Multi-Disciplinary Publishing Institute Pakistan
Vol. 4, NO. 1

Submitted: 07 JUN 2025 Accepted: 26 JUL 2025 Published: 27 JUL 2025

Global Strategies for Combating Antimicrobial Resistance through the One Health Approach: A Mini Review

Reviewl Article

Haleema Sadia[1], Muhammad Adil[2], Muhammad Waqas Nasir[3], Aleesha Nawaz[4], Ayesha Tariq[5], Ieman Tariq[6], Shams Ud Din Afghan[7]

[1]Department of Epidemiology & Public Health, University of Agriculture, Faisalabad, Pakistan.

[2]Department of Clinical Medicine & Surgery, University of Agriculture, Faisalabad, Pakistan.

[3]Division of Life Sciences and Medicine, The First Affiliated Hospital of USTC, University of Science and Technology of China, Hefei, Anhui, China.

[4]Department of Zoology, University of Jhang, Pakistan.

[5]Department of Microbiology, Cholistan University of Veterinary and Animal Sciences, Bahawalpur, Pakistan.

[6]Department of Microbiology, Cholistan University of Veterinary and Animal Sciences, Bahawalpur, Pakistan.

[7]Faculty of Allied Health Sciences Medical Lab Technician, Abasyn University, Peshawar, Pakistan.

Corresponding author: Muhammad Waqas Nasir
Email: waqasnasir@mail.ustc.edu.cn

Citation

Sadia, H., Adil, M., Nazir, M.W., Nawaz, A., Tariq, A., Tariq, L., & Afghan, Shams ud D. (2025). Global strategies for combating antimicrobial resistance through the one health approach: A mini review. *Open Access Public Health and Health Administration Review*, 4(1), 60-71.

WEBSITE: www.mdpip.com
ISSN: Print: 2959-619X
ISSN: Online: 2959-6203
PUBLISHER: MDPIP

Abstract

The introduction of antibiotics revolutionized medicine by significantly reducing the burden of bacterial infections. However, antimicrobial resistance (AMR) has emerged as a major global health and economic challenge. AMR arises primarily from the misuse and overuse of antimicrobials in human health, agriculture, and animal husbandry. It leads to treatment failures, prolonged illnesses, and increased mortality. The One Health approach, which integrates human, animal, and environmental health, provides a comprehensive framework for addressing AMR. The extensive use of critically important antimicrobials such as fluoroquinolones, cephalosporins, colistin, tetracyclines, and macrolides in food-producing animals is a key driver of resistance. Prudent antimicrobial use, infection prevention, and enhanced hygiene are vital in human healthcare. In animal agriculture, reducing prophylactic and growth-promoting antimicrobial use is essential. Surveillance systems help track resistance trends across sectors. Internationally, the WHO-led Global Action Plan (GAP), supported by the FAO and WOAH, emphasizes antimicrobial stewardship, resistance surveillance, and policy harmonization. At the national level, countries implement National Action Plans (NAPs) that promote public awareness, antimicrobial regulation, and research into alternatives. Tackling AMR requires a coordinated multisectoral response. The One Health approach embedded in both national and global strategies is crucial for preserving the efficacy of antimicrobials and safeguarding health across species and environments.

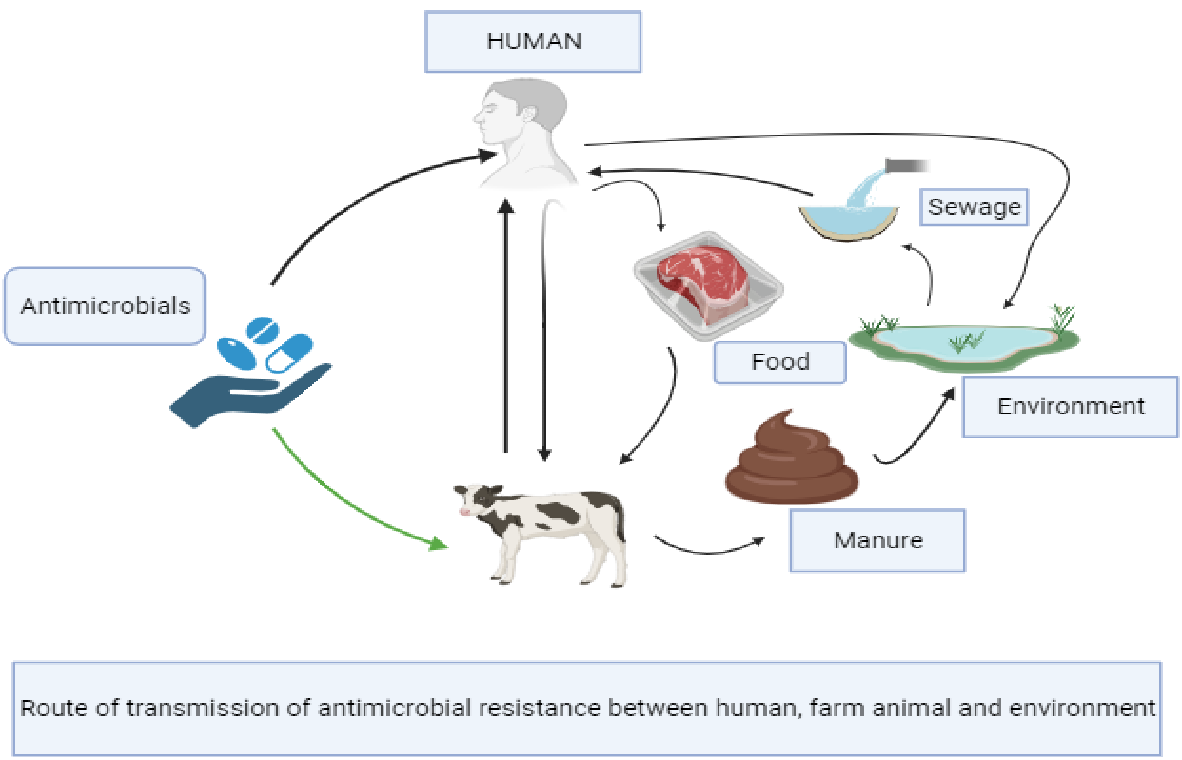
Keywords: One Health, Antibiotic, Antimicrobial Resistance, Hazard, Public Health.

