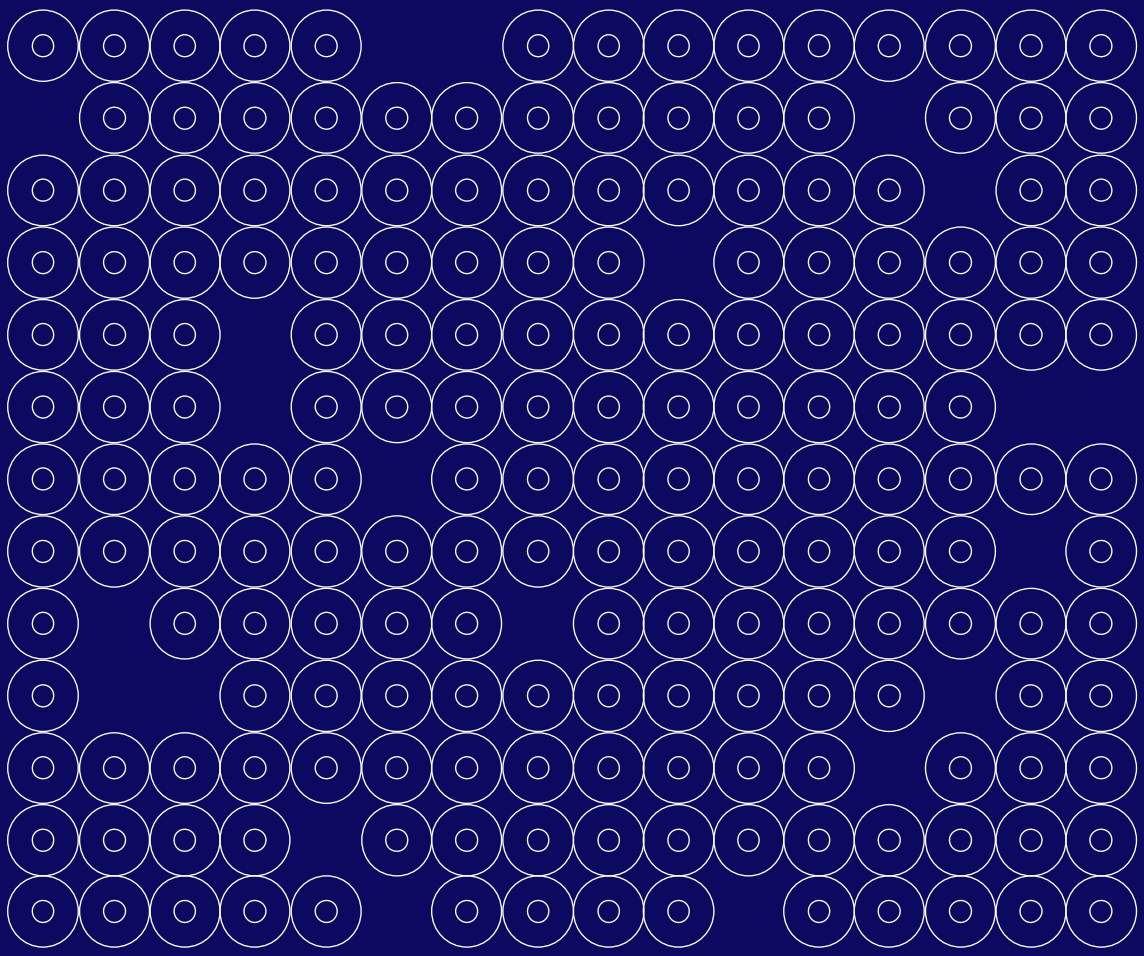
Supporting research and innovation on One Health AMR surveillance

Online workshop 23-24 March 2022



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DESIGN OH AMR

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Joint Programming Initiative on Antimicrobial Resistance

Contents

Abbreviations

AMC	Antimicrobial consumption
AMR	Antimicrobial resistance
AMS	Antimicrobial stewardship
AMU	Antimicrobial use
AST	Antimicrobial susceptibility testing
CLSI	Clinical and Laboratory Standards Institute
ECOFF	Ecological cut-off
EUCAST	European Committee on Antimicrobial Susceptibility Testing
HACCP	Hazard analysis critical control point
HIC	High-income country
JPIAMR	Joint Programming Initiative on Antimicrobial Resistance
LMIC	Low- and middle- income country
MDRB	Multi-drug resistant bacteria
MGE	Mobile genetic element
MIC	Minimum inhibitory concentration
MRA	Microbial risk assessment
QAC	Quaternary ammonium compounds
SRIA	Strategic Research and Innovation Agenda
WGS	Whole-genome sequencing

Introduction

This document gives an overview of the workshop on the Joint Programming Initiative on Antimicrobial Resistance (JPIAMR) research priority topic of surveillance, to inform the review of the JPIAMR Strategic Research and Innovation Agenda (SRIA) in preparation for the Horizon Europe One Health AMR partnership.

The surveillance workshop was organised by the Coordination and Support Action (CSA) DESIGN One Health AntiMicrobial Resistance (DESIGN OH AMR). The workshop was carried out by JPIAMR together with the Italian Ministry of Health on the 23 and 24 of March 2022, immediately after the final workshop of the Surveillance Networks funded under the 2018 Surveillance Network call.

This report reflects the opinions and identify common points raised by the expert participants in the workshop. It does not aim to be an exhaustive overview of the field of antimicrobial resistance (AMR) surveillance.

Since 2011, the JPIAMR has the mission to coordinate national funding of antimicrobial resistance research, guided by a shared SRIA, which sets common research priorities by aligning national and international AMR research strategies and programs. The One Health approach was incorporated into the agenda in 2014. The JPIAMR consists of 29 nations, including many non-European members, conducting joint actions to support research on AMR in humans, animals, and the environment.

JPIAMR has launched 15 joint transnational calls investing approximately 127M€ in 137 research projects and networks and supporting 1430 researchers from 77 different countries across the world. The research outputs and outcomes include the identification of six preclinical antibacterial candidates, six patents, and a substantial number of peer-reviewed scientific publications, policy guidelines, and other diverse research tools and resources.

Scientific rationale, aims and objectives

Surveillance is the continuous, systematic collection, analysis, and interpretation of data for action such as the planning, implementation, and evaluation of prevention and intervention initiatives[1].

Surveillance of AMR and antimicrobial consumption (AMC) or antimicrobial use (AMU)[2] are cornerstones in managing AMR; locally, nationally, and on a global level. Surveillance serves as an early warning system and supports relevant responses to emerging and escalating AMR and potential outbreaks of drug-resistant microorganisms within and between human and animal health settings, food production facilities, and the environment.

The 'One Health' perspective is an approach to designing and implementing programmes, policies, legislation and research in which multiple sectors communicate and work together to achieve better public health outcomes. The One Health approach is critical to addressing health threats at the animal, human and environment interface.[3]

The One Health approach requires interlinked and integrated surveillance models between the human, animal and environmental sectors and highlights the need for alignment of methods for data collection and analysis. This calls for robust systems for data collection, data management, data interpretation and data use on the national and global levels. Systems, technologies, and analytical approaches need to be tailored to current needs, but ideally also flexible, resilient and adaptable for future development.

