LETTER TO THE EDITOR

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Environmental Drivers of Antimicrobial Resistance in Low and Middle-Income Countries: The Impacts of a Changing World

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ABSTRACT: This letter highlights the impact of environmental drivers on antimicrobial resistance (AMR) in low and middle-income countries (LMICs) and highlights the need for a comprehensive approach to address this global health threat. Key factors, such as agricultural practices, wastewater treatment, and pollution, contribute to the development and spread of resistant pathogens. Utilizing the One Health approach, the paper emphasizes the importance of promoting responsible antimicrobial use, strengthening public health systems, investing in innovative research, and raising public awareness. By understanding and addressing these environmental drivers, we can work toward safeguarding global health and ensuring a sustainable future.

KEYWORDS: Antimicrobial resistance, environmental drivers, low and middle-income countries, One Health approach, sustainable practices

Dear Editor,

Antimicrobial resistance (AMR) represents one of the most pressing global health challenges of the 21st century.[1] It is a complex phenomenon driven by a multitude of interconnected factors, including environmental changes that contribute to the development and spread of resistance among bacterial, viral, and parasitic pathogens.[2] This paper highlights the role of environmental drivers in the emergence and dissemination of AMR, including agricultural practices, wastewater treatment, and pollution, and explores potential interventions and strategies for mitigating the public health threats of AMR in a changing environment using the One Health approach.

Agricultural practices, wastewater treatment, and pollution contribute to the development and spread of antimicrobial-resistant strains.[3] Overuse of antimicrobials in agriculture and livestock leads to resistant bacteria, which can be transmitted to humans.[4] Addressing this issue requires promoting sustainable agricultural practices. Wastewater treatment systems can disseminate AMR due to inadequate processes, necessitating improvement in treatment efficiency and responsible use of antibiotics.[5] Pollution, such as heavy metals and toxic substances, can lead to the selection and dissemination of resistant strains.[6,7]

Mitigating the public health threats of AMR in a changing environment requires a coordinated, multisectoral approach that considers the interconnectedness of human, animal, and environmental health. The One Health approach provides a valuable framework for addressing AMR by promoting collaboration between different sectors and disciplines, including human and veterinary medicine, agriculture, environmental sciences, and public health.[8-10] To combat AMR effectively, it is vital to promote responsible antimicrobial use in human and veterinary medicine through evidence-based guidelines, surveillance, and stewardship programs. Strengthening public health systems to monitor and respond to AMR, including robust surveillance networks and adequate diagnostic and treatment resources, is essential. Investment in research and development of novel antimicrobial agents, alternative therapies, and innovative diagnostics will help overcome challenges posed by resistant pathogens. Enhancing public awareness and fostering a culture of responsibility among stakeholders ensures sustainable use of antimicrobials and preserves their efficacy for future generations.

In low and middle-income countries (LMICs), the challenges posed by environmental drivers of AMR are often exacerbated by limited resources, infrastructure, and regulatory frameworks. Here are some examples that demonstrate the impact of these drivers on AMR in LMICs.[11]

In many LMICs, there is a high dependency on agriculture as a primary source of income and food security. Farmers often use antibiotics as a low-cost solution to prevent diseases and enhance growth in livestock, as well as to protect crops from pests and diseases. For instance, in India, the widespread use of antibiotics in the poultry industry has contributed to the emergence of resistant strains of bacteria, such as extended-spectrum beta-lactamase (ESBL)-producing E. coli.[12] These strains can spread to humans through the food chain, resulting in difficult-to-treat infections.

LMICs often struggle with inadequate wastewater treatment infrastructure, leading to the release of untreated or

partially treated wastewater into the environment. In Kenya, a study found high levels of antibiotic-resistant bacteria in rivers receiving untreated sewage from urban settlements.[13] This situation not only facilitates the spread of resistant pathogens but also puts communities relying on these water sources at risk of acquiring resistant infections.

LMICs often face challenges in regulating and controlling pollution due to rapid industrialization, weak enforcement of environmental regulations, and lack of resources. In Pakistan, the release of untreated industrial waste containing heavy metals and other toxic substances has been linked to the emergence of multidrug-resistant bacteria in water sources.[14] These pollutants can act as co-selective agents, promoting the development of resistance genes even in the absence of direct antibiotic exposure.