Introduction

AMR is a major issue that is associated with humans, animals, and the environment. In 2016, the United Nations General Assembly focused on sustainable development goals and addressed the issue of antibiotic resistance. This marked a significant moment in raising awareness and acting on this problem. The process of publicizing and addressing a public problem like antibiotic resistance involves defining the issue, demanding a solution, and gaining political recognition to develop and implement policies (Andremont *et al.,* 2014). The session resulted in a declaration of international commitment, highlighting the need for cooperation and national plans aligned with the Global Plan launched in 2015 by WHO, OIE, and FAO. This approach recognizes the interconnection of human health, animal health, and the environment (Badau, 2021). One Health is an interdisciplinary approach that acknowledges the interconnection between humans, animals, and the environment in enhancing community health. Respected organizations such as the IMF, World Bank, WHO, and G8 have recognized antimicrobial resistance (ABR) as a significant global health menace. They stress the significance of coordinated endeavors to tackle ABR, as diverse ecosystems play a role in its dissemination. Case studies in One Health shed light on the emergence and transmission of drug-resistant pathogens, highlighting the necessity for collaboration among professionals in the fields of human health, veterinary medicine, and environmental science to combat global issues (O'Neil, 2018). Antimicrobial resistance poses a complex ecological challenge that impacts the well-being of humans, animals, and the environment. To effectively address this issue, it is crucial to adopt a coordinated and multi-sectoral approach, such as One Health, which recognizes the diverse microbial populations and their interactions (WHO, 2015).

Figure 1

One Health framework showing the interconnected triad in AMR surveillance



The "One Health One World" idea incorporates molecular epidemiological elements to help understand the evolution or genetic relatedness of ABR in pathogens/vectors, hosts (humans or animals), and the surrounding environment on a global scale (So *et al.,* 2015). Inadequate antibiotic use in humans and animals, contaminated settings, and insufficient infection control procedures are all blamed for the rise of antibiotic-resistant blistering (ARB). Unreasonable antibiotic usage in people, animals, groups, and environments has led to the emergence of resistance reservoirs, which have led to the persistence of drug residues or resistance genes. ABR is dispersed through a variety of environmental reservoirs, such as soil, water, hospitals, industrial facilities, farm waste, and contaminated ecological niches. Researchers disagree about how much the ABR crisis is caused by animal production, though (McMichael *et al.,* 2015). ABR dispersal occurs in a variety of contaminated ecological contexts, including soil, water, hospital, industrial, farm waste, and hospitals (Mackenzie *et al.,* 2019). Pathogens with resistance genes are more likely to spread or move between humans, animals, and the surrounding environment. However, as of late, several researchers have questioned the role that the animal industry played in the ABR epidemic given the rarity of human illnesses linked to livestock or aquaculture (Burow *et al.,* 2015). Thus, monitoring AMR in humans, animals, and the environment depends heavily on surveillance technologies. Therefore, solving this issue calls for a cooperative, multidisciplinary strategy involving experts in environmental, animal, and human health. To decrease AMR and encourage the prudent use of antibiotics, a more robust cooperative strategy is advised (Aslam *et al.,* 2021). A One Health approach is the term used to describe this multimodal strategy for tackling AMR. In battling AMR, this study outlines worldwide approaches as well as certain difficulties encountered (Guardabassi *et al.,* 2020).

Method

The literature for this study was found using PubMed and Google Scholar databases, and a narrative review design was employed. Using Boelean operators, we used the following keywords: One Health, antimicrobial stewardship, strategies, cooperation, drug development, surveillance, alternatives, problems, drivers, awareness, environment, and "combating antimicrobial resistance." This analysis comprised published publications from January 2002 to July 2023.

Literature Review and Critical Discussion

Strategies to Overcome Antimicrobial Resistance (AMR)

Global Action Plan (GAR) on AMR

To address AMR using a "One Health" approach, the World Health Organization (WHO) established the GAP on AMR during the World Health Assembly in May 2015 in collaboration with the Food and Agriculture Organization of the United Nations (FAO) and the World Organization for Animal Health (OIE) (WHO, 2015). During this summit, the leaders of these countries agreed to develop multisectoral national action plans (NAPs) on AMR. As a result, countries committed to implementing the NAPs when they were developed and helped combat AMR. Five (5) main objectives are the focus of the GAP on AMR: 1) to increase awareness and understanding of AMR through effective communication, education, and training; 2) to fortify the body of information and evidence by research and surveillance; and 3) to maximize the use of antibiotic medications for the health of humans and animals; 4) to lower the incidence of infection through good sanitation, hygiene and infection prevention measures; and 5) to create an economic case for sustainable investment that considers the needs of all nations and raises spending on new medications, diagnostic equipment, vaccines and other interventions (Earnshaw *et al.,* 2013). As such, international cooperation amongst stakeholders in the fields of agriculture, the environment, human health, and animal health is required to monitor AMR, conduct additional research, and stop its spread. Regarding AMR in humans, animals, agriculture, and the environment, these goals highlight the necessity of utilizing a "One Health" approach.

