

Editorial

Tackling Antimicrobial Resistance in Jordan: Bridging Science, Research, and Policy for a Healthier Future

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ABSTRACT

Antimicrobial resistance (AMR) has become a critical global public health concern and remains one of the most complex challenges due to its multifaceted nature. Beyond its direct health consequences, AMR significantly increases healthcare expenditures and imposes considerable economic burdens. Jordan, like many other countries in the Eastern Mediterranean Region, is impacted by the growing crisis of AMR. As a middle-income country, Jordan faces unique challenges in tackling AMR while striving to protect the public health. In response to the global fight against AMR, Jordan took decisive action in 2017, which led to the development of Jordan's National Action Plan (NAP) for combatting AMR. AMR in Jordan represents a challenge that requires a concerted effort from researchers, healthcare professionals, policymakers, and the community. This special issue in the Jordan Journal of Applied Sciences (JJOAS) seeks to contribute to a deeper understanding of AMR dynamics and promote sustainable solutions by addressing key thematic areas, including epidemiology, Antimicrobial Stewardship, public awareness, and health policy. In alignment with Jordan's NAP for combatting AMR 2023-2025 under the objective of enhancing investment in activities, research, and innovations related to AMR, this special issue of JJOAS aims to provide a dedicated platform for advancing scientific knowledge and policy solutions to combat AMR in Jordan. Furthermore, this editorial serves as a call to action, encouraging researchers, academics, and practitioners to address the key thematic areas outlined above through original research, reviews, commentaries, and opinion papers. By fostering interdisciplinary collaboration and promoting evidence-based strategies, we aim to support both national and regional initiatives to combat AMR.

Introduction

Antimicrobial resistance (AMR) has become a critical global public health concern and remains one of the most complex challenges due to its complicated nature. Beyond its direct health consequences, AMR significantly increases healthcare expenditures and imposes considerable economic burdens. A recent study published in the Lancet highlighted the burden of AMR, estimating that bacterial AMR was responsible for 1.14 million deaths worldwide in 2021, with projections indicating this figure could rise to 1.91 million by 2050 (1). The critical nature of AMR was formally acknowledged during the 2016 high-level meeting of the UN General Assembly, where countries were encouraged to develop and implement National Action Plans (NAPs) to combat AMR (2). Despite global initiatives, the threat of drug-resistant infections continues to escalate at an alarming rate.

Jordan, like many other countries in the Eastern Mediterranean Region (EMR), is impacted by the growing crisis of AMR. As a middle-income country, Jordan faces unique challenges in tackling AMR while striving to protect public health. In response to the global fight against AMR, Jordan took decisive action in 2017 by establishing a multi-sectoral national committee dedicated to addressing the issue (3). This led to the development of Jordan's NAP for combatting AMR, which is aligned with the World Health Organization (WHO) Global Action Plan (GAP) on AMR. Since then, immense collaborative multi-sectoral and interdisciplinary efforts have been made to tackle AMR and reduce its adverse impact on public health.

The country is actively advancing the pillars of the WHO GAP on AMR, with a focus on enhancing AMR surveillance, improving Antimicrobial Stewardship (AMS) in both healthcare and veterinary sectors, optimizing the appropriate and rational use of antimicrobials,

raising awareness and understanding of AMR, promoting scientific research along with sustainable economic investment to combat AMR, as well as monitoring and evaluation of the NAP implementation (3). Understanding the epidemiology of AMR in Jordan is critical to developing targeted interventions. In Jordan, it is estimated that approximately 2,400 deaths were linked to AMR, with 625 deaths directly attributable to AMR in 2019 (4).

The Jordanian Ministry of Health launched the Jordan National AMR Surveillance System in 2017. This laboratory-based system depends on a network of 42 surveillance sites across the country (5). The current surveillance system primarily targets the following bacterial and fungal pathogens that are of significant public health and clinical relevance: *Escherichia coli*, *Klebsiella pneumoniae*, *Salmonella* spp. (non-typhoidal), *Pseudomonas aeruginosa*, *Acinetobacter* spp., *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Enterococcus faecalis*, *Enterococcus faecium*, and *Candida* spp (5).

