

The role cross-ecosystem interorganizational relationships could play in addressing the global anti-microbial resistance (AMR) challenge

Daniel Marshall BSc & Dr. Swetketu Patnaik

The role cross-ecosystem interorganizational relationships could play in addressing the global anti-microbial resistance (AMR) challenge

Summary:

Anti-Microbial Resistance (AMR) is one of the most pressing social challenges facing public health today, with 4.71 million AMR associated deaths taking place in 2021, a number which rises year by year. Our research found two ecosystems exist to combat AMR; An innovation ecosystem, looking to innovate new antimicrobial drugs, and a control ecosystem looking to ensure access and stewardship for antimicrobials. These ecosystems exist in a very co-dependent manner, and yet cross-ecosystem collaboration rarely occurs, exposing a gap in the AMR space which could potentially streamline tackling the issue. This paper highlights how inter-organization relationships (IORs) could fill this gap, whilst touching on the paradoxical reasons these IORs are not already in place.

Track: Inter-Organizational Collaboration Track

Word count: 3530

Antimicrobial Resistance as a Grand Challenge

Antimicrobial resistance (AMR) is one of the largest issues currently facing global health, with an ever-growing number of microbial infections becoming increasingly resistant to their common therapies (World Health Organization, 2025). This means the drugs used to treat bacterial, fungal, parasitic and viral infections are becoming increasingly ineffective, resulting in an increased risk of disease spreading, and more severe and fatal illnesses due to the antimicrobial drugs being unable to fight off the infection.

In 2021 it was estimated that around 4.71 million (95% UI 4.23–5.19) deaths were associated with bacterial AMR, including 1.14 million (1.00–1.28) deaths directly attributable to bacterial AMR (BAMR) (GBD 2021 Antimicrobial Resistance Collaborators, 2024). This number is estimated to grow annually, reaching 1.91 million (1.56–2.26) deaths attributable to BAMR and 8.22 million (6.85–9.65) deaths associated with BAMR in 2050, forecasting 39.1 million (33.0–46.0) deaths attributable to BAMR and 169 million (145–196) deaths associated with BAMR within the next 25 years. It is also worth pointing out here that whilst these statistics are extremely damning, they only consider BAMR, meaning the figures would become even more devastating if it was possible to capture the totality of AMR (i.e. including viral, fungal and parasitic antimicrobial resistance) (Muhaj, et al., 2022).

The issue is prevalent globally, contributing to more deaths than both HIV/AIDS and malaria (Thompson, 2022). Like many global health issues, the effects of AMR are at their worse in lower-income countries (Zhou,

et al., 2022), however negative effects are still felt directly in higher-income countries, with the most recently available report from the 'CDC' attributing at least 35,000 deaths to AMR in the USA each year (CDC, 2019) – an increase of 152% from their report six years prior (CDC, 2013). Likewise, in the United Kingdom, AMR contributed to 35,200 deaths in 2023, with the burden of AMR increasing 3.5% since 2019 (National Audit Office, 2025).

However, the burden of AMR goes beyond global health, with it also vastly impacting the global economy, an effect which is expected to worsen as the prevalence of AMR increases (Chokshi, et al., 2019). Globally it is estimated that AMR increases the cost of health care US\$ 66 billion annually, a number which is predicted to rise to US\$ 159 billion if global AMR rates continue to follow current trends (McDonnell, et al., 2024). However, given the rapid rise of AMR prevalence in some nations, particularly in low- and middle-income countries (LMICs), the global cost could become much worse. If resistance rates were to increase at the rate of the bottom 15% of countries, AMR health costs could rise to US\$ 325 billion, resulting in the global economy being US\$ 1.7 trillion worse off by 2050 (compared to following historical trends). As staggering as these figures are, the majority of such studies are carried out in high income countries (HICs), or using data from HICs, with the burden that is expected to be even more substantial in low and middle income countries (LMICs) often being under represented (Poudel, et al., 2023). Regardless, however the data is obtained it is still clear a large focus of tackling AMR needs to be targeted towards the countries with the highest prevalence and most devastating impact.

There are also great potential financial gains to be had with effectively tackling AMR through high quality treatment, including the development of new antibiotics, as by 2050 health costs could be US\$ 97 billion cheaper, whilst the global economy itself could be US\$ 990 billion larger (McDonnell, et al., 2024).

