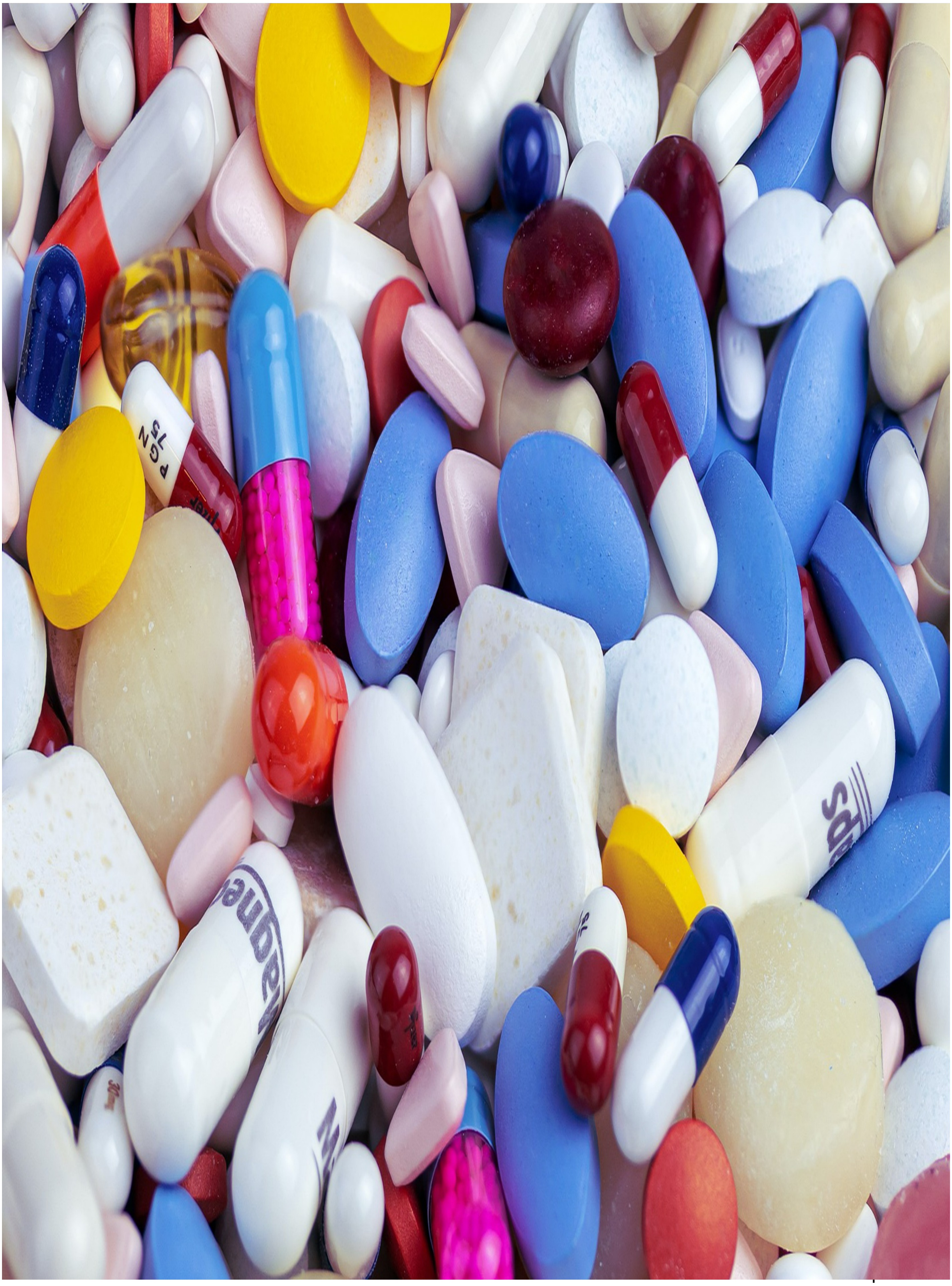
AMR IN THE COMMUNITY



About the AMR Global Health Strategy Group

The AMR Global Health Strategy Group is chaired by Christiane Dolecek, Associate Professor, Centre for Tropical Medicine and Global Health, University of Oxford and Mahidol-Oxford Clinical Research Unit, Scientific Lead and Co-PI on the Global Burden of Disease-Antimicrobial Resistance (GRAM) Study, and Andrew Jack, Financial Times Global education editor and coordinator of several health projects, including the FT Health: Future of Antibiotics. The Strategy Group brings together experts from around the world drawing on the skill sets and optimism of both the global North and South to collaborate in finding practical ways to tackle AMR. Reports of the activities of the AMR Group are designed to gather and share real-world experiences and lessons, give an opportunity to hear and learn from a diversity of voices from around the world, draw a community of practice together around key challenges, and drive a research and policy agenda for practical action.

Contents

Acknowledgements

We gratefully acknowledge the financial support of the INEOS Oxford Institute and of the ITU-WHO for making this workshop and report possible.

We are immensely grateful for the contributions of a wide range of experts, including scientists, clinicians, and public health officials.

Research and Writing Team

Andrew Farlow

Humayra Aisha Bashir

Mohamed Bella Jalloh

Yuzana Khine Zaw

Speakers

Joseph Sam Kamu
AMR Focal Person,
Ministry of Health,
Sierra Leone.

Nga T T Do
Oxford University Clinical
Research Unit (OUCRU)
Hanoi, Vietnam

Shamsudin Aliyu
HOD, Medical
Microbiology, Ahmadu
Bello University
Teaching hospital, Zaria,
Nigeria

Heimann Wertheim
HOD, Medical
Microbiology
Radboudumc, the
Netherlands, and
Project Lead ABACUS
consortium

Uthman Umar
Aminu Kano Teaching
Hospital, Kano,
Nigeria/Nigeria Field
Epidemiology &
Laboratory Network

Olanrewaju Jimoh
Consultant Medical
Microbiologist, ABU,
Zaria, Nigeria

Sussane Schink
Infectious Disease
Epidemiologist
Robert Kock Institute,
Berlin, Germany

Sebastian Haller
Senior Epidemiologist
Robert Koch Institute.

Nada Malou
Antibiotic project Scientific Lead, MSF; Driver of "Diagnoses of bacterial infection and AMR Group- ITU/WHO.

Yann Ferrisse
Head: Business Development & Analysis & SECURE project lead, (GARDP), Geneva, Switzerland.

GLOSSARY

Acronym	**Definition**
AI	Artificial Intelligence
AMR	Antimicrobial resistance
AMU	Antimicrobial Use
AST	Antimicrobial susceptibility testing
CA-MRSA	Community-Associated MRSA
CRP	C-Reactive Protein
DDD	Defined Daily Doses
GARDP	Global Antibiotic Research and Development Partnership
GLASS	Global Antimicrobial Resistance and Use Surveillance System
HA-MRSA	Hospital-associated MRSA
HICs	High-Income Countries
HGT	Horizontal Gene Transfer
IAGG	Inter-Agency Coordination Group

LMICs	Low- and Middle-Income Countries
LOMWRU	Lao-Oxford-Mahosot Hospital-Wellcome Trust Research Unit
MDR	Multi-drug resistant
MRSA	Methicillin-resistant Staphylococcus Aureus
NAFDAC	National Agency for Food and Drug Administration and Control
NG	Neisseria Gonorrhoea
STI	Sexually Transmitted Infection
VGT	Vertical Gene Transfer
WASH	Water, Sanitation, and Hygiene
WHO	World Health Organisation

Foreword

Antimicrobial resistance (AMR) is an evolutionary process in which microorganisms continue to proliferate in the presence of antimicrobial agents that would ordinarily kill or inhibit them. As a consequence, AMR is a major threat to human health around the world and tackling it a high priority. According to recent estimates, in 2019 for 23 bacterial pathogens across 204 countries there were 1.27 million (95% UI 0·911–1·71) deaths attributable to AMR, and 4.95 million (3·62–6·57) deaths associated with infections with antibacterial resistant pathogens. Globally, the impact of AMR-related mortality varies greatly, with the burden being greatest in developing countries.[1] The all-age death rate attributable to resistance in this study is estimated to be highest in western sub-Saharan Africa, at 27·3 deaths per 100 000 (20·9–35·3), and lowest in Australasia, at 6·5 deaths (4·3–9·4) per 100 000. Tackling AMR in LMICs is a key component of any global strategy to deal with the threat of AMR, because resistance in any part of the world is a risk to any other part of the world.

[1] Murray CJ, Ikuta KS, Sharara F, Swetschinski L, Robles Aguilar G, Gray A, et al. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. The Lancet [Internet]. 2022 Feb 12 [cited 2022 Jul 26];399(10325):629–55. Available from: http://www.thelancet.com/article/S0140673621027240/fulltext.

In 2014, the World Health Organization (WHO) released its Global Action Plan (GAP) for tackling the growing global threat of AMR. Although over 100 countries have produced National Action Plans (NAPs) to combat AMR at the national level and so to support global action, implementation remains weak in many countries. Particularly in contexts where regulation remains a challenge, implementation of national action plans do not translate into action or become a box-ticking exercise with limited productive outcomes. Countries need support and encouragement, including from each other, to turn their NAPs into practical action, and both high-income countries (HICs) and low- and middle-income countries (LMICs) need to work together, including by sharing methods, lessons, and resources.

To this end, the Global Health Strategy Group for Antimicrobial Resistance, part the Global Health Policy Partnership, an initiative of the University of Oxford, brought together diverse groups striving to make progress on tackling AMR in the community. This report synthesises insights and analysis from this workshop and from feedback and further engagements after the workshop. It highlights key challenges faced by communities with a particular focus on LMICs engaged in the fight against AMR. Lower respiratory infections accounted for more than 1·5 million deaths associated with resistance in 2019, making it the most burdensome infectious syndrome, and much of that burden falls in LMICs. Moreover, the report provides a spotlight on positive initiatives underway in a number of LMICs.

Without immediate bold action, humanity risks facing an end to the antimicrobial era, a time when common infections will no longer be treatable and many health interventions, such as surgery, will become extremely risky. Many opportunities exist to prevent this apocalypse. We need to act now!

"Community-associated antimicrobial resistance is still overlooked. And I think that's why this particular workshop is so important – it gives us an opportunity to focus on that and see what can be done."

Background to the Workshop

Tackling "AMR in the community" should be at the heart of any long-term strategy for dealing with the global threat of AMR but is often neglected, in not only LMICs but around the globe. This is due to the difficulties of creating standardised, reproducible, and viable metrics to assess surveillance of resistance, consumption of antibiotics at the community level, and creating and paying for regulatory mechanisms and the infrastructure to support broad implementation. AMR surveillance capabilities vary across different parts of the world, making standardisation difficult. This is a particular challenge for many short-term, human development and health initiatives that must prove their worth through short-horizon siloed impact measures.

There is a paucity of data from community-practice settings that adequately reflects local AMR trends, particularly in LMICs. In some regions there is widespread lack of appropriate antibiotics even as in other regions there is mass unregulated use of antibiotics and misuse; thus, there is a poorly understood AMR burden and a looming threat in the community. For example, *Methicillin-resistant Staphylococcus aureus (MRSA*) acquired in the community is thought to be an epidemic risk, with life-threatening implications.[2] *Multidrug resistant (MDR) and extensively drug resistant tuberculosis (XDR)* is yet another example[3].

Because such a high proportion of AMR-related data sources, such as microbial databases and hospital discharge data, rely on hospital-based sampling, community-associated infections are often under-recorded or mis recorded and data and priority setting inadvertently skewed. For example, in 2009, the WHO examined AMR in five distinct locations in India and South Africa using community-based surveillance methods.[4] However, surveillance was primarily based on *E. coli*, while attempts were made to include *S. Pneumoniae and H. Influenza*. Furthermore, sites with established surveillance systems were chosen such that samples came from urban regions next to 'major hospitals'. The study lacked data on AMR in animals or the environment. These data gaps in many LMICs point to the need to expand surveillance and microbiology laboratory capacity in such settings to cover livestock, environmental, and clinical infections. On a positive light, there are now concerted efforts towards filling these gaps. For example, The Oxford INOES Institute for Antimicrobial research has projects in LMICs namely the BARNADS and AVIAR study which aim to examine the burden of AMR in new-borns and the role flies and insects play on AMR spread respectively

As such data, builds up, carefully recorded with associated metadata (such as environmental, geospatial, socioeconomic, and other data), it will be easier to explore One-Health linkages, assess risk factors and routes of AMR, and refine appropriate interventions.

Pathogen distributions vary substantially between hospital-associated and community-associated infections. For example, the Global Burden of Disease study of AMR estimated that in 2019 globally 17.4% (95% CI 13.1 - 22.4) of lower respiratory and thorax infections were hospital-associated, varying from 27.9% (20.5 - 35.8) in Central Europe, eastern Europe, and central Asia to 9.3% (6.9 - 12.8) in Sub-Saharan Africa, and that globally 39.1% (32.4 - 61.5) of urinary tract infections were hospital-associated, varying from 64.5% (48.4 - 74.7) in Southeast Asia, east Asia, and Oceania to 24.9% (18.0 - 31.1) in Sub-Saharan Africa. Tackling risk factors in the community for these infectious syndromes is clearly an especially high priority in Sub-Saharan Africa.[5]

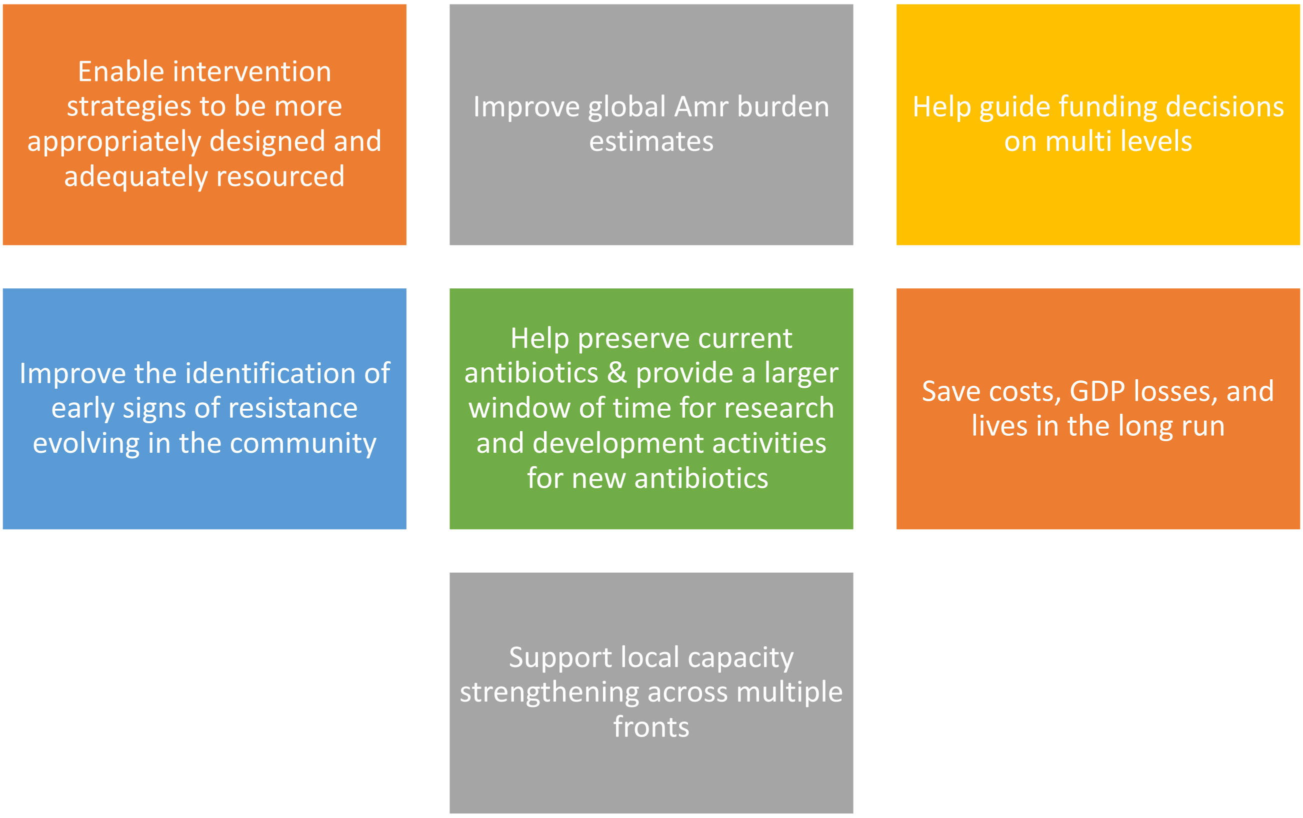
[2] Bubacz MR. Community-associated methicillin-resistant Staphylococcus aureus: an ever-emerging epidemic. AAOHN J. 2007 May;55(5):193-4. doi: 10.1177/216507990705500504. PMID: 17526296.

