Report

Fleming Fund: supporting surveillance capacity for antimicrobial resistance

Regional Networks and Educational Resources

Russell Dacombe, Justin Pulford, Selina Wallis, Minakshi Bhardwaj and Imelda Bates

Capacity Research Unit
Liverpool School of Tropical Medicine

June 2016

This is an independent study commissioned by the Wellcome Trust and funded by the Department of Health as part of the Fleming Fund

Contents

Executive Summary....2

Introduction 4

Methodology....4

- Literature Search....4
- Network and Resource Identification....4
- Data Extraction 5
- Key Informant Interviews 5

Findings on educational resources for supporting anti-microbial resistance surveillance 6

- AMR surveillance in humans....6
- Networks providing routine surveillance 6
- Research Based Networks 8
- AMR surveillance in food and animals....10
- Inactive Networks 11

Observations concerning these AMR networks 11

Findings on educational resources for supporting anti-microbial resistance surveillance 12

Table 1. International and Regional Networks identified....13

Table 2. Detailed descriptions: geographic coverage, size, coordinating centre and anti-microbial sensitivity (AST) standard 15

Table 3. Detailed descriptions: organisms and associated drug classes under surveillance, specimen types collected 19

Table 4. Detailed descriptions: types of support services available to network members 28

Table 5. Discontinued AMR surveillance networks 32

Table 6. Educational resources concerning AMR networks 33

Annex 1. Terms of Reference....39

Executive summary

This study was commissioned as part of the 'Fleming Fund: supporting surveillance capacity for antimicrobial resistance' for the project 'An analysis of networks and education resources supporting drug resistant infection surveillance in low and middle income countries (LMICs)' (see annex 1). The study objectives were to identify and describe drug resistance surveillance networks in LMICs and identify available educational resources that could support effective implementation of such networks.

We defined an anti-microbial resistance (AMR) surveillance network as a group of institutions (nationally) or countries (regionally/globally) that gather, analyse, compile and share the results of any aspect of antimicrobial resistance (e.g. antimicrobial resistance, antimicrobial use and antimicrobial quality). Publications with potential descriptions of, or references to, LMIC anti-microbial resistance (AMR) surveillance networks and educational resources from January 2000 to June 2016 were sought from electronic databases and from individuals involved in, or with knowledge of, such networks. A data extraction tool was designed to capture all aspects of an AMR surveillance network which we identified from the literature and our own experience and that of others working in AMR surveillance in LMICs. Only educational resources that were freely available were accessed and their content, scope and origin were documented.

Telephone interviews were conducted with key individuals associated with AMR surveillance networks that had been selected because the networks had national or international scope and represented a range of geographical locations and infections. Information collected covered data collection, technical support, training and external quality assurance. It also covered: mechanisms for sharing data, standard operating procedures and best practice; and barriers and enablers to the implementation and maintenance of the surveillance networks. Information was included on all the networks we identified but not all of the information was verified by interviews. This is important to note since it is possible that some of the identified networks may no longer be operational.

Twenty regional and international AMR surveillance networks were identified. Most of these provided routine AMR surveillance in specific regions (i.e. Europe, US, Central Asia, Latin America and Eastern Europe) or globally on certain topics (i.e. paediatric infections, tuberculosis, HIV, pneumonia, meningitis, gonorrhoea). In addition to the routine surveillance networks, we identified several research networks involved in AMR surveillance. These covered general AMR in different regions (i.e. Asia) or specific target groups (i.e. paediatrics), or organisms (i.e. salmonella, TB, E coli, nosocomial). We also identified four AMR surveillance networks for infections transmitted through food, water and zoonoses.

We identified a limited number of educational resources relevant for supporting AMR surveillance which are freely accessible on-line. These covered generic issues to do with AMR surveillance or public health surveillance in general and some focused on specific organisms or target groups such as data managers, laboratories or paediatricians. These resources will need to be reviewed by the different players involved in AMR surveillance so that it can be determined whether or not they meet their needs.

The European EARS-NET model seems to have been successful and could be considered for expanding to other regions such as central Asia. Coordination of activities and sharing of

information across these three types of networks (routine, research, food/water/zoonoses) may be beneficial to maximise synergy and avoid duplication, particularly of laboratory testing. Africa seems to be particular poorly served in terms of AMR surveillance networks. In-depth analysis of some of the more and less successful AMR surveillance networks would be helpful in guiding future programmes about what works and does not work in different contexts.

Introduction

This study was commissioned as part of the 'Fleming Fund: supporting surveillance capacity for antimicrobial resistance' for the project 'An analysis of networks and education resources supporting drug resistant infection surveillance in low and middle income countries (LMICs)' (see annex 1). The study objectives (described in full in 2.1 and 2.2 below) were to identify and describe drug resistance surveillance networks in LMICs and identify available educational resources designed to support effective implementation of such networks.

We defined an anti-microbial resistance (AMR) surveillance network as a group of institutions (nationally) or countries (regionally/globally) that gather, analyse, compile and share the results of any aspect of antimicrobial resistance (e.g. antimicrobial resistance, antimicrobial use and antimicrobial quality). The study activities covered:

- A literature review to identify global AMR surveillance networks with a focus on LMICs
- A description of the networks using a pre-designed matrix informed by existing AMR surveillance system literature including the WHO's Global Antimicrobial Resistance Surveillance System (GLASS) (3) and the OASIS tool for assessing epidemiological surveillance systems (4).
- Identification of challenges and successes in establishing and managing AMR surveillance networks with suggestions for how challenges may be addressed
- Identification of educational resources to support AMR surveillance networks, including their content, access and format

Methodology

Literature Search

Search strategy

Publications with potential descriptions of, or references to, low and middle income country (LMIC) AMR surveillance networks and educational resources were sought from a search of the Medline, Web of Science, Global Health, PubMed, Google Scholar and Google databases. The reference period for the search was January 2000 to June 2016 and the search was limited to English language publications. Additional information on potential surveillance networks and educational resources were sought from a manual search of references listed in retrieved articles. A Google search was also conducted to identify the web presence of relevant networks and resources and any associated documentation.

Network and resources identification

Retrieved publications, documents or reports were examined for references to AMR-relevant LMIC surveillance networks and resources. In the first instance, publication/document/report titles, abstracts and key words were reviewed and the full text was retrieved for those which were relevant for AMR. All LMIC surveillance networks and resources identified during the course of the full text review were recorded on an Excel spreadsheet. Our research team sent formal requests to their existing professional contacts

asking them to identify relevant surveillance networks and resources and to identify other key informants (described below). These were added to the Excel spreadsheet.

Data extraction

The research team developed and piloted a data extraction tool designed to capture the information necessary to assess each of the identified LMIC surveillance networks and educational resources. The components of the data extraction tool for AMR surveillance networks were based on the World Health Organisation's (WHO) GLASS manual for early implementation of an AMR surveillance system (3) and the OASIS tool for assessing epidemiological surveillance systems (4). Research team members reviewed all documents pertaining to each of the identified LMIC surveillance networks identified during the literature search in order to populate the data extraction tool. Additional data were sought from standard internet searches using the respective network name as a search term and through information obtained from key informant interviews. Only educational resources that were freely available were accessed and their content, scope and origin were documented.