National Action Plan (NAP)

Many nations throughout the world have created NAPs on AMR to address AMR under the GAP on AMR. These NAPs, which are used by nations to monitor AMR using a "One Health" approach, were created based on the goals established by the GAP on AMR. Since there are five (5) objectives in the GAP on AMR, most NAPs on AMR have been designed with an emphasis on the five objectives (Kariuki *et al.,* 2022).

Some nations used a One Health strategy to address AMR and built their NAPs under the GAP on AMR (Dyar *et al.,* 2013). Those nations that have created and executed their NAPs are obligated, provisionally, to carry out assessments in order to oversee the AMR. Furthermore, the response to AMR is deemed insufficient even with NAPs available. This could be the result of weak implementation skills, a lack of knowledge of the importance of tackling AMR, or a poor alignment of the NAPs with GAP (Lakoh *et al.,* 2023). The effectiveness of NAPs depends critically on the degree and vigor of national commitment to them, as well as each nation's ability to create its own NAP objectives (Willemsen *et al.,* 2022). Therefore, goals that assess the financial impact of policies put in place to maximize antibiotic use (AMU) in various nations must be included in NAPs to foster political commitment and involvement (Siachalinga *et al.,* 2022). Both GAP and NAP are presented in Table 1 with key objectives and challenges.

Table 1
Comparative Overview of Global and National Action Plans on AMR [20]

Plan Type	Key Objectives	Notable Successes	Common Challenges
Global Action Plan (GAP)	• Raise awareness • Improve surveillance • Reduce infections • Optimize AMU • Ensure sustainable investment	Strategic guidance Creation of frameworks for member states	Ensuring national commitment Coordinating global reporting
National Action Plans (NAPs)	• Align with GAP objectives • Context-specific strategies • Surveillance & AMS • Local capacity building	Adaptation to local AMR trends Development of multisectoral plans	Weak execution Insufficient funding and lack of knowledge for data sharing

Antimicrobial Stewardship (AMS) Programmes

Antimicrobial stewardship (AMS) initiatives encourage the prudent use of antibiotics by focusing on the best possible antimicrobial therapy selection, dosage, frequency, and duration. This results in the best possible clinical outcome for infection prevention or treatment, with minimal to no patient toxicity and a decrease in antimicrobial resistance (Lakoh *et al.,* 2023). AMU and patient treatment outcomes have improved because of the successful deployment of AMS programs, which are essential in the fight against AMR. Hospital-based AMS programs, NAPs, the GAP, and public health campaigns or awareness-sensitization are examples of AMS programs (Aiesh *et al.,* 2023). Using antibiotics sparingly as a tool to combat antimicrobial resistance is part of hospital-based antimicrobial therapy (AMS) programs. Since AMR is a complicated problem, developing AMS programs cannot be done in a one-size-fits-all manner. The resources available, the local context and setting (primary care, secondary care, or regional level, for example), and other factors all influence these programs' variations. These programs, which include prescribing recommendations, AMU monitoring, and HCW education, are aimed at encouraging the proper use of antibiotics in hospital settings (Masetla *et al.,* 2023). In addition to this, several outpatient AMS programs emphasize the promotion of antibiotic usage in outpatient settings, such as clinics and physician offices. Usually, these actions include monitoring antibiotic prescribing patterns, patient education, and health care workers' education (Arieti *et al.,* 2020).

AMU and AMR Surveillance Systems

One of the GAP in AMR's strategic priorities is surveillance, which assists nations in gathering information on the prevalence of AMR and AMU. This data is essential for enhancing patient outcomes, guiding policy, identifying individuals at risk, and suggesting interventions. Surveillance results indicate that improper and increased use has a role in the emergence and spread of antimicrobial resistance (AMR) in humans, animals, and the environment (Kalam *et al*., 2022). Evidence suggests that between 2010 and 2015, the defined daily (DDD) AMU increased by 65% (21.1 - 34.8 billion DDDs), reflecting an increase in AMU on a global scale. Monitoring AMR in people, animals, agriculture, and the environment requires the use of surveillance systems (Bennani *et al.,* 2021). Effective surveillance techniques show whether antimicrobial resistance (AMR) exists in each population. A more robust multisectoral strategy and effective coordination are needed for AMR surveillance. AMR in food-producing animals, including cattle, pigs, poultry, goats, and other animal products, is monitored with the use of surveillance techniques. To lessen or avoid instances of antibiotic-resistant bacteria and their genes, thorough observation of AMU is strongly advised (Simjee *et al.,* 2019). The following components of integrated surveillance of antimicrobial resistance (AMR) in food-borne bacteria are required by the WHO: sample sources, microorganisms of interest, sampling design, laboratory testing methodology, data management, validation, analysis, and reporting. Other published protocols have corroborated this. Furthermore, sufficient funding for an integrated system should come from sustained government investment, prioritization of AMR issues, integration with current surveillance systems, sector-wide coordination, and readily available, comparable, high-quality data (WHO, 2021). The WHO Global AMR Surveillance System (GLASS) states that surveillance systems must include suggested indicator species, like Enterococcus spp., whose presence in samples shows the resistance patterns of Gram-positive bacteria and *E. coli*, which is a priority microorganism (WHO, 2017). Other methods have confirmed this. Salmonella spp. and Campylobacter spp. are other suggested indicator bacteria for AMR surveillance in food-producing animals such as hens. It is therefore strongly advised that they be used as indicator organisms in AMR surveillance in poultry systems. Direct sampling from animals that generate food has been shown to yield trustworthy conclusions for a specific aspect of integrated surveillance of antimicrobial resistance in food-borne microorganisms (Bertagnolio *et al.,* 2023).

