications toolkit	Communication, Collaboration & Advoca	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	online	n/a	available online	WHO	Global	English - Russian - Chinese - Spanish - French			https://trello.com/b/tBoXeVae/tripartite-amr-communications-toolkit				n/a	materials produced as part of antibiotics awa	
promotional material	WHO WAAW Campaign material	Communication, Collaboration & Advoca	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	online	n/a	available online	WHO	Global	English - Russian - Chinese - Spanish - French			https://trello.com/b/Ymp4Behu/who-waaw-campaign				n/a	materials produced as part of antibiotics awa	
promotional material	Become an antibiotic guardian	Communication, Collaboration & Advoca	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	online	n/a	available online	Publich Health England	UK	English - Durch - French - Turkish - Russin - So			https://antibioticguardian.com/		62564		n/a	Pledge site for people to sign to reduce AMR	
resource site	Antibiotic action	Communication, Collaboration & Advoca	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	online	n/a	available online	British Society of Antimi	UK	English			http://antibiotic-action.com/antibiotic-action-resources/				n/a	list of 31 resources	
Video (animation)	The Antibiotic Apocalypse Explained	Foundational/Core Microbiology - Comm	1, 9, 10	video availab	6 minutes	Video available online	Kurzgesagt	German	English			https://www.youtube.com/watch?v=xZbcwi7SfZE				n/a		
Course	Reducing Antimicrobial Resistance: An Introduction	Foundational/Core Microbiology - Diagn	1, 3	online	25 minutes	currently running	NHS Health Education E	UK	English			http://cs1.e-learningforhealthcare.org.uk/public/AMR/AMR_01_001/d/ELFH_Session/9/session.html?lms=n#overview.html						
course	Understanding antibiotic resistance	Foundational/Core Microbiology	1	online	24 hrs	currently running	The Open University	UK	English			https://www.open.edu/openlearn/science-maths-technology/understanding-antibiotic-resistance/content-section-overview?active-tab=description-tab						
Publication	Annual Report of the Chief Medical Officer	Diagnostics Stewardship - Foundational/	2, 3, 5, 7, 8	online	n/a	Publication available onli	Department of Health a	UK	English			https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/138331/CMO_Annual_Report_Volume_2_2011.pdf						
Video (animation)	What causes antibiotic resistance? - Kevin Wu	Foundational/Core Microbiology	1, 10	online	4 minutes 30	Video available online	Ted-Ed	USA	English			https://www.youtube.com/watch?v=znnp-Ivj2ek						
Toolkit	Start smart then focus: antimicrobial stewardship toolkit for English hospitals (UK Government)	Diagnostics Stewardship	3, 5	online	n/a	available online	Publich Health England	UK	English			https://www.gov.uk/government/publications/antimicrobial-stewardship-start-smart-then-focus					published 2015	
Course	Antimicrobial Stewardship Programmes: Developing, Implementing & Measuring (ESGAP-GEIH Course 201	Diagnostics Stewardship	?	online	?	Restricted access	European society of clin	UK	English			http://esgap.escmid.org/?page_id=756						
Course	Quick tips: Gram-negative bacterial infections	Foundational/Core Microbiology	1, 3	online	10 minutes	available online	BMJ learning	UK	English			https://learning.bmj.com/learning/module-intro/qt-gram-negative.html?moduleId=10056749&searchTerm=%E2%80%9Cantimicrobial%20resistance%E2%80%9D						
Course	MRSA in hospital patients	Foundational/Core Microbiology	1, 3	online	1hr	available online	BMJ learning	UK	English									
Discussion forum	AMR National Action Plan discussion forum	Surveillance System Planning & Impleme	5, 6, 7	online	n/a	available online	WHO	Global	English			https://ezcollab.who.int/amr-nap?ReturnUrl=%2famr-nap%2fdiscussions%2fwq3t3btw						
Resource site	Information and resources on the government's plans to slow the growth of antimicrobial resistance.		2, 3, 4, 5, 7, 8	online	n/a	available online	UK Government	UK	English			https://www.gov.uk/government/collections/antimicrobial-resistance-amr-informat				n/a		
Resource guide	Antimicrobial Resistance: resource handbook		2, 3, 4, 5, 7	online	n/a	available online	UK Government	UK	English			https://www.gov.uk/government/publications/antimicrobial-resistance-resource-handbook						
Resource site	BMJ Learning		3, 5									https://learning.bmj.com/learning/home.html						
Resource site	Antimicrobial Resistance and Stewardship (NHS Education for Scotland)		3, 5									https://www.nes.scot.nhs.uk/education-and-training/by-theme-initiative/healthcare-associated-infections/educational-programmes/antimicrobial-resistance-a						
Resource site	Antimicrobial Resistance and Infections programme		3, 5				NHS Health Education E	UK	English			https://www.e-lfh.org.uk/programmes/antimicrobial-resistance-and-infections/						
Resource guide	Antimicrobial resistance - A training resources guide		3, 5									https://www.hee.nhs.uk/sites/default/files/documents/Antimicrobial%20resistance%20-%20A%20training%20resou					53 resources some already listed here - publ	
resource	BMJ best practice											https://bestpractice.bmj.com/info/us/						

Appendix D

See attached documents

Q1 What is your age?