AMR becoming a 'pandemic' has long theorised for a relatively long time, with a 2001 report by the World Health Organisation (WHO) releasing a 'Global Strategy for Containment of Antimicrobial Resistance', which outlined the potential risks of AMR, and steps that can be taken to avoid these coming into fruition (World Health Organisation, 2001). This initial widespread message was seemingly not received, or not effective, as WHO released a number of further reports in 2012, 2014 and 2022, all of which showed an increasing prevalence of AMR with minimal effective efforts to combat it (World Health Organisation, 2022).

This neglect of AMR continued in public perception too, with a 2021 study in the UK showing that amongst a sample of 2,555 individuals ages between 16-75, only 26% had heard of the term of the antimicrobial resistance, and an even lower 11% had heard of the acronym AMR (Food Standards Agency, 2021). There has been an increase in awareness from the 16% who were aware of the term antimicrobial resistance in the 2016 survey, but given the increased value of 2021 still only equates to ~1 in 4 people, this is not high enough. It is also not only the UK where public awareness is an issue, for example a 2018 study in North Jordan found that 70% of their 1060 participants, 70% had either never heard of the term antimicrobial resistance, or were unable to correctly define it (Yusef, et al., 2018). In fact, in some languages, the terms used to label and describe both AMR and efforts to tackle it are not directly translatable, making public understanding extremely difficult (Food and Agriculture Organization of the United Nations, 2023).

It is statistics and studies like these which I believe justify AMR being considered a Grand Challenge. . The concept of 'grand challenges' has become increasingly prevalent in organizational studies, as well as in wider research (Schwoon, et al., 2022). Whilst researchers definition of a Grand Challenge may vary slightly, most seem to agree, at-least in part, that it describes a complex issue that is widespread so affects many actors (Grand Challenges Canada, 2011) (Ferraro, et al., 2015) (Gümüşay, et al., 2022).. In 2015 Fabrizio Ferraro attempted to categorise the three features an issue must possess to be regarded as a grand challenge (Ferraro, et al., 2015). The first is the issue must be complex, involving a number of organizations and associations. Secondly, the issue must create future uncertainty. Finally the nature of the issue will lead to new issues as the original ones begin being tackled.

Ferraro's original features of a grand challenge were very organization-focused; however, many other experts have stated grand challenges are as much a social issue as they are an organisational issue. Gümüşay suggesting there should be fourth feature for issues to be considered grand challenges, with the issue itself needing to be widespread and affect a wide range of people (Gümüşay, et al., 2022).

This categorisation of what an issue needs to be considered a grand challenge creates a far more established definition than those used in earlier studies. A prior study from 2011 simply viewed grand challenges as a specific critical issue that would create widespread benefits if solved (Grand Challenges Canada, 2011). While this definition is more simplified than that of Ferraro, it does refer to the widespread nature of grand challenges outside of a business sense, supporting the definition from Gümüşay eleven years later.

Whilst I believe that Gümüşay's definition best captures the multifaceted nature of a severe issue that affects a wide range of actors, I feel that regardless of which definition you accept there is no justifiable counterargument for antimicrobial resistance being considered a grand challenge. If you follow Ferraro's defining features of a grand challenge then 1) AMR is not only an issue which multiple organisations have attempted to solve, but also an issue that has negatively impacted a number of organizations/associations especially in healthcare. 2) There is definite future uncertainty on a global scale as a result of AMR, especially the possibility of continued effective treatments. 3) As research has progressed into AMR, more issues have been uncovered, for example early ideas for solving the problem such as the use of second and third-line antimicrobials has led to further resistance issues (Llor & Bjerrum, 2014). If you choose to accept the more sociological definitions of 'Grand Challenges Canada' and Gümüşay where a wide range of people are impacted, then AMR still fits as millions dying from all across the globe each year.

Exploring the Ecosystem Combating AMR

Despite AMR being identified as a Grand Challenge, it is clear from the outline above that the current systems in place to tackle this challenge have thus far proven ineffective. To better understand why this is the case I wanted to explore the nature of the ecosystem that surrounds combating AMR in order to try and identify any potential fractures. Ecosystems, defined by Jacobides, et al.'s as a constellation of self-interested yet strongly interconnected organisational actors aiming at joint value creation (Jacobides, et al., 2024), have become a prevalent area of exploration to better understand the nature of grand challenges and the issue within them (Falcke, et al., 2023) (Ritala, 2023) (Raizada, 2025).