Key Informant Interviews

Key informant interviews (KIIs) were conducted with a senior member of purposively selected LMIC surveillance networks and/or with an individual familiar with a particular surveillance network. The networks were selected to provide a range of the major 'typologies' of surveillance for AMR, and to have international or regional scope. Potential KIs were identified during the literature search, through existing professional networks or by other key informants themselves (i.e. 'snowball' recruitment). An introductory email was sent to all prospective KIs in the first instance informing them about the study aims, requesting their participation and inviting them to identify a date/time for possible interview. Prospective KIs who did not response to the email invitation were subsequently contacted by telephone, provided with more details about the study and invited to participate.

All interviews were conducted by telephone and followed a structured topic guide, the contents of which were based on a review of relevant literature. The topic guide covered core functions of an AMR surveillance network (e.g. data collection, technical support, training, external quality assurance, and mechanisms for sharing data, standard operating procedures, and best practice). The interview guide also covered barriers and enablers to the implementation and maintenance of the surveillance networks, and solicited interviewees' knowledge of other LMIC surveillance networks and educational/training resources designed to strengthen AMR surveillance capacity. KIIs were audio-recorded when possible and when permission was granted and detailed written summary notes taken. Recordings were used to check the accuracy of the notes. All relevant KII data were entered into a specifically-designed excel spreadsheet for subsequent analysis. Networks for which we were able to include data from KII are marked with an "*" on the relevant tables. Data not marked with "*" cannot therefore be considered verified and therefore cannot be considered complete or up to date. This is important since it is possible that some of the identified networks may no longer be operational.

Findings on educational resources for supporting anti-microbial resistance surveillance

Twenty regional and international AMR surveillance networks were identified (tables 1, 2, 3 and 4). We also identified military United State of America (USA) AMR networks that operated in LMICs but were not included since they only monitored USA military personnel. We also excluded the European Surveillance of Veterinary Antimicrobial Consumption as it did not deal with AMR surveillance.

AMR surveillance in humans

Networks providing routine surveillance

European Antimicrobial Resistance Surveillance network

European Antimicrobial Resistance Surveillance network (EARS-NET) collects surveillance data mainly for the European Union (EU), which includes some middle-income countries such as Bulgaria and Romania. EARS-NET countries use EUCAST, a WHO approved standard for anti-microbial susceptibility testing (AST). EARS-NET also provides an annual round of external quality assurance (EQA). Data collected by the network is stored on The European Surveillance System (TESSy) database, which provides open access to participating countries and some publicly accessible information. Data concerning a specified list of bacteria/specimens/antimicrobial agents under AMR surveillance are uploaded and the database creates one record per patient, bacterium, antimicrobial agent and year.

EARS-NET has a co-ordinating committee to provide scientific support and coordinates with other related networks in the EU, namely the European Surveillance of Antimicrobial Consumption Network (ESAC-Net) and the Healthcare-Associated Infections Surveillance Network (HAI-Net).

EARS-NET has the following objectives:

- to collect comparable, representative and accurate AMR data;
- to analyse temporal and spatial trends of AMR in Europe;
- to provide timely AMR data for policy decisions;
- to encourage the implementation, maintenance and improvement of national AMR surveillance programmes; and
- to support national systems in their efforts to improve diagnostic accuracy by offering an annual EQA.

Only data from invasive ‘priority specimens’ (blood and cerebrospinal fluid) isolates are included in EARS-NET. It does not collect data on a syndromic basis or for other types of specimens due to the increasing likelihood of confounders influencing the data (e.g. inconsistent use of clinical case definitions and different sampling frames). Blood culture sampling can also suffer from random sampling errors due to differences in the frequency of blood culture collection; this complicates the accuracy of comparisons between hospitals and countries. This limitation, and variations in population coverage, are acknowledged by EARS-NET.

US CDC Global Disease Detection programme (GDP)

This purpose of the GDP is to detect outbreaks across the globe through ten global disease control centres. As part of this activity it may collect AMR data. It also supports a Field Epidemiology Training Programme.

Central Asian and Eastern European Surveillance of AMR Network (CAESAR)

Similar to EARS-NET this network collects data on eight organisms responsible for infections of cerebrospinal fluid and blood. According to the CAESAR 2014 report, five countries in the network have begun submitting data (Belarus, Serbia, Switzerland, the former Yugoslav Republic of Macedonia and Turkey). Another ten countries were in the process of submitting data. Like EARS-NET, CAESAR provides an annual EQA service to countries and promotes the EUCAST standard for AST.

The CAESAR network has identified the following challenges:

- limited human and financial resources to address the need for laboratory capacity building;
- continuing need to educate laboratory personnel;
- the need for implementation of updated guidelines on the standardization of antibiotic susceptibility testing (AST) (from the Clinical and Laboratory Standards Institute (CLSI) and EUCAST), laboratory methods for species identification and blood culturing;
- the need for standard operating procedures and quality control in laboratory practice;
- the need to improve sampling habits and utilization of medical microbiologic diagnostics in hospitals; and
- the need to improve laboratory information management and set up an infrastructure for central data collection at a national reference laboratory.

Workshops have been organised to try to address these challenges and laboratory twinning has been raised as a way to further improve capacity.

Red Latinoamericana de Vigilancia a las Resistencias Antimicrobianis (ReLARVA)

This network was launched in 1996 by WHO Pan-American Health Organization (PAHO) and obtains resistance data from 21 Latin American countries. The National Institute of Infectious Diseases of Argentina coordinates the network except for enteric pathogens, which are coordinated through the Canadian National Microbiology Laboratory for Enteric Pathogens. Representatives of national reference laboratories participate in a biennial meeting aimed at information sharing, standardization and networking.

The network participates in external quality assurance programmes for bacteriology and AMR coordinated by the National Administration of Health Laboratories and Institutes. The majority of members use WHO-NET software for reporting AMR data, though it is not mandatory in the network. PAHO has commented that funding for the consolidation of the network is a challenge.

Global Antimicrobial Resistance, Prescribing, and Efficacy Among Neonates and Children

After a pilot phase this programme was launched in November 2015 and has been actively trying to expand the number of sites in its network. It has the following aims:

- Characterisation of antimicrobial prescription rates among neonatal and paediatric patients using periodic point prevalence surveys

- Assessing blood stream infection burden and resistance patterns among neonatal and paediatric patients using routinely collected laboratory data

Global Gonococcal Antimicrobial Surveillance Program (GASP)

This re-established WHO programme has been collecting data on gonococcal resistance patterns since 2009. WHO Geneva coordinates this project with interregional collaborators in Africa, Asia, the Americas, Europe and the Western Pacific. Though many high-income countries have well developed GASPs, the programme recognises that LMICs require additional support to develop functional GASPs.

