Surveillance and monitoring for antimicrobial use and resistance

IACG discussion paper[1]

Disclaimer: This document reflects the discussions of IACG subgroup responsible for surveillance and monitoring so far and will be subject to change as the discussions continue. It does not necessarily reflect the views of the IACG as a whole.

Key messages

- Effective surveillance systems should be both coordinated and complementary among sectors and levels.
- Many low- and middle-income countries lack the basic capacity to establish and maintain surveillance systems to collect and use data on antimicrobial resistance and antimicrobial use.
- Integrated surveillance systems that connect and build on existing systems maximize the efficiency of resource use and provide more complete data.
- The priorities for surveillance depend on national capacity, concerns and contexts, informed by global guidance.
- Surveillance data are most effectively used to study trends and inform policies when they are of high quality and easily transferable and comparable among systems.
- Ensuring access to surveillance data comprises not only making figures available but also includes securing the resources and capacity to collect the data and to interpret them for use in public policy.
- Putting resources into AMR containment now – including surveillance – is one of the highest-yield investments a country can make to mitigate the impact of AMR.

1. Introduction

Surveillance and monitoring are widely acknowledged as critical components of the response to antimicrobial resistance (AMR) and are one of the five strategic priorities of the Global Action Plan (GAP) on AMR.[2] Through surveillance, countries can detect the emergence of AMR and collect the data on AMR prevalence and antimicrobial use (AMU)[3] necessary to guide patient treatment, identify populations at risk, inform policy development and assess the impact of interventions.

To be most effective, surveillance systems should be coordinated and complementary. They should cover human and animal populations and food as well as, when supported by scientific evidence and risk assessment, plant production and relevant aspects of the environment. They should also, as far as possible, provide harmonized – or equivalent – data that can be easily compared, exchanged, used or aggregated locally, nationally and globally.

[1] This paper was prepared by IACG members, in consultation with colleagues from FAO, OIE, WHO and the World Bank.
[2] Global action plan on antimicrobial resistance. Geneva: World Health Organization; 2015 (http://www.who.int/antimicrobial-resistance/global-action-plan/en/, accessed 22 March 2018).
[3] In this paper, the term "antimicrobial use" (AMU) is used to mean the volume of antimicrobials delivered. Depending on the data source, this may not reflect the actual amount administered. The authors also acknowledge the term "antimicrobial consumption (AMC)" is also used, and that AMU and AMC may have different meanings in different sectors.

This discussion paper, prepared by the ad-hoc Interagency Coordination Group (IACG) on AMR, draws on previous analyses by the tripartite organizations (FAO, OIE and WHO) and others to identify the critical components of effective surveillance systems for AMR and AMU and to invite discussion on how such systems can be strengthened.

The paper is not intended to be an in-depth description of existing surveillance systems but rather a platform for discussion on how such systems can contribute collectively in a coordinated, complementary way to tackle AMR and address human and animal health in a One Health approach.

We invite all stakeholders to consider the questions posed in sections 3.1–3.5 and to submit their perspectives to the IACG at iacg-secretariat@who.int.

2. Barriers to effective surveillance

In some sectors, such as plants, food processing and the environment, there are few, if any, international guidelines and standards for surveillance AMR and AMU, whereas there are generally well-established guidelines for surveying AMR and AMU in humans, animals and food of animal origin. These do not, however, necessarily include consideration of cross-sectoral issues or impacts that may pose significant barriers to coordinated surveillance. A further barrier may be difficulty in implementing international guidelines at the national level.

Other obstacles include a lack of robust legal and regulatory frameworks, limited professional services (for example, good veterinary services and systems to support data collection, identification and reporting) and poor coordination among the human, animal and other sectors.