To address these challenges, some LMICs have implemented interventions and strategies that target the environmental drivers of AMR. For example:

In Vietnam, the government has implemented a National Action Plan on AMR, which includes measures to reduce the use of antibiotics in livestock and aquaculture, such as the prohibition of certain antibiotics as growth promoters and the promotion of good animal husbandry practices.[15]

In South Africa, the eThekwini Municipality has invested in the improvement of wastewater treatment infrastructure, including the construction of new treatment plants and the upgrade of existing facilities, to reduce the release of resistant bacteria and antibiotic residues into the environment.[16]

In Bangladesh, a public-private partnership has been established to promote cleaner production technologies in the textile industry, which is a major source of water pollution. This initiative aims to reduce the release of hazardous chemicals and contribute to the mitigation of AMR-related risks.[17]

These examples illustrate the importance of addressing the environmental drivers of AMR in LMICs, where the challenges are often magnified by resource constraints and other factors. By targeting these drivers through context-specific interventions and strategies, LMICs can make significant progress in combating the global threat of AMR, see Table 1.

In conclusion, addressing environmental drivers of AMR is crucial for combating this global health threat. Understanding the roles of agricultural practices, wastewater treatment, and pollution allows us to create targeted interventions. The One Health approach emphasizes the interconnectedness of human, animal, and environmental health, and promotes collaboration across sectors to ensure sustainable antimicrobial use and preserve their efficacy. A proactive approach that acknowledges the interdependence of these factors is essential for safeguarding global health as the world adapts to new challenges, ensuring a healthier, more sustainable future for all.

Table 1. Examples of AMR programs in selected LMICs with suggested interventions.

COUNTRY	PROGRAM/ INITIATIVE	DESCRIPTION	SUGGESTED INTERVENTIONS	LINK
India	National Action Plan on AMR	A comprehensive framework aimed at combating AMR through awareness, regulation, and research in human health, animal husbandry, and agriculture.	Enhance surveillance networks, promote responsible antibiotic use, and invest in alternative therapies.	https://www.who.int/publications/m/item/india-national-action-plan-on-antimicrobial-resistance-(nap-amr)-2017-2021
Vietnam	National Action Plan for AMR	Focuses on reducing antibiotic use in livestock and aquaculture by prohibiting certain antibiotics as growth promoters and promoting good animal husbandry practices.	Develop and enforce regulations on antibiotic use and implement educational campaigns for farmers.	https://www.who.int/vietnam/health-topics/antimicrobial-resistance
Kenya	National Action Plan on AMR	Targets surveillance, infection prevention, and control measures while strengthening laboratory capacity and promoting research and development.	Improve wastewater treatment infrastructure, strengthen diagnostic and treatment resources, and foster collaboration between sectors.	https://www.who.int/publications/i/item/9789240062689
Pakistan	National Action Plan on AMR	Aims to reduce AMR by strengthening surveillance, promoting rational use of antimicrobials, and improving infection prevention and control measures.	Enhance public awareness, improve waste management practices, and foster multisectoral collaboration.	https://www.emro.who.int/pak/programs/antimicrobial-resistance.html
Bangladesh	National Action Plan on AMR	A multi-sectoral approach focusing on rational use of antimicrobials, awareness-raising, and capacity building in human health, animal health, and the environment.	Implement stricter regulations on toxic substances, develop cleaner production technologies, and promote sustainable practices.	https://www.who.int/publications/m/item/bangladesh-antimicrobial-resistance-containment-in-bangladesh-2017-2022

(Continued)

Table 1. (Continued)

COUNTRY	PROGRAM/ INITIATIVE	DESCRIPTION	SUGGESTED INTERVENTIONS	LINK
South Africa	Antimicrobial Resistance Strategy	Aims to reduce the incidence of AMR through improved surveillance, infection prevention, and control, as well as enhanced antimicrobial stewardship.	Encourage responsible antimicrobial use, invest in innovative diagnostic tools, and promote public awareness.	https://www.who.int/publications/m/item/south-africa-south-african-antimicrobial-resistance-national-strategy-framework-a-one-health-approach
Jordan	National Strategy for AMR	Focuses on strengthening surveillance, promoting rational use of antimicrobials, enhancing infection prevention and control, and improving awareness.	Implement guidelines for antimicrobial use, invest in research and development, and promote cross-sectoral collaboration.	https://www.who.int/publications/m/item/jordan-national-action-plan-for-combating-antimicrobial-resistance-in-the-hashemite-kingdom-of-jordan
Lebanon	National Action Plan on AMR	Aims to address AMR by promoting rational use of antimicrobials, enhancing surveillance and monitoring, and strengthening infection prevention and control measures.	Improve antimicrobial stewardship, enhance public awareness campaigns, and develop targeted interventions.	https://cdn.who.int/media/docs/default-source/antimicrobial-resistance/amr-spc-npm/nap-library/final–lebanese-amr-nap-lebanon-march-2019.pdf?sfvrsn=6268953e_1

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Author Contributions

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Data Availability Statement

In accordance with the present study, no datasets were generated or analyzed, rendering data sharing irrelevant to this article.

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