One of the primary drivers of AMR is the misuse and overuse of antimicrobials in humans, veterinary practice, and agriculture, which shapes the multifaceted nature of the growing challenge of AMR (6). In Jordan, factors contributing to inappropriate antimicrobial use include self-medication, lack of stringent prescription regulations, and the widespread availability of over-the-counter antimicrobial medications. Furthermore, the agricultural sector relies heavily on antimicrobials for livestock production, raising concerns about the transfer of resistant pathogens from animals to humans through food chain and the environment (7–9). This issue stems from the excessive and improper use of antibiotics in livestock, often for growth promotion and disease prevention instead of treating infections, which is complicated by insufficient regulations and insufficient enforcement around antimicrobials use in agriculture.

Furthermore, climate change, which is significantly impacting the EMR, is playing an important role in the rise and spread of AMR. A study found that increasing temperature has been linked to more drug resistance among common pathogens. The study reported that a 10°C rise in temperature was linked to a 4.2%, 2.2%, and 3.6% increase in antibiotic resistance for *Escherichia coli*, *Klebsiella pneumoniae*, and *Staphylococcus aureus*, respectively (10). As global temperatures continue to rise due to the climate crisis, AMR is becoming more prevalent (11). Higher temperatures are closely connected to AMR, as they promote faster bacterial growth and facilitate horizontal gene transfer, both of which contribute to the spread of resistance. Additionally, climate change may drive the emergence and re-emergence of infectious pathogens, further exacerbating public health challenges (11). Climate changes also affect agriculture, prompting increased antibiotic use in livestock to combat new disease patterns, which only adds to the AMR crisis. Therefore, addressing AMR demands a One Health approach that integrates human, animal, and environmental health, acknowledging the deep connection between AMR and climate change and their overlapping risks (10–12).

AMS programs play a crucial role in optimizing antimicrobial use while minimizing resistance development (13). AMS programs generally include interventions such as the establishment of evidence-based prescribing protocols, monitoring antimicrobial utilization to provide targeted recommendations, educating healthcare providers and the public, as well as strengthening infection prevention and control strategies to limit the spread of resistant pathogens (14,15). Hospitals and healthcare facilities must implement robust AMS programs that emphasize proper prescribing practices, and routine susceptibility testing. Equally important is the integration of stewardship efforts within veterinary sector and food production to ensure the responsible use of antibiotics across all sectors. National guidelines and continuous training for healthcare professionals and veterinarians are essential components of a comprehensive and effective AMS framework.

While AMR is a natural phenomenon, its primary causes and underlying factors are largely driven by human actions, particularly the misuse and overuse of antimicrobial agents (11). Public perception and knowledge of AMR significantly influence antimicrobial consumption behaviours (16). In Jordan, lack of awareness regarding the dangers of antimicrobial misuse poses a significant challenge. For instance, the misuse of antibiotics is a major public health threat in Jordan as revealed by a recently published systematic review (17). Additionally, another study showed significant gaps in the public's understanding regarding the appropriate use of antibiotics and AMR (18). Muflih and colleagues have examined the public knowledge of antibiotics, self-medication behaviors, and drug disposal practices among 1105 study participants (19). The findings revealed that 44.0% of the participants have practiced self-medication with antibiotics without seeking a medical advice and without prescription. The study also revealed that only 6.4% of participants returned unused antibiotics to pharmacies, while 26.6% improperly disposed antibiotics at home, such as in household waste, sinks, or wastewater (19). This was also highlighted in another study in Jordan which revealed mismanagement of unused, leftover, or expired medications (20). Misinformation and cultural beliefs may contribute to unnecessary antimicrobial use; thus, exacerbating resistance trends. Consequently, there is a growing need for implementing comprehensive public health initiatives to enhance the understanding of AMR and promote the appropriate and rational use of antimicrobials in the community (21,22). This is crucial to combat the growing challenge of AMR in the country. Public health campaigns should be tailored to educate communities on the risks associated with AMR, the importance of completing prescribed antimicrobial regimens, and the necessity of seeking professional medical advice before using antimicrobials. Social media and digital platforms can serve as powerful tools in disseminating official and accurate information regarding proper and rationale antimicrobial use and consumption.