Table 2
Classification of Antibiotic-Resistant Pathogens Based on WHO Priority Levels

Priority Level	Pathogen	Key Antibiotic Resistances
Critical	*Acinetobacter baumannii*	Carbapenems, Fluoroquinolones, Aminoglycosides, Polymyxins
Critical	*Pseudomonas aeruginosa*	Carbapenems, third-generation Cephalosporins, and Fluoroquinolones
Critical	*Enterobacteriaceae* (e.g., *Klebsiella pneumoniae*, *E. coli*)	Carbapenems, third-generation Cephalosporins (e.g., producing ESBL)
High	*Enterococcus faecium*	Vancomycin.
High	*Staphylococcus aureus*	Methicillin (MRSA), Vancomycin (VISA/VRSA)
High	*Helicobacter pylori*	Clarithromycin, Amoxicillin, Metronidazole
High	*Campylobacter spp.*	Fluoroquinolones
High	*Salmonellae*	Fluoroquinolones, third-generation Cephalosporins
High	*Neisseria gonorrhoeae*	Cephalosporins, Fluoroquinolones
Medium	*Streptococcus pneumoniae*	Penicillin, Macrolides
Medium	*Hemophilus influenzae*	Ampicillin
Medium	*Shigella spp.*	Fluoroquinolone

Extended-Spectrum Beta-Lactamase, Vancomycin-Intermediate *Staphylococcus aureus*, Vancomycin-Resistant *Staphylococcus aureus*, Methicillin-Resistant *Staphylococcus aureus*

Enough resources must be available in the laboratory utilized for AMR surveillance to isolate and cultivate target bacteria. According to this, it is necessary to isolate and identify the target bacterium using globally recognized microbiological techniques. Governments must thus sustainably fund staff and maintain sufficient laboratory resources for AMR surveillance (Simjee *et al.,* 2018). Furthermore, the European Committee on Antimicrobial Susceptibility Testing (EUCAST) or the Clinical and Laboratory Standards Institute (CLSI) must be used for antimicrobial susceptibility tests (AST). Aminoglycosides, carbapenems, amphenicols, cephalosporins, macrolides, glycopeptides, quinolones, tetracyclines, oxazolidinones, polymyxins, streptogramins, penicillin, glycylcyclines, and sulfonamides are among the antimicrobial classes that the WHO has recommended for AMR surveillance in poultry and other food-producing animals (Seo *et al.,* 2019). Good quality data that is readily available and comparable across industries and nations should be the result of the entire AMR surveillance procedure. Every piece of data collected for AMR surveillance needs to be thoroughly analyzed. To accomplish integrated data analysis, reporting, and risk communication successfully and efficiently, this needs to be well-coordinated and involve professionals. Additionally, epidemiological data needs to be accurately inputted and correspond with laboratory results. This is significant because the results must be shared with the relevant parties to develop measures to reduce the hazards associated with AMR. Sufficient databases should also be available for data entry, analysis, reporting, and sharing (Masetla *et al.,* 2023).

Biosecurity and Infection Prevention and Control Practices

Biosecurity refers to the application of strategies to stop the entry and spread of pathogens. Control of traffic (limiting the flow of people, animals, and other products into the farm area where animals are raised) and sanitation (disinfection and cleanliness) are a few biosecurity measures that involve isolating animals to prevent animal contamination from housing and personal protective equipment. Since infections can arise in human, animal, and environmental ecological systems, biosecurity is therefore a component of the One Health paradigm (Renault *et al.,* 2022). It is advised by biosecurity measures to segregate hens according to their age and species, which means keeping livestock animals of different ages in separate houses and refraining from rearing different animal species in the same housing environment. To maintain the marketability of animals and animal products, commercialization has put additional strain on the livestock industry, which has raised demand in the production areas for the management and regional eradication of infectious illnesses. Bio-exclusion and biocontainment are two measures that have been implemented to lessen the likelihood of the introduction and spread of infectious pathogens (Crew *et al.,* 2023). According to earlier research conducted in Belgium, the adoption of high-quality biosecurity measures decreased the usage of antibiotics in piggeries, which decreased mortality and increased productivity. Thus, by lowering the usage of antibiotics, biosecurity must be implemented to prevent the development of AMR. It is crucial to prevent and manage the sickness caused by resistant bacteria to combat AMR (Moralejo *et al.,* 2018). In public areas, healthcare settings, animal farms, and communal settings, infection prevention and control (IPC) practices aim to reduce the transmission of diseases and resistant germs. An extended illness, more hospital stays, and more expenses for both healthcare-related requirements and foods containing animals can result from IPC failure. Using efficient wash, sanitation, and hygiene (WASH) practices to decrease or prevent infection is one of the primary goals of the GAP on AMR. Promoting WASH practices is crucial, particularly in medical settings, educational institutions, marketplaces, and other communities (Ackers *et al.,* 2020).