The WHO Global Project on anti-tuberculosis drug resistance surveillance

The WHO Global Project on anti-tuberculosis drug resistance surveillance has collected data on tuberculosis resistance from 144 countries since 1994. The data is published annually in the Global Tuberculosis Report and includes data from routine country surveillance and national drug resistance surveys. In LMICs, routine surveillance is normally restricted to patients at high risk from multi-drug resistant TB (MDR-TB) (e.g. previously treated cases). Hence, countries are advised by WHO to carry out periodic MDR TB surveys to determine drug resistance in all tuberculosis cases. Standards for the phenotypic and molecular detection of drug resistance have been developed but, particularly for phenotypic detection, it is not clear if these have been fully implemented at national level. The TB supra-national network provides an EQA service, but its usage and hence the data it generates, can be erratic.

Global HIV Drug Resistance Surveillance Network

This WHO led network supports countries to conduct national surveillance surveys for HIV drug resistance (HIVDR). Their guidelines focus on the surveillance of HIVDR among patients starting first-line ART and on acquired HIVDR in populations experiencing virological failure while on first-line ART.

System of Networks for Surveillance of the Bacterial Agents Responsible for Pneumonia and Meningitis (SIREVA II)

This network focuses on vaccine-preventable bacterial causes of pneumonia and meningitis in Latin America in children under 5 years. It is coordinated by WHO-PAHO in partnership with Pfizer and GSK. Each participating country has sentinel sites to detect and culture isolates from children under 5 years. Suspected, probable and confirmed case definitions for pneumonia and meningitis have been agreed. There is a clearly laid out process for the reporting and sending of isolates and data to the national reference centres and for how these centres report to PAHO.

PAHO operates an EQA programme that rechecks isolates and conducts proficiency testing through two sub-regional reference centres. Training is also provided to laboratory staff including on the proper shipment of isolates. Laboratory evaluations are also undertaken to monitor quality.

Research Based Networks

Asian Network for Surveillance of Resistance Pathogens (ANSORP)

The Asian Network for Surveillance of Resistance Pathogens started in 1996 with a study investigating pneumococcal resistance in 14 centres in 11 Asian countries. Further projects followed on the nasopharyngeal carriage of drug-resistant pneumococci in Asian children, community-acquired pneumonia, fluoroquinolone-resistant *S. pneumoniae* and

antimicrobial resistance among enteric pathogens. The most recent study is focusing on community-acquired methicillin-resistant *S. aureus*, hospital-acquired pneumonia and ventilator-associated pneumonia.

The network has the following vision statements:

- ANSORP will continue to perform international multicentre research on antimicrobial resistance as well as clinical trials in the Asian region.
- ANSORP will remain an "independent" study group for the international collaboration study in the Asian region.

This research group is co-ordinated from South Korea and uses a WHO approved standard for AST, CLSI. ANSORP is support by the Asia Pacific Foundation for Infectious Diseases. Isolates collected from these research projects are added to the Asian Bacterial Bank. Since 2010, more than 45,000 isolates of important bacterial pathogens have been collected from 14 countries and preserved. The bank operates by charging for sending organisms to requesting laboratories. However, no EQA appears to be run by this network.

Bacterial Infections and Antibiotic Resistant Diseases among Young Children in Low-Income Countries (BIRDY)

The main objective of the BIRDY project is to assess the incidence, and medical and economic consequences, of severe childhood and neonatal infections caused by antibiotic resistant bacteria. This project uses the Institute Pasteur International Network of 32 institutions in Europe, North America, the Caribbean, Africa and South East Asia. This project is recruiting a cohort of pregnant women and following their children from birth to two years to determine the incidence of bacterial infections and resistance in neonates and children under two years. The study will also investigate the transmission of multi-resistant bacteria either by vertical transmission or by horizontal transmission.

Global Approach for Biological Research on Infectious Epidemics in Low income countries (GABRIEL)

The GABRIEL research network has investigated resistance in salmonella spp., tuberculosis and *E.coli*. Established in 2006 this research programme is supported by Fondation Mérieux laboratories in France and China. As well as conducting research into AMR in specific pathogens it also conducts capacity strengthening activities for the network, such as workshops on specific topics. It is also looking to strengthen partner laboratories to achieve ISO15189 accreditation.

International Nosocomial Infection Control Consortium

This consortium was formed in the late 1990s in Latin America. As part of a more general infection control remit the consortium collects AMR data. It now covers 66 countries in four continents. As a research focused network, the data it collects is driven by the objectives of its on-going research projects.

SENTRY Antimicrobial Surveillance Program

The SENTRY is a global programme initiated in 1997 and run by JMI Laboratories. It collects isolates from participating laboratories and tests them against a large panel of antibiotics. Isolates are obtained from bloodstream, skin and soft tissue, respiratory, urinary tract, pathogens from patients hospitalised with pneumonia, intra-abdominal and invasive fungal infections.

Basic patient and infection demographic information, molecular and phenotypic categorisations, and all susceptibility test results are catalogued onto the programme's Microbiology Visualisation Platform. Clients are charged to use this resource (e.g. to test specific drugs against specific isolate types or patient demographics).

Study for Monitoring Antimicrobial Resistance Trends (SMART)

This surveillance network is supported by Merck & Co. Inc. and has the following objectives:

- To monitor the in vitro susceptibility of gram-negative bacilli to antimicrobials in intra-abdominal and urinary tract infections
- To identify early changes in susceptibility patterns of community- or hospital-acquired organisms, including those that produce extended-spectrum beta-lactamases (ESBLs)

Participating sites collect up to 100 consecutive aerobic and facultative gram-negative bacilli from patients with intra-abdominal infections. Duplicate isolates are excluded. Data is collected on the duration of hospitalisation (<48 hours or ≥8 hours) at time of isolate recovery. Isolates recovered at <48 hours of hospitalisation are considered community acquired. A public accessible database exists which records the details of all project results. It has not been possible to confirm if this network is still active.

AMR surveillance in food and animals

Food and Waterborne Diseases and zoonoses network (FWD-NET)

FWD-NET is coordinated by the European Centre for Disease Control (ECDC) with the support of a coordination committee consisting of representatives from the EU Member States. The committee advises ECDC on ways to strengthen and improve surveillance and prevention for food and waterborne diseases and zoonoses in Europe and reviews technical documents relevant to the network.

The mission of FWD-NET is to improve and harmonise the systems in the EU in order to tackle multi-country foodborne outbreaks and to increase the scientific knowledge regarding aetiology, risk factors and burden of food and waterborne diseases and zoonoses.

The network has the following specific goals to strengthen surveillance:

- strengthen the integration of (laboratory) surveillance in humans, food, animals and environment
- support public health microbiology capability building with appropriate laboratory methods/techniques to enhance detection of international clusters and outbreaks caused by enteric pathogens
- facilitate detection of and response to multi-country foodborne outbreaks

As part of this role FWD-NET collects AMR data on salmonella and campylobacter and provides EQA for these organisms, including providing support for laboratories that perform poorly. Funds are available for experts to visit sites to train staff in new methodologies and for bi-annual AMR network meetings where technical issues are discussed.

