Original Research Article

ANTIMICROBIAL RESISTANCE (AMR) AT THE HUMAN-ANIMAL-ENVIRONMENT INTERFACE: A ONE HEALTH PERSPECTIVE

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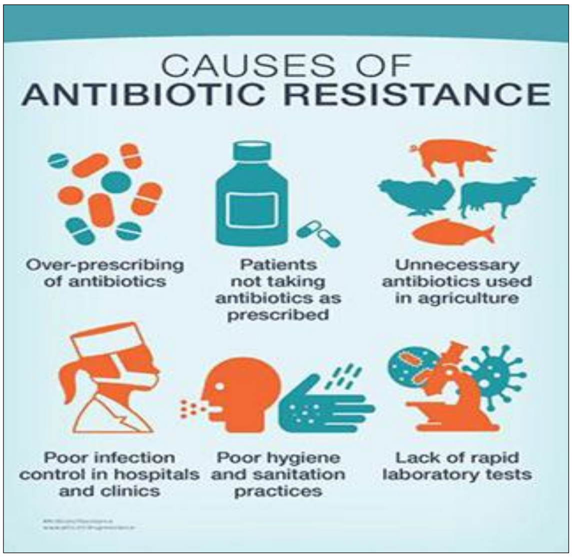
ABSTRACT

Antimicrobial resistance (AMR) is a looming global threat that compromises the efficacy of life-saving drugs in both human and veterinary medicine. The exaggerated misuse of antibiotics in humans, animals, as well as agriculture have led to the evolution and spread of multidrug-resistant organisms. This paper explores AMR from a One Health perspective, emphasizing the interconnectedness of human, animal, and environmental health. It examines drivers of resistance, surveillance challenges, and policy gaps, while also highlighting potential strategies for mitigation. Strengthening cross-sectoral collaboration and data sharing, particularly in low- and middle-income countries, is essential to address AMR sustainably.
Keywords: Antimicrobial Resistance; Human-Animal-Environment; Antibiotic stewardship; Cross-sectoral Collaboration; AMR Policy Gaps; Multidrug Resistance; AMR Surveillance; Public Health; Global Health

INTRODUCTION

Antimicrobial resistance (AMR) occurs when microorganisms evolve mechanisms to withstand the drugs which are designed to kill them. AMR is now recognized as a multifaceted crisis rooted in complex interactions between humans, animals, and the environment. The World Health Organization (WHO), Food and Agriculture Organization (FAO), and World Organisation for Animal Health (WOAH) have adopted a One Health framework to address this challenge. This paper delves into the dynamics of AMR at the human-animal-environment interface and evaluates current strategies and recommendations through One Health approach.

2. Drivers of AMR in One Health Context



2.1 Human Health Sector

Inappropriate antibiotic use in outpatient settings, self-medication, and over-prescription are significant contributors to resistance. In hospitals, poor infection control practices and inadequate diagnostic support increase the problem. Countries with unregulated access to antibiotics experience higher rates of resistant infections.

2.2 Animal Health and Agriculture

In animal husbandry, antibiotics are frequently used for growth promotion and disease prevention. This practice, especially in intensive farming, contributes to the selection of resistant bacteria, which can be transferred to humans via direct contact, consumption of contaminated products, or through the environment. Companion animals also serve as reservoirs and vectors of resistant pathogens.

2.3 Environmental route

Pharmaceutical waste, agricultural runoff and effluents from hospitals and industries contaminate water sources with antimicrobial residues and resistant genes. Wastewater treatment plants often lack the capacity to remove these contaminants, resulting in environmental reservoirs of AMR that affect wildlife and re-enter human populations through the food chain and water supplies.

3. Surveillance and Data Gaps

Integrated AMR surveillance remains weak, especially in low-resource settings. While WHO's Global Antimicrobial Resistance Surveillance System (GLASS) is expanding, data from veterinary and environmental sectors is still sparse. There is an urgent need for harmonized protocols and shared databases that link AMR data across sectors. Genomic surveillance and wastewater-based epidemiology are promising tools but require investment and infrastructure.

4. Current Trends Recent global analyses

Over 4.7 million deaths in 2021 were associated with bacterial AMR, with 1.14 million directly attributable to resistant infections.

From 1990 to 2021, mortality among adults aged 70+ rose by more than 80%, while deaths in children under five declined by over 50%.

The Global Research on Antimicrobial Resistance (GRAM) project forecasts that annual deaths directly due to AMR could escalate by 67.5%, reaching approximately 1.9 million by 2050—with AMR-influenced mortality rising to 8.2 million.

Cumulatively, 39 million lives could be lost to antibiotic-resistant infections between 2025 and 2050.

AMR may cost the global economy $1–3.4 trillion annually by 2030, and up to $412 billion per year in healthcare and productivity losses.

5. Challenges to Implementation

5.1 Policy Fragmentation:

Disconnected efforts between ministries of health, agriculture, and environment limit policy coherence.

5.2 Lack of Awareness:

Farmers, healthcare providers, and the public often lack awareness of AMR risks and proper antibiotic use.

5.3 Economic Pressures:

In low-income settings, antibiotics are used as a low-cost substitute for improved hygiene, vaccination, or biosecurity.

5.4 Research Gaps

Few new antibiotics are in development, and alternatives like vaccines or phage therapy remain underutilized.

6. Mitigation Strategies

6.1 Stewardship Programs

Antibiotic stewardship in both human and veterinary medicine is key. This includes strict prescription protocols, training for professionals, and public education campaigns.