[3] Gandhi, N. R., Nunn, P., Dheda, K., Schaaf, H. S., Zignol, M., Van Soolingen, D., ... & Bayona, J. (2010). Multidrug-resistant and extensively drug-resistant tuberculosis: a threat to global control of tuberculosis. *The Lancet*, *375*(9728), 1830-1843.

[4] World Health Organization. (2009). Community-based surveillance of antimicrobial use and resistance in resource-constrained settings: report on five pilot projects. World Health Organization. https://apps.who.int/iris/handle/10665/70036

[5] Murray, C. J., Ikuta, K. S., Sharara, F., Swetschinski, L., Aguilar, G. R., Gray, A., ... & Naghavi, M. (2022). Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *The Lancet*, *399*(10325), 629-655., Supplementary Appendix pp 17–30

A BETTER GRIP ON THE TRUE SITUATION OF AMR IN THE COMMUNITY WILL HAVE NUMEROUS BENEFITS:



- It will help improve global AMR burden estimates and their subclassification by infectious syndrome.
- It will enable intervention strategies to be more appropriately designed and adequately resourced, balancing the needs of hospital-based infection prevention and control programmes that focus on preventing health-care-associated infections, with the needs of community-based programmes that focus on community-health, water, sanitation, and hygiene interventions to modify the risk factors for generating AMR.
- It will help guide funding decisions on multiple levels, from how much to invest in different antimicrobial R&D projects to how much to invest in health protection and preventative measures.
- It will improve the identification of early signs of resistance evolving in the community, thus enabling quicker action to prevent resistance from spreading and becoming less controllable.
- Since AMR that starts in the community has the potential to reduce the efficacy of antibiotics, it is crucial to address AMR to help preserve the antibiotics that we have, while also providing a larger window of time for research and development activities for new antibiotics.

- It will support local capacity strengthening across multiple fronts (diagnostics, surveillance, new antibiotic development), the training of new generations of researchers from LMICs, and local responsibility for stewardship of antimicrobials and medicines, and health system strengthening efforts at all levels.
- It will save costs, GDP losses, and lives in the long run.

Purpose of the Workshop

"… I would like to say that AMR is a serious public health threat…concerted effort is needed from all stakeholders to determine its magnitude, distribution and determinants at the community level so that appropriate preventive strategies can be applied to address the threat. The time to act is now!"

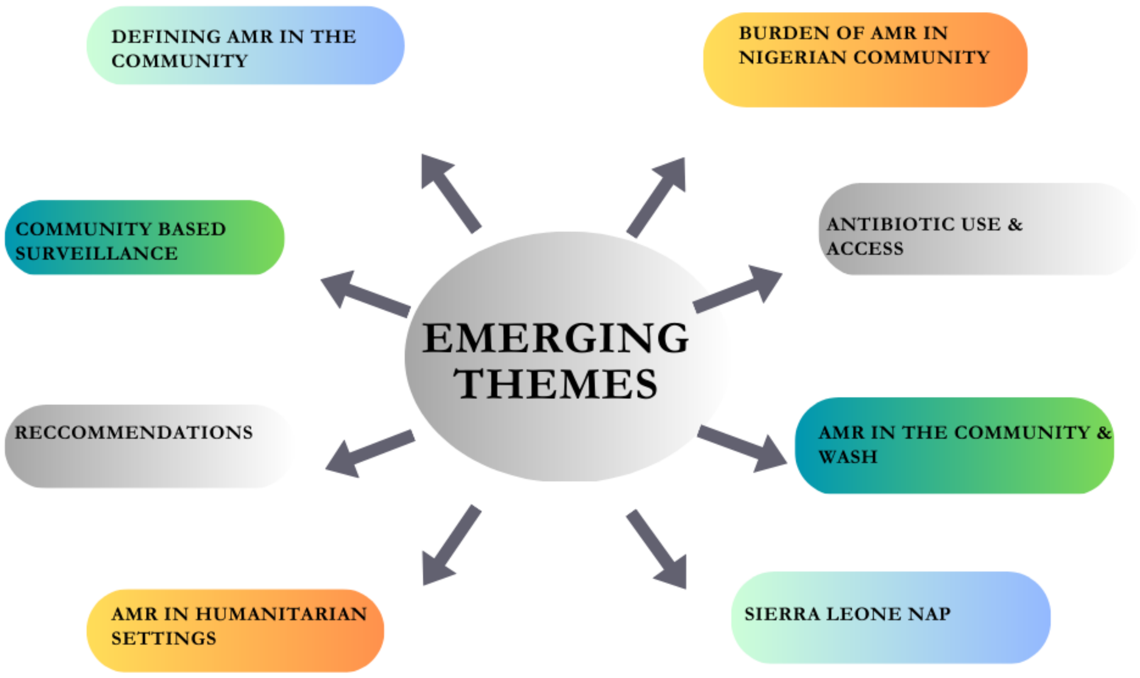
There is an urgent need to develop standardised, reproducible, and practical surveillance methods for assessing AMR and antimicrobial use in the community to inform the formulation of policies and interventions at the community level. It is equally important to include veterinary and environmental surveillance if a complete picture of AMR in the community is to be ascertained. We already know the crucial role WASH (Water, Sanitation, and Hygiene) plays in preventing AMR — be it in community or hospital-based settings. We also increasingly recognise that any surveillance method that is 'community facing' needs to be transdisciplinary, One-Health, cross-sectoral, and non-siloed.

A handful of initiatives, especially in wealthier countries, have been established to tackle AMR in the community such as the community antimicrobial use arm of the Antimicrobial Use and Resistance in Australia (AURA) and Community Engagement for Antimicrobial Resistance (CE4AMR).[6] However, such initiatives continue to face obstacles, particularly in resource-constrained settings that lack robust health systems and strong governance.

The Global Antibiotic Research and Development Partnership (GARDP) is, on the one hand, developing a public-health oriented portfolio of antibiotics (through a public-private partnership), including hospital-based and community-based products and, on the other hand, ensuring responsible stewardship of and sustainable access to antibiotic treatments, addressing the public health impact of antibiotic resistance. Combining access, appropriate use and the right business model at the community level is a challenge that must be addressed quickly.

Emerging Themes

[6] AURA. Community Antimicrobial Use | Australian Commission on Safety and Quality in Health Care [Internet]. [cited 2022 Feb 9]. Available from: https://www.safetyandquality.gov.au/antimicrobial-use-and-resistance-in-australia/community-antimicrobial-use. Community Engagement for Anti-microbial Resistance [Internet]. [cited 2022 Nov 2]. Available from: https://ce4amr.leeds.ac.uk/



Defining 'AMR in the community'

To begin, let us define AMR in the community, or to be more precise, what we mean by the community in terms of antimicrobial resistance. Any case of antimicrobial resistance occurring outside of a hospital setting would fall under this definition according to the European Union 's definition.[7] The Australian Commission on safety and quality in healthcare defines the community as 'aged care homes, general practices, community health services, and non-hospital settings'.[8] In many LMICs, a 'community' would be any clinical setting except tertiary hospitals.

On the other hand, a 'Community-associated infection' has a seemingly straightforward criteria and definition (see Box 1) and as a result, several pathogens are known culprits for community-associated infections.

During the workshop, Dr Shamsudin, Consultant Medical Microbiologist and Head of Medical Microbiology department, Ahmadu Bello University, Nigeria, began his presentation by drawing on the dictionary definition – 'People living in one particular area or people who are considered as a unit because of their common interests, social group, or nationality' – that it isn't limited to the confines of a hospital, especially teaching/tertiary hospitals where the majority of our data is from. Rather it encompasses primary healthcare settings, clinics and, crucially, non-healthcare settings, for example, farms, restaurants, households, and water bodies. Subsequently, discussions centred

7 Antimicrobial Resistance Tackling the Burden in the European Union Briefing note for EU/EEA countries Contents

8 Community Antimicrobial Resistance | Australian Commission on Safety and Quality in Health Care [Internet]. [cited 2022 Jun 16]. Available from: https://www.safetyandquality.gov.au/our-work/antimicrobial-resistance/antimicrobial-use-and-resistance-australia-surveillance-system-aura/community-antimicrobial-resistance

on drivers of antimicrobial resistance in the community, ongoing research and interventions, and finally challenges and recommendations.

Type of infection	Causative agent(s)	Traditional antimicrobial therapy	Current estimated community prevalence of resistance
Respiratory tract, conjunctivitis, otitis	*Streptococcus pneumoniae, Haemophilus influenzae, Moraxella catarrhalis*	Penicillin	20%–60%, ~20%, ~95%
"Strep" throat, impetigo	*Streptococcus pyogenes*	Penicillin, Erythromycin	45%, 10%–30%
Tuberculosis	*Mycobacterium tuberculosis*	Isoniazid, rifampin	0.7% (for both drugs combined)
Gonorrhea	*Neisseria gonorrhoeae*	Penicillin, Tetracycline	20%–90% 0%–46%
Skin and soft tissue, sepsis, pneumonia	*Staphylococcus aureus*	Methicillin	0.84%, but multiple outbreaks reported
Gastrointestinal, diarrhea	*Salmonella enteritidis, choleraesuis*	Non-typhi species should not be treated with antibiotics	Depends on subtype: multi-drug resistant strains, 1%–25%
	Shigella spp.	Ampicillin, Trimethoprim-sulfamethoxazole	78%, 46%
Enteric fever	*Salmonella typhi*	Fluoroquinolones, Third-generation cephalosporins	25%–40% resistant to one or more agents, 17%–20% resistant to >5 agents
Cholera	*Vibrio cholerae*	Supportive treatment, usually Tetracycline, Ampicillin, Co-trimoxazole	Resistance to at least one agent now >90%

Table 1| Emergence of antimicrobial resistance since 1980s among bacteria causing common community infections[9]

Mechanism of Community Antimicrobial Resistance

As the WHO explains it, 'AMR occurs when bacterial, fungi, viruses and parasites change over time and no longer respond to antimicrobial medicines.[10] Bacteria can thwart antibiotics through different mechanisms of action – antibiotic efflux, antibiotic modification, antibiotic sequestration, antibiotic target modification, target bypass, target protection.[11] They then tranfer resistance through either vertical Gene Transfer (VGT) or Horizontal gene transfer (HGT). HGT involves the transfer of antibiotic resistant genes (ARGs) by: 1) transformation; 2) transduction; or 3) conjugation.[12] (Figure 1)

[9] Larson E. Community Factors in the Development of Antibiotic Resistance. http://dx.doi.org/101146/annurev.publhealth28021406144020 [Internet]. [cited 2022 Jun 16];28:435–47. Available from: https://www.annualreviews.org/doi/abs/10.1146/annurev.publhealth.28.021406.144020

[10] Antimicrobial resistance [Internet]. [cited 2022 Jul 13]. Available from: https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance
European Commission, Joint Research Centre, Sanseverino I, Loos R, Navarro Cuenca A, Marinov D, Lettieri T. *State of the art on the contribution of water to antimicrobial resistance*. Publications Office; 2019. Available from: doi/10.2760/771124

[11] Peterson E, Kaur P. Antibiotic resistance mechanisms in bacteria: Relationships between resistance determinants of antibiotic producers, environmental bacteria, and clinical pathogens. Frontiers in Microbiology. 2018 Nov 30;9(NOV):2928.

[12] Furuya EY, Lowy FD. Antimicrobial-resistant bacteria in the community setting. Nature Reviews Microbiology 2006 4:1 [Internet]. 2006 Jan [cited 2022 Jul 14];4(1):36–45. Available from: https://www.nature.com/articles/nrmicro1325

In the presence of antibiotics, resistant pathogens do not die; instead, they gain a 'survival advantage', which creates a selective effect. Disease-causing pathogens together with normal flora are killed, making a person susceptible to more bacteria.[13]

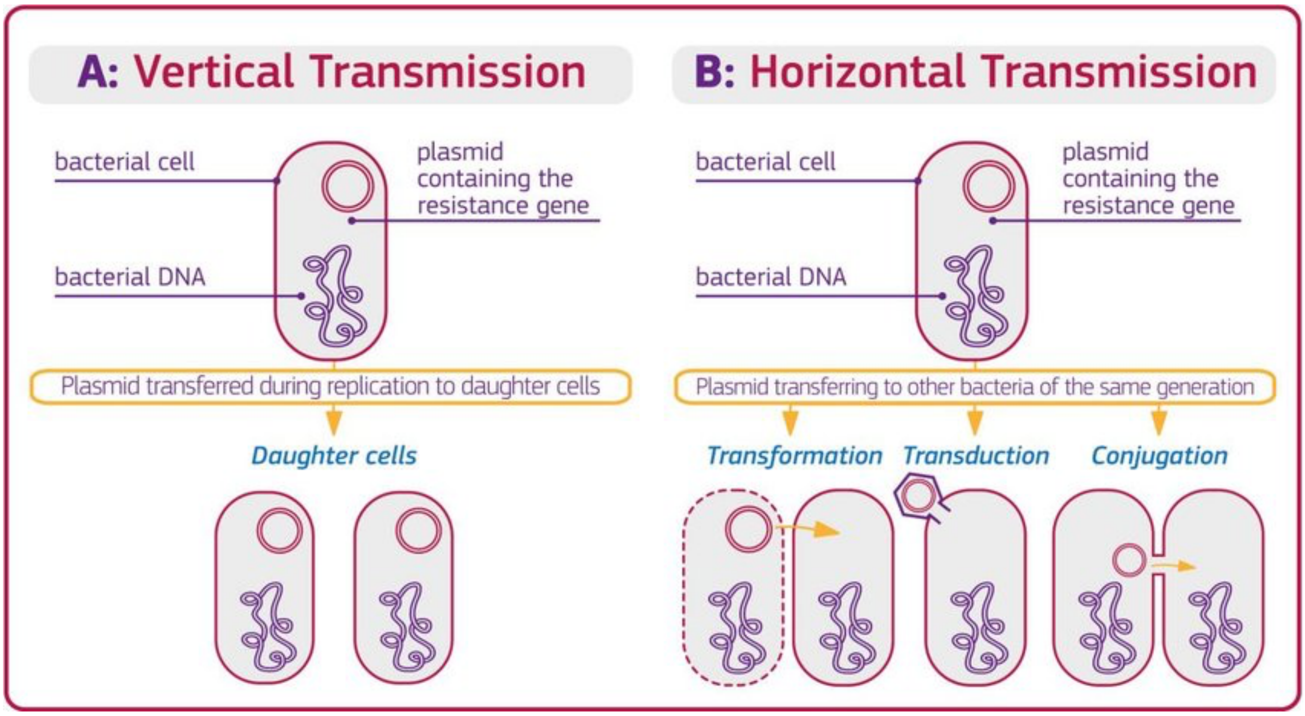


Fig 1| Vertical &Horizontal antimicrobial gene transfer[11]

[13] Peterson E, Kaur P. Antibiotic resistance mechanisms in bacteria: Relationships between resistance determinants of antibiotic producers, environmental bacteria, and clinical pathogens. Frontiers in Microbiology. 2018 Nov 30;9(NOV):2928. ;Furuya EY, Lowy FD. Antimicrobial-resistant bacteria in the community setting. Nature Reviews Microbiology 2006 4:1 [Internet]. 2006 Jan [cited 2022 Jul 14];4(1):36–45. Available from: https://www.nature.com/articles/nrmicro1325

The Burden of AMR in Nigerian Communities

Nigeria is a multi-diverse country of more than 200 million people spread over 910,770 km².[14] Dr Shamsudin explained that communities in Nigeria could be large and urban or very rural and very isolated. Community antimicrobial resistance has been on the rise in various parts of the country. A worrisome example he cited was a systemic review on the prevalence of *extended-spectrum beta-lactamase (ESBL) producing Gram-negative bacteria* in Nigeria by Tanko et al.[15] which found a high prevalence of *ESBL* (Extended Spectrum Beta-Lactamase) in both hospital and community settings. *ESBL* is an enzyme found in some strains of bacteria, that breaks down and destroy some commonly used antibiotics, including penicillins and cephalosporins, thus making such drugs ineffective for treating infections. Similarly, in north-western Nigeria, Garba et al.[16] observed

[14] Nigeria Population 2022 (Demographics, Maps, Graphs) [Internet]. [cited 2022 Jul 21]. Available from: https://worldpopulationreview.com/countries/nigeria-population

[15] Tanko N, Bolaji RO, Olayinka AT, Olayinka BO. A systematic review on the prevalence of extended-spectrum beta lactamase-producing Gram-negative bacteria in Nigeria. Journal of Global Antimicrobial Resistance. 2020 Sep 1;22:488–96.