Whilst reading journal and news articles around AMR provided useful insights into the state of the ecosystem combating AMR, such as the urgent need for more late-stage drug development or adopting One Health approaches to account for areas such as agriculture use, I felt that deeper immersion into the ecosystem around AMR was needed in order to understand the shortcomings on a deeper level. (Global AMR R&D Hub and WHO, 2023) (Jimenez, et al., 2023). This led to me attending seventeen AMR themed events, ranging from seminars, webinars and conferences, to virtually watching global conversations unfold through platforms like the United Nations General Assembly on AMR which took place in 2024. However, the further I immersed myself into the field of AMR research and drug discovery, the more fragmented this ecosystem appeared. Whilst the literature is very clear in the lack of drug discovery that has taken place, there was no one clear organisation leading the efforts to combat this, nor were there many groups working together in equal and inclusive mannerisms (with the voice of LMICs in particular being a big missing aspect). Instead, a number of separate organisations were present, all of whom are taking their own approaches and facing their own challenges without having many relationships with other key actors within the ecosystem. This inter-organizational fragmentation within the ecosystem therefore seemed to provide a good focus point to understand where the ecosystem is struggling, from a relational perspective. I would therefore set out to determine answers to two key research questions:

1. What are the causes of inter-organisation relational fragmentations?
2. What benefits could improving these relationships have on combatting AMR?

Planning Semi-Structured Interviews:

After reviewing literature around interorganizational relationships, semi-structured interviews were identified as another successful approach of data collection (Aciri, et al., 2014). To reach my research aims an unstructured interview would not be directed enough, as I would need to have some idea of the actors standing the space of AMR drug discovery to ensure my questions are effective. Whereas on the opposite end of the spectrum, a

structured interview would hinder free-flowing conversation, constricting me should these experts of the field bring up key features I am either less aware of, or feel would be useful to explore further. Another reason for choosing not to go down the structured route is that with this being an exploratory study, there is no great need to directly compare every response.

One of the biggest shortcomings of semi-structured interviews, however, is their ability to promote bias, both from the interviewer and the interviewee (Ruslin, et al., 2022). If I was to conduct semi-structured interviews, I would firstly need to keep my questions as open as possible, trying to avoid leading participants down a line of argument which matches my research desires, when it may not reflect their true feelings. In addition to this, I need to understand that participants may have vested interests, and their answers may carry a bias too in an attempt to protect these interests. This was the initial issue which stopped me wanting to conduct interviews. However, through understanding that this ecosystem was much more diverse, it became clear that there would be great value in interviewees providing their own perspectives on multiple areas across the ecosystem, rather than just their organizations shortcomings. Thus, making semi-structured interviews feel the most effective methodology

If I could identify key actors involved in the ecosystem and the organisations with, as well as those who are involved in maintaining the interorganizational relationships, then these would act as ideal candidates to conduct semi-structured interviews with. Conducting semi-structured interviews with these actors would allow me to gain their first-hand accounts of how their organizations work, and how they exist within the wider AMR drug discovery ecosystem. These interviews could also then reveal faultlines that exist both within these organizations, and also the relationships between other organizations.

From my immersion into the ecosystem I identified six-sub groups of actors: pharmaceutical industry, academia, advocacy, governmental, and a final group I termed ‘innovation bridgers’, who aim to work alongside pharmaceutical companies and promote innovation. I would then reach out to a number of key individuals within each sub-group, aiming to get representation from both HICs and LMICs within that space. My method of identifying key individuals came from looking at which individuals had played a key role within not just their own organization, but also how said organizations interacts with others within the ecosystem, whether it be through conference talks, joint reports, global discussions etc.

Conducting Interviews

We interviewed more than 30 experts belonging to different sub-groups within the AMR ecosystem. The interviews largely took place between May – December 2024, with a few happening after, and in most instances each interview lasted for 45-60 minutes. Each interview consisted of three main parts (a) background information on the interviewee and their organization's involvement in the larger AMR context; (b) information and insights on some of the key challenges they face in their activities to alleviate AMR; and (c) what could be done to address the relational challenges that are associated with this field.

Through conducting these semi-structured interviews with experts from across multiple sectors, including representatives from both High-Income countries (HICs) and Low-Middle Income Countries (LMICs), we were able to explore the fragmented ecosystem combatting AMR. This theme of fragmentation was consistent across every interview we conducted, with people from across the ecosystem of all backgrounds recognising that greater cross-sectoral inter-organization collaboration is needed to address the critical societal challenge of AMR.