Vaccine uses in AMR

Attenuated live vaccines and inactivated vaccines are both intended for veterinary use. Vaccines have the power to produce mucosal immunity, which shields animals from serious illness and reduces infection from living pathogens. Consequently, vaccinations decrease the need for antimicrobials in animal health by reducing animal diseases. Reducing the usage of antibiotics lowers the chance of antibiotic-resistant bacteria (AMR) developing in food-producing animals by preventing germs present in these animals from being exposed to these medications. To stop illnesses from happening, it is necessary to encourage the use of vaccines in animal husbandry (Micoli *et al.,* 2021). Analogously, vaccinations are administered to humans to prevent or lessen the severity of infections, which in turn lowers the need for antimicrobials and delays the development of AMR in the future. To lower AMU and increase immunization rates, the WHO created a framework (Rosini *et al.,* 2021).

One Health Concept for Surveillance and Management of AMR

A sustainable balance and optimization of the health of humans, animals, and the environment is the goal of One Health, an integrated and cohesive approach. As illustrated in Figure 1, this method acknowledges the relationship and interdependence between the health of people, animals, plants, the environment, and ecosystems. To address AMR in humans, animals, and the environment, a One Health approach emphasizes the need for a comprehensive, cooperative, transdisciplinary, and multisectoral strategy (Wu *et al.,* 2021). The WHO's global action plan on antimicrobial resistance (AMR) and the Food and Agriculture Organization (FAO)/Organization for Animal Health (OIE)/WHO Tripartite Collaboration on AMR are based on the idea of one health. Many systems have been built globally, and efforts have lately been made to produce guidelines for the integrated Surveillance of AMR on a global basis. Canada, where the Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARs) has been in existence since 2002, has highlighted the need for fresh understanding regarding the efficacy and cost-effectiveness of integrated AMR surveillance systems (Ma *et al.,* 2021). The Public Health Agency of Canada (PHAC) oversees this nationwide initiative, which aims to collect, integrate, analyze, and disseminate information about trends in AMU and AMR in particularly bacteria found in Canadian humans, animals, and food items obtained from animals. The program's objectives are to give an integrated approach to tracking AMU and AMR trends in people and animals, to make it easier to evaluate the effects of AM use in the human and agricultural sectors on public health, and to enable precise comparisons with data from other sources. The program's objectives are to give an integrated approach to tracking AMU and AMR trends in both humans and animals, to make it easier to evaluate the effects of AM use in the human and agricultural sectors on public health, and to enable precise comparisons with data from other nations with comparable surveillance systems (Musoke *et al.,* 2020). To combat AMR, a One Health approach is advised because resistant microorganisms can be found in humans, animals, and the environment. To combat antimicrobial resistance (AMR), a One Health approach is also required due to the transmission of antimicrobial-resistant bacteria from humans to animals and vice versa, from animals to the environment and vice versa, and from humans to the environment and vice versa. Consequently, it is essential to address AMR in humans, animals, and the environment by integrating AMR programs into a One Health strategy (de Mesquita *et al.,* 2022). It has been suggested to use the Delphi method in a One Health strategy to report AMR. According to the Delphi method, surveillance data reporting needs to be strategic and standardized to track antimicrobial resistance (AMR), offer interventional treatments, and influence policy. Monitoring the use of antibiotics by humans and animals that produce food, as well as the environment and antimicrobial residues in these animals, is also highly prioritized. To measure AMU and AMR using surveillance data gathered from people, animals, and the environment, a One Health strategy is crucial and offers points of interaction across several sectors (Adisasmito *et al.,* 2022).

Alternative to Antibiotics

Antibiotic usage and abuse are the primary causes of antimicrobial resistance (AMR), which has grown to be a major global public health concern. The creation of substitute strategies for antibiotics is essential in the fight against AMR. Probiotics, phages, and bacteriocins are only a few of the tactics that have been suggested (Callaway *et al.,* 2021). Probiotics are advantageous microorganisms that can repair the gut microbiota and stop harmful bacteria from proliferating. Bacteriocins are antimicrobial peptides made by bacteria that can stop the growth of other bacteria, whereas phages are viruses that particularly target and destroy bacteria. In vitro and animal studies have demonstrated encouraging outcomes with these alternative techniques. To evaluate their effectiveness and safety in human populations, more research is necessary. Using alternatives to antibiotics necessitates a One Health perspective, which acknowledges the connection between environmental, animal, and human health. To effectively address AMR and safeguard public health, cooperation between experts in human and animal health as well as researchers from other fields is crucial (Toroitich *et al.,* 2021).