The interactive online workshop with key stakeholders focused on:

- Identifying the main challenges and opportunities for integrated One Health AMR and AMC/AMU surveillance systems that are multisectoral and trans-disciplinary at the global, national, and regional/local levels.
- Identifying innovative and/or alternative surveillance systems and methods that integrate and triangulate AMR and AMC/AMU surveillance data to inform policy and practice interventions.
- Gathering information on gaps and priorities that are needed for improving surveillance using the One Health approach.
- Exploring and analyzing the potential and advantages of collaboration in surveillance for the future One Health AMR partnership.
- Adapting surveillance of AMR to the context specificities of LMICs.

The aims of the workshop were to:

- Develop a joint message to the AMR community on how research and innovation on surveillance can be improved and enhanced to take an interlinked, integrated and innovative One Health approach.

[1] https://ahpsr.who.int/publications/i/item/global-action-plan-on-antimicrobial-resistance
[2] https://www.flemingfund.org/wp-content/uploads/29e140d66670221b9d95aaaa108ef03e.pdf
[3] https://www.euro.who.int/en/health-topics/health-policy/one-health

- Raise awareness at the policy-making and political level of the need to conduct research on the improvement and development of conventional and innovative (alternate) AMR surveillance models, respectively.
- Build international bridges between national and global surveillance research and innovation activities.

The workshop was a mechanism for a consultation, and therefore entailed both discussions to identify a shared understanding on the steps needed to improve current AMR surveillance systems and models (aims, targets, expected deliverables/outputs and outcomes), and the ways to get there (cost-effective systems; target selection, methods for data collection and analysis that support for example decision-making and strategic action). The suggestions from experts during the workshop sessions will contribute to the update of the research and innovation objectives within the JPIAMR SRIA and serves to prepare the SRIA for the upcoming Horizon Europe One Health AMR Partnership.

Workshop participants

There were 340 participants from six regions and 76 countries who registered for the workshop.

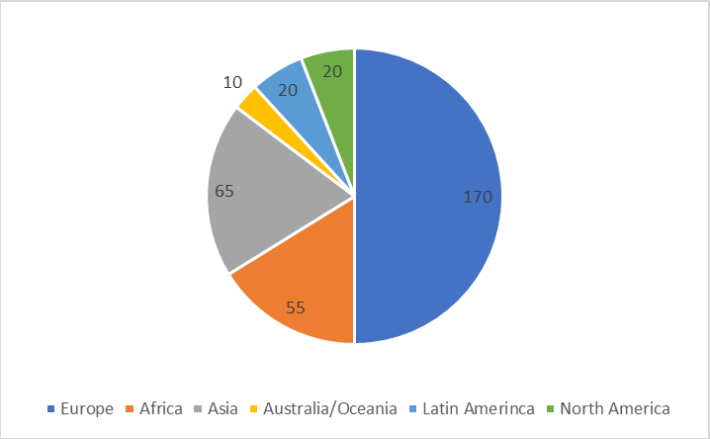

Figure 1. Distribution of participants registered for the workshop, by region.

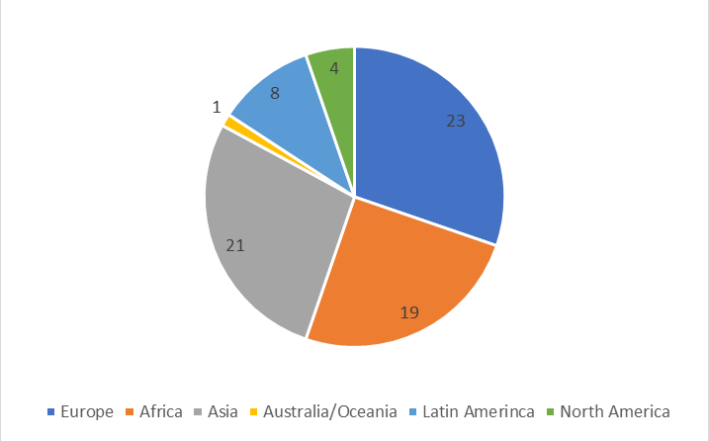

Figure 2. Distribution of countries represented, by region.

The target audience for the workshop included the following stakeholders:

- Policymakers: Ministries of Health, Ministries of Agriculture or similar, Ministries of Environmental Protection or similar and their responsible bodies within the relevant sectors.
- European and international organizations and networks such as the Quadripartite (WHO, FAO, OIE, UNEP), WHO-IACG, GLASS-AMR, EU-JAMRAI, Glopid-R.
- Regional networks such as the ECDC, EARS-Net, HAI-Net, FWD-Net, and their equivalents in other continents.
- National and regional funding agencies and research councils.
- Researchers working in AMR surveillance.
- Other researchers in the field of AMR.
- Private sector including pharmaceutical and biotech industries: BEAM Alliance members, AMR Industry Alliance, Pfizer, BD and other companies that have sponsored surveillance.

In total, more than 110 participants attended the live workshop (around 32% of those that had registered). Participants' email domains indicated that the workshop was followed by representatives of major AMR and research entities, throughout Europe and beyond, including representatives from funding agencies, policymakers and ministries, international organizations, and researchers in industry and in the public and private sectors.

In addition to the live event, a link to the recording of the plenary sessions of the workshop was sent to all that had registered and the video recording was also uploaded to YouTube.

The workshop generated a space for networking in the chat, where participants debated the issues raised in the sessions.

Workshop overview

The workshop was held in two half-day sessions and included plenary sessions on policy, round-table discussions and breakout sessions on specific topics addressing research gaps, challenges and needs.

Moderators and rapporteurs in each session facilitated the development of jointly agreed conclusions from the workshop.

The agenda can be found in Appendix I. and the recordings can be viewed on the following links:

Day One: https://youtu.be/EHo6pXSLCRM

Day Two: https://youtu.be/C06PdTxqn_s

The workshop was opened by a welcome address from the Italian Ministry of Health and the JPIAMR thematic group for surveillance. The following sections of this report describe the AMR surveillance gaps and challenges identified during the different workshop sessions.

First day plenary session

After the brief presentation of the JPIAMR initiative the following sessions were presented:

Introduction of Strategic Research and Innovation Agenda

Presented by Laura Plant, JPIAMR secretariat. This presentation described the JPIAMR strategic direction and the ongoing process for updating the SRIA, including restructuring of topics and cross cutting themes.

The priority topics have been refined and designed to encompass (1) therapeutics, (2) diagnostics, (3) surveillance, (4) transmission and evolution, and (5) prevention and interventions. The environment, initially listed separately, is now horizontally integrated into the other pillars.

The cross-cutting themes added are: One Health, diversity, social sciences, implementation science, innovation and international collaboration.

The strategic research agenda was set up in 2014, and innovation was integrated into the SRIA in 2018, highlighting the importance of innovation in the five pillars. Moreover, antifungal resistance was added to the topics in addition to antibiotic resistance in 2021.

