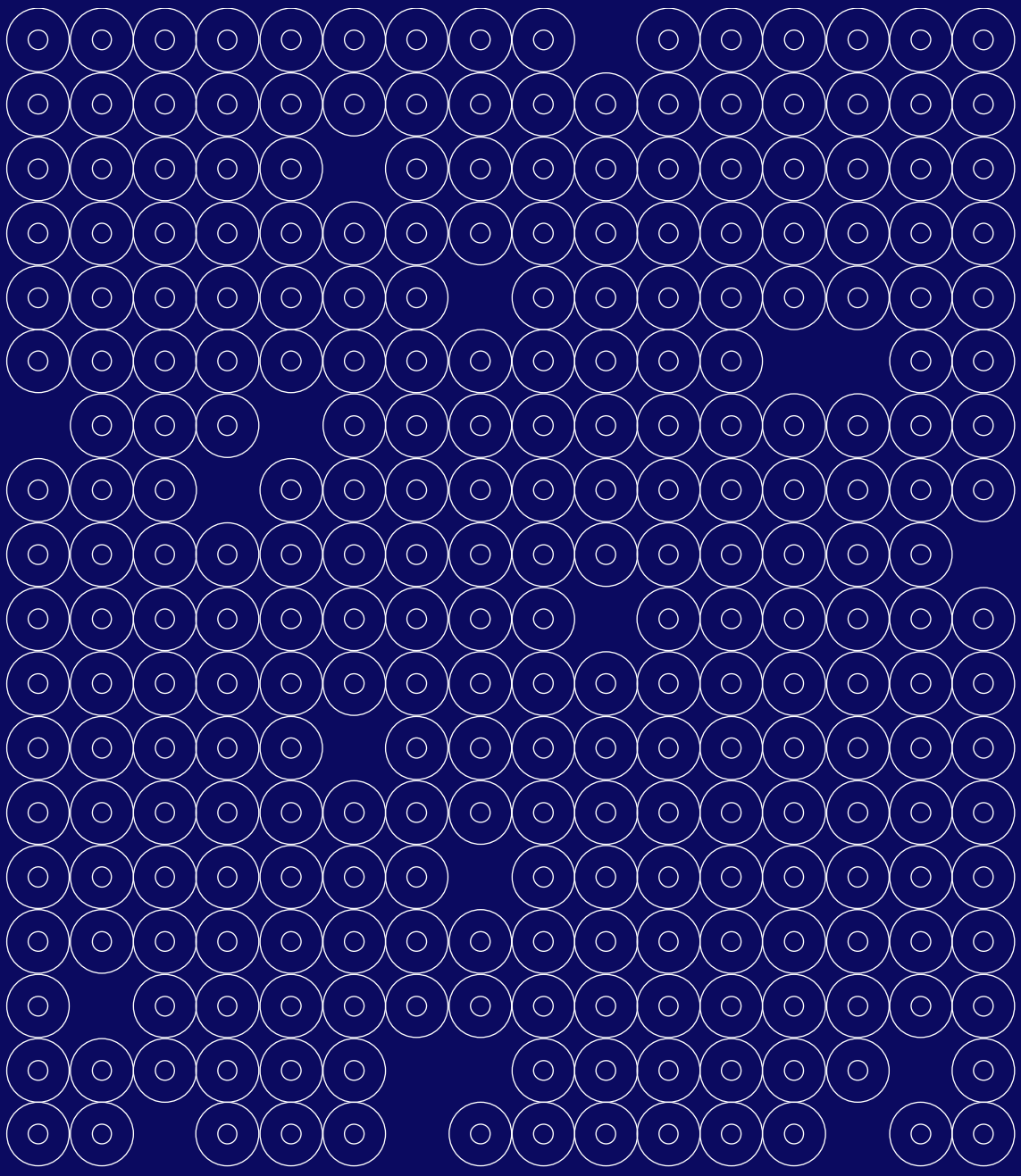
New Perspectives on Bacterial Drug Resistance

Online workshop 9 June 2022

CSA DESIGN OH AMR



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Background and Aims

The following report provides an overview of the consultation on bacterial drug resistance, organised by the Coordination and Support Action (CSA) DESIGN One Health AntiMicrobial Resistance (DESIGN OH AMR). The consultation was carried out by JPIAMR, together with UK Medical Research Council (MRC).