[16] Iliyasu G, Dayyab Mohammad F, Habib AG. COMMUNITY ACQUIRED PNEUMOCOCCAL PNEUMONIA IN NORTHWESTERN NIGERIA: EPIDEMIOLOGY, ANTIMICROBIAL RESISTANCE AND OUTCOME. J Infect Dis [Internet]. 2017 [cited 2022 Jul 21];12(1):15–9.

increasing resistance to commonly used antibiotics in community-associated *Streptococcus pneumoniae*.

Dr Usman Umar, from Aminu Kano Teaching Hospital (AKTH), also drew attention to the growing prevalence of resistant pathogens in Nigerian community settings. Recent research (publication forthcoming) he and some colleagues carried out demonstrated a prevalence of up to 3.7% in multi-drug resistant *Tuberculosis (MDR-TB)* among newly-diagnosed TB patients in Kano state. A fascinating example Dr Usman presented was a study on multi-drug-resistant *Staph Aureus (MRSA)* among horse-handlers and horses in Kano Metropolis by Sanda M et al,[17] Prevalence was 57.9% in horse handlers and almost 10% in horses. Other studies have demonstrated the presence of *MRSA* in livestock and companion animals who then serve as reservoirs and potential sources of infection for humans.[18](Figure 2). This notion of cross infection between horses and their handlers is worrisome, particularly in the Northern part of Nigeria especially Kano, Katsina, Zaria, and Sokoto where there is a long history and culture of keeping horses for 'performance and traditional purposes' often in close proximity to humans.

Figure 2 | Map of Nigeria showing the prevalence of Methicillin Resistant *Staph aureus* (MRSA) in different states

[17] Sanda M, Suleiman AB. Occurrence of Methicillin Resistant Staphylococcus aureus among Horses and Horse Handlers in Kano Metropolis, Northwestern, Nigeria. Dutse Journal of Pure and Applied Sciences (DUJOPAS). 2021;7(1):280–7

[18] Yamamoto T, Nishiyama A, Takano T, Yabe S, Higuchi W, Razvina O, et al. Community-associated methicillin-resistant Staphylococcus aureus: community transmission, pathogenesis, and drug resistance. Available from: http://eburst.mlst.net/

The Rise of Community-associated Methicillin Resistant Staph aureus (CA-MRSA)

Staphylococcus aureus is a gram-negative bacterium with a grape-like appearance carried by about one-third of the world's population in their noses. *Staph aureus* causes an array of infections from the skin and soft tissues (SSTI, e.g. impetigo) to infective endocarditis, urinary tract infections, pneumonia, osteomyelitis and prosthetic device infections and life-threatening toxic shock syndrome, bacteremia.[19](Figure 3)
*Staph aureu*s has developed resistance against many antibacterials.

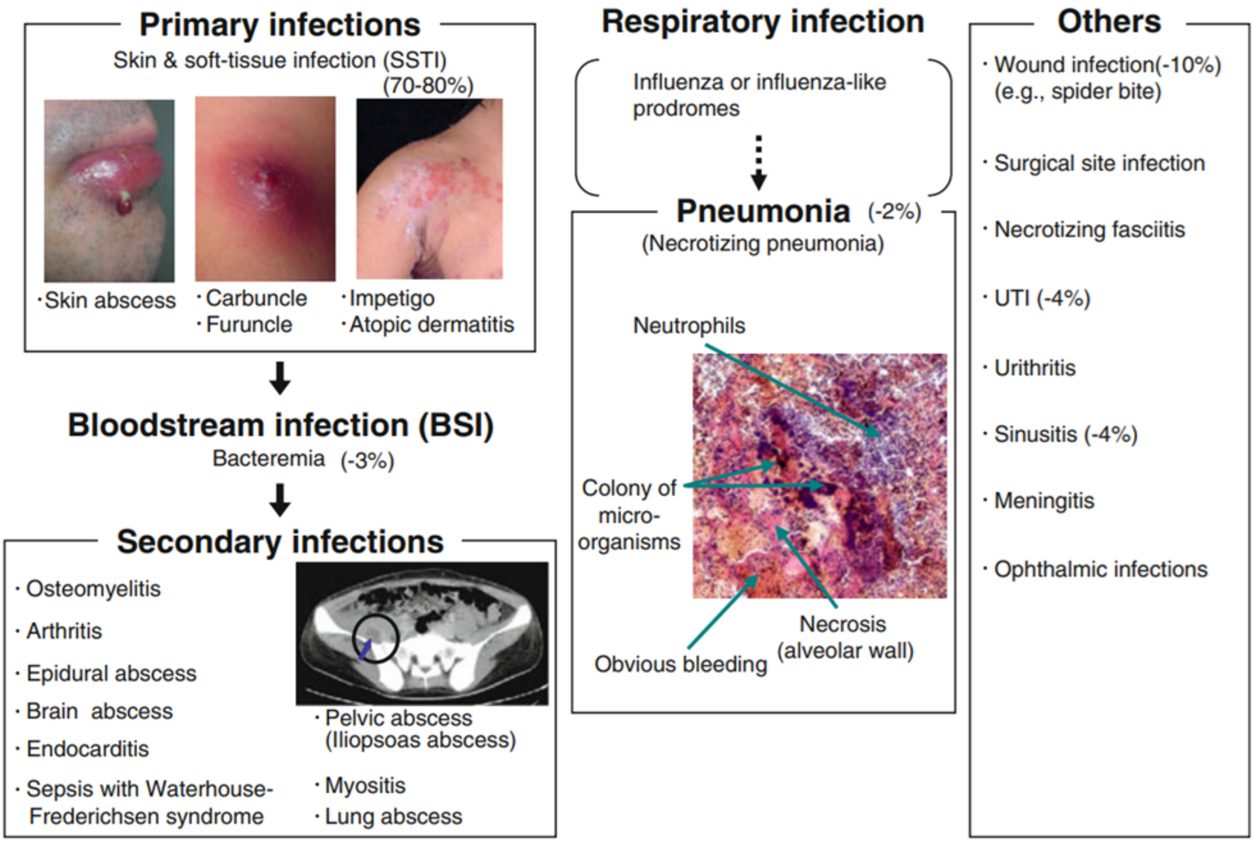


Figure 3 | Clinical Picture of Staph aureus infection[17]

In particular, Methicillin-resistant *staph aureus (*MRSA) has become a global threat to health. In 2019, MRSA alone was responsible for over 100,000 deaths attributable to antimicrobial resistance.[1]

---

[19] Staphylococcus Aureus - StatPearls - NCBI Bookshelf [Internet]. [cited 2022 Jul 26]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK441868/ , Staphylococcus aureus in Healthcare Settings | HAI | CDC [Internet]. [cited 2022 Jul 26]. Available from: https://www.cdc.gov/hai/organisms/staph.html

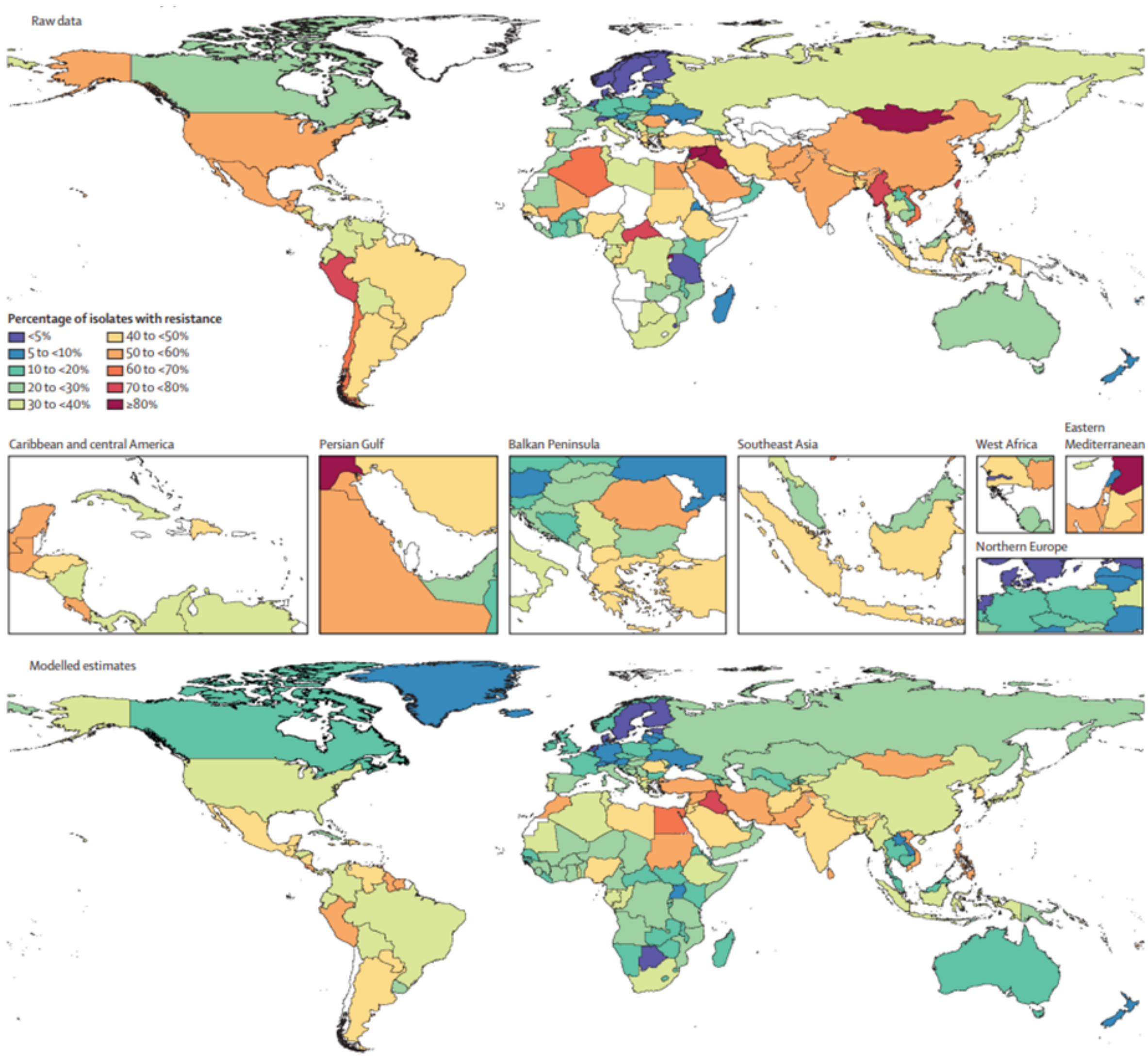


Fig 4 | Raw data and modelled estimates for the percentage of Methicillin-resistant Staphylococcus aureus by country and territory, 2019[1]

Hospital-associated MRSA (HA-MRSA) was first isolated in the early 1960s. Thirty years later, reports began to emerge of Community-associated MRSA infections (CA-MRSA) – 'MRSA isolated from outpatients with no history of hospitalization within the previous year, and who presented no other established risk factors for MRSA infection, such as surgery, residence in a long-term care facility, dialysis, or indwelling percutaneous medical devices or catheters.[20] What makes CA-MRSA troubling is its transmission via close contact in healthy populations and especially amongst children and young people. CA-MRSA is genetically distinct from HA-MRSA,[21]

[20] Rybak MJ, LaPlante KL. Community-associated methicillin-resistant Staphylococcus aureus: a review. Pharmacotherapy [Internet]. 2005 Jan [cited 2022 Aug 21];25(1):74–85. Available from: https://pubmed.ncbi.nlm.nih.gov/15767223/

[21] Kateete DP, Bwanga F, Seni J, Mayanja R, Kigozi E, Mujuni B, et al. CA-MRSA and HA-MRSA coexist in community and hospital settings in Uganda. Antimicrobial Resistance and Infection Control [Internet]. 2019 Jun 3 [cited 2022 Aug 21];8(1):1–9. Available from: https://aricjournal.biomedcentral.com/articles/10.1186/s13756-019-0551 / Loewen K, Schreiber Y, Kirlew M, Bocking N, Kelly L.

making it possible to differentiate between them in isolates (Table 2). This has made it possible to demonstrate the co-existence and spread of community-associated MRSA and hospital-associated MRSA in both community and hospital settings. However, several studies have shown that CA-MRSA is rising in hospital settings as well.[20,22]

This poses several questions. First, is CA-MRSA becoming more of a threat than HA-MRSA, and are current estimates representative of the true situation on the ground? In the systematic analysis of the Global burden of AMR in 2019 –- the latest and most comprehensive estimate of antimicrobial resistance –- one challenge was identifying and classifying community vs hospital-associated infections from the current data available. The majority of studies use clinical criteria to differentiate between CA-MRSA and HA-MRSA. In a retrospective study on Methicillin-resistant and methicillin-susceptible community-associated Staphylococcus aureus infection among children, Gomes et al.,[23] posit that contrasting frequencies of CA-MRSA might be due to the use of these healthcare associated risk factors. Therefore, there is a need for cheap, accurate, rapid and commercially available PCR based assays for all samples that detect prototypic strains of SCCmec types.

Second, as theories exist that the rise of CA-MRSA could be based on a combination of bacterial and social factors and not necessarily be the result of inappropriate antibacterial use,[10,15] has there been an improvement in the risk factors associated with CA-MRSA (Table 2)? We are already off-track on achieving the SDGs related to leading AMR risk factors: One in seven of the global population lives in slums and overcrowded areas. Meanwhile, antibiotic consumption increased by almost 50% between 2000 to 2018. By 2030, 1.6 billion people will be without safely-managed drinking water and 2.8 billion will still lack safely-managed sanitation.[24] These grim figures are a wake-up call for anyone thinking that tackling antimicrobial resistance can be a siloed battle. Other social determinants of health and quality of life, in general, must be improved as well.

Community-associated methicillin-resistant Staphylococcus aureus infection: Literature review and clinical update. Canadian Family Physician. 2017 Jul 1;63(7):512–20.
/ David MZ, Daum RS. Community-associated methicillin-resistant Staphylococcus aureus: Epidemiology and clinical consequences of an emerging epidemic. Clinical Microbiology Reviews [Internet]. 2010 [cited 2022 Jul 26];23(3):616–87. Available from: https://journals.asm.org/doi/10.1128/CMR.00081-09

[22] Loewen K, Schreiber Y, Kirlew M, Bocking N, Kelly L. Community-associated methicillin-resistant Staphylococcus aureus infection: Literature review and clinical update. Canadian Family Physician. 2017 Jul 1;63(7):512–20.