Importance of the transnational research on AMR

Presented by Giuseppe Ippolito, Italian Ministry of Health. This presentation stressed that despite more than 30 years of surveillance, AMR continues to increase and is difficult to control. The following gaps and challenges were described:

- Automation in surveillance systems. Clinical (human and veterinary) laboratories produce AMR data on a daily basis, which could be used for surveillance purposes. Thus, application of real time automation and access to data for action is a research gap.
- Alignment of surveillance frameworks and platforms between high-income countries (HICs) and low- and middle-income countries (LMICs). A minimum phenotypic and genomic surveillance framework and platform including whole genome sequencing (WGS) could improve resource use and capacity in LMICs.
- Genetic markers for the identification of transmission and outbreaks. Dissemination of multidrug-resistant bacteria (MDRB) should be analyzed at local level (for investigating outbreaks), but also at a healthcare-network level (to track inter-hospital dissemination). Hence, there is a need to mutualize WGS data in order to perform real-time epidemiology such as GISAID does for COVID-19.
- Prediction of AMR using artificial intelligence (AI). AI-based tools and mathematical new modelling should be explored to identify at-risk patients with more sensitivity and specificity in order to enable a personalized screening policy and support antimicrobial stewardship (AMS).
- Bringing the issue of AMR from the research setting closer to the citizenship. This requires communication efforts to clinicians, patients and to different sectors in the society.
- Definitions and endpoints for interventions. A clear, widely-accepted definition of community- and healthcare-acquired infections is needed, as well as better assessment of AMS efficacy.
- Ranking of antibiotics according to their impact on the microbiota, i.e. their capacity for driving resistance and inducing dysbiosis.
- Optimizing use/repurposing existing antibiotics, i.e. entrenching diagnostic AMS while also seeking ways to expand treatment options, e.g. via drug repurposing, monoclonal antibodies, collection of bacteria with metabolites with antibiotics activity
- Alignment at the political level. The three One Health components have different imperatives and vertical administrative arrangements precluding collaboration, consultation, communication and joint, horizontal decision-making.

Synthesis of the Network Call on Surveillance: Achievements and Recommendations

Presented by Etienne Ruppé, Université de Paris – Cité. This presentation addressed the key points extracted from the achievements and challenges reported during the preceding final meeting of the JPIAMR networks on surveillance[4] that focused on data collection and procedures for harmonization, as well as the environmental dimensions of AMR[5] and standardization of thresholds for AMS[6].

[4] https://www.jpiamr.eu/calls/7thcall/#information-application
[5] https://wedocs.unep.org/bitstream/handle/20.500.11822/38373/antimicrobial_R.pdf
[6] https://academic.oup.com/jac/article/75/Supplement_2/ii20/6024989
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- Harmonization was central to most of the funded networks, in terms of definitions, protocols (types of samples, wet-lab and dry-lab methods, outputs) and implementation in different settings. Harmonization and consensus procedures were often difficult to reach given the very diverse backgrounds of the areas and infrastructures in the countries represented in the networks. It was also raised that chasing a virtually impossible harmonization at all costs could carry a risk of spending too much time and effort to the detriment of the aims of surveillance.
- Mobile genetic elements: The networks agreed that tracing AMR could happen at the microorganism level but also at lower levels of granularity such as the analysis of mobile genetic elements (MGEs). Standardized laboratory and bioinformatic procedures and also curated databases aiming at putting MGEs as a potential outbreak agent will be needed in the coming years. Tracking microorganisms and MGEs among different compartments will require sequencing (short and long reads) and bioinformatic efforts.
- Some observations referred to the logistic challenges related to the pandemic (and are relevant although it falls outside the scope of this workshop report). First, network projects coordinators emphasized the importance of physical meetings, especially at the early stages of network formation. In-person inception meetings, where held, facilitated further dialogue and made it possible to continue working efficiently online. Second, the original agenda was to build a network for 12 months but due to the pandemic the period was extended and networks had the possibility to continue working for 3 years. The longer timeframe allowed for networks to expand or establish contact with other networks.
- The white papers published by the JPIAMR network projects should be reviewed for further concrete suggestions regarding surveillance research initiatives.

JPIAMR Network Call 2022: Diagnostics and Surveillance

Presented by Laura Kostelnickiene, JPIAMR Joint Call Secretariat. This presentation introduced the upcoming Diagnostics and Surveillance Network call[7], highlighting its focus areas, networking activities, network composition, envisaged outputs and the inclusion of early career researchers. Of note, networks in this call will be funded for 12 or 24 months.

Roundtable discussion

This section was moderated by Gianmaria Rossolini (University of Florence, Italy) with the participation of the panelists Christian Menge (Friedrich-Loeffler-Institut, Germany), Teresa M. Coque (Ramón y Cajal Institute for BioHealth Research-IRYCIS, Spain), Sergey Eremin (GLASS, WHO Headquarters), Chinyere Kyna Okoro (WHO AMR), Pilar Ramon-Pardo (Special Program on AMR, Pan American Health Organization) and Marcelo Galas (Antimicrobial Resistance Surveillance Specialist, Pan American Health Organization).

The discussion centered around major challenges of surveillance for the purpose of accurately monitoring selection and transmission events, for example the need to quantify and assess the impact of antimicrobial residues on AMR emergence/escalation

[7] https://www.jpiamr.eu/calls/network-call-2022/

in diverse environments as well as the integration and triangulation of AMR and AMU/AMC information, the dynamics and risk of transmission, and how to ensure the sustainable involvement of LMICs for a truly global approach.

Three main questions were the starting points for the discussion, the responses to which are outlined below.

How can we integrate innovation and sustainability in the different regional contexts for the best AMR surveillance?

This debate focused mainly on the barriers to standardization of systems for AMR/AMU/AMC surveillance and how research and innovation can support the development of systems to integrate and assess information in countries with different socioeconomic circumstances. Besides the need to standardize methodologies between centers of different countries, the panelists highlighted unmet needs essential to achieve efficient surveillance. These are to:

- Properly apply the distinct definitions of antimicrobial resistance (clinical, epidemiological, ecological) according to the analyzed OH setting[8].
- Develop standardized definitions of surveillance and outcome data. This is needed in order to collect data that is reliable and useful for evaluating prescribing practice and empirical therapy (e.g. standardized definitions to identify the most probable source of infection acquisition and stratification of patients by key criteria such as age, gender, or risk factors), and to establish the minimum number of isolates necessary to provide consistent data (applicable to the hospital setting).
- Establish selective reporting of AST data and AMS programs in the animal health sector.
- Develop clinical and/or ecological breakpoints (ECOFFs) for bacteria, fungi and viruses from non-human sources.

Enhanced laboratory capacity was highlighted for its role both in enabling work on models of integration, standardization and One Health interoperability, as well as a way to decrease inequalities between countries. Although not an innovation, integration of sequencing technologies and bioinformatic solutions into surveillance strategies in LMICs was mentioned by several panelists, including the point that availability of reagents can be a barrier to harmonization of protocols between HICs and LMICs.

Taken together, the panelists emphasized the need for sustained and targeted research focused on basic aspects of surveillance (minimum surveillance protocols/frameworks, identification of reservoirs, points of surveillance) or technical gaps (diagnostic tools, microbial risk assessment models/approaches), with the aim of identifying best-fit solutions to inform interventions in all settings.

How can research help to improve AMR surveillance?

This second question of the roundtable aimed to discuss what is needed to make surveillance useful for global objectives; One Health, Global Health and Planetary

[8] *Martinez et al, NMR 2014*

Health. Examples are One Health alignment of AMR/AMU/AMC data, estimation of the burden of AMR and assessment of the impact of interventions, or prioritization among pathogens.

One Health alignment of surveillance data on AMR/AMU/AMC is still not feasible because of the heterogeneous sources and fractured information. Recent initiatives to gather (and in many instances, to generate) this disparate information underline the relevance of supporting countries to use their own data for developing National Action Plans and protocols that are relevant to their real needs and resources.

Besides the weaknesses highlighted in the section 4.2.1, research is necessary to generate a sound, evidence-based foundation for tailoring surveillance systems that can inform decision making at the level of prescription or purchase decision as well as other local intervention measures. This requires a versatile conceptual AMR/AMU/AMC surveillance framework accompanied by improved platforms for data and knowledge exchange within and between OH settings at different geographic levels.