Many low- and middle-income countries (LMICs) do not have robust systems for collecting and analysing data on AMR and AMU because of lack of resources and capacity. Weak laboratory and communications infrastructure, lack of trained laboratory and clinical personnel and a high prevalence of counterfeit and substandard antimicrobials and diagnostics have been cited as challenges to surveillance in these countries.[4,5]

3. Components of an effective surveillance system

Many LMICs that lack surveillance systems or are in the early stages of developing one will initially focus on strengthening basic capacity and other factors to enable collection of data in each sector – such as good-quality veterinary services, legislation and human capacity – rather than on coordination among sectors or ensuring that data are comparable. The system must be designed to suit the country context. Studies in LMICs suggest that a sentinel surveillance system, with step-wise

[4] Dar OA, Hasan R, Schlundt J, Harbarth S, Caleo G, Littmann J et al. Exploring the evidence base for national and regional policy interventions to combat resistance. Lancet. 2016; 387:285–95.

[5] Opintan J, Newman MJ, Arhin RE, Donkor ES, Gyansa-Lutterodt M, Mills-Pappoe W. Laboratory-based nationwide surveillance of antimicrobial resistance in Ghana. Infect Drug Resist. 2015;8:379–89.

increases in the numbers and scope of participating sites, might be the most appropriate to facilitate AMR surveillance and participation in the Global Antimicrobial Surveillance System (GLASS).[6]

For those countries with elements of a functioning surveillance system, five components are necessary to ensure that it is both coordinated and complementary (see figure). This is not intended as a step-wise approach to surveillance; rather, the components work in parallel to ensure an effective surveillance system.

Each of these components is presented briefly below, with its importance, some associated issues and examples of relevant initiatives by the Tripartite and others. The IACG is seeking input from countries and other stakeholders on the greatest challenges and opportunities for effective surveillance for risk assessment and management. A number of questions are posed in each section to guide the discussion.

Fig. 1. Five components of an effective coordinated, complementary surveillance system.

[6] Seal AC, Gordon NC, Islam J, Peacock SJ, Scott JAG. AMR surveillance in low and middle-income settings – a roadmap for participation in the Global Antimicrobial Surveillance System (GLASS). Wellcome Open Res. 2017;2:92. doi: 10.12688/wellcomeopenres.12527.1.

4. Integration

Integrated surveillance systems built on a One Health approach[7] provide a more complete picture of AMR and AMU and facilitate analyses of trends over time and space and of relations among sectors.

Integration ideally works in multiple dimensions, within and among sectors and levels, including vertical alignment within public health initiatives and horizontal coordination among strategies for human and animal health, food production and may involve relevant aspects of plants and the environment. In practice, integration is more likely to be a "mosaic" within and among sectors, as the production systems in the animal and plant sectors are widely diverse, and their products are used in many different industries; for example, the animal sector alone comprises more than 50 sectors, from dairy to poultry to meat to crustaceans.

Key issues

Standards and guidelines for integrated surveillance

WHO, OIE and the FAO/WHO Codex Alimentarius each has guidelines and standards for use by national governments in establishing and extending surveillance systems for AMR and AMU in humans, animals and food systems. WHO Global AMR Surveillance System (GLASS) provides guidance for establishing AMR surveillance in human health and promotes integration with other surveillance programmes in public health and other sectors. The WHO/AGISAR guidance on integrated surveillance of AMR in foodborne bacteria extends usual public health surveillance to include elements of the food chain (humans, animals and food) and data on AMU.

The standards in the OIE Terrestrial Animal Health Code[8,9] and the OIE Aquatic Animal Health Code[10,11] provide guidance for establishing and harmonizing AMR and AMU surveillance systems for food-producing animals and products of animal origin intended for human consumption. Texts of the Codex Alimentarius Commission include Guidelines on Risk Analysis for Foodborne Antimicrobial Resistance, and work is under way within the Commission on new guidelines on integrated surveillance of foodborne antimicrobial resistance.

Similar guidelines are not yet available for the surveillance of AMR and AMU in plants and the environment and as they relate to food production. Several projects have, however, been begun to

[7] A One Health approach is defined by the US Centers for Disease Control and Prevention as "A collaborative, multisectoral, and trans-disciplinary approach – working at the local, regional, national, and global levels – with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment."

[8] Harmonisation of national antimicrobial resistance surveillance and monitoring programmes. In: Terrestrial Animal Health Code. Paris: World Organisation for Animal Health; 2017 (http://www.oie.int/fileadmin/Home/eng/Health_standards/tahc/current/chapitre_antibio_harmonisation.pdf accessed 16 May 2018).