Identification of Two Ecosystems

However, when reflecting back on Jacobides, et al.'s 2024 definition it became clear that whilst there are many self-interested and yet strongly interconnected actors within the AMR space, our initial findings from these

interviews revealed that the ecosystem combatting AMR is actually made up of two substituent ecosystems, who largely consist of different stakeholders and operate at different levels.

The first ecosystem is the ‘innovation’ ecosystem, which includes organizations and researchers focused on research and development (R&D) to create new antimicrobial products. This includes, but is not limited to, pharmaceutical companies, research institutions and funding organizations, all acting to innovate new solutions for combating AMR. This ecosystem tends to operate on a more global scale, with the overarching goal of discovering and developing new and innovative antimicrobials for worldwide use. This ecosystem is fairly consistent with prior research and development innovation ecosystems in the drug development setting, albeit with its own unique challenges in areas such as access to funding (Rosenblatt, et al., 2017).

In contrast, the second ecosystem, the ‘control’ ecosystem, aims to improve the stewardship and accessibility of antimicrobials. Key stakeholders in this ecosystem include advocacy group, public health advisors and social scientists. This ecosystem primarily functions at national and, in some cases, regional levels, addressing specific challenges faced in those areas, whilst also drawing input from the World Health Organization (WHO). Whilst in other healthcare settings and innovation ecosystems such actors may be considered to solely constitute the political environment of healthcare firms and instead act more as gatekeepers and facilitators (Naturale, 2024), in the unique context of AMR, and the need to educate and maintain stewardship over AMR drug usage. In this context the prior actors mentioned have their own self-interests away from the innovation ecosystem, aiming to maintain the drugs already available and alter their usage, without necessarily interacting with innovation actors to achieve this. However the control actors not only look for their own self-interest, but are also strongly interconnected organisational actors aiming at joint value of controlling the current AMR (Jacobides, et al., 2024) without necessarily aiming to innovate/develop new drugs.

There are some slight exceptions to these ecosystems such as ‘bridging organizations’ and policy influencers, who tend to exist in the space between both ecosystems, but even these seem to have much more of a role in one of the ecosystems than they do the other. For example, some may have a significant impact within the control ecosystem but have limited involvement in the innovation ecosystem, or they may address AMR solely from a national or regional perspective and therefore are not involved at a global level.

The Absence of Cross-Ecosystem Inter-Organizational Relationships

As a whole the inter-organizational relationships (IORs) take place within the same ecosystems. For example pharmaceutical companies will build relationships with research institutions to connect early level science, or funders will build relationships with pharmaceutical companies to try and push more drug development. Likewise in the control ecosystem you will find advocacy groups appealing to public health advisors in order to make social changes that improve the control over antimicrobial drugs.

Whilst these IORs can be beneficial within their own ecosystems, the very nature of AMR means in-ecosystem IORs simply will not suffice in order to truly tackle the societal challenge. AMR is a natural condition (albeit one that has been heavily increased by human action) that occurs when a particular microbial infection has become resistant to a particular therapy which aims to treat it, thus branding this therapy ineffective. Whilst resistance can occur naturally, it is still human activity through a wide-ranged misuse of antimicrobials, such as overprescription or stopping courses early, that speeds up the resistance process. This creates somewhat of a paradoxical effect whereby we need to ‘innovate’ new antimicrobial drugs in order to tackle the issue, but also ‘control’ the usage of antimicrobials to ensure they are available when needed but only used when necessary and in the correct way. This indicates a clear overlap, and an almost co-dependency should exist between the two ecosystems. For innovation to be sustainable, the control ecosystem must make sure the drugs can last through stewardship, yet for control and access to be possible, there must be innovation of new antimicrobials given so many infections are becoming resistant to the ones currently used.

Nearly all of the experts we interviewed agreed and emphasised the importance of this point, that innovation and control are essential in tandem, identifying the reality that there is a severe lack of collaboration between ecosystems as a real issue. Across the interviews and the immersion it was made clear that there is a need for greater collaboration among organizations at various levels, from global to local, across both ecosystems. There was a real sense of frustration from the individuals interviewed that this cross-ecosystem collaboration did not exist. However, as the AMR space operates largely at an organizational and state level, the individual frustrations are not enough to drive the change. Early themes coming out as to why reason these cross-

ecosystem collaborations are not taking place largely comes down to organizations vested interests, a lack of knowledge of the other ecosystem, and there being no real central organization to facilitate these cross-ecosystem relationships.