How to motivate different stakeholders to be involved in the support of research and innovation on AMR surveillance?

The development and success of surveillance (and infection control programs) has always been linked to the engagement and ownership of different stakeholders. Panelists agreed on the value of using targeted educational programs and communication to engage relevant stakeholders, beginning with awareness but also involving further steps towards concrete action that should be clearly defined. Specific gaps and challenges related to AMR surveillance should be explained to target audiences, describing which decisions can be made and which measures can be implemented (only) because of the availability of data, what the expected benefits for health and national economy are, and the surveillance capacity needed to provide accurate data at manageable costs. Across OH settings, the involvement of public health and health economics are relevant for the successful and sustainable implementation of AMR/AMC/AMU surveillance.

Second day plenary session

The second day opened with a very short reflection from the previous day, after which the following sessions were presented:

The importance of the research on One Health AMR Surveillance

Presented by Silvio Brusaferro, National Institute of Health, Italy. This session gave an overview of the importance of One Health surveillance, stating that addressing the rising threat of AMR requires a holistic and multi-sectoral approach as well as clear One Health definitions and policy models. The following areas for development were highlighted:

- Interdisciplinary collaboration, not only at the technical level but also when it comes to decision-making. Therefore, cross-sectorial and interdisciplinary collaboration at global and local levels should be promoted, with a clear aim to support

implementation that includes both scientific and political actors. For example, data needs to be translated into policies with a One Health approach.
- Improved integration of AMR generated from routine testing in diagnostic laboratories and AMC/AMU data collected at local, national and regional levels [9].
- Improved automatic alert systems for early detection of outbreaks and the monitoring of effects of consequential control actions.
- Using surveillance data to prioritize and follow-up on interventions.
- Harmonization of the use of WGS, bioinformatic solutions and interpretation of WGS data to support epidemiological surveillance.
- Development and/or improvement of databases and data analysis tools to support decision-makers and professionals (e.g. to support machine learning, mathematical modelling, or the application of artificial intelligence).

Fungal surveillance

Presented by Ana Alastruey-Izquierdo, Instituto Carlos III, Spain. This session provided an overview of the current situation regarding surveillance of antifungal resistance. It highlighted that antifungal resistance is rising in both yeasts and moulds, driven by the increasing prevalence of intrinsically resistant species and also the development of secondary resistance. In recent years an important new fungal pathogen, *Candida auris*, has been described as the cause of outbreaks that are difficult to control and eradicate, with pan-resistant isolates detected in clinical samples. Azole resistance in *Aspergillus fumigatus* is another rising One Health threat, linked to the presence of azoles in the environment used to prevent fungal infections in crops.

Despite the rise of antifungal resistance, surveillance capacity is very limited. National surveillance programs are scarce, limited and not interconnected. The only international program in which fungal infections are included is the SENTRY[10], which is a private initiative with several limitations. Recently, a pilot project within GLASS-WHO was initiated gathering retrospective data from blood stream infections, but this has not yet been implemented in the GLASS program. Environmental studies have been done in some countries but information is scattered and variable.

The main needs in antifungal resistance surveillance are to improve methods and increase laboratory capacity, especially in LMICs. CLSI and EUCAST have reference microdilution methods but these are cumbersome and not suitable for many clinical laboratories. The correlation between the results obtained with commercial methods used in clinical laboratories and reference methods depends on the fungal species and antifungal agent, and are not optimized. In many LMICs antifungal susceptibility-testing is not performed or restricted to reference laboratories. In addition, standardized methods and databases for typing and analysis based on genome sequencing are lacking.

[9] https://cdn.who.int/media/docs/default-source/antimicrobial-resistance/iacg-surveillance-and-monitoring-for-amu-and-amr-110618.pdf?sfvrsn=8a07c166_4
[10] https://www.jmilabs.com/sentry-surveillance-program/

The implementation of standardized and linked antifungal resistance surveillance networks at national and international levels together with international and harmonized definitions and datatypes is necessary.

Break-out sessions

The break-out sessions were moderated by Sabiha Essack (University of KwaZulu-Natal, South Africa), Luigia Scudeller (Azienda Ospedaliero-Universitaria, Italy) and Nilton Lincopan (Universidade de São Paulo, Brazil), with the support from rapporteurs Ulrica Dohnhammar (JPIAMR secretariat, Sweden), Sophie Gay (ANR Agence Nationale de la Recherche, France) and Maria Jose Ruiz (Italian Ministry of Health, Italy). Outcomes from each discussion are summarized in the following sections.

Session 1: Innovations in surveillance

This breakout group focused on surveillance systems, methods of data collection, data analysis and data interpretation within and between sectors, and the use of this data for action in line with the EU One Health AMR Partnership focus.

Participants were asked to consider how AMR and AMC/AMU surveillance systems can be innovated, standardized and correlated to (1) monitor emerging or escalating AMR and (2) inform and assess the impact of interventions. Participants were asked to address both fitness of purpose and fitness for purpose.

The discussion was guided by three questions that were brainstormed in turn:

- What are the main barriers and solutions for interlinked, integrated, innovative multi-sectoral One Health AMR & AMU/AMC surveillance?
- Are there representative innovative and/or alternative surveillance systems/methods that can serve as (1) early warning of emerging/escalating AMR and/or (2) proxies for conventional culture-based surveillance to monitor AMR trends?
- How can AMR and AMC/AMU surveillance data be integrated and triangulated to inform policy and practice interventions within and between the human, animal and environmental sectors?

Key points from this session included the need for:

- Quality-assured phenotypic and genotypic One Health surveillance systems, frameworks, and protocols. Surveillance, especially genomic surveillance, is in its infancy when it comes to One Health interfaces. Moreover, surveillance is undertaken in silos with minimal integration and triangulation of AMR and AMC/AMU trends. Even countries that have well-established surveillance in humans and livestock, report AMR and AMU trends separately, and there is little or no analysis at the interfaces. One exception is the JIACRA reports[11] on integrated surveillance in Europe published in the last few years.

[11] https://www.ema.europa.eu/en/veterinary-regulatory/overview/antimicrobial-resistance/analysis-antimicrobial-consumption-resistance-jiacra-reports

- Correlations. This refers to both correlation between AMU/AMC and AMR within and between humans, animals and the environment in diverse settings and correlations between phenotypes and genotypes; associations are currently investigated at best.
- Proxies and alternatives to conventional surveillance. Conventional surveillance depends on the availability of human, infrastructural (laboratory and equipment) and operational resources, as well as capacity and competency within the health, agricultural and environmental systems. Such systems require sample collection from humans and animals which is often invasive, and such surveillance is inherently biased towards developed countries and hospital and urban settings where resources are available. The current surveillance systems are not feasible in resource-constrained settings in LMICs, although these countries carry substantial burdens from AMR. Therefore, alternative, cost-effective and non-invasive – yet representative – systems for monitoring the emergence and/or escalation of AMR are critical. The same holds for the identification of validated proxies. The utility of data collected for clinical decision-making in human and veterinary medicine should also be explored.
- Linking (genomic) AMR surveillance to AMU/AMC, epidemiology and clinical outcome. There is a lack of protocols for surveillance of AMU/AMC in humans and animals that allow associations with AMR data. Genomic surveillance rarely informs clinical protocols, nor is it correlated with clinical outcomes in human or veterinary medicine. Moreover, surveillance systems are not integrated with epidemiological investigations or programmes. There is lack of interoperability, partly because quality assurance regarding genomic surveillance is in its infancy. Knowledge and a nomenclature need to be established for molecular/genomic approaches from different sources and between databases
- Definitions and nomenclature for surveillance that focuses on sewage and environmental compartments. The purpose of various types of surveillance, as well as sampling issues (location, volume, frequency etc.) for each of them, need to be established and agreed. Environmental surveillance can provide several types of information; prevalence of genes or organisms, the ecological development of microorganisms or monitoring of human activities (e.g. AMU or carriage of resistant organisms), the effect of interventions to name a few.