[9] Monitoring of the quantities and usage patterns of antimicrobial agents used in food-producing animals. In: Terrestrial Animal Health Code. Paris: World Organisation for Animal Health; 2017 (http://www.oie.int/fileadmin/Home/eng/Health_standards/tahc/current/chapitre_antibio_monitoring.pdf accessed 16 May 2018).

[10] Monitoring of the quantities and usage patterns of antimicrobial agents used in aquatic animals. In: Aquatic Animal Health Code. Paris: World Organisation for Animal Health; 2017 (http://www.oie.int/fileadmin/Home/eng/Health_standards/aahc/current/chapitre_antibio_quantities_usage_patterns.pdf, accessed 16 May 2018).

[11] Development and harmonisation of national antimicrobial resistance surveillance and monitoring programmes for aquatic animals. In: Aquatic Animal Health Code. Paris: World Organisation for Animal Health; 2017 (http://www.oie.int/fileadmin/Home/eng/Health_standards/aahc/current/chapitre_antibio_development_harmonisation.pdf, accessed 16 May 2018).

determine the prevalence of resistant microorganisms and determinants and AMU or exposure in food chains and the environment. These include the extended spectrum β-lactamases *Escherichia coli* (ESBL Ec) Tricycle AMR surveillance project and the Global Sewage Surveillance Project.

A recent report from UNEP, Frontiers 2017 (Emerging Issues of Environmental Concern), provides data sources and exposure pathways for AMR and AMU in the environment, which could be used to identify entry points for integrating environmental surveillance into existing systems.

Integration across sectors

AMR is a problem in multiple sectors, and resistant microbes can cross both geographical and ecological boundaries, and use of antimicrobials in humans, animals or plants can lead to the development of resistance in one of the other sectors. Coordination of surveillance among sectors is therefore a priority. Adopting a One Health approach to surveillance of AMR can address common drivers and reduce the health and economic impacts.

Several national and international projects and programmes are addressing AMR surveillance in several sectors. For example, the European Union publishes analyses (the Joint Interagency Antimicrobial Consumption and Resistance Analysis (JIACRA) of data on humans and food-producing animals, and the National Antimicrobial Resistance Monitoring System (NARMS) in the USA integrates data from surveillance in humans, animals and food. Other examples include the Danish Integrated Antimicrobial Resistance Monitoring and Research Programme (DANMAP) and the Colombian Integrated Surveillance Program for Antimicrobial Resistance (COIPARS).

Integration among levels

In some surveillance systems, data collection begins at local level and is reported nationally. Data on AMR and AMU collected in local and national monitoring systems can be represented in regional and global systems for surveillance of AMR and AMU. Examples of integration of national and local data at higher levels include the online European Surveillance of Antimicrobial Consumption Network (ESAC-Net), which contains reference data on consumption of antimicrobials in both the community and hospitals through the European surveillance system. The OIE initiative for data collection on antimicrobials intended for use in animals includes national data on AMU in animals, which is integrated for regional comparisons.[12]

[12] Guidance for completing the OIE template for the collection of data on antimicrobial agents intended for use in animals. Paris: World Organisation for Animal Health; 2017 (www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/AMR/A_AMUse_Final_Guidance_2017.pdf, accessed 16 May 2018).

Questions for stakeholders

- What are the opportunities for, and obstacles to, integrating data analyses within and across sectors?
- How can existing systems for collection of data on humans, animals and food be adapted to include data from plant production and environmental surveillance?
- How can initiatives involving surveillance data held in the private sector be integrated into global, public reporting systems?

4.1. Prioritization

An effective mechanism for prioritizing what to monitor in a coordinated surveillance system, when and how is important to ensure the best use of national resources. Sample sources, microorganisms and antimicrobial classes should all be prioritized. Prioritization may be based on international standards and guidelines but should also be tailored to local and national contexts, in response to national priorities, resources and the availability of data for characterizing hazards and the risks. Effective prioritization on AMR should aim to generate the most relevant public health indicators while taking into account both the practicality of measurement, for example by focusing on what is affordable, and feasibility, for example, according to the availability of antimicrobial susceptibility test methods locally or in the field.