Mitigating the effects of AMR requires strong policies and regulatory frameworks that enforce responsible antimicrobial use across all sectors. Although Jordan has made significant strides in developing NAP for combatting AMR in alignment with the WHO's GAP on AMR, challenges remain in implementing and enforcing regulations. A key priority is strengthening prescription-only policies for antimicrobials to reduce and control over-the-counter sales. Regulatory authorities must also ensure rigorous monitoring of antimicrobial use in the agricultural sector, promoting alternatives such as vaccines and probiotics to reduce reliance on antibiotics. Also, sustainable invest-

ments in research and innovation will further support evidence-based policymaking. The development of novel antimicrobials, alternative therapeutics, and rapid diagnostic tools can contribute to reducing unnecessary antimicrobial use while enhancing treatment efficacy. Encouraging interdisciplinary research collaborations across various sectors involved in human, animal, and environmental health will facilitate comprehensive AMR mitigation strategies under the One Health umbrella (23).

Conclusion

AMR in Jordan represents a multifaceted challenge that requires a concerted effort from researchers, healthcare professionals, policymakers, and the community. This special issue in the Jordan Journal of Applied Sciences (JJOAS) seeks to contribute to a deeper understanding of AMR dynamics and promote sustainable solutions by addressing key thematic areas, including epidemiology, AMS, public awareness, and health policy. In alignment with Jordan's NAP for combatting AMR 2023-2025 under the objective of enhancing investment in activities, research, and innovations related to AMR, this special issue of JJOAS aims to provide a dedicated platform for advancing scientific knowledge and policy solutions to combat AMR in Jordan. Furthermore, this editorial serves as a call to action, encouraging researchers, academics, and practitioners to engage in addressing the key thematic areas outlined above, through original research, reviews, commentaries, and opinion papers. By fostering interdisciplinary collaboration and promoting evidence-based strategies, we aim to support both national and regional initiatives to combat AMR.

Conflict of Interests

None

References

1. Naghavi M, Vollset SE, Ikuta KS, Swetschinski LR, Gray AP, Wool EE, et al. Global burden of bacterial antimicrobial resistance 1990-2021: a systematic analysis with forecasts to 2050. *The Lancet*. 2024 Sep 28;404(10459):1199–226. doi: 10.1016/S0140-6736(24)01867-1
2. United Nations. High-Level Meeting on Antimicrobial Resistance [Internet]. [Online]. 2016 [cited 2024 Dec 16]. <https://www.un.org/pga/71/2016/09/21/press-release-hl-meeting-on-antimicrobial-resistance/> (accessed 2024 Dec 16)
3. World Health Organization. Jordan's national action plan on antimicrobial resistance launches under royal patronage [Internet]. [Online]. 2023 [cited 2024 Dec 21]. <https://www.emro.who.int/jor/jordan-news/jordans-national-action-plan-on-antimicrobial-resistance-launches-under-royal-patronage.html> (accessed 2024 Dec 21)
4. Global Research on Antimicrobial Resistance (GRAM). The burden of antimicrobial resistance in Jordan [Internet]. [Online]. 2023 [cited 2024 Dec 16]. <https://www.healthdata.org/sites/default/files/2023-09/Jordan.pdf> (accessed 2024 Dec 16)
5. Jordan Ministry of Health. Jordan Surveillance of Antimicrobial Resistance Annual Report 2023. 2024.
6. Samtiya M, Matthews KR, Dhewa T, Puniya AK. Antimicrobial resistance in the food chain: Trends, mechanisms, pathways, and possible regulation strategies. *Foods*. 2022;11(19):2966. doi: 10.3390/foods11192966
7. Obaidat MM, Bani Salman AE, Davis MA, Roess AA. Major diseases, extensive misuse, and high antimicrobial resistance of *Escherichia coli* in large- and small-scale dairy cattle farms in Jordan. *J Dairy Sci*. 2018 Mar 1;101(3):2324–34. doi: 10.3168/jds.2017-13665
8. Burjaq SZ, Abu-Romman SM. Prevalence and Antimicrobial Resistance of *Salmonella* spp. From Irrigation Water in Two Major Sources in Jordan. *Curr Microbiol*. 2020;77(11):3760–6. doi: 10.1007/s00284-020-02178-x
9. Aleksh MO, Al-Qudah KM, Al-Saleh A. Prevalence of antimicrobial resistance among bacterial pathogens isolated from bovine mastitis in northern Jordan. *Rev Med Vet*. 2013;164(6):319–26.
10. MacFadden DR, McGough SF, Fisman D, Santillana M, Brownstein JS. Antibiotic resistance increases with local temperature. *Nat Clim Chang*. 2018;8(6):510–4. doi: 10.1038/s41558-018-0161-6