Promoting Access to Quality-Assured Antibiotics

Combating AMR in humans and animals requires ensuring access to quality-assured medications. In LMICs, the use of hazardous or ineffective antibiotics might result from a lack of access to quality-assured antibiotics, which can cause excess mortality. Insufficient supply of antibiotics may lead to the administration of less-than-ideal drug combinations, which raises the possibility of treatment failure and the emergence of resistance. Antimicrobial shortages not only directly impact healthcare outcomes but also increase expenditures, which is a hazard to public health. When the most suitable agents are unavailable, the use of substitute antimicrobials may be required, which could lead to increased costs and financial losses (Shukar *et al.,* 2021). Lack of antibiotics may cause consumers to buy SF (substandard and falsified) drugs, which might worsen the spread of resistant bacteria and undermine the One Health strategy for treating AMR. SF antibiotics have the potential to fail to treat infections and encourage the emergence of resistance because they may include inadequate or inaccurate active pharmaceutical ingredients (APIs). The spread of SF antibiotics is facilitated by a lack of regulatory supervision and quality control, especially in low-resource environments. Quality shortages in LMICs are frequently caused by several issues, including frail supply chains, inadequate infrastructure, problems with legislative and regulatory processes, and ineffective funding and drug pricing systems (Sharma *et al.,* 2020). A multifaceted strategy incorporating many tactics is needed to promote access to antibiotics with quality assurance. To guarantee the supply of secure and efficient antibiotics, it is first imperative to fortify regulatory frameworks and enforcement procedures. This entails enforcing strict quality control procedures, carrying out routine facility inspections, and taking tough action against phony and subpar medications. The proper use of antibiotics must also be made known to patients, healthcare providers, and the public. Education campaigns can highlight the significance of seeing a patient through the whole course of therapy, the risks associated with antibiotic resistance, and the necessity of using appropriate prescription practices. Additionally, rational antibiotic usage can be facilitated by enhancing the infrastructure of healthcare facilities and educating healthcare personnel in appropriate diagnosis and prescribing procedures. Eventually, the use of alternative medicines and preventive measures, such as vaccinations, can help lessen the need for antibiotics and maintain their usefulness for future generations by supporting research and development into novel antibiotics as well as these other areas. Using these tactics, we can endeavor to guarantee universal access to superior antibiotics when required, while also mitigating the increasing risk of antibiotic resistance (Kimura *et al.,* 2020).

Increasing Investment in the Development of New Antimicrobials

The process of creating new antimicrobials is laborious and costly; it can take ten to fifteen years and billions of dollars to get a new antibiotic to the market. The development of new antibiotics has seen a decrease in funding in recent years for a variety of reasons, including low profit margins, a lack of new markets, and the belief that antimicrobial resistance (AMR) is a long-term issue. Governments, pharmaceutical corporations, and foundations all have a part to play in increasing investment in this field to ensure the availability of novel antibiotics to treat AMR (Wylie *et al.,* 2022). It is imperative to offer incentives to companies producing antibiotics, particularly in situations where market forces are insufficient to stimulate innovation. Alternative incentive schemes can be used to either pull innovation by providing benefits for good outcomes, such as guaranteed revenue, or push innovation by subsidizing at-risk investments, such as government subsidies. Stakeholders have suggested other creative approaches, such as subscription models (like the Netflix model) ([Brown *et al.,* 2020). To maintain a healthy market, these models propose options including fixed annual payments for guaranteed supply, incentives to continue or increase output, and bids that guarantee distribution to many producers. There is a growing interest in finding creative solutions to address the problems related to antibiotic development and access, as evidenced by the exploration of alternative payment models for both new and older antibiotics by several countries, including Sweden and the UK. To address the difficulties in developing antibiotics and guarantee a steady supply of efficient treatments for antimicrobial resistance (AMR), LMICs must investigate and test such models. Furthermore, we can address the growing issue of microbial resistance and guarantee the availability of efficient therapies for future generations by prioritizing and increasing investment in the development of novel antibiotics (Sithole *et al.,* 2020). The discovery of antibiotics from natural sources, such as traditional medicines, has been urged to be strengthened and supported. The importance of natural items like plants as sources of antimicrobials has been recognized because of the rise in resistance to conventional antimicrobials. Furthermore, the WHO suggested that further research be done to find antimicrobials from natural sources, and some of these studies are now undergoing clinical and sub-clinical development (Ncube *et al.,* 2021).

Conclusion

The successful application of numerous tactics to combat AMR is crucial in resolving this issue, according to this review paper. However, there are numerous obstacles that make it difficult to develop and put into practice AMR prevention methods. Several nations continue to face obstacles in their efforts to combat this silent pandemic, such as a lack of AMR-trained personnel, financial difficulties, insufficient AMU and AMR surveillance, insufficient data sharing resources, a lack of awareness and knowledge of AMR, insufficient resources for disease diagnostics, behavioral problems with the prescription, dispensing, and use of antibiotics, a lack of capacity building, and ineffective AMS. As a result, the techniques for battling AMR must be developed, put into practice, and strengthened. Lastly, to encourage the prudent use of antibiotics and lower AMR, all healthcare facilities should create and implement long-term AMS programs.

Declarations

Ethical Approval and Consent to Participate: This study strictly adhered to the Declaration of Helsinki and relevant national and institutional ethical guidelines. Informed consent was not required, as secondary data available on websites was obtained for analysis. All procedures performed in this study were by the ethical standards of the Helsinki Declaration.

Consent for Publication: Written informed consent was taken from the patient for the case report and publication. None of the personal information will be disclosed in the final publication.

Availability of Data and Materials: Data for this study will be made available upon request from the corresponding author.

Competing Interest: The authors declare that they have no competing interests.

Funding: Not Applicable

Authors' Contribution: Haleema Sadia & Muhammad Adil conceptualized the idea and wrote the initial draft of the manuscript. All remaining authors contributed equally to design, referencing, diagrams, tables, and manuscript refinement.

Acknowledgement: The authors acknowledge the use of PubMed, Google Scholar, and other open-access scientific databases as primary sources for the literature included in this review.

References

Ackers, L., Ackers-Johnson, G., Welsh, J., Kibombo, D., & Opio, S. (2020). Infection prevention control (IPC) and antimicrobial resistance (AMR). *Anti-microbial resistance in a global perspective* (p. 53). Springer, Berlin.