Guidance on setting priorities in practice is lacking. Tools are available in other sectors of public health, such as the One Health Zoonotic Disease Prioritization Tool[13] established by the Centers for Disease Control and Prevention (USA), but there is no equivalent tool for countries to prioritize AMR surveillance.

Key issues

International lists

Lists of critically important antimicrobials (antibacterials) for humans and animals are available at international level, and in some cases at national level, to help countries set priorities for surveillance on the basis of risk. These include the WHO List of Critically Important Antimicrobials in human medicine, and the OIE List of Antimicrobial Agents of Veterinary Importance. Both can be used in setting up and implementing national antimicrobial stewardship, which, with data from AMR surveillance, are necessary for risk-management strategies.

The WHO Priority Pathogens List for R&D of New Antibiotics comprises the 12 families of antibiotic-resistant bacteria that pose the greatest threats to human health. It was conceived to stimulate research on and development of new antibiotics but could also be used for prioritizing pathogens nationally and internationally and thus for identifying a set of priority bacteria that should be surveyed.

[13] Salyer SJ, Silver R, Simone K, Barton Behravesh C. Prioritizing zoonoses for global health capacity building – themes from One Health zoonotic disease workshops in 7 countries, 2014–2016. Emerg Infect Dis. 2017;23;13.

The OIE recently introduced a list of priority animal pathogens for AMR surveillance into its standard on harmonization of national AMR surveillance and monitoring programmes (Chapter 6.7 of the OIE Terrestrial Animal Health Code).

WHO GLASS surveys resistance in eight priority bacterial pathogens, which include both community- and hospital-acquired pathogens, with and without links to the food chain, against which available treatments are being exhausted. Starting in 2018, GLASS will also monitor antimicrobial consumption by humans.

The Tripartite organizations have no international lists of critically important antiviral, antifungal or antiparasitic agents; however, the Global Action Fund for Fungal Infections (GAFFI), which includes many governments and national and international global health agencies among its implementing partners, maintains a list of fungal infections of the highest priority.[14] Furthermore, some viruses and parasites are commonly accepted as high priorities within organizations working on animal and human health, including influenza viruses, filoviruses, arenaviruses and coronaviruses and the malaria parasite, *Plasmodium*, and various species of *Trypanosoma*.

Low- and middle-income countries

Prioritization is particularly important for LMICs with constraints on infrastructure and resources, many of which have a particular need for surveillance but little capacity for doing it. Capacity-building, training, integration with other human and animal health surveillance initiatives and sustainability in the long term should be anticipated and supported by governments, donors and intergovernmental organizations.

Comprehensive assessments, such as WHO Joint External Evaluations, the OIE Performance of Veterinary Services (PVS) Pathway and the FAO Assessment Tool for Laboratory and Antimicrobial Resistance Surveillance Systems (ATLASS) can be used by countries to evaluate their surveillance and laboratory capacity, anticipate resource needs and plan surveillance.

WHO–OIE national "bridging workshops" facilitate cooperation and intersectoral collaboration between public health authorities and veterinary services. AMR is one of the topics of the workshops. GLASS provides specific tools for LMICs (the Core Components Checklist for National AMR Surveillance Systems) for planning and establishing AMR surveillance in humans.

Substandard and falsified medicines

Surveillance of the quality of medicines may also play a role in minimizing and containing AMR. Marking (bar coding) of medicines by the manufacturer allows tracing of low-quality medicines. WHO has a Global surveillance and monitoring system for substandard and falsified medical products, but there is no such system for antimicrobials used in animals or plants.

[14] GAFFI priority fungal infections. In: GAFFI Fact Sheets [website]. Geneva: Global Action Fund for Fungal Infections; 2018 (https://www.gaffi.org/media/fact-sheets/, accessed 18 April 2018).

Questions for stakeholders

- What further support do countries that are establishing surveillance systems need (in addition to existing tools) to implement a national surveillance system for AMR and AMU?
- How could countries be better supported in developing sustainable national or regional AMR surveillance strategies that are adapted to national contexts but still can inform national policies and contribute to international containment of AMR?
- What more can be done to facilitate the surveillance of falsified and substandard medicines in the human, animal and plant sectors and leverage the resulting data ?