Within this consultation, the following activities were carried out:

- Bibliographic analysis to inform development of workshop
- Workshop on the 9th of June 2022 for early career researchers to provide a fresh perspective on bacterial resistance, with a one health perspective: "New Perspectives on Bacterial Drug Resistance"

Scientific rationale

The clinical problem

Clinical bacterial drug resistance has been an issue for longer than we have had antibiotics. Since the development of the Sulphonamide drug prontosil in 1932, many millions have been invested into both drug development and understanding drug resistance. However, despite our best efforts, gaps in our research remain: whilst the need for novel therapeutics, efficient diagnostics, adequate surveillance and appropriate interventions is widely acknowledged, much of this is not in place. Multidrug-resistant organisms continue to pose an ever-increasing threat on health-care systems globally. Issues such as inadequate hand hygiene, high-level use of broad-spectrum antibiotics, patient comorbidities, and use of medical devices are known risk factors for colonization or infection with resistant organisms.

One Health perspective

Transmission occurs at the interface between the three One Health domains (human, animal, and environmental health). Reservoirs of bacterial resistance exist in all settings, and as a result, we must attempt to address bacterial drug resistance using a One Health approach.

Strategic rationale

Bacterial drug resistance is one of the underpinning issues the One-Health AMR Partnership will be tasked with addressing. To address bacterial resistance, we must use interdisciplinary approaches based on One Health principles.

Although many millions have been invested into this field, gaps in our research remain: whilst the need for novel therapeutics, efficient diagnostics, adequate surveillance and appropriate interventions is widely acknowledged, much of this is not in place. We still do not know exactly where all of the gaps and opportunities for research are, and despite the existence of National Action Plans, we struggle to see exactly where research should be in five years' time.

By better understanding where the gaps are in our understanding of the problem of bacterial drug (and plant therapeutic) resistance, we can improve our targeting of research funding, and promotion of policy, advocacy, and antimicrobial stewardship to ensure that the most important gaps are tackled in the near future.

Aim of the Event

Antibiotic resistance is prevalent in bacterial infections across the world, threatening many of the fundamentals of modern medicine. A huge amount of work and funding has been focused on understanding antibiotic resistance and developing novel strategies to overcome this growing problem. The question is, where are the remaining research gaps in this area?

The aim of this workshop was to ask Early to Mid-Career Researchers to give us their thoughts on this question as they move to future leadership positions, to best focus future research to tackle antibiotic resistance.

Medical Research Council

The Medical Research Council (MRC) is one of the seven disciplinary research councils, working together as a part of UK Research and Innovation (UKRI). UKRI also encompasses Research England, which is responsible for supporting research and knowledge exchange at higher education institutions in England, and the UK's innovation agency, Innovate UK. The MRC's vision is for an outstanding research and innovation system in the UK that gives everyone the opportunity to contribute and to benefit, enriching lives locally, nationally, and internationally.

The heart of the MRC's mission is to improve human health through world-class medical research. To achieve this, we support research across the biomedical spectrum, from fundamental lab-based science to clinical trials, and in all major disease areas. We work closely with the NHS and the UK health departments to deliver our mission and give a high priority to research that is likely to make a real difference to clinical practice and the health of the population.

The MRC's mission is to:

- encourage and support research to improve human health
- produce skilled researchers
- advance and disseminate knowledge and technology to improve the quality of life and economic competitiveness of the UK
- promote dialogue with the public about medical research.