To summarize, barriers to integrated surveillance data analysis include limited data collection, lack of (or low) harmonization at different levels, lack of interoperability between data from different sources, and a lack of quality assurance for resistance data originating from genomic surveillance. Innovation in the area of surveillance must inform culture-dependent and culture-independent methodology with transversal implications including links between national data collections comprising data generated in research projects, from disease surveillance in humans and animals, AMR and AMU/AMC data, and epidemiological and environmental sources. Quality control across systems and sources is necessary for future interoperability.

Session 2: Surveillance, pandemic preparedness and climate action

In this session, participants discussed the needs and possibilities to integrate the many aspects impacting on AMR, including climate change, into future One Health surveillance systems in order to significantly improve the pandemic preparedness level which could be taken as the most convincing argument to address stakeholders to take urgent action.

The discussion was structured by two main questions:

- How should One Health AMR surveillance activities be designed to achieve pandemic preparedness and prompt climate action? For example, how can climate be included in surveillance activities (climate-informed AMR surveillance)? Should the term "climate" be replaced with "societal changes"?
- How can we ensure global, international, and national adoption of preparedness in AMR plans?

The following knowledge gaps were highlighted and possible actions suggested:

- A descriptive concept that captures the complex relation between AMR, climate and time should be adopted. Climate change was considered by the participants a long-lasting process impacting on many different cause-and-effect relationships, which are difficult to integrate in surveillance programs. Natural environment destruction, disruption of ecosystems, reduction of biodiversity and differences in rainfall leading to alterations in water use and contamination can be taken as examples. Consequently, a broad concept of Public Health that considers factors influencing the climate change risk (e.g. animal and human behavior, societal changes) must be adopted in appreciation of the complexity of the system. In this sense, the recently coined term "lateral public health" may also be appropriate to describe the concept. (reference). A resulting multidimensional framework modelling the system has to include time as one important dimension.
- Establish the likelihood of transmission events. To cope with the given complexity of AMR climate and development over time, a feasible approach might be to simplify the multidimensional network of transmissions of AMR bacteria and of AMR determinants from one niche and from one bacterial strain, respectively, to the next into a chain of different transmission pathways. It is unrealistic to address all the transmission pathways by surveillance programs. However, the transmission events must be better understood at a mechanistic level in order to assign the likelihood of transmission to occur in a given setting to certain (molecular) markers.
- Align and harmonize protocols across sectors. To generate an overarching concept of AMR transmission within and between the different sectors, surveillance must be conducted with aligned methods for the human, the animal, and the environmental sector. Alignment can be achieved by establishing standardized protocols (e.g., at laboratory level for AST) or by cross-compatible methods (e.g., by establishing tailored sampling schemes for different sectors) which collate supplementary data from different fields if applying identical protocols is not feasible (i.e., hospital surveillance for human data versus herd surveillance for livestock data versus surface water surveillance for environmental data).

- Identify and characterize the elements of microbial risk assessment (MRA; hazard, exposure, vulnerability) for the acquisition or transmission of resistant microorganisms. Each transmission event disclosed by future One Health surveillance activities has a yet vastly unknown probability to occur. The factors (”drivers”) influencing the probabilities for acquisition or transmission are multifactorial, especially environmental ones: e.g. loss of biodiversity, urbanization, conflicts, climate change, and others. For MRA, the various elements should be deconstructed by introducing several levels of drivers, i.e., proximate drivers (e.g. animal/human contact and human/human contact), and ultimate drivers (e.g. climate changes, globalization of movements of goods, people, and animals).
- Improve the MRA models to Quantify the likelihood and magnitude of acquiring and/or spread AMR. Determining the probabilities of transmission events offer the opportunity to quantify the impact of drivers when they change over time as well as to quantify the efficacy of intervention measures. Research must eventually be targeted at identifying which transmission events are the most informative, as continuous sampling of the entire system is too resource-demanding to be implemented in a sustainable manner. Critical control points for surveillance, monitoring and MRA programs, similar to the Hazard Analysis Critical Control Point (HACCP) concept practiced in the food safety area for decades must be identified.
- Establish early warning points for AMR in environmental compartments. Preparedness was discussed as a higher degree of attention to prevention and detection of threats, ideally before they cause human disease outbreaks. A suitable example suggested was wastewater surveillance which should be considered by public health authorities. Wastewater surveillance can give information about both the AMR situation at the source (human communities, hospitals, livestock farms) and about the to-be-anticipated risk for human exposure depending on the use of water (e.g. for washing, drinking, or food preparation) depending on the local setting. For correct interpretation of gained data and for improving the preparedness level, research must identify AMR determinants that might become clinically relevant in the future but that are currently unknown.
- Develop digital solutions for data management in order to cope with, scale up, and made globally available the amount of data generated by multisectoral, interdisciplinary One Health surveillance. Of note, many already existing data (e.g., from clinical testing in human and veterinary medicine) are not yet used but can be exploited to speed up the process of setting up dynamic models for the multidimensional framework that represent the entire environment-animal-human system.

COVID-19 has shown that the countries that have dealt best with the pandemic are not necessarily the ones that have the best surveillance systems. Social scientists and communication experts must be involved in efforts to mainstreaming AMR prevention into national plans for climate adaptation, biodiversity, environmental protection, initiatives for societal change and other sectors that need to be involved in reducing risks and promoting early warning. Training, education and capacity building are key areas to be funded as a basis for global implementation of OH AMR surveillance, as well as a broad public health approach engaging all parts of society (governmental and non-governmental actors, civil society, academia, individuals and communities).

One Health projects are necessarily multidisciplinary projects (including social sciences and digital sciences). In order to generate actionable data ("actionable data" or useful data for policymakers), the following aspects must be considered:

- Pathogen prioritization within and between sectors, to support comparability between stakeholders.
- One Health alignment of surveillance data on AMR/AMU/AMC, for the same reason as above.
- Training, education and capacity building as a basis for global implementation of harmonized protocols and prioritization of different issues not necessarily restricted to LMICs.
- Training, education and capacity building to implement digital solutions to improve data management that improve medical decisions
- Harmonize criteria for monitoring programs (different interventions, different sectors).
- Improve Monitoring models, with systems dynamic modelling and identification of critical control points; with control points selected to provide both the most sensible data for risk assessment and prediction, and for measuring the impact/confirm the success of interventions.
- Improving the format to communicate data and made them intelligible for different stakeholders.
- Using surveillance data at critical control points to estimate the burden of AMR and assess the impact of interventions (monitoring).

Session 3: Environmental Dimensions of AMR: Residues (Emissions) and Resistance

The first topic (residues/emissions) was raised to open a discussion on how to mitigate discharges of antimicrobials into the environment. This issue would be in turn essential to measure the impact of antimicrobial pollution on biodiversity and integrate environmental monitoring data, e.g. monitoring surface water, solid waste, and airborne particulate matter. In this way, the environment pillar adds another key parameter to the AMU/AMC of other sectors, all needed to implement a One Health surveillance framework. Techniques to collect, analyze and communicate environmental surveillance information to improve the integration of information across sectors.