[23] Gomes RT, Lyra TG, Alves NN, Caldas RM, Barberino MG, Nascimento-Carvalho CM. Methicillin-resistant and methicillin-susceptible community-associated Staphylococcus aureus infection among children. Braz J Infect Dis [Internet]. 2013 Sep [cited 2022 Jul 26];17(5):573–8. Available from: https://pubmed.ncbi.nlm.nih.gov/24055391/

[24] WHO-UNICEF. Progress on household drinking water, sanitation and hygiene 2000–2020: Five years into the SDGs. World Health Organisation and the United Nation's Children's Fund, Geneva. 2021 [cited 2022 Jul 18]. Available from: https://www.who.int/publications/i/item/9789240030848

Characteristics	Community-associated MRSA (CA-MRSA)	Hospital-associated MRSA (HA-MRSA)
Time & Location of emergence	1990s- Community	1960s- Hospitals
Genotype	SCCmec type IV,V	SCCmec type I,II,III
Virulence factors	Panto-Valentine leucocidin(PVL genes) often present-more virulent	Uncommon to have PVL genes
Predominant type of Infection	Skin & soft tissue	Respiratory, Urinary tract, bloodstream and post surgical infections
Antibiotic Susceptibility	Susceptible to a range of antibiotics, Resistant to Beta-lactam antimicrobials	Limited range of antibiotic susceptibility, Resistant to non-Beta-Lactam antibiotics
Risk Factors	Living/working in group setting Overcrowding Lack of water in homes Recent antibiotic use Playing contact sports Prior history of CA-MRSA infection	Indwelling percutaneous catheter Surgery, hospitalization, residence in care-facility, dialysis
Doubling Time	Shorter doubling time	Longer doubling time

Table 2|Comparison of Ca-MRSA& HA-MRSA, adapted from Loewen et al[21]

Community-Based Surveillance

"The emergence of antimicrobial resistance within communities is inevitable and of grave concern"

Infectious disease surveillance has typically relied on data acquired at the hospital level when patients present themselves for treatment. There is however a major limitation built into this: the inability to record events from those not reporting to hospitals or those facing stark health inequities with regards to access to such healthcare. It is becoming increasingly popular to work with communities to collect health data for public health surveillance purposes.[25] The danger is that such data is extracted to help the purposes of others, such as to protect others from epidemics and pandemics, but not to benefit the generators of such data. A truly equitable surveillance system makes sure to first and foremost create benefit to those who participate in it.

Curation of AMR data via surveillance methods is a critical objective of the WHO GAP on AMR. Within the human-animal-environment nexus, there are several systems for collecting data on AMU and AMR. It is often the case that these are siloed, in which each sector plans, implements, analyses, and reports on its own surveillance for AMR and AMU.

Moreover, surveillance systems such as the WHO's Global Antimicrobial Resistance and Use Surveillance System (GLASS), are limited by the self-reported nature of data, extreme data heterogeneity, and lack of comparability between countries because of varying approaches to data curation. Additionally, there are incongruences between the methods used to monitor human antimicrobial usage and those used to monitor animal antimicrobial usage.[26] Conversely, the UK AMR contingency plan illustrates a collaborative effort across sectors to harmonise surveillance methodologies and interpretation.[27] However, it is limited by the absence of environmental data on AMR and was primarily designed for high-income settings

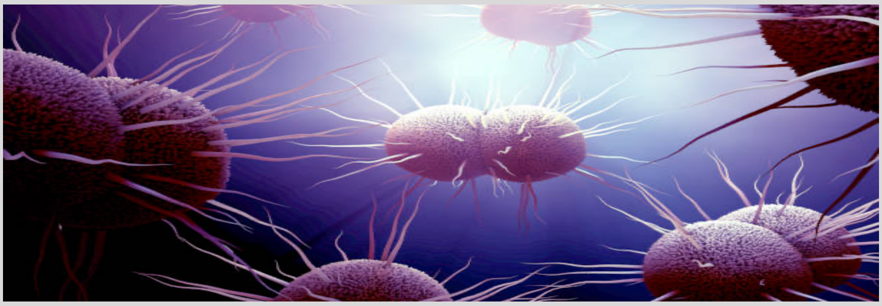
[25] Guerra J, Bayugo Y, Acharya P, Adjabeng M, Barnadas C, Bellizzi S, et al. A definition for community-based surveillance and a way forward: Results of the who global technical meeting, france, 26 to 28 june 2018. Eurosurveillance [Internet]. 2019;24(2). Available from: http://dx.doi.org/10.2807/1560-7917.ES.2019.24.2.1800681

[26] Umair M, Mohsin M, Sönksen UW, Walsh TR, Kreienbrock L, Laxminarayan R, et al. Measuring Antimicrobial Use Needs Global Harmonization. Glob Challenges - Wiley Online Libr [Internet]. 2021; Available from: https://onlinelibrary.wiley.com/doi/10.1002/gch2.202100017

[27] Veterinary Medicine Directorate. Response to the identification from an animal of a resistant bacterial isolate of risk to human or animal health: Contingency plan - GOV.UK [Internet]. GOV.UK. 2021 [cited 2022 Jul 19]. Available from: https://www.gov.uk/government/publications/resistant-bacteria-from-animals-of-possible-risk-contingency-plan/response-to-the-identification-from-an-animal-of-a-resistant-bacterial-isolate-of-risk-to-human-or-animal-health-contingency-plan

Case Reports of Multidrug Resistant Neisseria Gonorrhoeae Infections: Lessons from a Nigerian Community Setting

Dr Olanrewaju Jimoh, Ahmadu Bello University, Nigeria presented two cases of *Neisseria Gonorrhoea* to illustrate the impact of AMR in the community in Nigeria. In both cases, multi-drug resistant Neisseria Gonorrhoea (NG), the causative organism of the sexually transmitted infection (STI), Gonorrhoea, was isolated. This is no surprise as, recently, the WHO reported a rapid increase in antimicrobial-resistant NG globally. Alarmingly, this also includes resistance to last-line antibiotics used for treating Gonorrhoea.[28]



Case 1

History

- 35-year-old male, single civil servant
- 7 days history of dysuria &copious purulent urethral discharge
- hx of unprotected intercourse 2 days prior to symptoms
- Partner:33-year-old divorcee

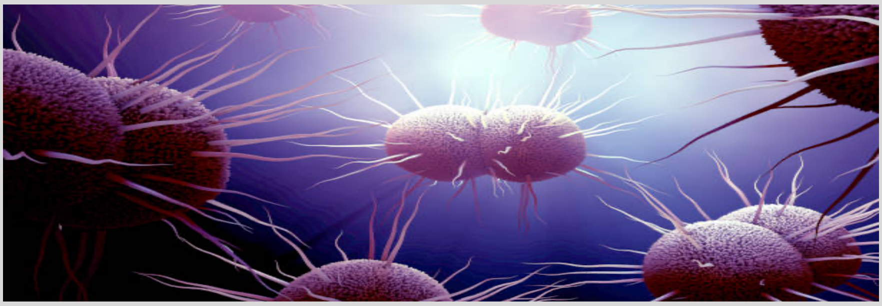
Self-Medication

- TCN, flagly & ampliclox for 3 days, then
- Ciprofloxacin 500mg daily for 10 days

At Presentation

- He was reviewed & examined
- diagnosis of poorly treated/drug resistant NGI made
- MCS result: *Neisseria gonorrhoeae* (NG) sensitive to only ceftriaxone
- Other drugs tested (Pen, TCN, Cip)
- Treatment: Cefixime 800mg+Azithromycin 2g stat
- Counselling done
- Symptoms abated within 48 hrs
- Sexual contact declined assessment
- Presented 2 months later with similar symptoms

[28] Multi-drug resistant gonorrhoea [Internet]. [cited 2022 Jun 28]. Available from: https://www.who.int/news-room/fact-sheets/detail/multi-drug-resistant-gonorrhoea



Case 2

History

- 41-year-old, married male aero technician
- 2 weeks history of dysuria & copious, purulent urethral discharge
- Did not divulge sexual exposure history
- Symptoms began after a week's trip
- He received Ciprofloxacin for 7 days with no improvement
- Claimed to treating 'toilet disease'
- Wife pregnant in her third trimester

At Presentation

- He was reviewed & examined
- diagnosis of poorly treated/drug resistant NGI made
- MCS result: *Neisseria gonorrhoeae* sensitive to only ceftriaxone
- Other drugs tested (Pen, TCN, Cip)
- Treatment: Ceftriaxone 1g+Azithromycin 2g stat
- Counselling done
- Symptoms abated within 48 hrs
- Declined bringing wife for treatment
- Wife delivered a baby boy six weeks later, Baby's eye swab positive for NG

Dr Olanrewaju explained that based on the case presentations above, it is possible that the current data on the number of cases of Multi-drug Resistant *Neisseria gonorrhoea* (MDR NG) in the community is just the tip of the iceberg, for several reasons. First, infections in women tend to be asymptomatic and so are not recorded.[29] Second, patients do not always disclose their contacts

[29] Zheng Y, Yu Q, Lin Y, Zhou Y, Lan L, Yang S, et al. Global burden and trends of sexually transmitted infections from 1990 to 2019: an observational trend study. The Lancet Infectious Diseases [Internet]. 2022 Apr 1 [cited 2022 Jun 29];22(4):541–51. Available from: http://www.thelancet.com/article/S1473309921004485/fulltext

and, when they do, contacts often decline to be interviewed because of the stigma attached to STIs in communities in Nigeria. Third, there is much self- and inappropriate treatment. He stressed that both patients in the case studies had only presented to the hospital when their symptoms had not abated following long periods of self-medication or inappropriate treatment from medicine vendors and pharmacies. The 'misuse and overuse of antimicrobials as a driver of antimicrobial resistance' in the community, was a recurrent theme during the workshop.

Dr. Olanrewaju alluded to the fact that much of the burden connected with STIs in society falls on women. This reflects findings in a recent study that observed that 'female individuals had a higher age-standardised DALY rate (33·31 per 100000 person-years) than male individuals (12·11 per 100000 person-years).[30] That is, they lost more years in full health due to STIs are compared to men. Moreover, women seek treatment less frequently than men for a range of reasons, including asymptomatic infection, stigma, and lower economic power.

.

[30] Zheng Y, Yu Q, Lin Y, Zhou Y, Lan L, Yang S, et al. Global burden and trends of sexually transmitted infections from 1990 to 2019: an observational trend study. The Lancet Infectious Diseases [Internet]. 2022 Apr 1 [cited 2022 Jun 29];22(4):541–51. Available from: http://www.thelancet.com/article/S1473309921004485/fulltext

Antibiotic Use and Access in LMICs

"….. antibiotics are seen as the most effective, the most powerful, so whatever patients think is severe illness, then it's what they think antibiotics would be able to resolve"

The WHO AWaRe Classification for Antibiotics

The WHO AWaRe classification of antibiotics was developed as a tool to support better antibiotic stewardship, while ensuring access to life-saving antibiotics, and to reduce antimicrobial resistance.
Under the classification, antibiotics are divided into three groups - Access group, Watch group, and Reserve group
The target: 'by 2023, 60% of all antibiotics consumed must be Access, the group with the lowest risk of encouraging resistance'.
The Goal: 'reduce the use of Watch Group and Reserve Group antibiotics (the antibiotics most crucial for human medicine and at higher risk of resistance), and to increase the use of Access antibiotics where availability is low'
An updated version of the WHO AWaRe antibiotic book has been recently released. It aims to serve as a tool kit for both primary healthcare and hospitals on the management of infections

Globally, the antibiotic consumption rate increased by 46% from the year 2000 to 2018, with the most increase in antibiotic use recorded in central Europe, eastern Europe, and central Asia and the lowest use in Sub-Saharan Africa (Figure 3).[31]

[31] Browne AJ, Chipeta MG, Haines-Woodhouse G, Kumaran EPA, Hamadani BHK, Zaraa S, et al. Global antibiotic consumption and usage in humans, 2000-18: a spatial modelling study. Lancet Planet Heal [Internet]. 2021 Dec 1 [cited 2022 Jul 4];5(12):e893–904. Available from: https://pubmed.ncbi.nlm.nih.gov/34774223/

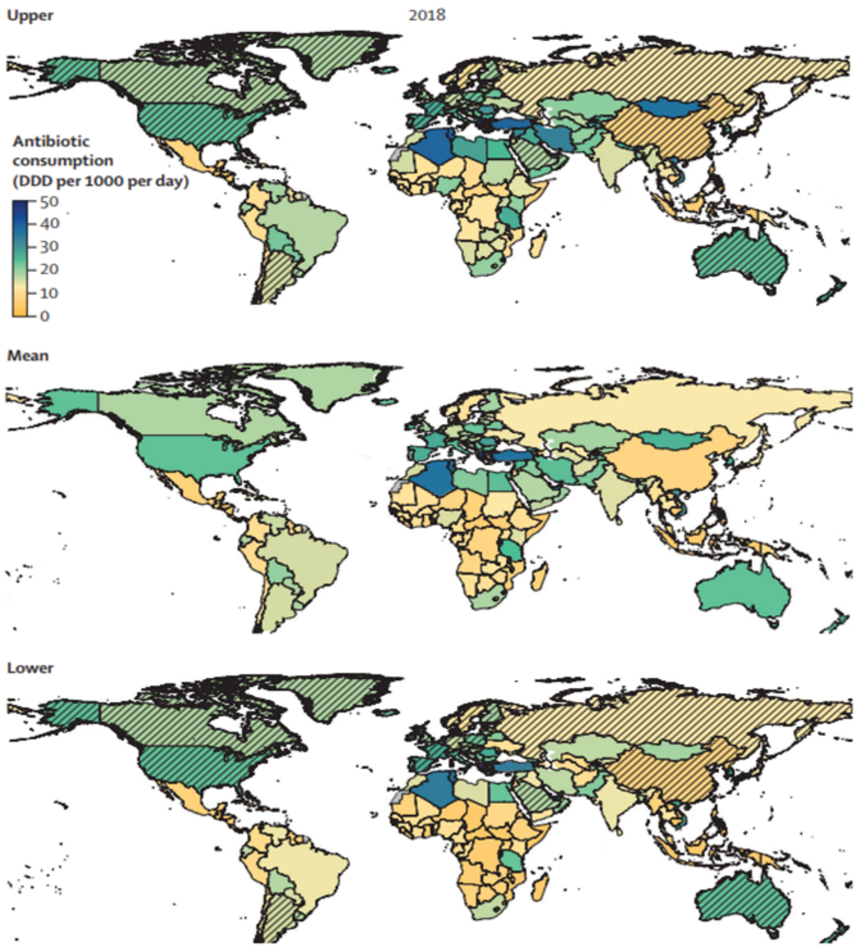


Fig 7 | Global antibiotic consumption in 2018[34]

Estimates of antibiotic consumption rates in DDD per 1000 population per day. The mean map combines the modelled estimates for LMICs, and the imputed dataset for HICs. The upper and lower maps represent the upper and lower 95% uncertainty intervals for the LMIC model, with HICs shaded. DDD=defined daily doses. HIC=high-income country. LMIC=low-income and middle-income country.

Many LMICs still lack universal access to antimicrobials even though such medicines are recognised as an integral part of the human right to health.[32] Despite lower rates of usage, there is a greater burden of inappropriate community use of antimicrobials in a number of LMICs, particularly in Southeast Asia.[33](Figure 8)

[32] Mendelson M, Røttingen JA, Gopinathan U, Hamer DH, Wertheim H, Basnyat B, et al. Maximising access to achieve appropriate human antimicrobial use in low-income and middle-income countries. Lancet [Internet]. 2016 Jan 9 [cited 2022 Jul 1];387(10014):188–98. Available from: http://www.thelancet.com/article/S0140673615005474/fulltext

[33] Punpuing S, Sunpuwan M, Khan MHS WA, Matin MSS MA, Ahmed S, Karim MPH MM, et al. Community-based antibiotic access and use in six low-income and middle-income countries: a mixed-method approach. The Lancet Global Health [Internet]. 2021 [cited 2022 Jul 4];9:e610–9.