International Surveillance of Reservoirs of Antibiotic Resistance (ISRAR)

The aim of this programme is to investigate the potential for a global surveillance system to track antibiotic resistance in commensal bacteria by collecting global environmental and veterinary commensal isolates. This programme is a joint research collaboration of the laboratories at the Tufts University School of Medicine Center for Adaptation Genetics and

Drug Resistance, Alliance for the Prudent Use of Antibiotics (APUA) country chapters, and the U.S. National Biodefense Analysis and Countermeasures Center Biological Threat Characterization Program. It has not been possible to confirm if this network is still active.

World Health Organization Global Salm-Surv

This project aims to enhance laboratory-based surveillance and outbreak detection and response through five components that promote capacity building, collaboration and communication. These components comprise International Training Courses, an External Quality Assurance System, Focused Regional and National Projects, an Electronic Discussion Group, and a Country Databank. Though primarily a capacity strengthening programme it encourages the formation of research partnerships, which produce AMR data and also sends isolates to a specimen bank. It has not been possible to confirm if this network is still active.

Inactive Networks

Our literature search identified a number of AMR surveillance networks that no longer appear to be active. These networks are listed in Table 5, alongside their respective area of geographical coverage and duration. Reasons for network discontinuation were not examined as a part of this study, although some of the listed networks were time-limited projects (e.g. ARPEC). Other networks may possibly have evolved into other regional surveillance initiatives (e.g. SAPNA).

Observations concerning these AMR networks

These networks are very variable in terms of their organisation, geography, operation and diseases and organisms covered so it is not possible, or helpful, to directly compare them. However, our research has identified some interesting observations and examples of innovative practice that may be useful for informing future regional AMR surveillance networks:

- There are strong antimicrobial surveillance networks in the EU and Latin America regions (e.g. EARS-NET and ReLARVA).
- Central Asia has started to develop a regional network based on the EARS-NET model, so this region may be considered for future investment to build up their AMR capacity.
- A significant proportion of AMR activities emanate from research projects and networks. These research-based networks may be in a good position to identify laboratories with capacity to do good quality AMR surveillance and which could therefore be brought into a formal regional AMR network.
- Research-based AMR networks are driven by project objectives and short-term funding cycles. They may therefore find it difficult to take a long-term strategic approach to tackling AMR challenges, but clearly have an important role to play in any long-term AMR strategy determined by a global or regional agency.
- It will be important to verify which of these networks are still active and to carry out in-depth analyses of successful and unsuccessful networks to learn lessons for future programmes about how to set up, manage, recruit members and coordinate such networks.
- Despite the high burden of infectious diseases in Africa there appears to be very little AMR network coverage across the continent

- The SENTRY network has set up a good quality specimen bank, and charges for access and testing with isolates obtained from its network. This is an interesting model for ensuring financial sustainability of the network, which it may be possible to replicate in other AMR networks that collect high quality data and samples.

Findings on educational resources for supporting anti-microbial resistance surveillance

We identified a limited number of educational resources relevant for supporting AMR surveillance (table 6) which are accessible and freely available as on-line tools, slide sets or downloadable pdf documents. Several were available through the networks discussed above (see table 1). We also identified reports of international and national AMR surveillance activities (e.g. from the EU but these were not included in this section as they did not specifically provide educational resources to support AMR surveillance. http://ecdc.europa.eu/en/publications/surveillance_reports/Pages/index.aspx and Canada http://nccid.ca/collection/antimicrobial-resistance/)

The scope of most of the resources concerned general issues to do with AMR surveillance though not all of them were designed explicitly for this purpose (e.g. World Bank 2002 is concerned with public health surveillance in general). Some focused on specific infections such as lower respiratory tract infections, tuberculosis. Salmonella, E. coli and Listeria monocytogenes or on specific target groups such as community paediatricians, laboratories or national data managers. A couple of websites functioned as resource centres bringing together searchable published articles, policies, reports and web tools to facilitate actions on antibiotic resistance or hosting a platform for exchanging information, priorities and results on infectious diseases and AMR surveillance.

The content of the educational resources was heterogeneous and varied from generic topics such as how to design a programme for integrated surveillance of antimicrobial resistance and how to collect and report AMR data, to specific topics such as protocols for individual organisms. The most comprehensive resources and up to date are the Integrated Surveillance of Antimicrobial Resistance Guidance from the WHO Advisory Group (2013) and the ReAct - Action on Antibiotic Resistance toolbox from Uppsala University though this is not exclusively concerned with surveillance. Different players involved in AMR surveillance will require different types of educational resources with content orientated towards their needs. The WHO and ReAct documents provide helpful comprehensive information and would be a good basis for developing future additional resources. The nature of these resources would need to be determined through consultations with the different cadres of AMR surveillance players and mechanisms for making sure that these resources were regularly updated and revised would need to be ensured.

Table 1: International and Regional Networks Identified

Network Acronym	Full Network Name
ANSORP	Asian Network for Surveillance of Resistance Pathogens
BIRDY	Bacterial Infections and antibiotic Resistant Diseases among Young children in low-Income countries
CDC GDD	US CDC Global Disease Detection programme
CAESAR	Central Asian and Eastern European Surveillance of AMR Network
EARSnet	European Antimicrobial Resistance Surveillance network
FWDnet	Food and Waterborne Diseases and zoonoses network
GABRIEL	Global Approach for Biological Research on Infectious Epidemics in Low income countries
GARPEC	Global Antimicrobial Resistance, Prescribing, and Efficacy Among Neonates and Children
GASP	Gonococcal Antimicrobial Surveillance Program
GFN	Global Foodborne infections Network
GLOBAL Project	WHO Global Project on anti-TB drug resistance surveillance
HIVResNet	Global HIV Drug Resistance Surveillance Network
INICC	International Nosocomial Infection Control Consortium
ISRAR	International Surveillance of Reservoirs of Antibiotic Resistance
ReLAVRA	Red Latinoamericana de Vigilancia a las Resistencias Antimicrobianis

Network Acronym	Full Network Name
SENTRY	SENTRY Antimicrobial Surveillance Program
SIREVA	System of Networks for Surveillance of the Bacterial Agents Responsible for Pneumonia and Meningitis
SMART	Study for Monitoring Antimicrobial Resistance Trends
WHO GSS	WHO Global Salmonella Surveillance

Table 2. Detailed descriptions: geographic coverage, size, coordinating centre and anti-microbial sensitivity (AST) standard

Network	Participating Countries	No. of Laboratories	Coordinating Centre	AST Standard
ANSORP	China, Taiwan, Vietnam, South Korea, Hong Kong, India, Japan, Malaysia, Philippines, Sri Lanka, Thailand, Singapore, Indonesia, Philippine, Saudi Arabia	23	Samsung Medical Centre, Seoul, South Korea	CLSI
BIRDY*	Madagascar, Senegal, Cambodia (anticipated expansion)	3 + (if needed)	Institut Pasteur	No Data
CDC GDD	GDD supported over in over 50 countries through CDC Centres located in: Bangladesh, Guatemala, Kazakhstan, China, Egypt, India, Kenya, South Africa, Georgia and Thailand.	10 Disease Control centres	CDC	No Data
CAESAR	Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kyrgyzstan, Montenegro, the Republic of Moldova, the Russian Federation, Serbia, Switzerland, Tajikistan, the former Yugoslav Republic of Macedonia, Turkey, Turkmenistan and Uzbekistan and Kosovo	Multiple	WHO Collaborating Centre for AMR Epidemiology and Surveillance at the National Institute for Public Health and the Environment, the Netherlands	EUCAST, CLSI
EARS - Net	All 28 EU Member States + Iceland & Norway	900+	European Centre for Disease	EUCAST