The second topic raised in this session was devoted to the surveillance of resistance to biocides, where the co-selection of bacterial resistance to them call for more frequent susceptibility testing. The COVID-19 pandemic has considerably increased the production, sales, and use of biocides[12]. Therefore, monitoring of level of tolerance and changes in the susceptibility to biocides can provide an operative evaluation of the microbial susceptibility in healthcare settings and at the household level, as well as in the food industry and in animal husbandry, with additional implications for the environment.

[12] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8019131/

In this session, the discussion was structured by the following questions:

- How to create and integrate surveillance data of AMR-relevant pollutants on a global platform? What data from antimicrobial pollution will be important to include in this platform? What pathogens and antibiotics could be used as biomarkers?
- How to extend surveillance of resistance to biocides? Which compounds should be prioritized (quaternary ammonium compounds (QACs), triclosan, chlorhexidine, silver)?
- How to establish methods and interpretative criteria to define resistance or tolerance to biocides in bacteria and fungi for surveillance purposes?

Regarding the integration of data on surveillance of pollutants relevant for AMR into existing surveillance platforms participants agreed on the need for the following:

- Baseline AMR data in the environment (including resistome/metagenomic data).
- Differentiation between AMR due to human contamination and due to the local environmental microbial communities.
- Investigation of the type and diversity of selective pressure and effects of drug mixtures (co-selection, cross-selection, collateral sensitivity) of antimicrobial resistance by biocides.
- Establishment of ecological cut-off values (ECOFFs) for environmental bacteria and different antimicrobials.
- Development of breakpoints for several sectors (human medicine, veterinary medicine).
- Training and educational programs to clearly differentiate breakpoints from the ECOFFs as appropriate.
- Simple data collection protocols for prioritized pathogens, e.g. *E. coli* to correlate data between sectors.

In terms of extending surveillance to include biocides and heavy metals, participants recognized the need for the prioritization of substances to monitor. Participants further recognized that causative agents of healthcare-associated infections may be resistant to antibiotics, disinfectants and/or antiseptics and/or heavy metals. However, standardized methods of susceptibility testing and minimum inhibitory concentrations (MICs) of biocides and heavy metals are not available. There was thus consensus that:

- Resistance to antibiotics should be the priority for further research and innovation. Nonetheless, resistance to biocides and heavy metals seem to be increasingly important for the environmental dimensions of AMR (e.g. enabling persistence of bacteria, co-selection with specific antibiotics, cross-resistance).
- There is a need for pilot studies to identify the occurrence of resistance to biocides and heavy metals.
- There is a need to explore effects of the use of biocides and heavy metals on AMR, resistance to biocides and heavy metals, co-selection, and cross resistance.
- Compounds for possible surveillance purposes need to be prioritized according to their relevance for AMR, considering the context where they are used (sites and geographical distribution).

Regarding the establishment of methods and criteria to define resistance or tolerance to disinfectants in bacteria and fungi, participants agree that methods to monitor resistance to antiseptics and disinfectants must be validated. Currently the main difficulties encountered in this field are:

- The absence of ECOFFs and MIC data for antiseptics.
- The need for improved risk assessment models.

Participants recommended that working groups to establish methods and criteria for determining susceptibility in biocides and heavy metals are created, that include CLSI and EUCAST members. Since resistance to biocides and disinfectants is a public health issue, there is also a need for policy engagement and therefore a clear message regarding the role of this type of resistance would be valuable.

Closing remarks

The JPIAMR Surveillance thematic group chair, Dr Ana Alastruey, closed the workshop with a discussion of its major outcomes, highlighting the importance of international research collaboration and the research priority setting in AMR. Innovation and sustainability are key to achieve this, as is the importance of learning from good practice examples.

Summary

One of the main conclusions of this workshop was the importance of unmet needs in the field of AMR surveillance guiding the update of the SRIA and associated roadmap of activities for the surveillance theme.

The workshop included a presentation of key points based on achievements and challenges of the previous JPIAMR Surveillance Network Call. These were:

- the continuous need for harmonization of definitions, data between sources and analysis
- efforts to formulate and agree on definitions regarding AMR in the environment,
- establishment of thresholds for the evaluation of efficacy of antimicrobial stewardship interventions.

The importance of international research collaboration and research priority setting in AMR was emphasized. This encompasses traditional surveillance activities updated and improved by applying new tools and also new perspectives such as the triangulation AMR/AMU/AMC and the study of predictive factors on AMR using syndemic approaches, applying artificial intelligence and mathematical modelling, and the possibility of learning from good practice examples. A specific research gap that was mentioned recurrently was the need to develop a minimum common phenotypic and genomic surveillance framework and platform that is useful and relevant in LMICs as well as HICs. It was suggested that sequencing facilities and other infrastructure built for COVID diagnostics could be re-routed for AMR purposes, e.g., to expand the use of WGS particularly in LMICs.

Ongoing efforts, from the collection of data from discrete research projects to large international collaborations, are necessary to continue to support successful research in the field of AMR surveillance. Among them, the application of digital solutions for data and metadata collection, new personalized medicine tools (AI, medical device, etc.) and novel phenotypic and (meta)genomic approaches, tools and technologies have been mentioned.

The workshop highlighted the need for a One Health surveillance framework with protocols/recommendations for different sectors that include a minimum sampling framework, powered sample sizes, description of sample sources and frequency, standard operating procedures (SOPs) for sampling and laboratory investigations, and integrated and triangulated analytics that support reliable conclusions regarding prevalence and transmission of AMR across sectors.

For the purpose of detection of emerging or escalating AMR, the surveillance procedures superior to, or representative of, conventional surveillance in both human and veterinary clinical medicine need to be implemented, so that they can support routine decision-making. A particular requirement is the development of norms and standards for veterinary surveillance and stewardship, including the development of clinical breakpoints for the veterinary sector, and selective collection and reporting of AST data from animals.

More knowledge is needed regarding the association or correlation between (genomic) AMR surveillance and AMU/AMC, epidemiology of infections and clinical outcome. Protocols, guidelines or SOPs for quality assurance regarding data collection, management and analysis are also needed to produce reliable data for the purpose of relevant analysis and evidence-based action.

The "motivation" of stakeholders is essential to involve them in understanding the global implications of AMR and the implementation of Public Health programs ("Lateral Public Health"). Here, targeted communication based on behavioral science is required, with specific tools and clear messages developed for each sector. Involvement of stakeholders starts with awareness, but needs to include governmental and non-governmental actors and also several steps (e.g. in terms of a roadmap) to reach sustainable change.

The influence of climate change on AMR and other microbial threats was discussed and considered as a complex issue. One recommendation to link surveillance to the scientific analysis of the problem was to disaggregate the analysis of the different parameters.

A main point on surveillance of AMR in the environment was "when, where and what to measure", i.e., establishment of critical control points of different targets (i.e., antibiotic resistance genes, antibiotic residues, etc.), techniques, and guidelines for sampling, analysis and interpretative criteria. A special mention was deserved to the need of baseline data in different environments.

Surveillance of resistance to other antimicrobials (such as heavy metals and biocides) are additional factors to consider. Methodological aspects (protocols, guidelines, etc.) as well as research on their effects (i.e., minimum selective concentrations for selection (MSCs), selection patterns, etc.) should be considered.