The Coordination and Support Action DESIGN OH-AMR

In 2021, the European Union (EU) launched "Horizon Europe", its framework funding programme for Research and Innovation. The creation of objective-driven and ambitious partnerships to support of EU policy objectives is one of the instruments deployed by the EU in this framework programme. In June 2017, the European Commission (EC) adopted the "EU One Health Action Plan against AMR" to address the emergency of

antimicrobial resistance (AMR) and its frightening consequences on Public Health. ”Boosting research, development and innovation” is one of the three main objectives of this action plan. Through the creation of a partnership ”One Health AMR” (OH AMR), EC and Member States aim to support the research and innovation objectives of the EU Action plan against AMR. The candidate partnership is expected to be launched in 2025. In order to prepare the launch of this partnership, the Coordination and Support Action (CSA) DESIGN One Health AntiMicrobial Resistance (DESIGN OH AMR) has been created in response to the HORIZON-HLTH-2021-DISEASE-04-05 call: “A roadmap towards the creation of the European partnership on One Health antimicrobial resistance (OH AMR).” In this framework, the CSA launched consultations on a broad range of key priority topics to inform the strategic research and innovation agenda of the future partnership.

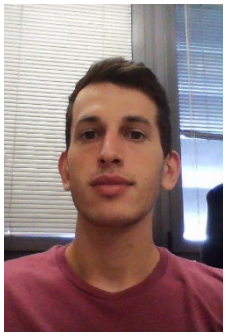
Steering Group, Chair and Speakers

Dr Gwen Knight (Chair)
Associate Professor, London School of Hygiene and Tropical Medicine, UK

Dr Gwen Knight's research focuses on investigating new methods to control the spread of Mycobacterium tuberculosis in South Africa, with a particular focus on the impact of antiretroviral therapy and isoniazid preventative therapy on long term TB disease incidence. She recently worked on a collaborative project to investigate the cost-effectiveness of TB vaccines funded by AERAS as well as a project to determine the population level impact on transmission of a shortening of TB drug regimens funded by the TB Alliance. Dr Knight is part of the TB modelling team and is affiliated with both the Centre for the Mathematical Modelling of Infectious Diseases and the TB Centre.

Dr Fernanda Paganelli
Assistant Professor, UMC Utrecht, NL

Dr Paganelli is assistant professor in the department of Medical Microbiology at the UMC Utrecht and coordinator of the microbiome studies for the Exposome HUB. She is an expert in molecular microbiology and has set-up a microbiomics workflow to study the microbiome dynamics in different patients' cohorts. Furthermore, she coordinates a European consortium (MISTAR-JPIAMR) and is part of Dutch One Health programs to study the resistome in the humans and animals. She has published more than 20 articles, including last co-author in leading scientific journals as Nature, Mbio, J. of infectious diseases and J. of Clinical Infectious Diseases.



Dr Mattia Pirolo
Post-Doctoral Research Assistant, University of Copenhagen, DK

I am a One Health microbiologist focusing my activities on multidrug-resistant bacteria of clinical and veterinary relevance, including methicillin-resistant *Staphylococcus aureus* (MRSA) and *Staphylococcus pseudintermedius* (MRSP), enterotoxigenic *Escherichia coli* (ETEC), ESKAPE bacteria and Cystic Fibrosis (CF) pathogens. I am currently involved in international research projects aimed at reducing antimicrobial consumption in pig production and at developing new diagnostic tools to rapidly identify antimicrobial-resistant pathogens in companion and farming animals. More recently, I partially moved my research interests to the investigation of the pig respiratory and gut microbiome and its influence in health and disease.

Dr Edward Haynes
Molecular Biologist, FERA, UK

Dr Haynes is a molecular Biologist at Fera Science, working on the Genomics and epidemiology of a bacterial disease. Dr Haynes is currently part of the sequencing team at Fera, studying plant pathology, untargeted detection of novel viruses, and the genomics of bacterial and fungal pathogens of plants and honeybees. His main interests are in genomic epidemiology of foodborne pathogens of humans, as well as microbial community analyses, for example in relation to untargeted detection of pathogens, or Antimicrobial Resistance (AMR) genes. He recently started a position as Science Fellow on the cross-departmental PATH-SAFE project, which will be developing a pilot surveillance system applying genomic tools to foodborne pathogens and AMR across the agri-food chain.