6.2 Regulation and Policy

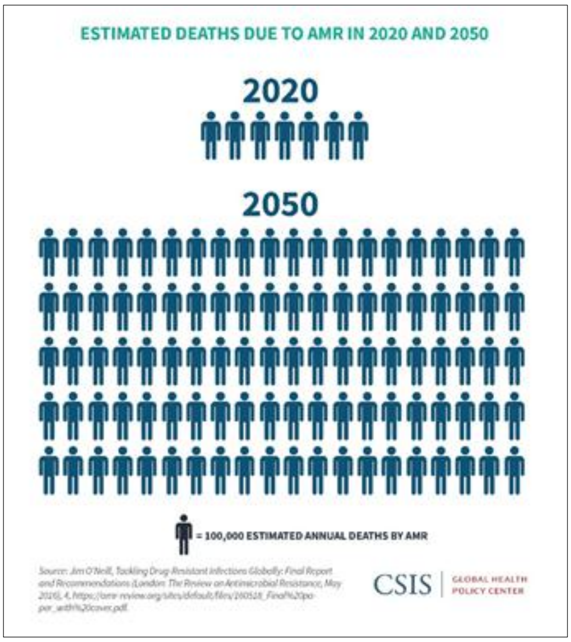
Countries must enforce bans on non-therapeutic antibiotic use in animals, regulate over-the-counter sales, and implement national action plans aligned with the Global Action Plan on AMR.

6.3 Integrated Surveillance

Multi-sectoral surveillance systems should be implemented to track resistance patterns and antibiotic usage across humans, animals, and the environment.

6.4 Research and Innovation

Investment in novel antibiotics, rapid diagnostics, and alternative treatments such as probiotics, immunomodulators, and vaccines is essential.



7. Case Studies

Netherlands: Implemented strict veterinary antibiotic use regulations, reducing usage by over 60% without impacting animal health.

India: Initiated the National Action Plan on AMR (2017), but still faces challenges due to over-the-counter antibiotic sales and poor waste management.

8. Research highlights

When cattle are given antibiotics to treat mastitis which is bacterial inflammation of the mammary glands, their milk retains the antibiotics for a long time, increasing the probability of antimicrobial resistance (AMR). Now researchers at West Bengal University of Animal and Fishery Sciences (WBUAFS) report how to overcome this problem with a known polyherbal drug.

Experimenting with Bengal goats, the researchers have shown that a commercially available mammary protective polyherbal drug (fibrosin), when given alongside the antibiotics, can diminish antimicrobial resistance..

Since persistence of antibiotics for a prolonged period in milk triggers antimicrobial resistance (AMR), the polyherbal drug could be used as a supportive therapy to treat sensitive bacterial infections in cattle to minimise development of AMR, the authors say.

Key highlights: Fibrosin®, a commercial herbal drug is used for a long time as supportive therapy in mastitis.

Fibrosin® was given orally 1 h prior to intramuscular ceftriaxone to study disposition kinetics. Ceftriaxone showed a reabsorption half-life (t½Ka′) of 0.18±0.003 h in presence of Fibrosin®. The reabsorption rate constant of ceftriaxone (3.86±0.10 h^{-1}) suggested rapid intestinal reabsorption.

Scientists have discovered that tulsi leaf extract enhances the bioavailability of an antibiotic used to treat mastitis, a mammary gland infection in goats1. The leaf juice also protects tissues from inflammation-induced damage.

The researchers say the combination of the leaf extract and the antibiotic may emerge as an effective treatment strategy for lactating goats, cows and buffaloes.

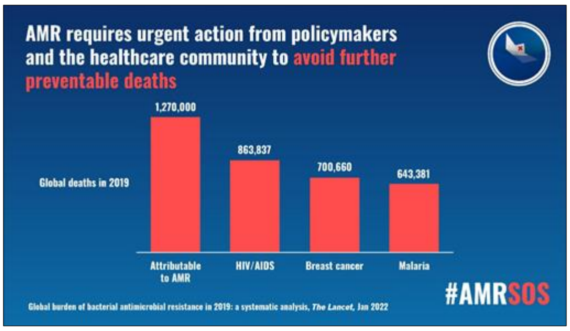
Scientists at the West Bengal University of Animal and Fishery Sciences in Kolkata, induced mastitis in goats. One group, treated as control, received only ceftriaxone antibiotic. The other group received a single dose of the antibiotic, followed by a single dose of tulsi leaf juice every day for a week.

The team, led by Tapas Kumar Sar, found the presence of ceftriaxone and its active metabolite ceftizoxime in goat milk as long as five days after its administration. Researchers say the leaf extract increased the longevity of the drug molecules in body fluids by inhibiting their removal through excretion.

The leaf extract also decreased the minimum inhibitory concentrations of both ceftriaxone and ceftizoxime. “It means that the drug and its metabolite can kill the disease-causing bacteria at a lower dose, sparing healthy cells and reducing the risks of drug resistance,” Sar says.

CONCLUSION

Antimicrobial resistance exemplifies the need for a truly integrative approach to health. The One Health framework is not only ideal but necessary to address the interconnected drivers of AMR. While the threat is grave, it is not invincible. Coordinated action, supported by political will, scientific innovation, and public engagement, can subside the resistance and preserve antimicrobial efficacy for future generations. Antimicrobial resistance is a silent pandemic, yet one that we still have the tools to defeat. With coordinated global action rooted in One Health, we can turn the tide. The time to act decisively is now—our collective future depends on it.



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