Suggested calls

During the workshop, some potential calls related to One Health surveillance were suggested by participants. They are related to the current Surveillance pillar of the JPIAMR, and aligned with the gaps and challenges identified in this report.

- One Health Surveillance: Novel approaches, tools and technologies, e.g., exploring the metagenomic perspective.
- Association/Correlation between AMR, AMU, AMC and epidemiological data.
- Knowledge and research on the mobile genetic elements comprising antibiotic resistance genes and on drivers of its spread.
- Research on source attribution in metagenomic AMR surveillance.

Standardization and innovation of surveillance systems

Although not solely an issue for research and innovation to address, several issues regarding standardization, harmonization, updating/improvement, and innovation of surveillance systems were underlined by the workshop participants. These relate to the following challenges:

- Barriers to standardization of programs for surveillance of AMR, AMU and AMC (and the triangulation between) as well as analysis and assessment of all three types of data.
- Definitions of operational units of surveillance (AMR, AMC, infections, other public health indicators, etc.).
- Pathogen prioritization within One Health sectors.
- The use and application of AMR definitions (clinical, epidemiological, ecological) in different One Health sectors.
- Establishment and definition of clinical breakpoints for veterinary isolates.
- Establishment and definition of ECOFFs of different antibiotics for non-human bacteria.
- Establishment of criteria for ranking antimicrobials critical for human and animal use.
- Using surveillance data optimally, e.g. to estimate the burden of AMR and aid implementation of interventions, primarily by sharing data for action from existing local and regional surveillance programs with the public and private sectors and considering the recommendations in global programs.

Final remarks

Interdisciplinary and multisectoral collaboration is of huge importance, not only at the technical level but also in decision-making. From the AMR surveillance field, interdisciplinarity can be promoted by a clear approach to include scientific and political actors in implementation of findings and development of new and established systems. To fully achieve this, data gathered in each sector needs to be translated into implementation policies with a One Health approach.

Surveillance in antifungal resistance is very scarce. The priority should be to develop standardized and linked antifungal resistance surveillance networks at national and international levels, together with internationally harmonized definitions and methods that are suitable for HICs and LMICs alike.

This workshop was a tool for consultation, and its outcome represents the voices of invited speakers and those participants that registered and took active part in the discussions. The time-frame and the online format created some constraints for a deeper discussion and exploration of suggestions and arguments. In the preparation of this report, the JPIAMR thematic group on surveillance has combined their impressions, notes and conclusions from the workshop.

Annex 1. Workshop agenda

Day 1: 23 March 2022

12:45-13:00 Dial in and sound check

13:00-13:15 Welcome and opening, Maria Jose Ruiz Alvarez, Italian Ministry of Health. Moderator: Sabiha Essack, Antimicrobial Research Unit, University of KwaZulu-Natal, Durban, South Africa

13:15-14:30 Plenary session

Introduction of Strategic Research and Innovation Agenda, Laura Plant, JPIAMR secretariat, SRC, Sweden

Importance of the transnational research on AMR, Giuseppe Ippolito, General Director, DGRIC, Italian Ministry of Health

Synthesis Network Call Surveillance: achievements & recommendations. Etienne Ruppé, Université Paris Diderot, France

JPIAMR Network Call 2022: Diagnostics and Surveillance, Laura Kostelnickienė, Joint Call Secretariat 2022, The Research Council of Lithuania

14:30-14:45 Virtual coffee break

14:45-16:15 Roundtable discussion: AMR Surveillance: Focusing on integration, triangulation, transmission dynamics and risk, AMU and residues in the environment. Environment Data, role of AI, AMR surveillance in LMIC. All aspects under a global vision. Questions and open discussion on challenges and opportunities. Moderator: Gianmaria Rossolini, University Florence, Italy. Panellists: Teresa Coque; Sergey Eremin; Christian Menge; Chinyere Kyna Okoro; Pilar Ramon-Pardo; Jesus Rodriguez Baño

16:15-16:30 Wrap up and closing of the day, Sabiha Essack

Day 2: 24 March 2022

12:45-13:00 Dial in and sound check

13:00-13:10 Welcome and Opening, Maria Jose Ruiz Alvarez, Italian Ministry of Health. Moderator: Ana Alastruey Izquierdo, Instituto de Salud Carlos III, Spain

13:10-14:00 Plenary session

The importance of the research on the One Health AMR Surveillance, Silvio Brusaferro, President of National Institute Health, Italy

Fungal Surveillance in AMR, Ana Alastruey Izquierdo, Instituto de Salud Carlos III, Spain

14:00-15:15 Breakout sessions

Session 1: Innovations in surveillance. Moderator: Sabiha Essack, University of KwaZulu-Natal, Durban, South Africa. Rapporteur: Ulrica Dohnhammar, JPIAMR Secretariat, SRC, Sweden

How can AMR and AMC/AMU surveillance systems be innovated, standardized and correlated to (1) monitor emerging or escalating AMR and AMC/AMU and (2) inform and assess the impact of interventions? Assessing fitness of purpose and fitness for purpose.

Session 2: Surveillance, pandemic preparedness and climate action. Moderator: Luigia Scudeller, IRCCS Azienda Ospedaliero-Universitaria di Bologna, Italy. Rapporteur: Sophie Gay, ARN, France.

One Health AMR drivers are multifactorial, especially environmental ones: e.g. loss of biodiversity, urbanization, conflicts, climate change, and others. Preparedness means greater attention to prevention and detection of threats, ideally before they cause disease outbreaks. Mainstreaming AMR prevention into national plans for climate adaptation, biodiversity, environmental protection, societal changes and other sectors can reduce risks and promote early warning. Surveillance data are key to these aims.

Session 3: Environmental dimensions of AMR; residues (emissions) and resistance. Moderator: Nilton Lincopan, University of São Paulo, Brazil. Rapporteur: Maria Jose Ruiz Alvarez, DGRIC, Italian Ministry of Health.

Development of an innovative OH surveillance framework – techniques to collect, analyse and communicate surveillance data. Challenges to achieve integration across sectors. Surveillance of resistance to disinfectants.

15:15-15:30 Virtual coffee break

15:30-16:00 Plenary session

Presentation of the breakout results by the moderator to the audience.

16:00-16:15 Concluding remarks and closure by Ana Alastruey and Nilton Lincopan

Annex 2. Workshop speakers

Day 1

Maria Josè Ruiz Alvarez, MD, PhD. Scientific officer at the Directorate General for Research and Innovation in Healthcare, Italian Ministry of Health. She is a member of the Research Coordination and Support Service (CORI) in the Italian National Institute of Health (ISS) and a European Correspondent for Italy in ECRIN (European Clinical Research Infrastructure Network). Before joining the CORI, she worked as researcher at the HIV Centre (ISS). She represents the Italian Ministry of Health in several transnational collaborations and international funding programmes, mainly in the field of One Health Antimicrobial Resistance and Personalised Medicine. As such, she is member of the Management Board of JPIAMR and works on different related CSA and ERANet initiatives. At the national level, she is working on the National Plan on Antimicrobial Resistance.