Dr Chantal Morel
Researcher, Universitäts Klinikum Bonn, DE

Dr Chantal Morel is a health economist specialising in infectious diseases, and in issues related to antimicrobial resistance in particular. Her work revolves mainly around the use of new financing arrangements and incentives to bolster innovation in the antibiotic pipeline to produce better products, improve surveillance of resistance, support antibiotic stewardship, and increase access to antibiotics where there clinical need currently unmet by supply. Dr Morel also does much work in estimating the cost of antimicrobial resistance and in the comparison of AMR-related interventions on an economic level (e.g. via cost-effectiveness, cost-utility analyses).

Dr Yinka Somorin
Marie Sklodowska-Curie, Fellow National University of Ireland (NUI), Galway

Dr Yinka Somorin is an early career scientist with a strong passion for excellence in academic research, teaching and developing human capacity. Dr Somorin is currently a Marie Sklodowska-Curie Fellow at the National Centre for Laser Application based at the National University of Ireland (NUI), Galway under the SPARKLE Fellowship programme, co-funded by the Marie Skłodowska-Curie Actions (EU) and Science Foundation Ireland. Dr Somorin's current research is focussed on the deployment of emerging technologies to develop novel applications. Under the mentorship of Prof Gerard O'Connor, Dr Somorin's current project is employing advanced manufacturing, laser technologies and tissue engineering to develop a scalable cardiac patch for cardiovascular disease management.

Invited Talks

Policy and National Action Plans - Dr Chantal Morel

Dr Morel discussed the critical challenges in this field, including limited implementation of National Action Plans (NAP), limited support for efforts to slow growth of AMR and inadequate investment. Dr Morel noted that most NAPs have varied components and foci, and those in Low and Middle Income Countries (LMICs) often incorporated components chosen by other countries.

Dr Morel noted the importance of having a national AMR champion to really push home the messages regarding the impact of AMR and noted one of the biggest challenges relates to the lack of evidence of what the increase in AMR costs countries at a national level. Dr Morel also discussed the issues of funding for implementation of NAPs. Dr Morel highlighted the SNAP ONE project, aiming to attribute a cost to AMR at country level in Zambia and Malawi using the framework set up by the GAP ONE network. Dr Morel noted the importance of developing standardised methodology to calculate the cost of AMR. Dr Morel also focussed on the limited global effort, in particular from high income countries, noting that this would likely only change if there is a case for self-interest for High Income Countries (HIC). Evidence from the COVID-19 pandemic shows that they can and will invest when there is an outbreak.

Human Health - Dr Fernanda Paganelli

Dr Paganelli discussed the major challenges for human health posed by the growing issue of antimicrobial resistance, noting that Antimicrobial resistance (AMR) has become one of the major Global Health Challenges. Dr Paganelli pointed out that rapidly evolving pandemics such as SARS-CoV-2 gain focus and traction, whilst AMR emergence is an endemic problem, slowly increasing, often under the radar, but depriving future generations of effective therapies if we cannot control it. Dr Paganelli underlined the issues posed by our lack of knowledge about the dynamics of the ARGs (antibiotic resistant genes) and ARB (antibiotic resistant bacteria) reservoirs, the abiotic and biotic selective pressures, and its consequences on the health of humans, animals, and the environment which precludes a risk assessment analysis. Dr Paganelli discussed the complex, multifactorial nature of AMR and the need to study this issue in a more complex, multifactorial way developing a better understanding of reservoirs of AMR in the ecosystem, and the impacts of dysbiosis on the transmission of resistance.