Network	Participating Countries	No. of Laboratories	Coordinating Centre	AST Standard
			Prevention and Control (ECDC)	
FWD – Net*	All 28 EU Member States	28+	ECDC	EUCAST
GABRIEL	Cameroon, Mali, Madagascar, Brazil, Paraguay, Haiti, Laos, China, Bangladesh, Lebanon, Cambodia	18	Emerging Pathogens Laboratory (EPL), Lyon (France) and Christophe Mérieux Laboratory, Beijing (China)	No Data
GARPEC	South Africa, UK, Italy, Turkey, China, Thailand, USA, Brazil, Argentina, Australia.	12		
GASP	Australia, Austria, Argentina, Bahrain, Belgium, Bolivia, Brazil, Bhutan, Brunei, Cambodia, Canada, Chile, China/Hong Kong, Columbia, Côte d'Ivoire, Cuba, Cyprus, Denmark, Ecuador, El Salvador, Fiji, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Korea, Kenya, Latvia, Madagascar, Malaysia, Malta, Mongolia, Morocco, Namibia, New Zealand, Papua New Guinea, Paraguay, Peru, Philippines, Portugal, Romania, Russia, Singapore, Slovakia, Slovenia, Spain, South Africa, Sri Lanka, Sweden, Tanzania, Thailand, The Netherlands, Tonga,	No data	WHO	

Network	Participating Countries	No. of Laboratories	Coordinating Centre	AST Standard
	Norway, Uganda, Uruguay, Venezuela, Viet Nam United Kingdom, USA, Zimbabwe			
GFN	184 member states and territories	Multiple	WHO	CLSI, NCCLS
GLOBAL Project	114 countries worldwide	Multiple	WHO	N/A
HIVResNet	Participating countries worldwide can send samples to 33 accredited laboratories for analysis.	33	WHO	N/A
INICC	Egypt, Kenya, Libya, Morocco, Nepal, Sudan, Tunisia, Argentina, Bolivia, Botswana, Brazil, Columbia, Costa Rica, Cuba, Ecuador, El Salvador, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Dominican Republic, Uruguay, Venezuela, China, Georgia, India, Indonesia, Iran, Jordan, Saudi Arabia, Kuwait, Lebanon, Malaysia, Mongolia, Pakistan, Philippines, Qatar, Singapore, Sri Lanka, Oman, Thailand, Turkey, UAE, Vietnam, Yemen, Bulgaria, Cyprus, Greece. Kosovo, Lithuania, Macedonia, Poland, Romania, Russia, Serbia, Slovakia, Spain, Ukraine.	2000+		
ISRAR	APUA Global Chapters in conjunction with local laboratories in India, South Korea, Turkey, Thailand, Vietnam, Bangladesh, Georgia, and Uganda	No Data	Tufts University School of Medicine Center	No Data

Network	Participating Countries	No. of Laboratories	Coordinating Centre	AST Standard
ReLAVRA	Argentina, Bolivia, Brazil, Bahamas, Cuba, Chile, Barbados, Ecuador, Columbia, Jamaica, El Salvador, Costa Rica, Trinidad and Tobago, Guatemala, Mexico, St Lucia, Nicaragua, Peru, Paraguay, Venezuela.	519	National Institute of Infectious Diseases of Argentina	CLSI
SENTRY	35 nations.	150 labs	Iowa, United States and Adelaide, Australia	CLSI, NCCLS
SIREVA	Argentina, Brazil, Chile, Colombia, Mexico, Uruguay, Bolivia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Paraguay, Peru, and Venezuela	471	PAHO	No data
SMART	Canada, USA, Mexico, Guatemala, Dominican Republic, Panama, Columbia, Ecuador, Venezuela, Puerto Rico, Chile, Argentina, Brazil, South Africa, Morocco, Tunisia, Spain, France, UK, Lithuania, Czech Republic, Latvia, Estonia, Germany, Romania, Serbia, Croatia, Greece, Georgia, Hungary, Kazakhstan, South Korea, China, Taiwan, Vietnam, Thailand, Philippines, Malaysia, Singapore, New Zealand, Australia, India, Jordan, Israel, Lebanon, UAE, Saudi Arabia.	282 hospital sites	Merck & Co., Inc., Whitehouse Station, NJ, USA	CLSI
WHO GSS	No Data	No Data	No Data	CLSI

* Results verified by a network representative

Table 3. Detailed descriptions: organisms and associated drug classes under surveillance, specimen types collected

Network	Organisms	Drug Class	Specimens
ANSORP*	Acinetobacter sp.	Imipenem, meropenem, colistin, tetracycline, ciprofloxacin, rifampicin, cefepime, ceftazidime, amikacin, piperalicillin/tazobactam Tigecycline, ampicillin-sulbactam	
	Stenotrophomonas maltophilia	Imipenem, meropenem, colistin, tetracycline, ciprofloxacin, rifampicin, cefepime, ceftazidime, amikacin, piperalicillin/tazobactam Tigecycline	
	Pseudomonas aeruginosa	Imipenem, meropenem, colistin, tetracycline, ciprofloxacin, rifampicin, cefepime, ceftazidime, amikacin, piperalicillin/tazobactam Tigecycline	
	Enterococcus sp.	vancomycin, teicoplanin, ampicillin, tetracycline, erythromycin, ciprofloxacin, rifampicin, streptomycin, gentamicin, linezolid	
	Escherichia coli	ampicillin, gentamicin, ciprofloxacin, ceftazidime, AZT, Imipenem, Tigecycline, trimethoprim-sulfamethoxazole, cefotaxime, piperalicillin/tazobactam, amikacin, ampicillin-sulbactam, ertapenem	
	Klebsiella pneumoniae	ampicillin, GEN, ciprofloxacin, ceftazidime, AZT, Imipenem, Tigecycline, trimethoprim-sulfamethoxazole, cefotaxime, piperalicillin/tazobactam, amikacin, ampicillin-sulbactam, ertapenem	