Adisasmito, W. B., Almuhairi, S., Behravesh, C. B., Bilivogui, P., Bukachi, S. A., & Casas, N. (2022). One Health: A new definition for a sustainable and healthy future. *PLOS Pathogens, 18*, e1010537.

Aiesh, B. M., Nazzal, M. A., Abdelhaq, A. I., Abutaha, S. A., Zyoud, S. H., & Sabateen, A. (2023). Impact of an antibiotic stewardship program on antibiotic utilization, bacterial susceptibilities, and cost of antibiotics. *Scientific Reports, 13*, Article 5040.

Andremont, A., Muller, S., Kouchner, B., & Muller, S. (2014). *Antibiotiques, le naufrage: [notre santé en danger]*. Bayard.

Arieti, F., Gopel, S., Sibani, M., Carrara, E., Pezzani, M. D., Murri, R., et al. (2020). White paper: Bridging the gap between surveillance data and antimicrobial stewardship in the outpatient sector. *Journal of Antimicrobial Chemotherapy*.

Aslam, B., Khurshid, M., Arshad, M. I., Muzammil, S., Rasool, M., Yasmeen, N., *et al.* (2021). Antibiotic resistance: One Health One World outlook. *Frontiers in Cellular and Infection Microbiology, 11*, Article 771510.

Badau, E. (2021). A One Health perspective on the issue of antibiotic resistance. *Parasite, 28*.

Bennani, H., Cornelsen, L., Stark, K. D. C., & Hasler, B. (2021). Characterization and mapping of the surveillance system for antimicrobial resistance and antimicrobial use in the United Kingdom. *Veterinary Record, 188*, e10.

Bertagnolio, S., Suthar, A. B., Tosas, O., & Van Weezenbeek, K. (2023). Antimicrobial resistance: Strengthening surveillance for public health action. *PLOS Medicine, 20*, e1004265.

Brown, E., O'Brien, M., Georges, K., & Suepaul, S. (2020). Physical characteristics and antimicrobial properties of Apis mellifera, Frieseomelitta nigra, and Melipona favosa bee honeys from apiaries in Trinidad and Tobago. *BMC Complementary Medicine and Therapies, 20*, Article 85.

Burow, E., & Käsbohrer, A. (2017). Risk factors for antimicrobial resistance in *Escherichia coli* in pigs receiving oral antimicrobial treatment: A systematic review. *Microbial Drug Resistance, 23*(2), 194–205.

Callaway, T. R., Lillehoj, H., Chuanchuen, R., & Gay, C. G. (2021). Alternatives to antibiotics: A symposium on the challenges and solutions for animal health and production. *Antibiotics, 10*, Article 471.

Crew, C. R., Brennan, M. L., & Ireland, J. L. (2023). Implementation of biosecurity on equestrian premises: A narrative overview. *Veterinary Journal, 292*, Article ID: 105950.

de Mesquita, S., Saraiva, M., Lim, K., do Monte, D. F. M., Givisiez, P. E. N., Alves, L. B. R., & de Freitas, N. O. C. (2022). Antimicrobial resistance in the globalized food chain: A One Health perspective applied to the poultry industry. *Brazilian Journal of Microbiology, 53*, 465–486.

Dyar, O. J., Huttner, B., Schouten, J., & Pulcini, C. (2017). What is antimicrobial stewardship? *Clinical Microbiology and Infection, 23*, 793–798.

Earnshaw, S., Mendez, A., Monnet, D. L., Hicks, L., Cruickshank, M., Weekes, L., & Ross, S. (2013). Global collaboration encourages prudent antibiotic use. *The Lancet Infectious Diseases, 13*(12), 1003–1004.

Guardabassi, L., Butaye, P., Dockrell, D. H., Fitzgerald, J. R., & Kuijper, E. J. (2020). One Health: A multifaceted concept combining diverse approaches to prevent and control antimicrobial resistance. *Clinical Microbiology and Infection, 26*, 1604–1605.

Kalam, M. A., Rahman, M. S., Alim, M. A., Shano, S., Afrose, S., Jalal, F. A., & Haque, M. A. (2022). Knowledge, attitudes, and common practices of livestock and poultry veterinary practitioners regarding the AMU and AMR in Bangladesh. *Antibiotics, 11*, Article 80.

Kariuki, S., Kering, K., Wairimu, C., Onsare, R., & Mbae, C. (2022). Antimicrobial resistance rates and surveillance in Sub-Saharan Africa: Where are we now? *Infection and Drug Resistance, 15*, 3589–3609.

Kimura, S., & Nakamura, Y. (2020). *Poor quality pharmaceuticals in global public health*. Springer, Singapore. https://doi.org/10.1007/978-981-15-2089-1

Lakoh, S., Bawoh, M., Lewis, H., Jalloh, I., Thomas, C., Barlatt, S., & Kamara, A. (2023). Establishing an antimicrobial stewardship program in Sierra Leone: A report of the experience of a low-income country in West Africa. *Antibiotics, 12*, Article 424.

Ma, F., Xu, S., Tang, Z., Li, Z., & Zhang, L. (2021). Use of antimicrobials in food animals and the impact of transmission of antimicrobial resistance on humans. *Biosafety and Health, 3*, 32–38.

Mackenzie, J. S., & Jeggo, M. (2019). The One Health approach—Why is it so important? *Tropical Medicine and Infectious Disease, 4*, Article 88.