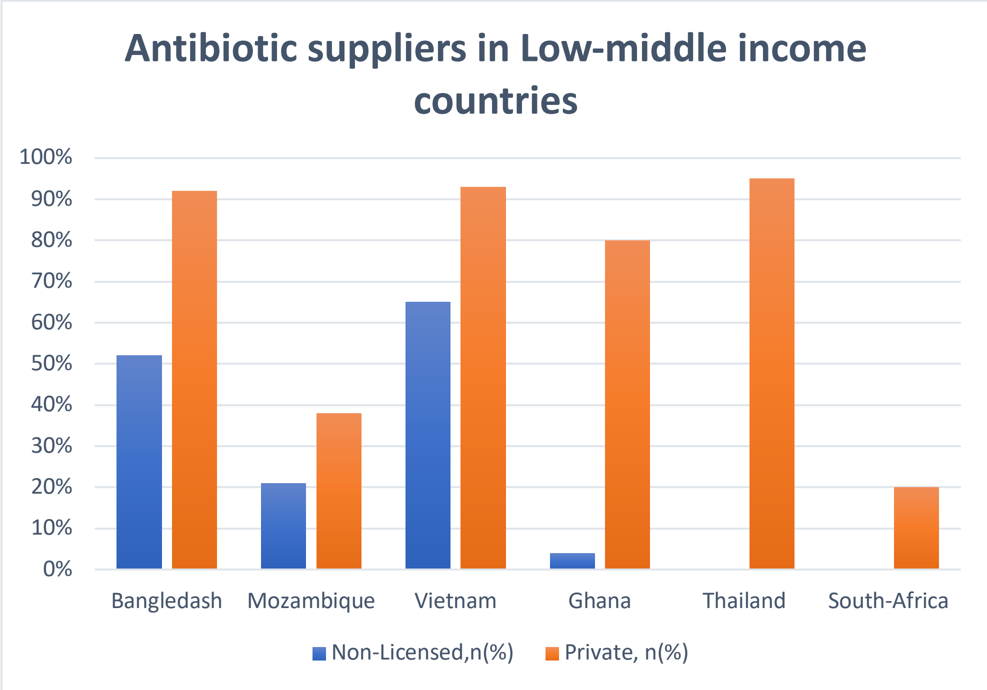


Fig 8| Antibiotic suppliers & access in select low- and middle-income countries. Adapted from Punpuing et al. [36]

Providers face extra obstacles including lack of access to tools to accurately diagnose and administer antimicrobials, and inadequate health systems for the management and use of antimicrobials. Thus, evidence-based interventions in communities and healthcare settings can increase access to appropriately prescribed antimicrobials and tame the overuse of inappropriate antimicrobials. Several key measures will be needed to achieve access while preventing overuse of antimicrobials, including sustainable financing, governance, and leadership. It is quite evident that several key measures will be needed to achieve better access to antimicrobials for those who need them but lack access to them while preventing overuse of antimicrobials, including:

Non-human use of antibiotics - a case study of Nigeria

Antimicrobials are used increasingly in veterinary medicine, fishing, and livestock production. The WHO estimates that the agricultural sector accounts for almost 80% of the global consumption of antibiotics.[34] These antibiotics are utilised in livestock for the treatment and prevention of diseases, as feed additives, and as growth promoters.[35] This has contributed to the emergence of resistance against medically relevant antimicrobials such as fluoroquinolones and third-generation cephalosporins.[36] While the costs of managing and consuming livestock (especially intensively-reared) might be pushed lower, the costs to human health and health care systems rises – a classic negative economic externality.

[34] Stop using antibiotics in healthy animals to prevent the spread of antibiotic resistance [Internet]. [cited 2022 Jun 22]. Available from: https://www.who.int/news/item/07-11-2017-stop-using-antibiotics-in-healthy-animals-to-prevent-the-spread-of-antibiotic-resistance

[35] van Boeckel TP, Glennon EE, Chen D, Gilbert M, Robinson TP, Grenfell BT, et al. Reducing antimicrobial use in food animals. Science (1979) [Internet]. 2017 Sep 29 [cited 2022 Jun 16];357(6358):1350–2. Available from: https://www.science.org/doi/10.1126/science.aao1495

[36] Holmes AH, Moore LSP, Sundsfjord A, Steinbakk M, Regmi S, Karkey A, et al. Understanding the mechanisms and drivers of antimicrobial resistance. The Lancet [Internet]. 2016 Jan 9 [cited 2022 Jun 22];387(10014):176–87. Available from: http://www.thelancet.com/article/S0140673615004730/fulltext

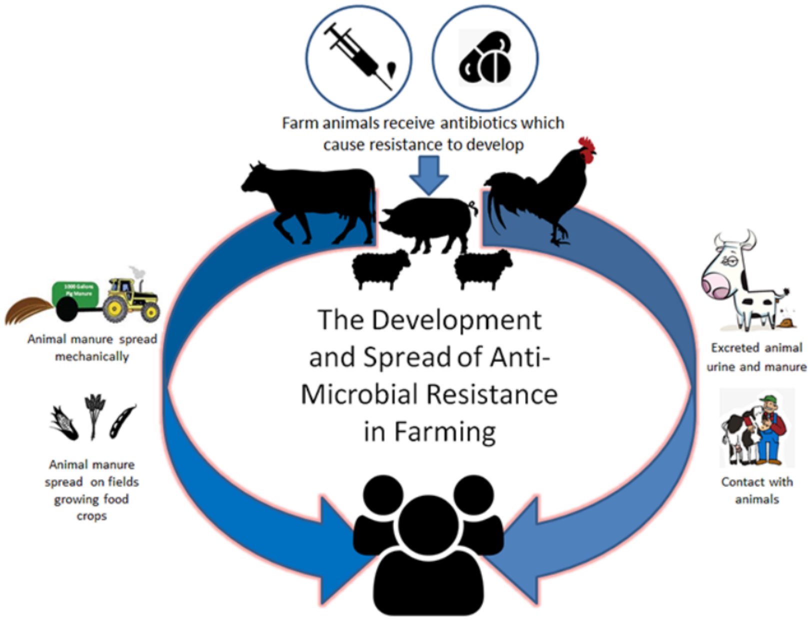


Fig 5| Indiscriminate use of antibiotics among animals and in agriculture[37]

It was no surprise therefore that non-human use of antimicrobials emerged as a major theme during the workshop, especially in the presentations on 'Overview of AMR Challenges in Nigeria: Need for Community Approach' and 'Determinants of Antimicrobial Resistance in the Nigerian Community Setting'. Presenters and participants, drawing on their experiences in Nigeria, discussed the unregulated, indiscriminate use of antibiotics in animal husbandry and the paucity of data on AMR outside of human healthcare settings in in LMICs in general and in Nigeria in particular. If such data were more available in a regular and timely fashion, it could be used to highlight the dangers and to incentivize action.

Although Nigeria's National Agency for Food and Drug Administration and Control (NAFDAC) has banned the use of antibiotics as growth promoters and Nigeria's National Action Plan includes policies and regulations on animal antibiotic use ,there remains widespread misuse of antibiotics across Nigeria.[36-37] A cross-sectional survey consisting of 384 households in North-central Nigeria showed that 58% of pastoralists self-prescribed antibiotics for their livestock and almost 35% purchased such drugs from 'animal drug hawkers'.[38] Additionally, 40% used antibiotics for prophylaxis while about 5% still made use of antibiotics to promote the growth of their livestock. This is consistent with a previous study in which nearly 90% of veterinarians indicated that farmers had initiated antibiotic therapy without prescription or oversight.[39]

[37] What is AMR - Teagasc | Agriculture and Food Development Authority [Internet]. [cited 2022 Aug 21]. Available from: https://www.teagasc.ie/animals/amr/what-is-amr/
36 NAFDAC bans use of antibiotics in animal feed - Punch Newspapers [Internet]. [cited 2022 Jun 22]. Available from: https://punchng.com/nafdac-bans-use-of-antibiotics-in-animal-feed/
37 Nigeria: National Action Plan for Antimicrobial Resistance [Internet]. [cited 2022 Jun 16]. Available from: https://www.who.int/publications/m/item/nigeria-national-action-plan-for-antimicrobial-resistance
[38] Alhaji, Nma Bida, and Tajudeen Opeyemi Isola. "Antimicrobial usage by pastoralists in food animals in North-central Nigeria: The associated socio-cultural drivers for antimicrobials misuse and public health implications." *One health (Amsterdam, Netherlands)* vol. 6 41-47. 9 Nov. 2018, doi:10.1016/j.onehlt.2018.11.001
[39] Adekanye UO, Ekiri AB, Galipó E, Muhammad AB, Mateus A, la Ragione RM, et al. Knowledge, Attitudes and Practices of Veterinarians Towards Antimicrobial Resistance and Stewardship in Nigeria. Antibiotics. 2020 Aug 1];9(8):1–16. Available from: /pmc/articles/PMC7460309/

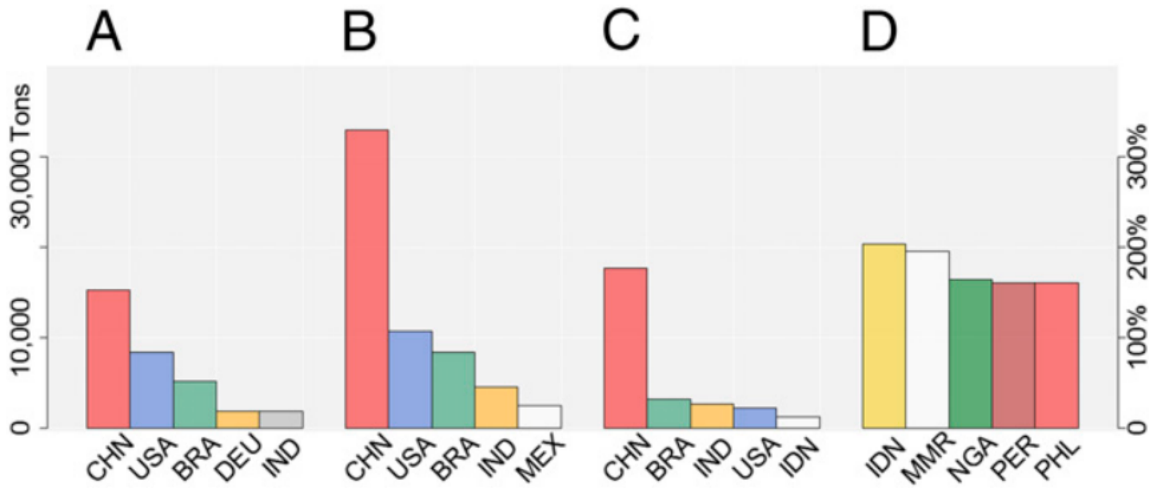


Fig 6: **Pattern of antimicrobial consumption in livestock**[10]

a | Largest five consumers of antimicrobials in livestock in 2010. **b** | Largest five consumers of livestock in 2030 (projected). **c** | Largest increase in antimicrobial consumption between 2010 and 2030. **d** | Largest relative increase in antimicrobial consumption between 2010 and 2030. CHN, China; USA, United States; BRA, Brazil; DEU, Germany; IND, India; MEX, Mexico; IDN, Indonesia; MMR, Myanmar; NGR, Nigeria; PER, Peru; PHL, Philippines.

In the workshop, adherence to antimicrobial withdrawal periods in animal husbandry was also discussed. An example of the regulations Germany had in place and adherence to those regulations was cited. In comparison, in Nigeria less than 20% of pastoralists reported following withdrawal periods.[40]

As we focus on low-income countries, we must not forget that high- and middle-income countries are themselves complacent in livestock antimicrobial consumption. China was the country with the highest consumption in 2010. Van Boeckel et al. estimate that by 2030, China's livestock sector will consume a third of the world's antimicrobials, making it the world's biggest individual contributor to AMR through inappropriate use of antimicrobials in animals.[21]

Social scientists working within AMR discusses the limitations of collecting data through global databases such as WHO and OIE:

> "Although WHO and OIE have standardised methodologies to collect country-level antimicrobial usage in humans and animals for global reporting and consulting companies like IQVIA gather and sell additional proprietary data, more granular level detail about

[40] Alhaji NB, Isola TO. Antimicrobial usage by pastoralists in food animals in North-central Nigeria: The associated socio-cultural drivers for antimicrobials misuse and public health implications. One Heal. 2018 Dec 1;6:41–7.

antibiotic usage on farms and in particular clinical and residential settings is required for targeted reduction strategies." [41]

Furthermore, social scientists working within AMR also critiques on global antibiotic consumption data reflecting on how the information on antibiotic consumption is drawn from import and sales data at a national level and how LMICs have been reported as major contributors to the global increase in antibiotic use (critiquing claims from Van Boeckel et al., 2020 and Klein et al., 2018), despite data being available from only 16 African countries. [21, 42, 43]

While many LMICs such as Nigeria have commendable 'One Health' strategic plans (NAP 2017-2022) (Table 3), in the eyes of those making efforts to tackle AMR in LMICs surely countries like China have a greater responsibility in antimicrobial stewardship and surveillance in their livestock industries. As a matter of global equity, China needs to get its AMR house in order.

OBJECTIVES	STRATEGIC INTERVENTIONS
4.1 Improve access to quality antimicrobial agents for infections in humans and animals	4.1.1 Promote optimal procurement and distribution of quality antimicrobials and diagnostics for human and animal use 4.1.2. Enhance local production of quality antimicrobial agents and diagnostics for human and animal use 4.1.3. Expand NHIS coverage to include more enrollees
4.2 Promote antimicrobial stewardship in human and animals	4.2.1 Promote the use of up to date treatment guidelines and ensure prudent use in humans and animals 4.2.2 Promote optimal prescribing and dispensing of antimicrobials in humans and animals
4.3 Strengthen regulatory agencies across all sectors (humans, animals and environment) to enable them perform their mandate with regards to antimicrobials	4.3.1 Strengthen the capacity of regulatory agencies across 'One Health' sectors (i.e. human, animals, food products and environment) 4.3.2 Enhance inter-sectoral coordination and collaboration between/amongst regulatory agencies

Table 3: Excerpt from the Nigeria National Action Plan on AMR (2017-2022)[44]

[41] Kirchhelle, C., Atkinson, P., Broom, A., Chuengsatiansup, K., Ferreira, J. P., Fortané, N., ... & Chandler, C. I. (2020). Setting the standard: multidisciplinary hallmarks for structural, equitable and tracked antibiotic policy. *BMJ Global Health*, *5*(9), e003091.
[42] Klein, E. Y., Van Boeckel, T. P., Martinez, E. M., Pant, S., Gandra, S., Levin, S. A., ... & Laxminarayan, R. (2018). Global increase and geographic convergence in antibiotic consumption between 2000 and 2015. *Proceedings of the National Academy of Sciences*, *115*(15), E3463-E3470.
[43] Nayiga, S., Kayendeke, M., Nabirye, C., Willis, L. D., Chandler, C. I., & Staedke, S. G. (2020). Use of antibiotics to treat humans and animals in Uganda: a cross-sectional survey of households and farmers in rural, urban and peri-urban settings. *JAC-Antimicrobial Resistance*, *2*(4), dlaa082.
[44] Nigeria: National Action Plan for Antimicrobial Resistance [Internet]. [cited 2022 Jun 16]. Available from: https://www.who.int/publications/m/item/nigeria-national-action-plan-for-antimicrobial-resistance

These findings are a salutary reminder that more needs to be done to combat AMR in the community. Among the suggested solutions were more practical regulatory and government interventions, as well as a multifaceted approach that incorporates community-based behavioural initiatives. More attention needs also to be made to the lessons from social sciences, anthropology, economics and other areas. Finally, collaboration between locals, farmers, veterinarians, and regulatory agencies needs to be embraced.