Network	Organisms	Drug Class	Specimens
	Enterobacter sp.	ampicillin, gentamicin, ciprofloxacin, ceftazidime AZT, Imipenem, Tigecycline, trimethoprim-sulfamethoxazole, cefotaxime, piperalicillin/tazobactam, amikacin, ampicillin-sulbactam	
	Proteus sp.	ampicillin, gentamicin, ciprofloxacin, ceftazidime, AZT, Imipenem, Tigecycline, trimethoprim-sulfamethoxazole, cefotaxime, piperalicillin/tazobactam	
	Citrobacter sp.	ampicillin, gentamicin, ciprofloxacin, ceftazidime, AZT, Imipenem, Tigecycline, trimethoprim-sulfamethoxazole, cefotaxime, piperalicillin/tazobactam	
	Staphylococcus aureus	oxacillin, penicillin, ciprofloxacin, clindamycin, erythromycin, vancomycin, tetracycline, trimethoprim-sulfamethoxazole, gentamicin, rifampicin, linezolid	
	Streptococcus pneumoniae	penicillin, amikacin, amoxicilin-clavulanic acid, ceftriaxone, cefuroxime, erythromycin, azithromycin, clarithromycin, levofloxacin, moxifloxacin, gemifloxacin, ciprofloxacin, CD, trimethoprim-sulfamethoxazole vancomycin, linezolid, Tigecycline, imipenem, rifampicin, tetracycline	
BIRDY	All infections in <2 year olds in cohort	amikacin; ampicillin, amoxicillin, amoxicilin-clavulanic acid, ampicillin-sulbactam, azithromycin, ceftazidime; clindamycin, ciprofloxacin, colistin; CLA, clarithromycin, cefepime, ceftriaxone, cefotaxime, erythromycin;	all

Network	Organisms	Drug Class	Specimens
		ertapenem, cefuroxime, gentamicin, gemifloxacin, Imipenem, levofloxacin, linezolid, meropenem; moxifloxacin, oxacillin, penicillin, piperacillin-tazobactam, rifampicin, streptomycin, teicoplanin, tetracycline; Tigecycline, trimethoprim-sulfamethoxazole, vancomycin	
CDC GDD	No data	No data	No data
CAESAR*	Streptococcus pneumoniae	Penicillin Oxacillin (screen) Erythromycin Norfloxacin (screen) OR Levofloxacin OR Moxifloxacin	Blood or cerebrospinal fluid as appropriate (CSF)
	Staphylococcus aureus	Cefoxitin (disk screen) Vancomycin	
	Enterococcus faecalis	Ampicillin Gentamicin-High Vancomycin	
	Enterococcus faecium	Ampicillin Gentamicin-High Vancomycin	
	Escherichia coli and Klebsiella pneumoniae	Piperacillin-tazobactam OR Amoxicillin-clavulanic acid Gentamicin OR Tobramycin OR Amikacin Ceftriaxone OR Cefotaxime OR Ceftazidime Ciprofloxacin OR Ofloxacin OR Levofloxacin Meropenem OR Imipenem OR Ertapenem	
	Pseudomonas aeruginosa	Piperacillin/tazobactam Ceftazidime Cefipime Ciprofloxacin OR Levofloxacin Gentamicin OR Tobramycin OR Amikacin Imipenem OR Meropenem	
	Acinetobacter species	Fluoroquinolones, Aminoglycosides, Carbapenems, Amikacin, Polymyxins	

Network	Organisms	Drug Class	Specimens
EARS - Net	Escherichia coli	Aminopenicillins, Fluoroquinolones, Third-generation cephalosporins, Aminoglycosides, Carbapenems, Polymyxins	Blood or CSF as appropriate
	Staphylococcus aureus	MRSA, Rifampicin, Fluoroquinolones, Linezolid, Vancomycin, Daptomycin	
	Enterococcus faecalis & faecium	High-level aminoglycoside resistance, Vancomycin, Aminopenicillins, Teicoplanin, Linezolid	
	Klebsiella pneumoniae	Fluoroquinolones, Third-generation cephalosporins, Aminoglycosides, Carbapenems, Polymyxins	
	Streptococcus pneumoniae	Penicillins, Macrolides, Fluoroquinolones, Third-generation cephalosporins	
	Pseudomonas aeruginosa	Piperacillin-tazobactam, Ceftazidime, Fluoroquinolones, Aminoglycosides, Carbapenems, Amikacin, Polymyxins	
	Acinetobacter spp	Fluoroquinolones, Aminoglycosides, Carbapenems, Amikacin, Polymyxins	
FWD – Net*	*Salmonella*	Aminoglycosides, Aminopenicillins, Amphenicols, Carbapenems, Cephalosporins, Dihydrofolate reductase inhibitors, Macrolides, Polymyxins, Quinolones, Sulphonamides, Tetracyclines	Not standardised
	Campylobacter	Aminoglycosides, Macrolides, Quinolones, Tetracyclines	
GABRIEL*	Mycobacterium Tuberculosis	Rifampicin and Isoniazid plus fluoroquinolone and at least one of three injectable second-line drugs (i.e., amikacin, kanamycin, or capreomycin)	Blood, sputum or faeces as appropriate

Network	Organisms	Drug Class	Specimens
	Respiratory pathogens (viral and bacteria)	no test for the moment	
	E coli ETEC	Ampicillin, Azithromycin, Ciprofloxacin, Ceftriaxone, Doxycline , Erythromycin, Nalidixic Acid, Norfloxacin , Streptomycin , Sulfomethoxazole trimethoprim, Tetracyline, Cefixime, Amikacin	
	Salmonella typhi	Ampicillin - Cotrimoxazole - Chloramphenicol - Ciprofloxacin - Ceftriaxone	
GARPEC			
GASP	*N. gonorrhoeae*	azithromycin, cephalosporins, quinolones	
GFN			
GLOBAL Project	*M.tuberculosis*	Rifampicin, streptomycin, ethambutol, isoniazid, fluoroquinolones, amikacin, kanamycin, or capreomycin	Predominantly sputum
HIVResNet	HIV		Blood
INICC	Varies based on research projects being carried out	Varies based on research projects being carried out	Varies based on research projects being carried out
ISRAR			
ReLAVRA	Enterococcus spp.		Blood, urine, sputum (all types)

Network	Organisms	Drug Class	Specimens
	Klebsiella pneumoniae	Imipenem, third generation cephalosporins	
	Acinetobacter spp.		
	Pseudomonas aeruginosa,		
	Streptococcus, (several species both community acquired and hospital based)		
	Staphylococcus aureus	Oxacilin	
	Escherichia coli	Ciprofloxacin, Nitrofurantoin, Co-trimoxazole, Cefalotin	
	Enterobacter spp.		
	Salmonella spp.		
	Shigella spp.		
	Vibrio cholerae		
	Escherichia coli		
	Neisseria meningitidis		
	Neisseria gonorrhoeae	Ciprofloxacin, penicillin, tetracycline, cefotaxime/cefatriaxone	
	Streptococcus pneumoniae		
	Campylobacter		

Network	Organisms	Drug Class	Specimens
	β haemolytic streptococcus		
SENTRY*	Acinetobacter spp.	Cephalosporins, other β-lactams, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole, Polymixin B	Blood, sputum, skin cell, intraabdominal
	Enterobacter spp.	Cephalosporins, other β-lactams, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole, Polymixin B	
	Escherichia coli	Cephalosporins, other β-lactams, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole, Polymixin B	
	Haemophilus influenzae	Cephalosporins, other β-lactams, macrolides, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole, Choranphenicol	
	Klebsiella pneumoniae	Cephalosporins, other β-lactams, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole, Polymixin B	
	Moraxella catarrhalis	β-lactams, macrolides, fluoroquinolones, tetracycline, Trimethoprim/sulfamethoxazole, chloramphenicol	
	Proteus spp.	Cephalosporins, other β-lactams, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole, Polymixin B	