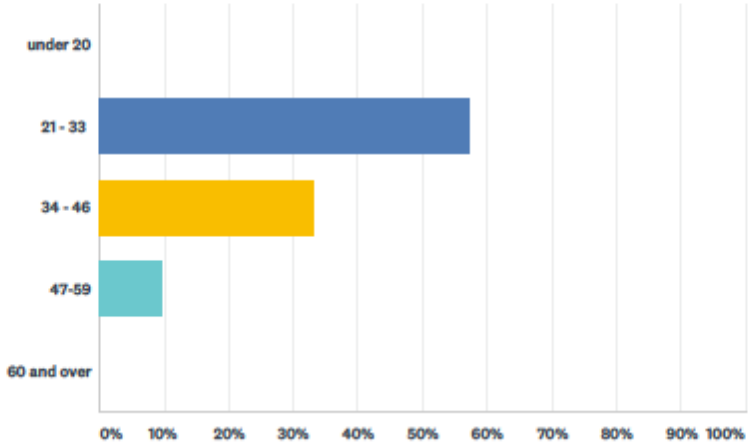
Answered: 6 Skipped: 0



ANSWER CHOICES	RESPONSES	
under 20	0.00%	0
21 - 33	0.00%	0
34 - 46	83.33%	5
47-59	16.67%	1
60 and over	0.00%	0
TOTAL		6

Q1 What is your age?

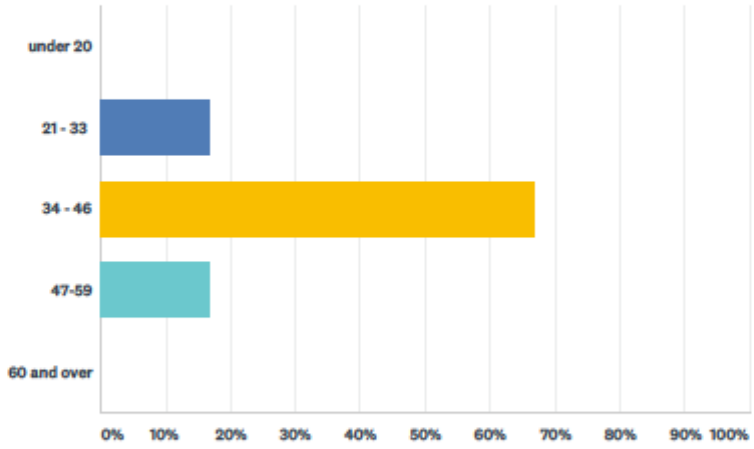
Answered: 21 Skipped: 0



ANSWER CHOICES	RESPONSES	
under 20	0.00%	0
21 - 33	57.14%	12
34 - 46	33.33%	7
47-59	9.52%	2
60 and over	0.00%	0
TOTAL		21

Q1 What is your age?

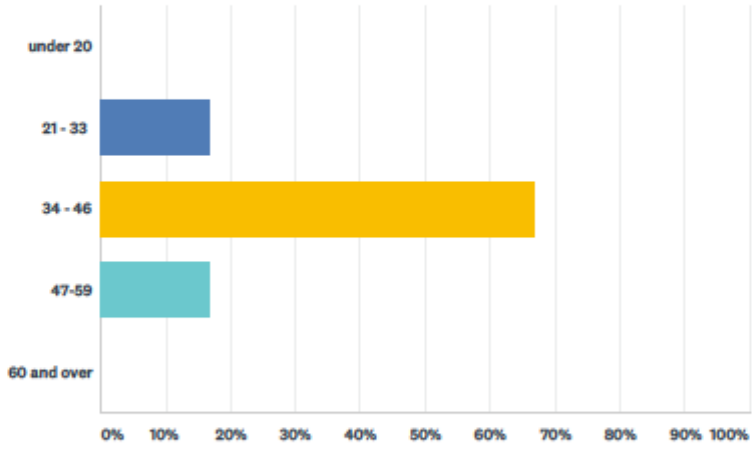
Answered: 12 Skipped: 0



ANSWER CHOICES	RESPONSES	
under 20	0.00%	0
21 - 33	16.67%	2
34 - 46	66.67%	8
47-59	16.67%	2
60 and over	0.00%	0
TOTAL		12

Q1 What is your age?

Answered: 12 Skipped: 0



ANSWER CHOICES	RESPONSES	
under 20	0.00%	0
21 - 33	16.67%	2
34 - 46	66.67%	8
47-59	16.67%	2
60 and over	0.00%	0
TOTAL		12