Governance for AMR

In 2016, the United Nations (UN) General Assembly released a political declaration (resolution A/RES/71/3) calling for the establishment, in consultation with the World Health Organization, the Food and Agriculture Organization of the United Nations and the World Organization for Animal Health, of an ad hoc Inter-Agency Coordination Group (IACG). The group was mandated to 'provide practical guidance on approaches to ensure sustained effective global action to address antimicrobial resistance' and submit a report by the 73rd general assembly (2019).[45]

[45] Seventy-First Session of the General Assembly – UNODA [Internet]. [cited 2022 Aug 21]. Available from: https://www.un.org/disarmament/meetings/firstcommittee-71/

The IACG released their report in April 2019, titled 'No Time to Wait: Securing the Future from Drug Resistant Infections'. The recommendations are summarised below[46]:

In terms of Accountability and Global Governance of AMR, IACG recommended 'constituting a One Health Global Leadership Group (GLG) on AMR; an Independent Panel on Evidence for Action against AMR; and a multi-stakeholder partnership platform to address the breadth of sectoral interests in AMR governance'. This led to the formation of a Global AMR governance structure. Currently, it includes WHO, Food and Agriculture Organization (FAO), World Organization for Animal Health (OIE), and UN Environment Programme (UNEP).[47]

---

[46] NO TIME TO WAIT: SECURING THE FUTURE FROM DRUG-RESISTANT INFECTIONS REPORT TO THE SECRETARY-GENERAL OF THE UNITED NATIONS. 2019

[47] Comprehensive Review of the WHO Global Action Plan on Antimicrobial Resistance - Volume 1: Report [Internet]. [cited 2022 Aug 21]. Available from: https://www.who.int/publications/m/item/comprehensive-review-of-the-who-global-action-plan-on-antimicrobial-resistance

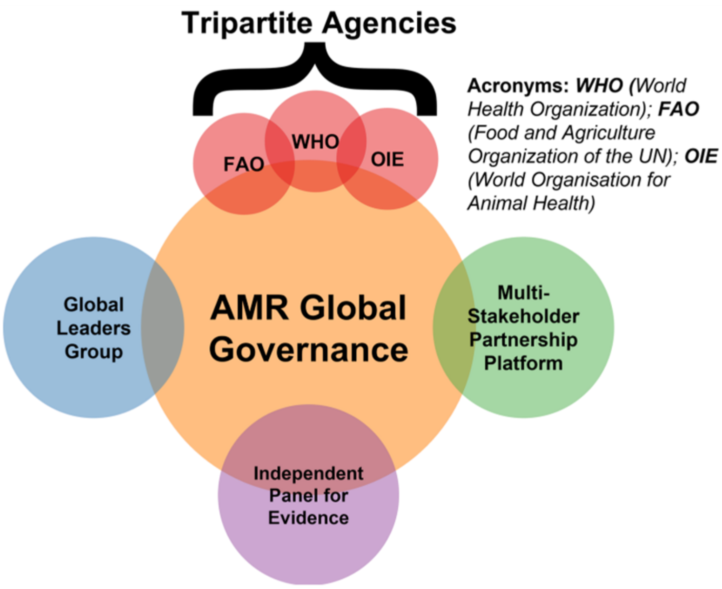


Fig 9| Antimicrobial Resistance (AMR) Global Governance Structure[39]

However, in January 2022, The WHO's comprehensive review on The Global Action Plan on AMR identified a number of shortcomings and challenges in the current governance structure, including:

1. Lack of operationalization of the independent panel and multi-stakeholder partnership panel with the Independent Panel

2. Lack of transparency of the Global Leaders deliberations

3. A tripartite structure that neglects other AMR stakeholders

4. Lack of clarity on how the governance structure will collaborate with existing structures on the ground

5. Inability of the Global Leader's group to identify financing mechanisms to sustain global AMR efforts

The quote from the WHO's comprehensive Review on The Global Action Plan on the state of AMR governance is apt:

"The AMR Governance structure has not come together in a way that engages the breadth of international agencies that must be enlisted, mobilizes financing required for carrying out its work, nor ensures the necessary accountability to deliver on the GAP on AMR. It needs to be revised."

Case Study: AMR Situation and Progress in Sierra Leone

The National Strategy Plan of Sierra Leone to combat AMR utilises a One Health approach to ensure the involvement of all sectors, including the environmental, agricultural, and human sectors. Six strategic objectives are included in the strategic plan[48]:

1. Establish a governance structure for the implementation of the AMR strategic plan.
2. Improve awareness and understanding of antimicrobial resistance through effective communication, education and training.
3. Strengthen the knowledge and evidence base through laboratory, surveillance, and research.
4. Reduce the incidence of infection through effective sanitation, hygiene, and infection prevention measures.
5. Optimize the use of antimicrobial agents in human, animal, and plant health.
6. Develop the economic case for sustainable investment and actions to combat AMR.

While the strategy aligns with the WHO's Global Action Plan (GAP), an additional objective regarding governance structure is incorporated. With a clear vision for a society in which antimicrobials are managed as a valuable asset for present and future generations in the treatment of infections in humans, animals, the environment, and the agricultural sector, the Sierra Leone NAP aims at addressing AMR at multiple levels, including hospital and community settings.

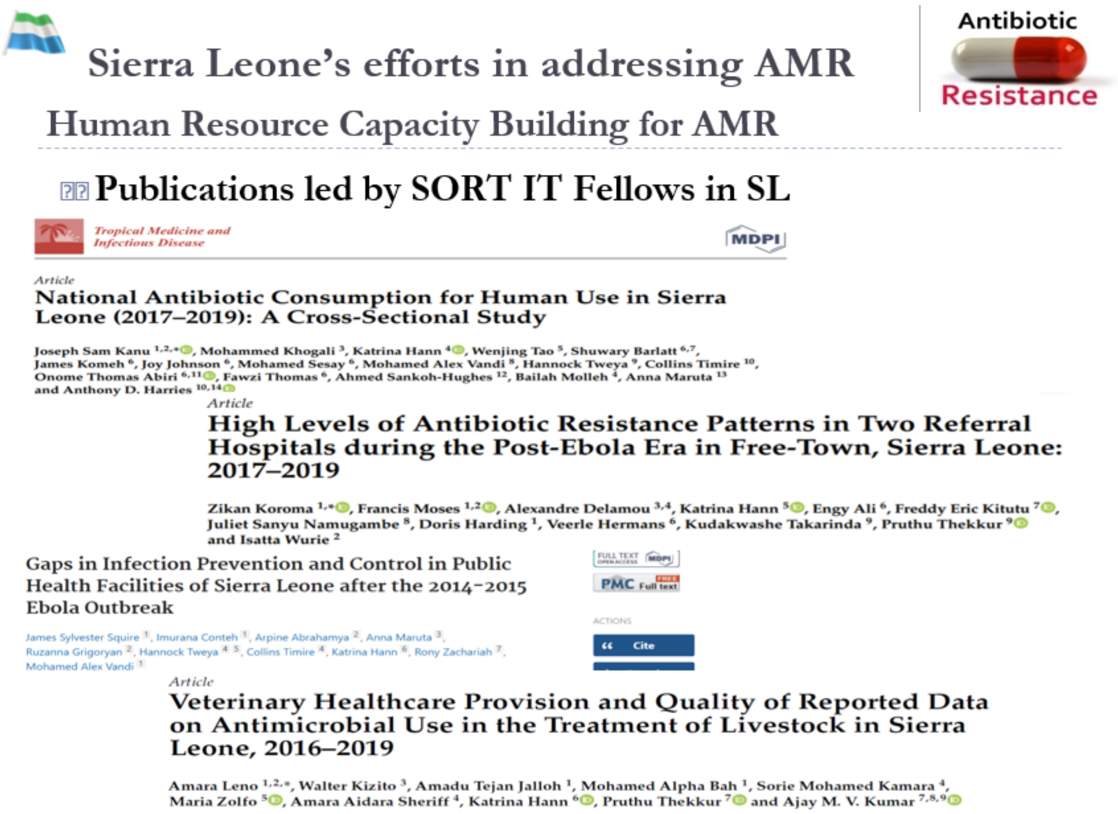
The Sierra Leone governance structure consists of AMR Focal Persons/Points for the human, agricultural, and environmental sectors. The AMR Technical Working Group (TWG) and three sub-TWGs were established with specific terms of reference. The sub-TWGs are[68]:

48 Abiri T. GOVERMENT OF SIERRA LEONE. 2017

1. Antimicrobial Stewardship
2. Surveillance and Laboratory
3. Education and Research

In addition, ad hoc committees have been established for specific needs, such as the AMR Curricula Coordinating Committee which oversee the review and integration of pre-service AMR curriculum in training institutes.

Beside its NAP, Sierra Leone is strengthening its human capacity for operational research to investigate AMR through several initiatives. One is the [AMR-SORT IT project](). The Structured Operational Research and Training Initiative (SORT IT) is a global partnership-based initiative coordinated by TDR, the UNICEF/UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases.[49]



The second training programme is called Qualifying the Workforce for AMR Surveillance (QWArS), which aims to implement standardised training packages that consider local needs and that result in formal qualifications to improve the development of laboratory capacity.

Last, is the integration of AMR into the pre-service and in-service curricula of training institutions so that when prospective health care workers enter the workforce, they are conscientious about AMR and stewardship practices.

---

[49] AMR-SORT IT. AMR-SORT IT 2020 Annual Report: The Structured Operational Research and Training IniTiative on tackling antimicrobial resistance in Africa, Asia and Latin America – Progress, Achievements, Challenges. 2021; Available from: https://www.who.int/tdr/capacity/strengthening/sort/en/

Evolution of C-reactive protein Point -of-care Test Studies in Vietnam, Thailand

Inappropriate antibiotic usage at the population level contributes to antimicrobial resistance, Dr Nga, a researcher from OUCRU, Hanoi, noted that research has demonstrated a correlation between resistance and the prescribing of antibiotics in primary care. Moreover, nearly two thirds of all antibiotic prescriptions are written by primary care physicians or health workers.[50,51]

Dr Nga described the evolution of a community-based initiative utilising C-reactive Protein (CRP) to reduce antibiotic prescribing in primary healthcare in Vietnam and Thailand. The target population consisted of patients with mild acute respiratory infections. The studies involved confirmed the efficacy of the CRP intervention in these settings. However, in Dr Nga's words - 'all these studies were conducted in the research context with the close support from the study team and close monitoring. Therefore, this may have influenced the prescribing practice.'

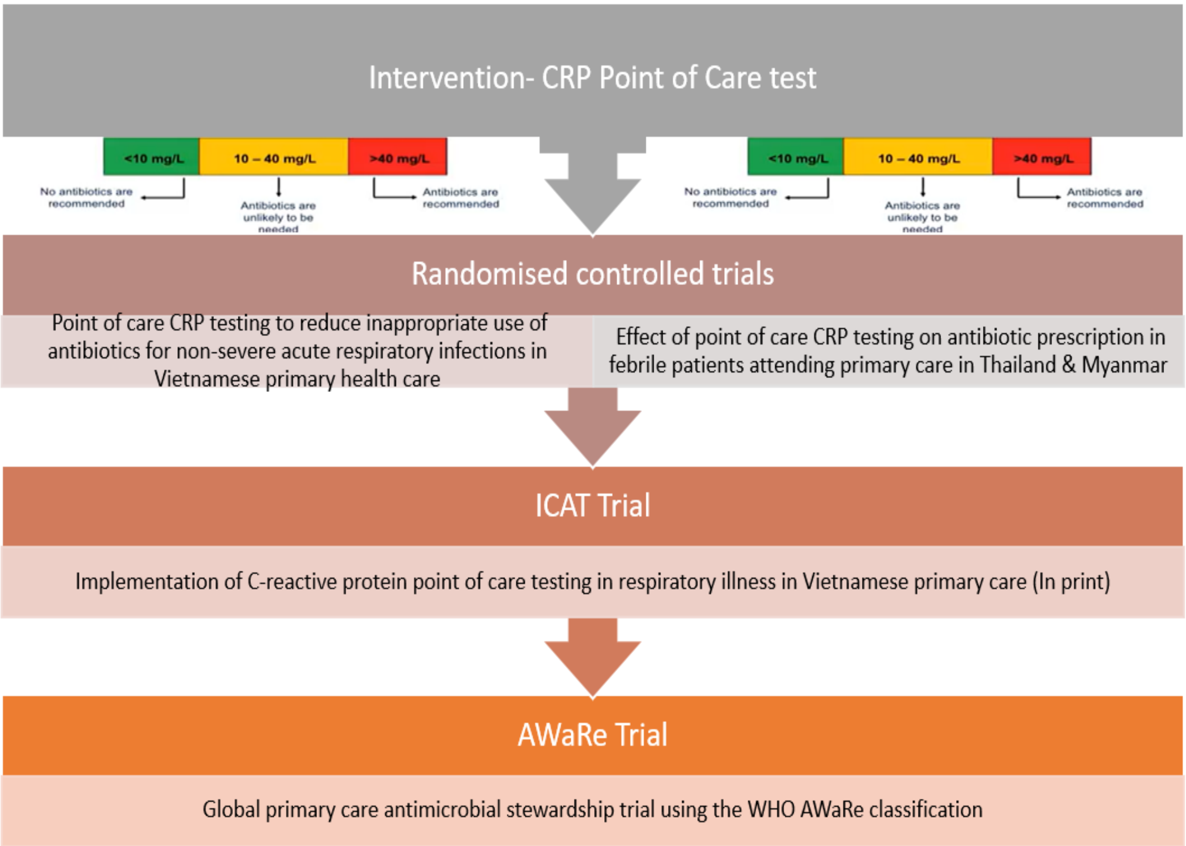


Fig 9| Evolution of C-reactive protein Point -of-care Test Studies in Vietnam, Thailand

[50] Sulis G, Adam P, Nafade V, Gore G, Daniels B, Daftary A, et al. Antibiotic prescription practices in primary care in low- and middle-income countries: A systematic review and meta-analysis. PLoS Med [Internet]. 2020 Jun 1 [cited 2022 Aug 21];17(6). Available from: https://pubmed.ncbi.nlm.nih.gov/32544153/

[51] Goossens H, Ferech M, vander Stichele R, Elseviers M. Outpatient antibiotic use in Europe and association with resistance: a cross-national database study. Lancet [Internet]. 2005 Feb [cited 2022 Aug 21];365(9459):579–87. Available from: https://pubmed.ncbi.nlm.nih.gov/15708101/

To better inform the wider-scale implementation of this CRP intervention, a pragmatic cluster randomised control trial (ICAT Trial) was carried out in 48 common (primary) health centres in Vietnam.[52] Some of the challenges faced are shown below:

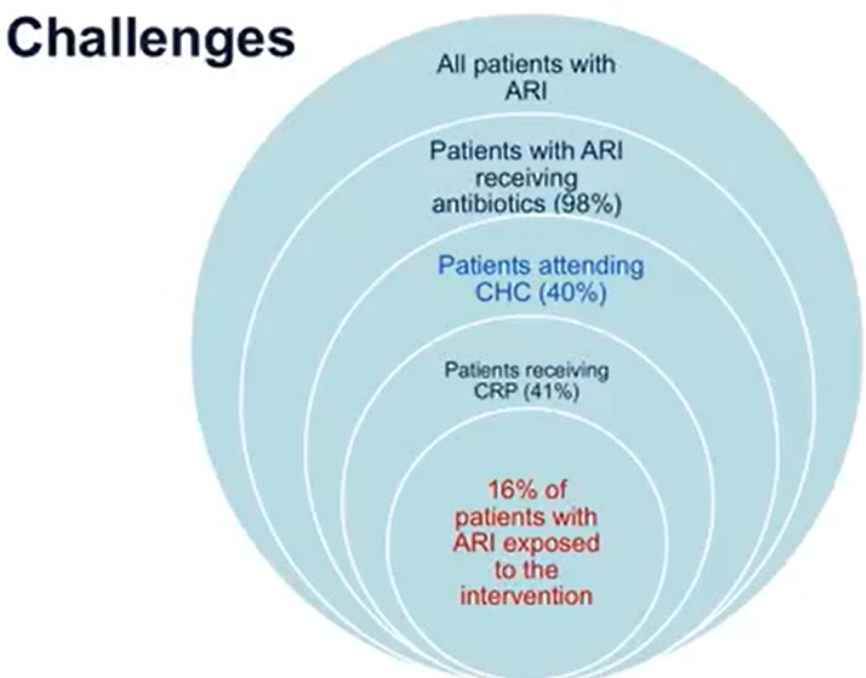


Fig 10: challenges encountered during ICAT trial

Nga and her team are working on another study to explore the visibility, acceptability, and willingness of consumers to pay for the CRP point-of-care test in pharmacies, in the hope that the CRP intervention can have the optimal impact in reducing unnecessary antimicrobial prescription in primary care settings. Social science findings from the CRP trial also discuss the importance of understanding contextual factors, the local language, and conceptions of illness and medicines for the successful implementation of the trial.[53,54]

.

[52] Thi Thuy Do N, Greer RC, Lubell Y, Dittrich S, Vandendorpe M, Nguyen VA, et al. Implementation of C-reactive protein point of care testing to improve antibiotic targeting in respiratory illness in Vietnamese primary care (ICAT): a study protocol for a cluster randomised controlled trial. BMJ Open [Internet]. 2020 Dec 1 [cited 2022 Aug 21];10(12):e040977. Available from: https://bmjopen.bmj.com/content/10/12/e040977

[53] Khine Zaw, Y., Charoenboon, N., Haenssgen, M. J., & Lubell, Y. (2018). A comparison of patients' local conceptions of illness and medicines in the context of C-reactive protein biomarker testing in Chiang Rai and Yangon. *The American journal of tropical medicine and hygiene*, *98*(6), 1661.

C-Reactive Protein

C-reactive protein (CRP) is a biomarker for inflammation, such that its detection or non-detection enables health care providers to distinguish between viral and bacterial infections, thus enabling the better focusing of antibiotics on bacterial infections and avoiding inappropriate used and overuse of antibiotics for treating viral infections.

The point of care test (CPOCT) is a rapid finger prick test, which can be carried out at home by patients.