Network	Organisms	Drug Class	Specimens
	Pseudomonas aeruginosa	Cephalosporins, other β-lactams, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole, Polymixin B	
	Salmonella spp.	Cephalosporins, other β-lactams, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole	
	Serratia spp.	Cephalosporins, other β-lactams, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole, Polymixin B	
	Shigella spp.	Cephalosporins, other β-lactams, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole	
	Stenotrophomonas maltophilia	Cephalosporins, other β-lactams, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole, Polymixin B	
	Staphylococcus aureus	Cephalosporins, other β-lactams, MLS, fluoroquinolones, gentamicin, rifampin,chloramphenicol, tetracycline, doxycycline, Trimethoprim/sulfamethoxazole, vancomycin, teicoplanin, quinupristan/dalfopristin, linezolid	
	Coagulase Negative Staphylococcus	Cephalosporins, other β-lactams, MLS, fluoroquinolones, gentamicin, rifampin,chloramphenicol, tetracycline, doxycycline, Trimethoprim/sulfamethoxazole, vancomycin, teicoplanin, quinupristan/dalfopristin, linezolid	

Network	Organisms	Drug Class	Specimens
	Enterococcus spp.	β-lactams, MLS, fluoroquinolones, levofloxacin, gentamicin, streptomycin, rifampin, chloramphenicol, tetracycline, doxycycline, Trimethoprim/sulfamethoxazole, vancomycin, teicoplanin, quinupristan/dalfopristin, linezolid	
	Burkholderia cepacia	Cephalosporins, other β-lactams, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole	
	Citrobacter spp.	Cephalosporins, other β-lactams, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole	
	Morganella morgannii	Cephalosporins, other β-lactams, fluoroquinolones, aminoglycosides, tetracycline, Trimethoprim/sulfamethoxazole	
SIREVA	*Streptococcus pneumonia, Haemophilus influenza, Neisseria meningitidis*.	No Data	CSF, blood, and pleural fluid
SMART	Gram-negative isolates	Ertapenem, imipenem, cefepime, ceftazidime, ceftazidime-clavulanic acid, cefoxitin, ciprofloxacin, amikacin, levofloxacin, cefotaxime, cefotaxime-clavulanic acid, piperacillin-tazobactam, ampicillin-sulbactam and ceftriaxone	intra-abdominal infections and urinary-tract infections
WHO GSS	Salmonella, Campylobacter	No data	No data

Table 4. Detailed descriptions: types of support services available to network members

Network	EQA	Training	Technical Assistance
ANSORP	No data	No data	No data
BIRDY	No Data	No Data	No Data
CDC GDD	No Data	No Data	No Data
CAESAR*	EQA is provided annually through UK-NEQAS	Training in the form of national workshops and multi-country workshops is provided. Main focus is on microbiologic methods (in particular EUCAST), data management (data collection, IT aspects of data capture and transfer, data quality control, data security) and epidemiology (interpretation of AMR surveillance data and sources of bias).	Technical support is provided
EARS - Net	EQA is provided annually through UK-NEQAS	No data	No data
FWD – Net*	ECDC funds an annual AST EQA for *Salmonella* and *Campylobacter* based on the set up of the EU protocol. It includes 8 strains of each organism and covers the priority and the optional list of antimicrobials. In addition to phenotypic AST, it also covers detection and confirmation of	Financial support is available for experts to visit laboratories in another country to learn new methods during a few days. This requires a formal application to be submitted to ECDC by the expert	ECDC arrange bi-annual AMR meetings for the network where technical issues are discussed as one of several topics. At these meetings, the AST EQA organiser also presents the overall results of the EQA and feedback on problematic issues. Labs that experience problems in the EQA can also contact the organiser directly to get

Network	EQA	Training	Technical Assistance
	ESBL-, acquired AmpC, and carbapenemase-producing *Salmonella* spp and resistance gene testing as well as species determination of *Campylobacter*. The AST EQA is also offered for free to the EU enlargement countries		assistance in finding the source behind the problem.
GABRIEL*	For Tuberculosis, a panel of sensible and resistance strains are sent to the members, and this panel is tested in blind by LIPA assay. For pneumonia, we have also a panel control for the respiratory pathogens to control the tests perform on site	Different types of training are organised: tutorial training to allow technology transfer and workshop to improve the skills of the members (in molecular biology, epidemiology, bioinformatics …)	Fondation Merieux analyse the raw data and provide advices when necessary. They go on site for training before to start a research study to check the capacity of the human resources
GARPEC			
GASP	No Data	No data	No data
GFN			
GLOBAL Project	Supra-national laboratories provide EQA services		Various development projects, predominantly US funded, provide technical assistance to national TB programmes.
HIVResNet	No Data	No data	Various development projects, predominantly US funded, provide

Network	EQA	Training	Technical Assistance
			technical assistance to national HIV programmes.
INICC		INICC offers training in the application of tools to consolidate capacities locally, targeted specifically at doctors, nurses, pharmacists, ancillary staff and healthcare facilities' administrators and managers in the private and public sectors. INICC is working on the design of the appropriate technology for the analysis of healthcare-associated infection process and outcome.	
ISRAR			
ReLAVRA			
SENTRY*	No EQA	No training	Network members have access to all the data
SIREVA	EQA – (rechecking of isolates and proficiency testing) by the National Centre for Streptococcus, Edmonton, Alberta, Canada through three quality control centres in Brazil, Colombia & Mexico.	Training of lab staff	Performance evaluations
SMART	No Data	No data	No data

Network	EQA	Training	Technical Assistance
WHO GSS	Yes –annual cycles	Yes - offers international training courses at nine sites in the six WHO regions to achieve its goal	Yes

* Results verified by a network representative

Table 5. Discontinued AMR surveillance networks

Acronym	Full Network Name	Coverage	Duration
ARMed	Antibiotic Resistance Surveillance and Control in the Mediterranean Region	Mediterranean	2003-2006
ARPEC	Antibiotic Resistance and Prescribing in European Children	Europe	2010-2016
EANMAT	East Africa Network for Monitoring Antimalarial Treatment	East Africa	1997-2006
INSPEAR	International Network for the Study and Prevention of Emerging Antimicrobial Resistance	International	1998-?
MYSTIC	Meropenem Yearly Susceptibility Test Information Collection	International	1997-2008
netSPEAR	Network for Surveillance of Pneumococcal Disease in the East African Region	East Africa	2003-2009
SAPNA	South Asian Pneumococcal Network Alliance	South Asia	2004-2008