Dr Paganelli pointed out that development and implementation of efficient interventions will allow us to improve hygiene and preserving the healthy microbiome to prevent colonisation are necessary and novel approaches must be considered, including:

- Alternative therapeutics such as biodegradable antibiotics and faecal microbiota transplantation.
- Preventing transmission between animals, community, and patients
- Socioeconomic measures to break the ecological connectivity (One Health approach)

Animal Health - Dr Mattia Pirolo

Dr Pirolo discussed the focus of the One Health Antimicrobial Resistance (OHAR) group, on discovery and development of solutions for improving diagnosis and antimicrobial therapy of bacterial infections in animals using a One Health approach. Dr Pirolo pointed out that there were two key strategic themes in this field:

1. **Improved therapy**: minimize selection of antimicrobial resistance by optimizing use, choice, dosage, and duration of antimicrobial therapy
2. **Improved diagnostics**: rapid and accurate identification and antimicrobial susceptibility testing of bacterial pathogens is of key importance for guidance of antimicrobial choice

Dr Pirolo noted that the Antimicrobial Advice ad hoc Expert Group (AMEG) of the European Medicines Agency has classified antimicrobials for use in animals into four categories. Antimicrobials in animals are limited and not available for all disease conditions. Dr Pirolo went on to discuss the AVANT project, looking at alternatives to veterinary antimicrobials and the FARM CARE project, studying interventions to control antimicrobial resistance in pig farms. Dr Pirolo also discussed the issue with veterinary diagnostics, focusing on point of care testing, which is less well developed in the veterinary field than for human health.

Plant Health - Dr Ed Haynes

Dr Haynes discussed AMR in crop agriculture, noting that the use of antibiotics in agriculture can drive the evolution of AMR. However, the vast majority of work done to understand antibiotic use and AMR in agriculture to date has focussed on livestock.

Dr Haynes discussed the recent study of antimicrobial use in crops, focussing on the following questions and noting the low levels of engagement, indicating a likely issue with capacity in this field:

- What crop diseases are being controlled by antibiotics?
- What is known about antibiotic presence in the crop environment?
- What technologies are available for antibiotic and AMR detection?
- What is the evidence of co-selection of AMR by other agrichemicals?
- What are the knowledge gaps?

Dr Haynes pointed out that primary use of antibiotics in plant agriculture is to control bacterial diseases of pome, stone and citrus fruit, and vegetables, with the largest use on fireblight (apples) and potentially now citrus greening (citrus) in the USA. Resistance has arisen, but timing of spraying can reduce or eliminate presence of antibiotics themselves in fruit. Resistance mechanisms may also be different to those seen in human/livestock pathogens.

Recent work based on plant protection product recommendations in Low- and Middle-Income Countries suggests that rice has the highest proportion of recommendations for antibiotic use. Also, antibiotics are sometimes recommended for fungal diseases or invertebrate damage and used throughout year. Direct antibiotic use in crop agriculture,

where known, appears lower than in livestock agriculture. However, where regulations are weak or non-existent use may be widespread.

Dr Haynes also discussed the alternative sources of antimicrobials in crops, citing manure, sewage, and grey water as potentially important sources of antibiotics in crop agriculture. Antibiotics and AMR genes in the environment are readily assimilated into plants, but the results are highly variable, according to

- Compound
- Plant type
- Soil type and physical condition e.g., soil moisture
- Initial concentration- which is related to manure type and pre-treatment/application method/irrigation water
- Exposure time

Dr Haynes discussed the phenomena of co-selection, cross-resistance, adaptive resistance, diagnostics and surveillance of AMR in crops. Analytical methods to monitor the levels of antibiotics in cereals, fruit and vegetables published in the available literature are limited, compared with those available for the analysis of animal tissues. The role of a non-targeted approach to residue monitoring using high High-Resolution Mass Spectrometers will become increasingly important in the identification of residues present in edible crops. This approach has the potential to monitor for the presence of residues of thousands of different compounds, of all chemical classes. Dr Haynes also discussed diagnosis of resistance:

- Phenotyping – methods developed to phenotype individual bacterial cells.
- Targeted molecular – LAMP assays to detect genes and infer phenotype.
- Non-targeted – metagenomic and metatranscriptomic approaches.