4.2. Comparability

Countries may ultimately be able to use multisectoral data and metadata from surveillance systems to inform national and local decisions provided the data are of sufficient quality and the technical capacity to interpret them exists. Data from national surveillance systems should be harmonized so that they can be aggregated and compared to identify trends across sectors. Collection of national surveillance data should follow international data models to ensure broader assessments of AMR and AMU and track regional and global progress.

Key issues

Multiple data types

Systems for surveying resistant microorganisms vary widely among sectors and in the type of data and metadata collected. The differences include information on the pathogen, determinants of resistance, the commodity, the classes of antimicrobials tested, the sampling design, laboratory methods, analysis and reporting.

Data on the volume of antimicrobial agents used by individual consumers or farms are difficult to obtain, and systems for surveying AMU are often based on a variety of other data, including on sales or wholesale distribution, imports, production, clinical or prescribing data.

Harmonizing data on AMR and AMU in consistent models, with consistent metrics, remains a significant challenge. International organizations often have to rely on data from countries with different capacities for data collection and variable sources and integrity of data.

Some organizations have responded to the problem by creating data models, collection templates or frameworks and publishing them, in the hope that national systems will use their format. Practical metrics for data collection and reporting are also necessary in order to align the data received. For example, milligrams of antimicrobial agent per kilogram of animal biomass is established throughout the OIE database as the common measure of AMU in animal species, to ensure consistent reporting from all countries, whatever the stage of development of their surveillance systems.

Even countries that have adopted international standards and metrics in order to harmonize data collection often submit incomplete or poor-quality data in the initial stages of reporting and capacity development, which can make it difficult to interpret and communicate results.

The Tripartite is working to promote the harmonization of data from different AMR and AMU surveillance systems in a new initiative, known as the Tripartite Integrated Surveillance System for AMR/AMU (TISSA). Still in the early stages of development, TISSA will provide a platform for publication of data collected from different sectors by global and regional surveillance systems. It will address how to enable coordinated data-sharing and harmonized analysis..

Standardized methods for surveying AMR and AMU

The quality of data on AMR can be improved by the use of standardized methods for determining susceptibility to antimicrobial agents. Globally accepted standards include those of the Clinical and Laboratory Standards Institute (CLSI) and the European Committee on Antimicrobial Susceptibility Testing (EUCAST). Standardized epidemiological methods are also important to determine how a given population is affected and to compare effects. GLASS provides epidemiological standards for surveillance in human health.

The OIE Manual of Diagnostic Tests and Vaccines for Terrestrial Animals provides standards on laboratory methods for bacterial antimicrobial susceptibility testing, and the FAO Assessment Tool for Laboratory and Antimicrobial Resistance Surveillance Systems includes recommendations for improving laboratories and national AMR surveillance systems and ensuring use of standardized methods to ensure the collection of validated, comparable data on AMR.

Alternatively, the quality of data on AMR can be improved by following national recommendations, such as the National Clinical Recommendations on antimicrobial susceptibility testing of the Russian Federation.

The OIE Terrestrial Animal Health Code and the OIE Aquatic Animal Health Code both include recommendations for the development and standardization of systems for surveying AMU. WHO has issued methods for monitoring antimicrobial consumption in humans.[15]

Surveillance systems should be dynamic and allow for the development and inclusion of new monitoring and surveillance tools. Recently, the contribution of genotypic information, such as that derived from whole genome sequencing (WGS), to AMR surveillance has been described. WGS facilitates the characterization of individual microbes along with their resistance determinants, including resistance to compounds not routinely tested phenotypically. Bacteria that have identical resistance patterns caused by different mechanisms can be differentiated by WGS.[16] In order to include new types of information, guidelines and standards at the national or international level may need to be developed or adapted.

Alternatives to continuous surveillance

Point prevalence surveys (PPS) for collecting data on AMR or AMU from a few sentinel sites can provide a relatively quick assessment that is less resource intensive than continuous surveillance. Such surveys can be used to supplement existing surveillance in high-income countries but are particularly useful for providing a “snapshot” of resistance in LMICs without the infrastructure for continuous surveillance.