Potential Benefits of Cross-Ecosystem Interorganizational Relationships

Sharing knowledge and understanding through IORs has been proven as a beneficial tactic to reach goals quicker (Loebbecke, et al., 2016), so a cross-ecosystem IOR would more than likely serve to helping combat AMR quicker, and yet due to the lack of knowledge and understanding currently in place, it is almost as if the organizations feel it is wrong to do this. This has created a unique environment where the literature suggests that a greater level of cross-sector IORs, which can also transfer to cross-ecosystem IORs, would help combat the societal issue, expert individuals across both ecosystem agree a greater level of these IORs would be beneficial, and yet the current structural relationships between organizations and ecosystems mean potentially crucial IORs are not emerging.

However, if cross-ecosystem IORs were to begin taking place on more consistent and inclusive levels, key actors could begin to work together on aligned messages, understand the needs of other sectors and tailor their actions towards it, thus meaning the actions of one ecosystem can therefore benefit the other.

Options for Final Submission / Development Before Conference:

I wanted to ensure this submission detailed the uniqueness that surrounds the IORs in this space, but I also have data analysis that could indicate further reasons why these IORs may not be occurring, and also expert opinions on the potential benefits of creating cross eco-system IORs which would fit in naturally when presenting

The discussions and feedback I would get from presenting this paper would then help contextualise it more away from AMR-specific findings, and assist with fine-tuning the transferability of findings to other aspects of IORs.

References

- Acri, M. C. et al., 2014. Interorganizational Relationships among Family Support Organizations and Child Mental Health Agencies. *Administration and Policy in Mental Health and Mental Health Services Research*, 41(4), pp. 447-454.
- CDC, 2013. *Antibiotic Resistance Threats In The United States 2013*, Atlanta: CDC Press.
- CDC, 2019. *Antibiotic Resistance Threats in the United States 2019*, Atlanta: CDC Press.
- Chokshi, A., Sifri, Z., Cennimo, D. & Horng, H., 2019. Global Contributors to Antibiotic Resistance. *Journal of Global Infectious Diseases*, 11(1), pp. 36-42.
- de Kraker, M. E. A., Stewardson, A. J. & Harbarth, S., 2016. Will 10 Million People Die a Year due to Antimicrobial Resistance by 2050?. *PLOS Medicine*, 13(11), p. e1002184.
- Falcke, L., Zobel, A.-K. & Comello, S. D., 2023. How firms realign to tackle the grand challenge of climate change: An innovation ecosystems perspective. *Journal of Product Innovation Management*, 41(2), pp. 403-427.
- Ferraro, F., Etzion, D. & Gehman, J., 2015. Tackling Grand Challenges Pragmatically: Robust Action Revisited. *Organization Studies*, 36(3), pp. 363-390.
- Food and Agriculture Organization of the United Nations, 2023. *FAO publishes antimicrobial resistance terms in different languages*. [Online]
Available at: <https://www.fao.org/antimicrobial-resistance/news-and-events/news/news-details/en/c/1632404/>
[Accessed 02 05 2025].
- Food Standards Agency, 2021. *AMR Consumer Awareness Survey*, London: Food Standards Agency.
- GBD 2021 Antimicrobial Resistance Collaborators, 2024. Global burden of bacterial antimicrobial resistance 1990-2021: a systematic analysis with forecasts to 2050. *The Lancet*, 404(10459), pp. 1199-1226.
- Global AMR R&D Hub and WHO, 2023. *ncentivising the Development of New Antibacterial Treatments: 2023 Progress Report*, Berlin & Geneva: Global AMR R&D Hub and WHO.
- Grand Challenges Canada, 2011. *The Grand Challenges Approach*, Toronto: Mclaughlin-Rotman Centre for Global Health..
- Gümüşay, A. A., Marti, E., Trittin-Ulbrich, H. & Wickert, C., 2022. How Organizing Matters for Societal Grand Challenges. *Research in the Sociology of Organizations*, Volume 79, pp. 1-14.
- Jacobides, M. G., Cennamo, C. & Gawer, A., 2024. Externalities and complementarities in platforms and ecosystems: From structural solutions to endogenous failures. *Research Policy*, 53(1), p. 104906.
- Jarzabkowski, P., Bednarek, R., Chalkias, K. & Cacciatori, E., 2019. Exploring inter-organizational paradoxes: Methodological Lessons from a study of a grand challenge. *Strategic Organization*, 17(1), pp. 120-132.
- Jimenez, C. E. P. et al., 2023. One Health WASH: an AMR-smart integrative approach to preventing and controlling infection in farming communities. *BMJ Global Health*, 8(3), p. e011263.
- Llor, C. & Bjerrum, L., 2014. Antimicrobial resistance: risk associated with antibiotic overuse and initiatives to reduce the problem. *Therapeutic Advances in Drug Safety*, 5(6), pp. 229-241.
- Loebbecke, C., van Fenema, P. C. & Powell, P., 2016. Managing inter-organizational knowledge sharing. *The Journal of Strategic Information Systems*, 25(1), pp. 4-14.
- McDonnell, A. et al., 2024. *Forecasting the Fallout*, Washington DC: Center for Global Development..
- Muhaj, F. F. M., George, S. J., Nguyen, C. D. & Tying, S. K., 2022. Antimicrobials and resistance part II: Antifungals, antivirals, and antiparasitics. *Journal of American Academy of Dermatology*, 86(6), pp. 1207-1226.
- Naghavi, et al., 2024. Global burden of bacterial antimicrobial resistance 1990–2021: a systematic analysis with forecasts to 2050. *The Lancet*, 404(10459), pp. p1199-1226.