Dr Haynes suggested the following future areas of focus:

- A greater understanding of antibiotic metabolism or bioaccumulation in plants, to help with future risk assessments.
- Many widely used agrichemicals remain to be assessed for their ability to co-select for AMR.
- Methods to encourage participation in information sharing activities could be developed.
- Increased surveillance could be taken to assess prevalence of antibiotics and AMR genes/bacteria on crops imported from countries which are either unknown risk but large-scale suppliers, or countries where misuse is suspected, or both

Gaps in AMR Research - Dr Yinka Somorin

Dr Somorin gave an extensive overview of both the issues caused by AMR and where gaps remain in our understanding of this problem. Dr Somorin highlighted that West Africa has the highest burden of AMR, noting 27.3 deaths/100,000 directly attributable to AMR and 114.8 deaths/100,000 associated with AMR. Dr Somorin noted that lower Respiratory and Thorax, Bloodstream and Intra-abdominal infections were the most

predominant. Dr Somorin also underlined the importance of considering the burden of AMR in a local context.

Dr Somorin suggested that AMR could be tackled by reducing infection and therefore the need for antimicrobials and proposed a focus on the following solutions:

- Water, sanitation, and hygiene practices
- Surveillance to understand prevalence of resistance and data gaps
- Expand microbiology laboratory capacity (Infrastructure & Personnel)
- Vaccines
- Prescription practice
- Improved diagnostics
- Better access to antibiotics
- Education to promote Behavioural Change

Speaker Abstracts

Comparing empirical treatment regimens for the programmatic management of drug-resistant tuberculosis

Finn McQuaid

Choosing the most effective regimen for a patient requires accurate and timely drug susceptibility testing (DST). In the last decade there has been wide-spread roll-out of rapid molecular tests that can identify M. tuberculosis, (TB) and mutations conferring rifampicin resistance. However, for potent second-line drugs, DST coverage is lower and results less timely when available. To support clinicians, policymakers must provide empiric treatment recommendations for situations where a patient is diagnosed with rifampicin-resistant (RR) TB but where additional DST results are unavailable.

Approximately half of patients with RR-TB do not have rapid access to fluoroquinolone DST. Policymakers are faced with two choices for this group. First, they could recommend starting a treatment regimen that assumes fluoroquinolone susceptibility. Second, they could recommend starting treatment with a regimen that assumes fluoroquinolone resistance. Both options have risks that vary according to population characteristics, in particular the prevailing fluoroquinolone resistance prevalence. These risks include treatment failure and onward transmission (a regimen is given assuming fluoroquinolone-susceptibility to a patient with a fluoroquinolone-resistant organism) or unnecessary adverse events and increased costs (a regimen is given assuming fluoroquinolone-resistance to a patient with a fluoroquinolone-susceptible organism). Policymakers must decide which risk is more acceptable on a population level.

This question, how best to prescribe empirically and how that decision should change as a population's resistance profile changes, extends beyond TB and fluoroquinolones. New methods are required to allow quantitative comparisons of the risks and benefits between regimen choices, to support treatment guideline development for when key DST information is unavailable.

AMR research to inform national policy

Eve Tresco Emes

In order to make policy decisions given finite resources, we need to understand the epidemiological and health economic implications of antimicrobial resistance and AMR-related policies at the population level and across all relevant sectors

This requires accurate quantification of two relationships: (i) what specific effect do policies have on the overall prevalence/burden of resistant infections? and (ii) what are the full health economic implications of these changes to the AMR burden across all relevant sectors, expressed in like terms?

Present research has not been able to answer these questions, and generally does not seek to. AMR is often approached from a microbiological lens; and when the population

level is considered, AMR is conceived as primarily a human health problem and with limited methodologies, ignoring much (if not most) of its impact.