Table 6. Educational resources concerning AMR networks

Resource/ linked network	Type of Resource / intended use	Access	Website and contacts
React toolbox/ ReAct	A web-based resource for taking action on antibiotic resistance. Throughout the toolbox a narrative text guides the user on how to work with the problem, combining practical advice with examples from the field and providing links to external resources that may be useful in different settings The Toolbox is intended for use by those already working with antibiotic resistance in some way, or are interested in taking action. The main target audience for the Toolbox is health care professionals, civil society organisations and policy makers in low-and middle-income countries. Focus on antibiotic resistance rather than surveillance networks	Free, online web based- collaborative. You may copy and re-use content on the ReAct Toolbox website (that are not materials posted from and/or clearly cited from other sources), provided always that you give proper credit to ReAct.	http://www.reactgroup.org/toolbox/ ReAct - Action on Antibiotic Resistance Uppsala University Box 256, SE-751 05 Uppsala, Sweden Phone: +46 (0)18 471 66 07 Fax: +46 (0)18 471 66 09 E-mail: react@medsci.uu.se

Resource/ linked network	Type of Resource / intended use	Access	Website and contacts
React resources / ReAct	The resource centre includes a selection of published articles, reports and web tools to facilitate action on antibiotic resistance. Facts and Tools Policy and Reports ReAct-produced material Reference Library The Resource Centre is a searchable database, a web-based “library”, to help people gain easy access to scientific articles, policy documents and reports related to antibiotic resistance.	Free, online	http://www.reactgroup.org/resource-center.html *Update: Link no longer active. Interested parties may wish to contact the ReAct group using the details above*

Resource/ linked network	Type of Resource / intended use	Access	Website and contacts
Arpec	Web based training programme will be developed by the ARPEC team. This will provide a range of educational modules on optimal antibiotic prescribing and antimicrobial resistance. Eventually it will be possible to modify the online content to produce country specific training, potentially containing data obtained from our collaborators. It is anticipated that making the training modules more relevant to the different countries will improve the training dissemination through ESPID and the EAP. An Educational Group was formed within ARPEC to tackle the issue of training in antibiotic use for children in Europe. A basic slide set directed at paediatricians in training likely to become community prescribers has been produced and is available online. Collaboration with ESPID (Education Committee) will lead to the development and implementation of an online training course on antibiotic utilisation for children.		http://penta-id.org/training/past-projects/arpec-educational-tool/
CDC-GDD	Shareable resources showcase the depth and diversity of the Global Disease Detection program		http://www.cdc.gov/globalhealth/healthprotection/gdd/resources/index.html

Resource/ linked network	Type of Resource / intended use	Access	Website and contacts
	as we work with countries to build capacity to find and stop outbreaks around the world		
Integrated Surveillance of Antimicrobial Resistance Guidance from a WHO Advisory Group / WHO	Pdf document To provide WHO Member States with key information on designing a programme for integrated surveillance of antimicrobial resistance.	Online	http://apps.who.int/iris/bitstream/10665/91778/1/9789241506311_eng.pdf
Antimicrobial resistance (AMR) reporting protocol 2015 / EARS-net	Pdf document data collection guidelines for reporting countries' data managers	Downloadable document	http://ecdc.europa.eu/en/activities/surveillance/EARS-Net/Documents/2015-EARS-Net-reporting-protocol.pdf
GLOBE portal (Global Link for Biomedical Expertise Online) / GABRIEL	A dedicated website for the network members to exchange and communicate their priorities and research results on infectious diseases and more particularly on the lower respiratory tract infections and tuberculosis.		http://gabriel.globe-network.org/en/gabriel/resources

Resource/ linked network	Type of Resource / intended use	Access	Website and contacts
standard molecular typing protocols / FWD-net	For PFGE on Salmonella (excluding S. Tyhpmurium and S. Enteritidis) and E. coli isolates: PulseNet International 2013-03 PFGE protocol for Salmonella and E. coli For PFGE on Listeria monocytogenes isolates: PulseNet PFGE protocol for Listeria monocytogenes Alternative, comparable method for PFGE-typing of Listeria monocytogenes isolates is published by the European Union Reference Laboratory for Listeria monocytogenes		http://ecdc.europa.eu/en/healthtopics/food_and_waterborne_disease/surveillance/Pages/index.aspx
Public health surveillance toolkit			http://siteresources.worldbank.org/INTPH/Resources/376086-1133371165476/PHSurveillanceToolkit.pdf
Core Elements of Hospital Antibiotic			https://www.cdc.gov/getsmart/healthcare/pdfs/core-elements.pdf

Resource/ linked network	Type of Resource / intended use	Access	Website and contacts
Stewardship Programs			
National Healthcare Safety Network (NHSN)			http://www.cdc.gov/nhsn/acute-care-hospital/aur/
Guide for establishing laboratory-based surveillance for antimicrobial resistance			http://apps.who.int/medicinedocs/documents/s20135en/s20135en.pdf

Annex 1. Terms of reference

Supporting Surveillance Capacity for Antimicrobial Resistance: Regional Networks and Educational Resources

This document has been drafted in response to the Request for Proposal (RFP) issued by the Wellcome Trust on 28 January 2016, titled: 'Fleming Fund: supporting surveillance capacity for antimicrobial resistance'. The RFP contained three themes and this proposal is to address the terms of reference (ToR) for one of them, specifically 'an analysis of networks and education resources supporting drug resistant infection surveillance in low and middle income countries (LMICs)'. The ToR presented two objectives (described in full in 2.1 and 2.2 below) which, in broad terms, require the identification and assessment of drug resistance surveillance 'networks' in LMICs and of available 'educational resources' designed to support effective implementation of such networks.

We would define a drug resistance surveillance network as a group of institutions (nationally) or countries (regionally/globally) that gather, analyse, compile and share the results of any aspect of antimicrobial resistance (e.g. antimicrobial resistance, antimicrobial use and antimicrobial quality). The Capacity Research Unit (CRU), Liverpool School of Tropical Medicine (LSTM), has extensive experience assessing laboratory and research systems within LMICs and identifying site- and system-specific capacity strengthening pathways. As such, we believe we are strongly positioned to meet the stated ToR objectives which we would achieve by drawing on our existing expertise and networks to complete the following five activities:

1 Identify drug resistance surveillance networks through a systematic review of the published and grey literature and through consultation with existing contacts in LMICs and relevant research and development organisations.
2 Assess the scope, strengths and weaknesses of each identified network against a study-specific evaluation matrix. The matrix will be informed by existing surveillance system benchmarks such as the WHOs Global Antimicrobial Resistance Surveillance System (GLASS) and the OASIS tool for assessing epidemiological surveillance systems. The assessment of each surveillance network will be based on information obtained during the aforementioned review of published and grey literature and through key informant interviews with members from each network or individuals with working knowledge of a network.
3 Produce a report comparing and contrasting each network according to the evaluation matrix, identifying best performing networks regionally and detailing key recommendations for strengthening regional surveillance networks.
4 Identify existing educational resources to support strengthening of current drug resistant infection surveillance systems through a systematic review of the published and grey literature, through consultation with existing contacts in LMICS and relevant research and development organisations and during the aforementioned key informant interviews with network members.
5 Produce a report detailing the identified education resources, their respective scope (i.e. which component(s) of a surveillance system they are designed to support) and how to access them. The report will also detail current gaps in the available education resources, with respect to both scope and access.