Masetla, M. A., Ntuli, P. N., Abraham, V., Godman, B., Witika, B. A., Mudenda, S., & Mwila, C. (2023). Antimicrobial stewardship for outpatients with chronic bone and joint infections in the orthopedic clinic of an academic tertiary hospital, South Africa. *Antibiotics, 12*, Article 1142.

McMichael, C. (2015). Climate change-related migration and infectious disease. *Virulence, 6*(6), 548–553.

Micoli, F., Bagnoli, F., Rappuoli, R., & Serruto, D. (2021). The role of vaccines in combating antimicrobial resistance. *Nature Reviews Microbiology, 19*, 287–302.

Moralejo, D., El Dib, R., Prata, R. A., Barretti, P., & Corrêa, I. (2018). Improving adherence to standard precautions for the control of health care-associated infections. *Cochrane Database of Systematic Reviews, 2*, CD010768.

Musoke, D., Kitutu, F. E., Mugisha, L., Amir, S., Brandish, C., Ikhile, D., & Nakiggude, J. (2020). A One Health approach to strengthening antimicrobial stewardship in Wakiso District, Uganda. *Antibiotics, 9*, Article 764.

Ncube, B. M., Dube, A., & Ward, K. (2021). Establishment of the African Medicines Agency: Progress, challenges and regulatory readiness. *Journal of Pharmaceutical Policy and Practice, 14*, Article 29.

O'Neill, J. (2018). *Tackling drug-resistant infections globally: Final report and recommendations*. HM Government and Wellcome Trust.

Renault, V., Humblet, M. F., & Saegerman, C. (2022). Biosecurity concept: Origins, evolution and perspectives. *Animals, 12*, Article 63.

Rosini, R., Nicchi, S., Pizza, M., & Rappuoli, R. (2020). Vaccines against antimicrobial resistance. *Frontiers in Immunology, 11*, Article 1048.

Seo, K. W., Shim, J. B., & Lee, Y. J. (2019). Comparative genetic characterization of third-generation cephalosporin-resistant *Escherichia coli* isolated from a layer operation system in Korea. *Poultry Science, 98*, 1472–1479.

Sharma, A., Singh, A., Dar, M. A., Kaur, R. J., Charan, J., Iskandar, K., & Islam, S. (2022). Menace of antimicrobial resistance in LMICs: Current surveillance practices and control measures to tackle hostility. *Journal of Infection and Public Health, 15*, 172–181.

Shukar, S., Zahoor, F., Hayat, K., Saeed, A., Gillani, A. H., Omer, S., & Khan, T. M. (2021). Drug shortage: Causes, impact, and mitigation strategies. *Frontiers in Pharmacology, 12*, Article ID: 693426.

Siachalinga, L., Mufwambi, W., & Lee, L. H. (2022). Impact of antimicrobial stewardship interventions to improve antibiotic prescribing for hospital inpatients in Africa: A systematic review and meta-analysis. *Journal of Hospital Infection, 129*, 124–143.

Simjee, S., McDermott, P., Trott, D. J., & Chuanchuen, R. (2018). Present and future surveillance of antimicrobial resistance in animals: Principles and practices. *Microbiology Spectrum, 6*, ARBA-0028-2017.

Sithole, T., Mahlangu, G., Salek, S., & Walker, S. (2020). Evaluating the success of ZaZiBoNa, the Southern African Development Community Collaborative Medicines Registration Initiative. *Therapeutic Innovation and Regulatory Science, 54*, 1319–1329.

So, A. D., Shah, T. A., Roach, S., Chee, Y. L., & Nachman, K. E. (2015). An integrated systems approach is needed to ensure the sustainability of antibiotic effectiveness for both humans and animals. *Journal of Law, Medicine & Ethics, 43*(S3), 38–45.

Toroitich, A. M., Dunford, L., Armitage, R., & Tanna, S. (2022). Patients access to medicines—A critical review of the healthcare system in Kenya. *Risk Management and Healthcare Policy, 15*, 361–374.

Willemsen, A., Reid, S., & Assefa, Y. (2022). A review of national action plans on antimicrobial resistance: Strengths and weaknesses. *Antimicrobial Resistance and Infection Control, 11*, Article 90.

World Health Organization. (2015). *Global action plan on antimicrobial resistance*. WHO, Geneva, Switzerland.

World Health Organization. (2017). *Integrated surveillance of antimicrobial resistance in foodborne bacteria: Application of a One Health approach*. WHO, Geneva, Switzerland.

World Organization for Animal Health. (2021). *OIE terrestrial animal health code*. https://www.woah.org/en/what-we-do/standards/codes-and-manuals/terrestrial-code-online-access/?id=169&L=0&htmfile=chapitre_antibio_harmonisation.htm

Wu, D., Elliott, C., & Wu, Y. (2021). Food safety strategies: The One Health approach to global challenges and China's actions. *China CDC Weekly, 3*, 507–513.

Wylie, M. R., & Merrell, D. S. (2022). The antimicrobial potential of the neem tree *Azadirachta indica*. *Frontiers in Pharmacology, 13*, Article ID: 891535.

Note: **Open Access Public Health and Health Administration Review** is recognized by the Higher Education Commission of Pakistan in the Y category.

Disclaimer/ Publisher's Note: The statements, opinions, and data contained in all publications in this journal are solely those of the individual author(s) and not of the MDPIP and/ or the editor(s). MDPIP and editor(s) disclaim responsibility for any injury to the people or property resulting from any ideas, methods, instructions, or products referred to *in the content.*