National Audit Office, 2025. *Investigation into how government is addressing antimicrobial resistance*, London: Department of Health & Social Care, & Department for Environment, Food & Rural Affairs.

Naturale, L., 2024. *The Business of Healthcare: Lining the Pockets of Pharmaceutical Companies, Providers, and Politicians*. s.l.:Otis Publishing.

O'Neill, J., 2016. *Tackling Drug-Resistant Infections Globally: Final Report and Recommendations*, s.l.: Government of the United Kingdom.

Poudel, A. N. et al., 2023. The economic burden of antibiotic resistance: A systematic review and meta-analysis. *PLOS One*, 18(5), p. e0285170.

Raizada, A. S. S., 2025. Organizing ecosystems for the greater good: An integrative review. *Journal of Cleaner Production*, Volume 498, p. 145148.

Ritala, P., 2023. Grand challenges and platform ecosystems: Scaling solutions for wicked ecological and societal problems. *Journal of Product Innovation Management*, 41(2), pp. 168-183.

Rosenblatt, M. et al., 2017. Innovation in development, regulatory review, and use of clinical advances. In: M. J. M. M. e. a. Finkelman EM, ed. *Vital Directions for Health & Health Care: An Initiative of the National Academy of Medicine*. Washington: National Academies Press, p. Section 18.

Ruslin, M. S., Rasak, M. S. A., Alhabsyi, F. & Syam, H., 2022. Semi-structured Interview: A Methodological Reflection on the Development of a Qualitative Research Instrument. *IOSR Journal of Research & Method in Education*, 12(1), pp. 22-29.

Schwoon, B., Schoeneborn, D. & Scherer, A. G., 2022. Enacting a Grand Challenge for Business and Society: Theorizing Issue Maturation in the Media-Based Public Discourse on COVID-19 in Three National Contexts. *Business & Society*, p. OnlineFirst.

Thompson, T., 2022. The staggering death toll of drug-resistant bacteria. *Nature*, pp. doi: <https://doi.org/10.1038/d41586-022-00228-x>.

Wangrin, M., Vimalnath, P. & Tietze, F., 2023. *Enabling the Circular Economy: An Exploratory Study on IP Challenges in Innovation Ecosystems*, Cambridge: Centre for Technology Management (CTM).

World Health Organisation, 2001. *WHO Global Strategy for Containment of Antimicrobial Resistance*, Geneva: WHO Press.

World Health Organisation, 2022. *Global Antimicrobial Resistance and Use Surveillance System (GLASS) Report 2022*, Geneva: WHO Press.

World Health Organization, 2025. *Antimicrobial resistance*. [Online]
Available at: <https://www.who.int/health-topics/antimicrobial-resistance>
[Accessed 14th May 2025].

Yin, R., 2003. *Case Study Research: Design and Methods*. 3rd ed. Thousand Oaks, CA: Sage.

Yusef, D. et al., 2018. Knowledge, practices & attitude toward antibiotics use and bacterial resistance in Jordan: A cross-sectional study. *Infection, Disease & Health*, 23(1), pp. 33-40.

Zhou, N. et al., 2022. Global antimicrobial resistance: a system-wide comprehensive investigation using the Global One Health Index. *Infectious Diseases of Poverty*, 11(92).