Various studies from HIC have shown its usefulness in guiding antibiotic prescription in primary care. Yet, very few studies are available from LMICs.

The ABACUS Project

ABACUS project

AntiBiotic ACcess and USe

Irrational use of antibiotics is a major driver of resistance. But why do individuals use antibiotics? Antibiotics are used to treat infections, but they are also used in a wide range of scenarios where they are not needed. For example, in some LMICs, antibiotics are mixed with alcohol to prevent gastric ulcers, and antibiotics are inappropriately used to treat gastrointestinal symptoms, menstrual cramps, and other respiratory problems[15] (Figure 11). These were among the findings from the ABACUS project, presented by Heiman Wertheim. ABACUS is an international collaboration involving three African countries (Mozambique, Ghana, South Africa) and three Asian countries (Bangladesh, Vietnam, Thailand) with research partners in Europe.

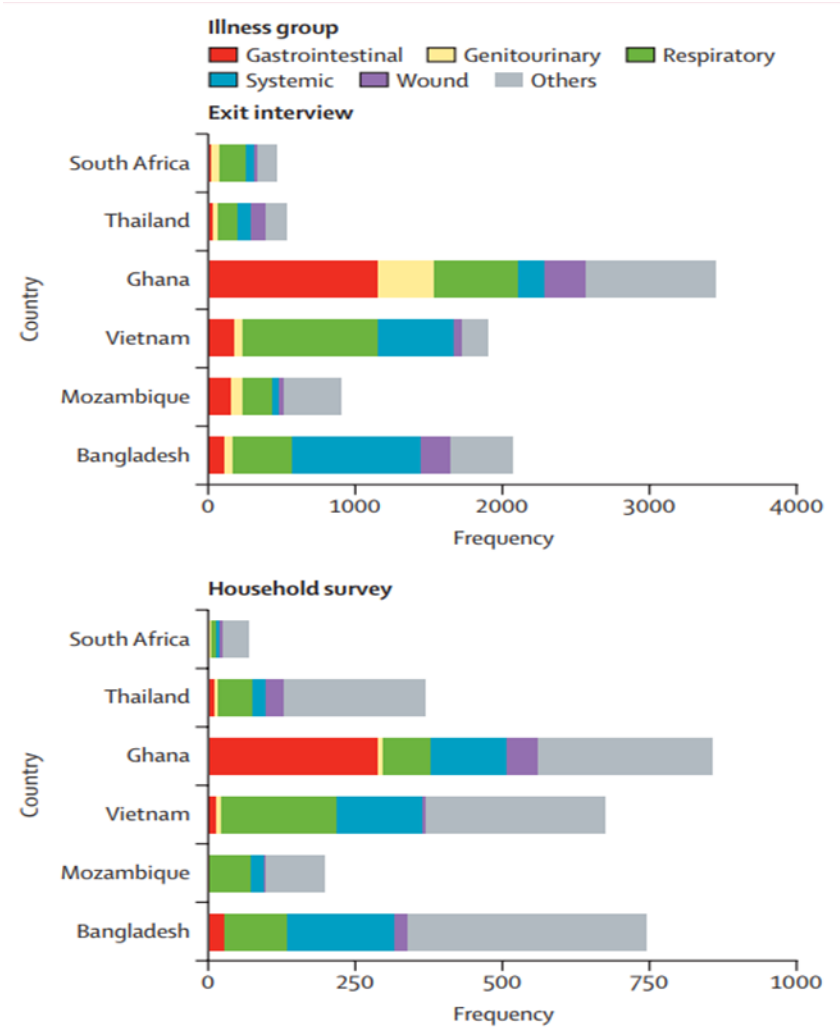


Fig 11: Reported indications for antibiotics obtained at drug suppliers through exit interviews and reported antibiotic use by household members in the past month, obtained through household surveys[15]

The ABACUS I project explored antibiotic access and use. Its main aim was to use a comparative approach to assess antibiotics access and use-practices across communities in six LMICs, to identify key drivers and identify targets for social interventions to improve antibiotic use and access. The second phase of the project, ABACUS II explored 'confusion in identifying antibiotics.' An example Heiman gave was 'Ya Chuud' (Figure 12) in Thailand, packets of non-prescribed mixed medicines which often contain unidentified antibiotics.

From the rich data derived from ABACUS I & II, the group has organised round tables with key stakeholders which have come to the consensus that better identification is needed for antibiotics and all drugs in general. The research team is also working with drug designers, and Paul Newton of Lao-Oxford-Mahosot Hospital-Welcome Research Unit, LOMWRU (mystery shoppers project), to develop different prototypes for better drug recognition.

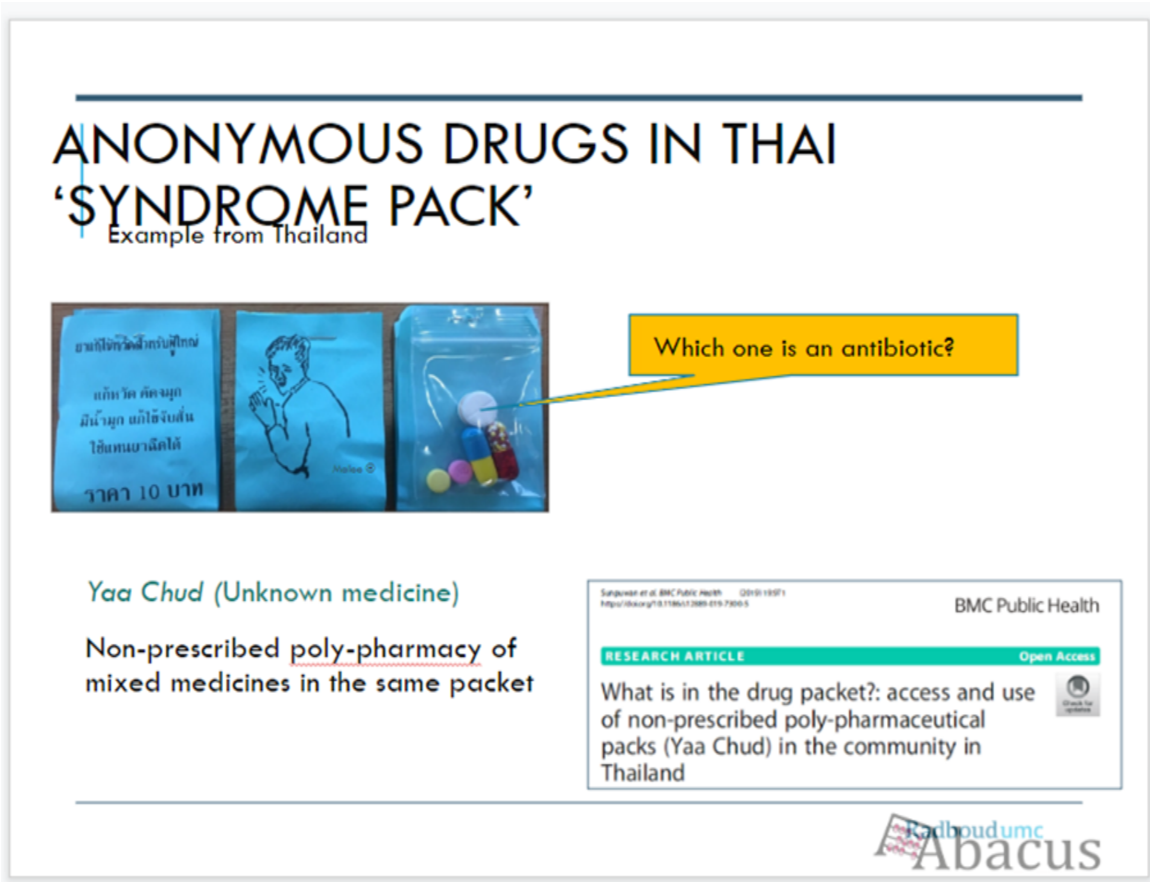


Fig 12: Example of Yaa Chud

"Antimicrobial resistance may not seem as urgent as a pandemic, but it is just as dangerous. It threatens to unwind a century of medical progress and leave us defenceless against infections that today can be treated easily."

-Tedros Adhanom Ghebreyesus (WHO Director-General)

AMR in Humanitarian Settings

We have seen how big a threat antimicrobial resistance is in communities and how it can spread to hospital settings. Some communities however are especially vulnerable to this threat – those in conflict/humanitarian settings. The world is grappling with the most conflict it has seen since 1945. According to the United Nations, 2 billion people, about 1 in 4 of the world's population, currently live in conflict-affected areas, including in countries like Afghanistan, Yemen, Myanmar, Syria, Sudan and Ukraine.[55] In 2022 alone, 274 million people will need humanitarian care or assistance.[56]

In these conflict/humanitarian settings, there is a breakdown of healthcare systems, overcrowding and a lack of basic water, sanitation, and hygiene, all major drivers of antimicrobial resistance.[57] Soaring rates of injuries due to blast and gunshot wounds, with debris and resultant tissue damage make people living in conflict areas highly susceptible to drug-resistant infection. Medicines Sans Frontiers (MSF), which provides humanitarian healthcare in over 70 countries, describes the level of multidrug resistance in these settings as 'alarming'.[58] In a retrospective analysis of their laboratory database of patients with Post-traumatic Osteomyelitis, they found 50% of isolates to

[55] U.N.: 1 out of 4 of the world's population live in areas affected by violence : NPR Available from: https://www.npr.org/2022/03/31/1089884798/united-nations-conflict-covid-19-ukraine-myanmar-sudan-syria-yemen?t=1661641309631

[56] Global Humanitarian Overview 2022 | Global Humanitarian Overview [cited 2022 Aug 27]. Available from: https://gho.unocha.org/

[57] Goldberg J, Clezy K, Jasovský D, Uyen-Cateriano A. Leaving no one behind: the need for a truly global response to antimicrobial resistance. Lancet Microbe [Internet]. 2022 Jan 1 [cited 2022 Aug 28];3(1):e2–3. Available from: http://www.thelancet.com/article/S2666524721003037/fulltext

[58] Kanapathipillai R, Malou N, Hopman J, Bowman C, Yousef N, Michel J, et al. Antibiotic resistance in conflict settings: lessons learned in the Middle East. JAC Antimicrob Resist [Internet]. 2019 Jan 1 [cited 2022 Aug 28];1(1). Available from: https://academic.oup.com/jacamr/article/1/1/dlz002/5438284

be resistant to first-line antibiotics and, disturbingly, third-generation cephalosporins.[59] Similarly, other studies have shown a high rate of Extended-Spectrum Beta-lactamase-Producing *Enterobacteriaceae* (ESBL-PE) in communities with refugees and those with war injuries.[47]

Furthermore, there is a risk of the spread of drug-resistant infections from host communities to refugees and vice-versa, and, in an increasingly globalised world with more international travel and migration, antimicrobial-resistant infections can reach communities far much easier than before.[60] [61]

Osman et al refer to this as a 'catch-22' situation. They present data on AMR in Syrian refugees and the risk this might pose to their Lebanese host community. Conversely, they posit how the presence of high amounts of MDR *E. coli* in Lebanese irrigation water could spread to refugee camps which are located close to agricultural areas or sources of water.[49] In light of this, the WHO carried out a 'Community-based antimicrobial resistance screening among Syrian refugees and the host community in Turkey'.[48] While this study found no major difference between the AMR profile of the Syrian community and the host community in Turkey (fig 13), the WHO advocates that 'robust estimates of the community burden of AMR in countries receiving high numbers of migrants are needed to inform definitive measures to facilitate the prevention, detection and treatment of AMR'.[48]

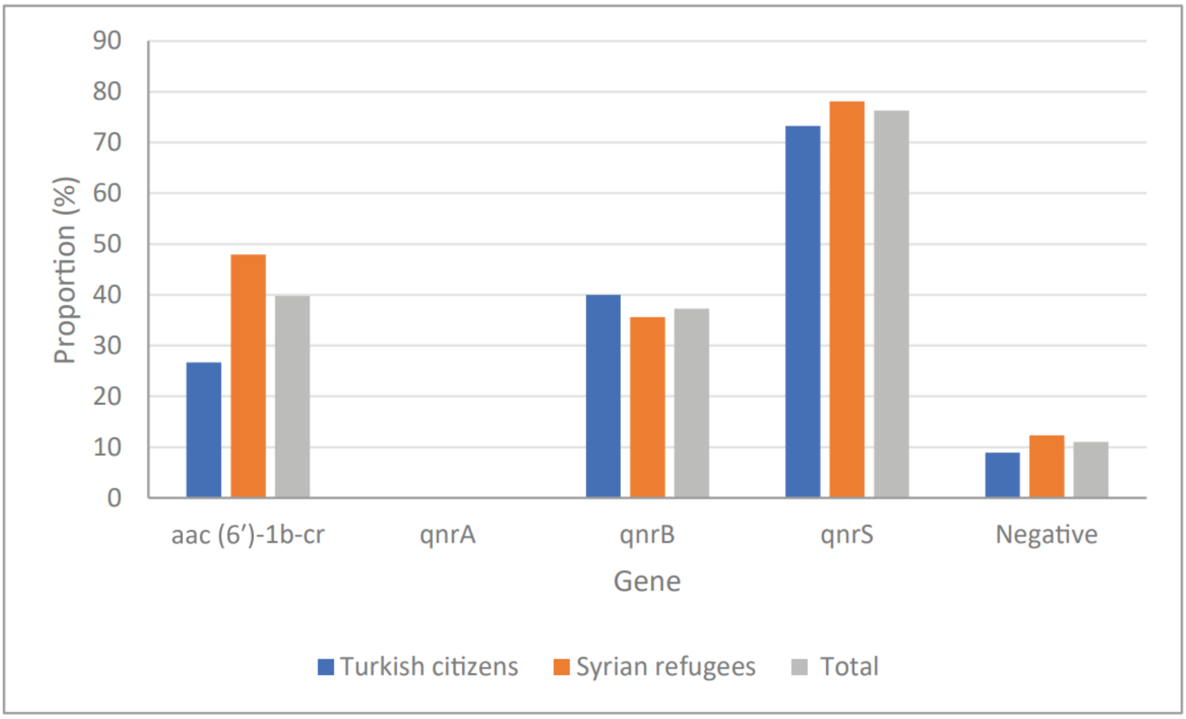


Fig 13|. Distribution of quinolone resistance genes in *E. coli* isolates from Turkish citizens and Syrian refugees[62]

[59] Fily F, Ronat JB, Malou N, Kanapathipillai R, Seguin C, Hussein N, et al. Post-traumatic osteomyelitis in Middle East war-wounded civilians: Resistance to first-line antibiotics in selected bacteria over the decade 2006-2016. BMC Infect Dis [Internet]. 2019 Jan 31 [cited 2022 Aug 28];19(1):1–8. Available from: https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-019-3741-9

[60] Community-based antimicrobial resistance screening among Syrian refugees and the host community in Turkey. 2021 [cited 2022 Aug 28]; Available from: http://www.who.int/about/licensing.

[61] Osman M, Cummings KJ, el Omari K, Kassem II. Catch-22: War, Refugees, COVID-19, and the Scourge of Antimicrobial Resistance. Front Med (Lausanne). 2022 Jun 24;0:1791.

Antibiogo: smartphone-based app for the interpretation of Antibiotic Susceptibility Test (AST)

Most conflict settings are in LMICs. This created a double AMR burden. To effectively tackle this double burden, there is a need to shift away from simply copying and pasting solutions from the global north.

Dr Nada Malou, Project scientific lead at La Foundation MSF, and Driver of 'diagnoses of bacterial infection and AMR Group- ITU/WHO Focus Group on Artificial Intelligence for Health talked about some of the challenges they face in antimicrobial testing in LMICs. Some were the shelf-life of reagents, availability of antibiotic discs and using minimum inhibitory concentration (the lowest concentration that, under defined *in vitro* conditions, prevents the growth of bacteria within a defined period of time). Most significant though is the lack of human resources to correctly interpret Antibiotic Susceptibility Tests (ASTs). Dr Nada explained how this led to the development of Antibiogo, a mobile application specifically designed for LMICs, which uses Artificial Intelligence (AI) and an existing expert database system to aid non-expert lab technicians in interpreting antibiograms (which measure the overall profile of antimicrobial susceptibility testing results of a specific microorganism to a battery of antimicrobial drugs).[62]

Antibiogo is available offline, free and will be open access for all LMICs. It was launched in summer 2022 in MSF laboratories in Mali, the Central African Republic, Jordan and Yemen.