This means that we are left unable to answer some very urgent and fundamental questions, including (i) whether or not 'prudent' antimicrobial use (AMU) alone is enough to result in an unsustainable level of resistance; (ii) the extent to which animal AMU contributes to human AMR at the population level; (iii) how the concerns of different stakeholders compare to each other in the context of AMR; (iv) which national-level policies are worth implementing, and the appropriate amount of resources to allocate to them

This presentation introduced a comprehensive framework for answering these questions in a way which is maximally informative to policy. The framework is complex and therefore aspirational, aiming to contribute to agenda setting in future research.

The burden of antimicrobial resistance in populations affected by humanitarian crises

Kevin van Zandvoort

Over 82 million people are forcibly displaced worldwide as a result of armed conflict, food insecurity, or other humanitarian crises. Crisis-affected populations experience increased disease and mortality rates, with respiratory infections and diarrheal diseases the leading causes of mortality. A substantial proportion of these infections is caused by bacterial pathogens.

Crises often occur in low- and middle-income countries, in settings that already face several antimicrobial resistance burden challenges. Certain risk factors that can accelerate both the emergence and spread of AMR are often prevalent in crises, including overcrowding, malnutrition, inadequate water, sanitation and hygiene systems, and insufficient access to curative and preventative healthcare. Insecurity can result in unreliable supply chains, affecting antibiotic availability, quality, and stewardship. In armed conflicts, heavy metals following the use of munitions and destruction of buildings may contaminate the environment, which can further drive AMR development.

High resistance rates have been observed for different pathogens in a number of settings. In the Democratic Republic of Congo, 75% of bacteria in neonatal sepsis cases were resistant to WHO recommended antibiotics. However, in general, there is a lack of data on the AMR burden in the majority of crisis-affected populations. More research is needed to improve our understanding of the AMR burden. While research can be challenging in these settings, it will allow humanitarian actors to develop effective mitigating strategies and better address the needs of these people.

The path of least resistance: Infection Prevention and Control

Nidhee Jadeja

The challenge of AMR is closely linked with hospital-acquired infections (HAIs). Conditions in low and middle-income countries are said to be a "perfect storm" for high rates HAIs, due in part to more complex care services being offered, inadequate infection prevention and control (IPC) capacity and infrastructure, and overcrowding. In the first ever global report on IPC released this year by the WHO, only four out of 106 countries analysed had all the minimum requirements for IPC in place at the national level. LMICs face substantial IPC implementation challenges that are not yet fully understood. Yet there is a significant dearth of implementation research compared to drug-development and surveillance in global AMR efforts. IPC against AMR is a cornerstone in combatting the spread of AMR and should be a high priority for global health researchers and policy makers. The Covid-19 pandemic has exposed the gaps in IPC measures in countries but also offers an unprecedented opportunity for us to better understand and address the implementation challenges in LMIC health systems. It is now urgent to address the key implementation research gaps towards strengthening IPC for HAIs and AMR in LMICs.

Generating evidence on potential (non-)inferiority of no antibiotic prescribing strategies for common conditions in companion animals and consequences in terms of antimicrobial resistance

Koen Pouwels

Efforts to reduce antibiotic prescribing have largely focused on reducing antibiotic prescribing among humans and food producing animals. However, while the sales of antibiotic for food-producing animals reduced substantially in the UK, antibiotic sales in companion animals did not. Importantly, a survey among several European countries indicated that broad-spectrum antimicrobials and critically important antimicrobials for human medicine represent more than two-thirds of the total number of antibiotic courses among companion animals.

There are several reasons to aim to reduce antibiotic use in companion animals, including lowering the risks of side effects for the treated animal; preventing or reducing the development and transmission of AMR within the treated pet; and the onward transmission of resistant bacteria or mobile genetic elements to owners.