Sabiha Essack, Antimicrobial Research Unit, University of KwaZulu Natal, South Africa. Sabiha Essack is the South African Research Chair (SARChI) in Antibiotic Resistance and One Health and Professor in Pharmaceutical Sciences at the University of KwaZulu-Natal (UKZN). She is also the Vice Chair of the WHO Strategic and Technical Advisory Group for Antimicrobial Resistance (STAG-AMR), Senior Implementation Research Advisor at the International Centre for Antimicrobial Resistance Solutions (ICARS) in Denmark, member of the Scientific Advisory Board of the Joint Programming Initiative on AMR (JPIAMR) and member of the International Pharmacy Federation (FIP) AMR Commission. Professor Essack is chairperson of the Global Respiratory Infection Partnership (GRIP), serves on the Advisory Board of the Combating Antibiotic Resistant Bacteria Biopharmaceutical Accelerator (CARB-X), the Fleming Fund Expert Advisory Group and is a member of the Wellcome Trust Surveillance and Epidemiology of Drug Resistant Infections Consortium (SEDRIC).

Laura Plant has a PhD in Microbiology and a research background in the field of bacterial pathogenesis and immunity. Since 2013, she has worked with research support with specialisation in research funding as a Grants Specialist at Karolinska Institute and as a Senior Research Officer at the secretariat of the Joint Programming Initiative on Antimicrobial Resistance at the Swedish Research Council. Her work focuses on supporting the JPIAMR scientific portfolio through driving and coordinating JPIAMRs scientific activities. She supports and

manages JPIAMRs EU-funded projects, is a Swedish National Programme Committee Expert for Widening and ERA in the Horizon Europe framework programme, and is the Swedish delegate in the Global AMR R&D Hub board.

Giuseppe Ippolito is since September 2021 Director General of the General Directorate for Research and Health Innovation of the Italian Ministry of Health. In the previous 23 years he was the Scientific Director of the National Institute for Infectious Diseases (INMI) “Lazzaro Spallanzani” in Rome and since 2009 the Director of the WHO Collaborating Center for clinical care, diagnosis, response and training on Highly Infectious Diseases. He graduated in Medicine at the University La Sapienza in Rome in 1978, and obtained a specialty degree in infectious diseases (1981), and dermatology (1984) and a Master’s Degree in Organization and Management of Health Institutions in 1997.

Etienne Ruppé (PharmD, PhD) is a clinical bacteriologist. After studying Pharmacy and Medical Biology at the Universities of Tours and Paris Descartes, he worked on the development of an automated detection system for the main antibiotic resistance genes in the intestinal microbiota, within the framework of the NOSOBIO project (financed in part by the OSEO investment bank). He did his PhD on the epidemiology of commensal, multidrug-resistant Enterobacterales and participated as scientific leader in the VOYAG-R project which aimed to measure the rate of acquisition of multidrug-resistant enteric bacteria during travel in tropical areas. He then left for a first post-doctoral internship in the pre-industrial demonstrator MetaGenoPolis. Within the framework of the European project EvoTAR, he worked on the identification of antibiotic resistance genes in the intestinal microbiota and their dynamics during various antibiotic exposures. He then did a second post-doctoral fellowship in the genomic research laboratory of the University Hospital of Geneva where he worked on the development of clinical metagenomics. There, he notably founded the first International Conference on Clinical Metagenomics (ICCMg). In 2017, he was appointed Assosciate Professor at the University of Paris Diderot and the Bichat-Claude Bernard Hospital, then Full Professor at the University of Paris in 2021. His area of expertise is antibiotic resistance in a global approach.

Laura Kostelnickiene is on a mission to help research teams build projects with a scientific impact. Trained as an economist, she has a background in the banking sector and advertising, providing stakeholders with a unique experience for over ten years. She works with programme funders all over Europe and represents national interests on budgets and procedures to ensure the implementation and success of national projects. In addition, she organizes training seminars to address applicant needs. She is a programme coordinator for the Research Council of Lithuania and today she represents the Joint Call Secretariat of the forthcoming JPIAMR Network Call 2022 on Diagnostics and Surveillance.

Gian Maria Rossolini, Full Professor at the Department of Clinical Experimental Medicine, Clinical Microbiology of the University of Florence, Italy. He has carried out research activities mainly in the following fields: a) genetics and physiology microorganisms, with particular regard to aspects relating to antimicrobial agents and bacterial chemoresistance; b) microbial biotechnologies aimed at the development of systems for heterologous gene expression and the creation of new products and protocols for the molecular diagnostics of infectious agents and resistance determinants. Prof Rossolini is a member of the Management Board and the Steering Committee of JPIAMR.

Day 2

Ana Alastruey, Spain's National Institute of Health Carlos III, is a research scientist at the Mycology Reference Laboratory of Spain. She has a PhD in microbiology and a MSc in bioinformatics. After completing her degree she was a Postdoctoral researcher at the Public Health Research Institute (New Jersey, USA) working in antifungal resistance. She joined Spanish National Centre for Microbiology (Madrid, Spain) in 2011 where she leads the moulds unit. She has been a visitor Scientist at The Fungal Biodiversity Centre (CBS, Utrecht, The Netherlands), Austrian Institute of Technology (AIT, Seibersdorf, Austria) and European Bioinformatics Institute (EMBL-EBI, Hinxton, UK). Her main area of research is focused in Medical mycology: Identification and early diagnosis of invasive fungal infections, standardization of antifungal susceptibility testing methods, resistance mechanisms to antifungals and taxonomy of fungal species. She has published over 130 peer reviewed papers, including several guidelines for diagnosis of fungal infections. She chairs the Fungal priority Pathogens list of WHO, is the current chair of the EFISG Study group from ESCMID, the director of Latin-American programs for GAFFI (Global Action

Fund for Fungal infections), Spanish delegate in the ECMM (European Confederation of Medical Mycology) board, Fellow of the ECMM (FECMM), vice president of the Spanish Society for Mycology (AEM) and the co-supervisor of the EUPHEM (European Public Health Microbiology training program) from ECDC in Spain.

Silvio Brusaferro President of the Italian National Institute of Health; Full Professor of Hygiene and Public Health at the University of Udine. Speaker of the Scientific Technical Committee (STC) with the role of advising and supporting the coordination activities to overcome the epidemiological emergency due to the spread of Coronavirus, Member of the EU Scientific Advice Platform on Covid-19 and Co-chair of the Global Health Summit Scientific Panel. He is actively engaged, at national and international level, in Public Health issues related to quality in healthcare, clinical risk and patient safety, infection prevention and control, antimicrobial resistance, best practices in public health and development of social networks to support health.

Luigia Scudeller (since March 2021 head of the Research and Innovation Unit of IRCCS Azienda Ospedaliero-Universitaria in Bologna, Italy) is a clinical epidemiologist with a clinical background in the Infectious Diseases field. Most of her research projects have been and are in the Infectious Diseases field. She is Medical Guideline Director of the European Society of Clinical Microbiology and Infectious Diseases since 2018 and Associate Editor of Clinical Microbiology and Infection since 2019. In 2019, she started coordinating a multidisciplinary international network (GAP-ON€) aiming at devising a strategy to obtain reliable estimates of costs attributable to AMR, in a global, fully One Health integrated approach.

Nilton Lincopan is currently is an Associate Professor at the Department of Microbiology, Institute of Biomedical Sciences, Universidade de São Paulo, Brazil, where he is coordinator of the Bacterial Resistance and Therapeutic Alternatives Lab. His research focuses on the monitoring and genomic characterization of drug-resistant bacteria at the human-animal-environment interface, in Brazil and South America. Their current project is the creation of the One Health Brazilian Resistance (OneBR) network that aims to create an Integrated Genomic Database for Surveillance, Diagnosis, Management and Treatment of Antimicrobial Resistance in the Human-Animal-Environment Interface.