PPS protocols need not be limited to one country. For example, a PPS protocol for determining

[15] McDermott, PF *etal,* Antimicrob. Agents Chemother. September 2016 vol. 60 no. 9 5515-5520 (http://aac.asm.org/content/60/9/5515.full)

[16] WHO methodology for a global programme on surveillance of antimicrobial consumption. Geneva: World Health Organization; 2017 (http://www.who.int/medicines/areas/rational_use/WHO_AMCsurveillance_1.0.pdf?ua=1).

antimicrobial prescribing practices in hospitals, prepared by the University of Antwerp, has been adapted for use globally.[17] WHO will shortly release a similar protocol and conduct surveys in Africa and other regions.

Most PPS protocols and other initiatives for collecting data at points of care have been designed for use in hospitals, and strategies should be developed to survey AMU and AMR in communities, where most antimicrobials are used and where unbiased AMR rates are not yet known.

Questions for stakeholders

- What support do Member States need to strengthen national surveillance systems and improve the quality, collection and submission of their data to global surveillance databases?
- What more can be done to harmonize collection of data on AMR and AMU among sectors and levels?
- What additional work is needed on methods for testing antimicrobial susceptibility or to include new technologies in existing systems (e.g. WGS)?

4.3. Availability

For surveillance data to be useful in tracking AMR and AMU, they should be easy to obtain and easy to use for designing actionable strategies. First, therefore, they must be available to policy-makers and other stakeholders in public reports. Further, countries that have robust data should share them through existing global systems. In LMICs, lack of human resources may pose a real barrier to availability of data. For example, many countries require significant support in reporting AMU data to OIE, because they lack the resources to either collect the data or to validate them for accuracy. Another major challenge, particularly in LMICs, is moving from generating data to translating it into useful information and then policy.

Key issues

Data collection

Many countries do not have systems for sustainable collection of good-quality data. For example, only 22 of 42 (52%) GLASS-enrolled countries could provide data for the first GLASS report on AMR surveillance in common bacterial human pathogens.[18] Of the 146 countries that provided data for the second OIE annual report on antimicrobial agents intended for use in animals, 107 (73%) provided quantitative data. Barriers to data submission reported by countries included lack of a regulatory framework and lack of cooperation between national authorities and the private sector.[19]

[17] Versporten A, Drapier N, Zarb P, Caniaux I, Gros MF, Miller M et al. the global point prevalence survey of antimicrobial consumption and resistance (global-PPS): a worldwide antimicrobial web-based point prevalence survey. Open Forum Infect Dis. 2015;2(Suppl1);147.

[18] Global Antimicrobial Resistance Surveillance System (GLASS) report: early implementation 2016–17. Geneva: World Health Organization; 2017 (http://www.who.int/glass/resources/publications/early-implementation-report/en/, accessed 15 April 2018).

[19] OIE Annual report on antimicrobial agents intended for use in animals. Paris: World Organisation for Animal Health; 2017 (http://www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/AMR/Annual_Report_AMR_2.pdf, accessed 18 April 2018).

Many countries need support in establishing basic systems for collecting data on AMR and AMU and in validating them for accuracy before they consider the format in which to publish the data or how to interpret them.

Publication of data

At global level, data on AMR and AMU in humans and AMU in animals are collected and published by GLASS and the OIE Global database on antimicrobial agents intended for use in animals, respectively.

Initiatives to publish data on AMR are also under way in the private sector. For example, a pilot project by the Wellcome Trust and the Open Data Institute is collecting data on human susceptibility to antibiotics from the pharmaceutical industry and determining how to make it available openly and to create a consistent framework, with common standards and methods, so that data from different programmes can be amalgamated and studied.[20]

Despite these initiatives, significant gaps remain in the availability of data. For example, no information is available on AMU in plants, and the total global production of antimicrobials, including classes, distribution and intended use, is not well documented.

Accessibility

Publication of national data increases awareness, transparency, accountability and understanding of policy decisions. Even if data are publicly available, however, they are not necessarily "accessible" in terms of being useful and useable. Countries also have to have the technical capacity in epidemiology and general public health required to translate data for use in developing public policy.