11. Magnano San Lio R, Favara G, Maugeri A, Barchitta M, Agodi A. How Antimicrobial Resistance Is Linked to Climate Change: An Overview of Two Intertwined Global Challenges. Vol. 20, International Journal of Environmental Research and Public Health. MDPI; 2023. doi: 10.3390/ijerph20031681 PMID: 36767043
12. Hendriksen RS, Munk P, Njage P, van Bunnik B, McNally L, Lukjancenko O, et al. Global monitoring of antimicrobial resistance based on metagenomics analyses of urban sewage. Nat Commun. 2019;10(1):1124. doi: 10.1038/s41467-019-08853-3
13. Hassan SK, Dahmash EZ, Madi T, Tarawneh O, Jomhawi T, Alkhob W, et al. Four years after the implementation of antimicrobial stewardship program in Jordan: evaluation of program's core elements. Front Public Health. 2023;11:1078596. doi: 10.3389/fpubh.2023.1078596 PMID: 37325334
14. Bankar NJ, Ugemuge S, Ambad RS, Hawale D V, Timilsina DR. Implementation of Antimicrobial Stewardship in the Healthcare Setting. Cureus. 2022;14(7):e26664. doi: 10.7759/cureus.26664
15. Shallal A, Jarrah J, Prentiss T, Suleyman G, Veve MP, Banat A, et al. Lessons from the field: Supporting infection prevention and control and antimicrobial stewardship in Amman, Jordan. J Infect Public Health. 2023;16:78–81. doi: 10.1016/j.jiph.2023.10.044
16. Salam MA, Al-Amin MY, Salam MT, Pawar JS, Akhter N, Ra-baan AA, et al. Antimicrobial resistance: A growing serious threat for global public health. Healthcare (Basel). 2023;11(13):1946. doi: 10.3390/healthcare11131946
17. al-magableh M, Eldos B, Aldughmi S, Bani Hamad L, Abdel Karim R, Damseh R, et al. A Systematic Review of Misuse of Antibiotics in Jordan. Jordan Med J. 2024 Aug 27;58(3). doi: 10.35516/jmj.v58i3.998
18. Yusef D, Babaa AI, Bashaireh AZ, Al-Bawayeh HH, Al-Rijjal K, Nedat M, et al. Knowledge, practices & attitude toward antibiotics use and bacterial resistance in Jordan: A cross-sectional study. Infect Dis Health. 2018 Mar 1;23(1):33–40. doi: 10.1016/j.idh.2017.11.001
19. Muflih SM, Al-Azzam S, Karasneh RA, Bleidt BA, Conway BR, Bond SE, et al. Public knowledge of antibiotics, self-medication, and household disposal practices in Jordan. Expert Rev Anti Infect Ther. 2023 Apr 3;21(4):477–87. doi: 10.1080/14787210.2023.2182770
20. Naser AY, Amara N, Dagash A, Naddaf A. Medications disposal and medications storage in Jordan: A cross-sectional study. Int J Clin Pract. 2021 Mar 1;75(3):e13822. doi: 10.1111/ijcp.13822
21. Abdelmalek S, AlEjilat R, Rayyan WA, Qinna N, Darwish D. Changes in public knowledge and perceptions about antibiotic use and resistance in Jordan: a cross-sectional eight-year comparative study. BMC Public Health. 2021;21(1):750. doi: 10.1186/s12889-021-10723-x
22. Al-Btoush HA, Aleidi SM, Al-Odinat HA, Qaisi NT. Assessment of knowledge, behaviour and awareness towards antibiotic use and resistance: a cross sectional study from south Jordanian society. Journal of Pharmaceutical Health Services Research. 2023 Sep 1;14(3):327–32. doi: 10.1093/jphsr/rmad024
23. Hartinger SM, Medina-Pizzali ML, Salmon-Mulanovich G, Larson AJ, Pinedo-Bardales M, Verastegui H, et al. Antimicrobial Resistance in Humans, Animals, Water and Household Environs in Rural Andean Peru: Exploring Dissemination Pathways through the One Health Lens. Vol. 18, International Journal of Environmental Research and Public Health. 2021. doi: 10.3390/ijerph18094604