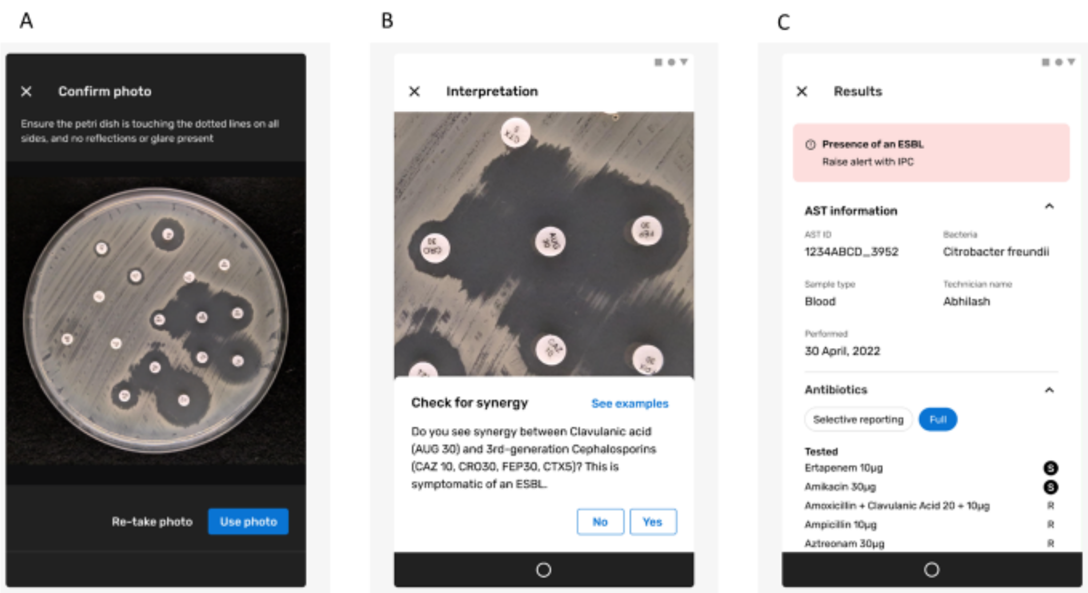


Fig 14 | How Antibiogo works[64]

[62] Antibiogo [Internet]. [cited 2022 Aug 27]. Available from: https://antibiogo.org/

A- MEASURE EASILY
Take a picture of the Petri dish, and measure inhibition zone diameters for each antibiotic disc
B- GENERATE RESULTS
After image analysis, answer guided interpretation questions to generate AST results.

"Antibiogo is innovative in that it was created based on the need identified in countries with limited resources, was developed with users in these countries and with their data, and was tested in the people who are going to benefit from it. The development model of this medical device is the reverse of the one we usually observe, and meets real needs observed in LMICs"- Dr Nada Malou

Better Drug Identification & Use

Countries are coming up with novel ways to enhance drug identification and combat falsified and substandard drugs.

In India, there is a Red Line program. Medicines with a red line on their pack signify that they should not be consumed without a prescription.

In Nigeria, NAFDAC has deployed the Mobile Authentication Service (MAS) for antimalarials and antibiotics. SMS and scratch codes are used to detect substandard and falsified drugs.

Antibiotic Use in Adults & Paediatric Outpatients -The German Angle

After delving into antibiotic use and access in LMIC communities, Sussane Schink and Sebastian Haller provided an insight into the German health-care system, and a reminder that AMR is not limited to developing countries, and that the global north needs to work on its own shortfalls in terms of antibiotic surveillance and stewardship (see figure on community antibiotic consumption in Europe).

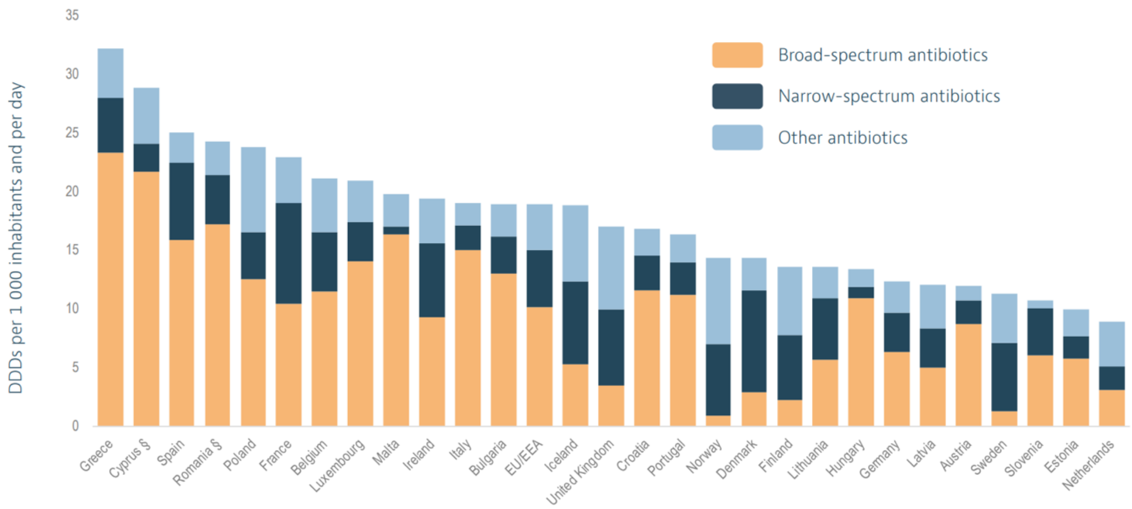


Fig 15 | Consumption of antibiotics in the community, EU/EEA† , 2017[63]

The figure shows huge differences in DDD between Greece/Cyprus/Spain and Sweden/Netherlands. Germany has one of the lowest consumption of antibiotics in the community

In the German healthcare system, primary care physcicans and specialists such as peadiatricitans and dentists work in outpatient settings that are not affiliated to hospitals, and therefore not under federal surveillance systems. The majority of antibiotic prescriptions (85%) are from these outpatient settings.

The study presented by Susanne Schink and Sebastian Haller from the Robert Kock Institute, Berlin, looked at antibiotic consumption (through prescription data) in outpatients by regional distribution over time, medical specialty, and patient age. The purpose was to work out better ways to target groups and regions for specific antibiotic stewardship activities, and also to be able to provide individual feedback reports to physician. In addition, the findings of the study will contribute to a national report. Feedback from the study to healthcare professionals who prescribe antibiotics will enable them to compare their own use of antibiotics to that of their peers in the hopes that this will incentivise them to improve their own prescription behaviours.

Perhaps more compelling is the regional differences Susanne described in antibiotic prescription despite similar disease patterns in the country - Western Germany has had consistently higher antibiotic prescriptions than Eastern Germany.[64] Reasons offered for this variation include the cultural differences between the east and west, as well as the distribution of physicians in the various regions.[65] Evidence has been lacking on the exact cause, however, findings from an ongoing mixed methods study (SARA) could shed more light on this.

63

64 Holstiege J, Schulz M, Akmatov M, Steffen A, Batzing J. Update: The Outpatient use of systemic antibiotics in Germany from 2010 to 2018- a population-based study. Berlin; 2019 Aug.

65 Scholle O, Asendorf M, Buck C, Grill S, Jones C, Kollhorst B, et al. Regional Variations in Outpatient Antibiotic Prescribing in Germany: A Small Area Analysis Based on Claims Data. Antibiotics [Internet]. 2022 Jul 1 [cited 2023 Mar 28];11(7):836. Available from: https://www.mdpi.com/2079-6382/11/7/836/htm

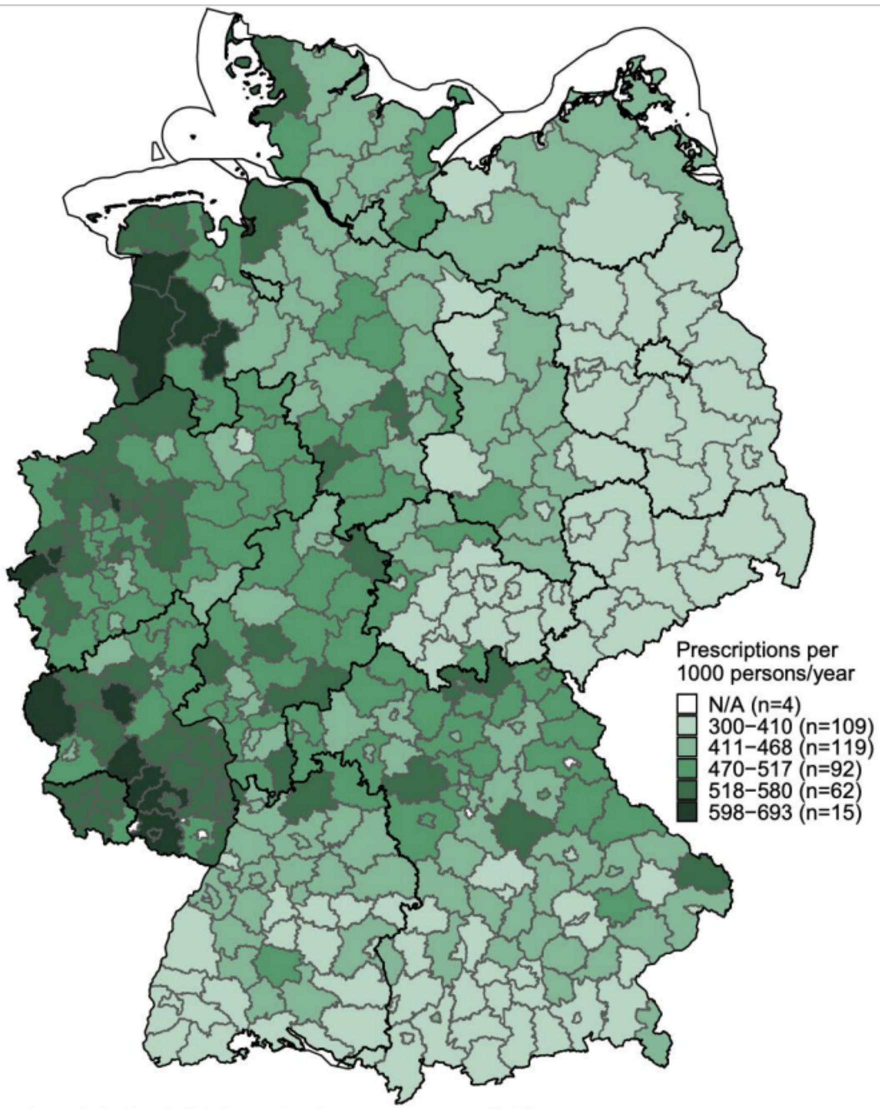


Fig: Standardized Prescription rates of antibiotics in adults >18 years by districts in Germany,2018[67]

Darker green represents higher antibiotic prescriptions, seen mainly in districts in eastern Germany

Water Supply, Sanitation, and Hygiene (WASH)

Basic hygiene is a pressing global priority. Water, Sanitation, and Hygiene (WASH) is key, but we underestimate how difficult it is to achieve in many parts of the world. There are 2 billion people without access to safe drinking water, 3.6 billion without proper sanitation, and 2.3 billion without handwashing facilities at home.[23] Globally, this is expected to cause more than one million deaths per year.[66]

Failing to hit the Sustainable Development Goals (SDGs) on WASH (SDG 6) will have a knock-on effect for infections such as diarrhoeal diseases, the abuse and overuse of antibiotics, which contribute to the spread of resistant microbial strains, and every aspect of social and economic development. Stopping infections from arising in the first place will eliminate risk factors that promote resistance. For instance, recent evidence from a Lancet report indicates that WASH programmes – such as drinking water filtered at the point of use – lowered the risk of diarrhoea

[66] Prüss-Ustün A, Wolf J, Bartram J, Clasen T, Cumming O, Freeman MC, et al. Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: An updated analysis with a focus on low- and middle-income countries. Int J Hyg Environ Health [Internet]. 2019 Jun 1 [cited 2022 Jul 18];222(5):765–77. Available from: https://pubmed.ncbi.nlm.nih.gov/31088724/

in children in developing countries by up to fifty percent.[67] Further, handwashing promotion combined with broader hygiene education reduced diarrhoea by thirty percent.

While environmental drivers of AMR remain relatively unexplored, it is essential to recognise the interaction between humans, animals, and the environment in the emergence and spread of clinically significant resistant microbial strains. Wastewater and unsanitary open defecation are typical sources of pathogens, including antibiotic-resistant bacteria. Hence, efforts to bridge a gap between humans and the environment by improving water and sanitation facilities are crucial not only for minimising the spread of resistance, but also for reducing the likelihood of new resistance emerging.[68]

There is a big opportunity in many countries to capitalise on the higher appreciation many people now have for the importance of regular hand-washing and hygiene for preventing infections such as COVID-19. The message should be that the new habits acquired, and investments made, in response to COVID-19, should be maintained to protect against other diseases. We need to continue to raise awareness and scope best practices in low-resource settings.[69] The international community needs to double-down on its efforts to deliver the human rights of every child to have access to clean water, basic toilets, and good hygiene practices.

---

[67] Wolf J, Hubbard S, Brauer M, Ambelu A, Arnold BF, Bain R, et al. Effectiveness of interventions to improve drinking water, sanitation, and handwashing with soap on risk of diarrhoeal disease in children in low-income and middle-income settings: a systematic review and meta-analysis. Lancet [Internet]. 2022 Jul 2 [cited 2022 Jul 18];400(10345):48–59. Available from: http://www.thelancet.com/article/S0140673622009370/fulltext

[68] Macintyre A, Wilson-Jones M, Wvelleman Y. Prevention first: Tackling AMR through water, sanitation and hygiene | AMR Control [Internet]. One Health. 2017 [cited 2022 Jul 18]. Available from: http://resistancecontrol.info/2017/prevention-first-tackling-amr-through-water-sanitation-and-hygiene/

[69] WHO. World Hand Hygiene Day 2021: Seconds save lives - clean your hands! [Internet]. World Health Organisation, Geneva. 2021 [cited 2022 Jul 18]. Available from: https://www.who.int/campaigns/world-hand-hygiene-day/2021

The Way Forward - Recommendations

Over the course of the workshop, participants delved into the causes and drivers of antimicrobial resistance from a community perspective. So also, on how the present data and interventions on antimicrobial resistance will continue to be peripheral if there is no triangulation of data from individuals, households, primary health care facilities, agriculture, and the environment. Most significantly, speakers and attendees explored courses of action drawn from their own research findings, experiences, and contexts.

We present below some of the recommendations at three stakeholder levels:

Government & Policy Makers	Research & Technical Capacity	Community
• Formation and implementation of laws discouraging sales of antimicrobials without prescription • Policy to ensure that contacts of STIs are followed up • Set up policy mandating the various committees on AMR to regularly review and make treatment guidelines on available and accessible • Include AMR activities into the annual work plan and budget of each sector within the one health platform • Improve WASH infrastructure • Universal Healthcare	• Cheap, effective Community screening especially for high risk and vulnerable populations • Initiate and maintain surveillance for AMR pathogens in community • Build the capacity and infrastructure of primary healthcare centres, clinics, agricultural and environmental facilities • Participatory research • Strengthen laboratory capacity of facilities in the community • New drugs and vaccines	• Promote awareness, education and behaviour change campaigns on AMU, sanitation and hygiene • Community engagement and sensitisation on the effects of self-medication to individual and community as a whole

"…Going forward, we really need to make sure we continue to strengthen our multisectoral AMR working group that requires key stakeholders that is- engagement of both the agricultural sector and the human sector…. That will include for example engagement with patients, community members, trade, pharmaceutical sector."

A GARDP Secure sector (or maybe just an antibiotic section to go in…I am working on it to be inserted)

Cover photo 1   Photo by Myriam Zilles on Unsplash
Cover photo 3 Photo by Namnso Ukpanah on Unsplash
Cover photo 4 Photo by Roberto Sorin on Unsplash

Cover photo 5 Photo by Jason Leung on Unsplash

Cover photo 7 Photo by Julie Ricard on Unsplash
Cover photo 8 Photo by Liz Martin on Unsplash
Cover photo 9 Photo by Towfiqu barbhuiya on Unsplash