Making data available in a simple format that is not too information-dense and includes interpretable figures and enough context to understand them correctly remains a challenge in many countries. This would significantly increase the potential uses and users of data.

Publishing data in a format that enables further manipulation and analysis – for example in a spreadsheet – requires investment but adds value to the data and improves access, especially to large data sets. Use of modern web-based tools can improve accessibility. For example, the European Food Safety Authority, the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC), the AntiMicrobial Resistance Map (AMRmap) in the Russian Federation and the National Antimicrobial Resistance Monitoring System (NARMS) in the USA all publish data on interactive databases that allow users to query and visualize the data.

Knowledge sharing

Information exchange and knowledge sharing – such as of case studies, success stories and best practices in surveillance – are tried and tested methods of fostering a "community of practice" to strengthen skills and capacity. Supporting knowledge sharing through online platforms or networking events could help resource-poor countries to strengthen their capacity for collecting, publishing and analysing data on AMU and AMR. Established tools and tactics might be tailored for

[20] Open Data Institute tackles antibiotic resistance with Wellcome Trust grant. Manufacturing Chemist. 7 February 2018 (https://www.manufacturingchemist.com/news/article_page/Open_Data_Institute_tackles_antibiotic_resistance_with_Wellcome_Trust_grant/139330) accessed 24 March 2018).

individual countries, and initiatives could be designed to ensure that lessons are learnt from other, related fields of work, such as tracking resistance to drugs used in HIV/AIDS, tuberculosis and malaria that could be used as examples for AMR surveillance.

OIE training seminars for national focal points for veterinary products, which are designed to increase the understanding of national veterinary authorities of the key issues in AMR control, include knowledge-sharing components for the exchange of experience and lessons among participants from various regions.

Knowledge-sharing networks can also join sectors and locations. The Transatlantic Taskforce on Antimicrobial Resistance (TATFAR), for example, promotes collaboration and coordination among Canada, the European Union, Norway and the USA. Since its inception in 2009, the Taskforce has increased information exchange, strengthened understanding of best approaches and practices and fostered peer relationships.[21]

Questions for stakeholders

- What support do countries require to develop and report accurate national data and share them on global surveillance systems?
- What data formats and visualization tools are most useful for reporting and further analysis?
- How can lessons be learnt from initiatives in HIV, tuberculosis and malaria to improve surveillance of AMR and AMU?

4.4. Sustainable investment

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

In resource-constrained settings, spending on surveillance may be a low priority, particularly if the data collected are considered to be only an international public good and not for practical management of AMR and AMU nationally and locally. The question is the role of the international community in funding national surveillance systems, particularly as reliance on international support in the long term is ultimately unsustainable.

Key issues

Cost

The World Bank has shown that putting resources into containment of AMR, including through surveillance, is one of the highest-yield investments a country can make. If AMR is not checked, it is predicted that it will cost the global economy US$ 1–3.4 trillion each year by 2030 and that LMICs will experience the greatest drops in economic growth.[22] In comparison, the annual cost of

[21] TATFAR work. In: TATFAR (website). Atlanta (GA): Centers for Disease Control and Prevention; 2018 (https://www.cdc.gov/drugresistance/tatfar/about.html, accessed 9 April 2018).

[22] These calculations are based on World Bank simulations for two scenarios, of a low and a high impact of AMR. See: World Bank. Drug-resistant infections: a threat to our economic future (discussion draft). Washington DC: The World Bank

containing AMR, which the World Bank estimates as US$ 9 billion, is very small, and the Bank calculates that the economic rate of return on this investment would be 31–75%, depending on how much of the cost of containing AMR can be mitigated.[23]

Although these figures apply to the costs and benefits of AMR containment efforts as a whole, the same principle applies to surveillance; in all cases, the cost of establishing and sustaining a surveillance network should be weighed against the benefits. In all cases, work is required to calculate surveillance-specific costs and benefits.