An important gap in the current evidence base is the impact of (behavioural) interventions on antibiotic resistance among bacteria that are part of the microbiome at the time of antibiotic treatment. Multidisciplinary research projects are needed for the design, implementation and analysis of randomised controlled trials that evaluate the effectiveness of antibiotic stewardship interventions or no-prescribing strategies for common reasons of consultations with companion animals. This requires not only assessment of the impact of immediate clinical outcomes, but also impact of antibiotic use on the microbiome of companion animals and their owners and a better understanding of the subsequent consequences of an altered microbiome.

Registered Participants

Figure 1. Map of registrations received.

Statistics

A total of 161 potential participants registered for the event and 85 took part on the day. Registrations were received from across the globe (see Figure 1) and participants on the day included individuals from as far afield as the Ukraine, Canada, and Brazil. The event aimed to encourage attendance from early-stage researchers, and 20% of the registrants were students. The most commonly represented type of organisations were Universities and Research Institutes (67%) and clinical organisations, including hospitals, clinics, and public health organisations (13%). Other types of organisations included funding bodies and policy making organisations. Following the event, the recording on YouTube reached 126 views in two weeks.

Consultation

Upon registration, participants were asked to list what they felt were the most pressing gaps in the field of bacterial drug resistance research. Several common themes emerged from these responses including:

- Improved clinical trial design- non inferiority trials
- Understanding the links between antibiotic prescribing behaviours and development of resistance
- Resistance in the microbiome and what a healthy microbiome looks like
- Large-scale international initiative for collection and analysis of genomic data and phenotypic metadata on both sensitive and resistant strains of bacteria
- Development of novel therapeutics and alternatives to antibiotics

Workshop Outcomes

The workshop ended with a discussion of the common themes raised by all speakers. It was noted that much of the existing debate has focussed on developing new antibiotics and ensuring sustainable economic initiatives to enable this.

Areas thought to me more neglected included:

- Rapid, accessible diagnostics for humans, plants and animals and economic incentives to enable these
- Prevention of infection
- understanding the source of the infection,
- Stewardship and preventing unnecessary use of antimicrobials
- Further understanding the role of resistance in a healthy microbiome
- Understanding drivers and transmission of resistance in crops
- Additional focus and finance to understand the challenges faced by LMICs
- Local context can have a considerable impact on development of disease and resistance

Annex I. Workshop Agenda

JPIAMR Workshop

New Perspectives on Bacterial Drug Resistance

Date: 9th June 2022 12:00 BST-14:30 BST
Location: Online- Zoom

Purpose: To identify key priorities, challenges, and opportunities for research in the topic of antibiotic resistance in order to define future priorities for funding bodies. To achieve this the workshop aims are:

- To identify our existing knowledge regarding antibiotic resistance
- To identify knowledge gaps for further research
- To consider the policy implications of bacterial drug resistance
- To identify and prioritise future research priorities for bacterial drug resistance

Workshop Start: 12:00 BST

12:00 Welcome and introduction (5 minutes)

JPIAMR and Dr Gwen Knight (LSHTM)

12:05 Short Keynotes:

Perspectives on bacterial drug resistance (10 min each)

Speakers:

Policy and National Action Plans - *Dr Chantal Morel (University of Bonn)*

Human Health - *Dr Fernanda Paganelli (UMC Utrecht)*

Animal Health - *Dr Mattia Pirolo (University of Copenhagen)*

Plant Health - *Dr Edward Haynes (FERA)*

12:45 Break (15 mins)

13:00 Presentations: Short perspectives from Early Career researchers

Finn McQuaid (LSHTM)

Nidhee Jadeja (Imperial College London)

Yinka Somorin (National University of Ireland)

Koen Pouwels (University of Oxford)

Kevin van Zandvoort (LSHTM)

Eve Tresco Eames (LSHTM)

14:00 Open discussion session and questions for Speakers (30 min)

Moderator: *Dr Gwen Knight*

14:30 Closing remarks (5 mins)

Speaker: *Dr Gwen Knight*

Workshop Close 14:35 BST