At global level, the 2016 Commission on a Global Health Risk Framework for the Future and the O'Neill Review on AMR recommended an annual investment on the order of US$ 4.5 billion to improve surveillance capacity as part of wider enhancement of emergency response capability. At national level, the cost of establishing and maintaining a surveillance system depends on national data requirements, priorities and capacity. According to the World Bank,[24] the cost of the laboratory component of establishing a national AMR surveillance system can be relatively low if there is already a network of well-functioning laboratories. For example, in Kenya, the estimated budget for starting and running an AMR surveillance laboratory network, with a national reference laboratory and eight county or satellite laboratories, is about US$ 160 000, excluding the general operating budgets for the laboratories.[25] The Kenyan network, however, covers only public health, and the cost of a multisectoral system is likely to be much higher.

In most cases, national analyses of the cost of both AMR containment in general and of AMR and AMU surveillance in particular are still missing.

Funding sources

Funding for surveillance is not always a priority of national governments, particularly in LMICs. Some international initiatives offer financial and technical support for building laboratory and surveillance capability in these countries, including the surveillance elements of the Global Health Security Agenda and the Fleming Fund, funded by the United Kingdom. They also include initiatives such as the World Bank's Regional Disease Surveillance Systems Enhancement programme, which supports countries in the Economic Community of West African States in strengthening national surveillance systems and intercountry collaboration.[26] While the programme is not specifically for AMR, its latest phase is explicitly AMR-sensitive. The programme is partly financed by countries themselves from their allocations of International Development Association funds and partly by a regional integration matching fund mechanism.

Group; 2016 (http://documents.worldbank.org/curated/en/323311493396993758/pdf/114679-REVISED-v2-Drug-Resistant-Infections-Final-Report.pdf, accessed 15 April 2018).

[23] The World Bank report (ibid) states that: "Assuming that investments would be made for seven years before any benefits materialize, the ERR [economic rate of return] ranges from 31% annually (if only 10% of AMR costs can be mitigated) up to 88% annually (if 75% of AMR costs are avoided)."

[24] Drug-resistant infections: a threat to our economic future (discussion draft). Washington DC: The World Bank Group; 2016 (http://pubdocs.worldbank.org/en/527731474225046104/AMR-Discussion-Draft-Sept18updated.pdf, accessed 25 March 2018).

[25] Drug-resistant infections: a threat to our economic future (discussion draft). Washington DC: The World Bank Group; 2016 (http://pubdocs.worldbank.org/en/527731474225046104/AMR-Discussion-Draft-Sept18updated.pdf, accessed 25 March 2018).

[26] Regional disease surveillance systems enhancement (REDISSE) phase III [website]. Washington DC: The World Bank Group; 2018 (http://projects.worldbank.org/P161163?lang=en, accessed 15 April 2018).

The private sector also has a part to play in funding AMR action, including surveillance. A 2017 report by the World Bank International Working Group on Financing Preparedness called on national governments to incorporate the private sector into their preparedness strategies, including using regulation to ensure that companies invest in mitigating risks such as AMR if their business contributes directly or indirectly to it.[27] More attention is needed to exploring the options for involving the many different private companies and businesses that impact and influence AMR.

The World Bank has committed itself to publish a global investment framework for AMR action by 2019, which will be based on financing assessments that include national priorities, needs, gaps and best-value interventions and include options for mobilizing resources from both public and private sources. The framework is to be a comprehensive instrument for mapping and quantifying financing needs worldwide and coordinating global investments in action to combat AMR. It is intended as a tool for policy-makers, planners, development finance institutions, donors and others to direct AMR financing to where it is needed most, including for surveillance.

Questions for stakeholders

- How can countries be supported in doing economic case studies to demonstrate the costs and benefits of surveillance and to attract investors?
- What tools are required to address the investment required for surveillance of AMR and AMU?
- What role can the private sector play in financing surveillance?

[27] Sands P, Casserley D, Chaves R, Evans TG, Gupta S, Hazlewood J et al. From panic and neglect to investing in health security: Financing pandemic preparedness at a national level. Washington DC: The World Bank Group; 2017 (http://documents.worldbank.org/curated/en/979591495652724770/pdf/115271-REVISED-FINAL-IWG-Report-3-5-18.pdf, accessed 17 May 2018).