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GLOBAL INFECTION PREVENTION AND ANTIMICROBIAL RESISTANCE MANAGEMENT IN HEALTHCARE: A REVIEW

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ABSTRACT

Antimicrobial resistance (AMR) has emerged as one of the most pressing global health threats, undermining decades of progress in infectious disease control, patient safety, food security and economic development. This review synthesises current literature spanning the global burden of AMR, its structural and environmental drivers, its clinical and patient-safety consequences, and the range of health-system, technological and policy responses being deployed to contain it, with particular attention to challenges faced by low-resource and low- and middle-income settings. The evidence indicates that AMR is a multifactorial problem rooted in the interconnected health of humans, animals and the environment, and that no single intervention — whether stewardship, surveillance, novel drug development, or artificial intelligence — is sufficient in isolation. Coordinated action anchored in a One Health framework, backed by sustained investment in laboratory capacity, prescriber education, infection prevention and control (IPC), and international collaboration, is essential to prevent AMR from eroding the effectiveness of modern medicine.

KEYWORDS: Antimicrobial Resistance, Infection Prevention And Control, One Health, Antimicrobial Stewardship, Healthcare-Associated Infections, Low- And Middle-Income Countries.

1. INTRODUCTION

Antimicrobial resistance occurs when bacteria, fungi, viruses and parasites evolve mechanisms that render previously effective antimicrobial agents ineffective. It is no longer a distant or theoretical concern: global analyses attribute close to five million deaths annually to conditions associated with bacterial AMR, with more than one million deaths directly caused by resistant infections. Pathogens of greatest concern include Mycobacterium tuberculosis and the ESKAPE group — Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa and related organisms — several of which feature on the WHO's updated 2024 bacterial priority pathogens list alongside carbapenem-resistant Enterobacterales and drug-resistant Neisseria gonorrhoeae. Left unaddressed, resistant infections are projected to cause up to ten million deaths annually by 2050.

Because resistant organisms disseminate readily across borders through travel, trade, food systems and horizontal gene transfer between microorganisms, AMR is fundamentally a global — not merely a hospital-based — problem. Healthcare-associated infections (HAIs) compound this risk by allowing resistant strains to spread within clinical settings, particularly where infection prevention and control (IPC) practices, hand hygiene, sterile technique and surveillance infrastructure remain underdeveloped. This review draws together current literature to examine the scope of the AMR crisis, its principal drivers, its consequences for healthcare delivery and patient safety, and the technological, educational and policy strategies proposed to manage it, with particular emphasis on the added burden faced by low-resource settings.

2. Global Burden, Drivers, and Structural Challenges

2.1 Scale and Drivers of the Crisis

The rise of AMR reflects the convergence of several structural factors: inadequate public and professional awareness, a drying pipeline of novel antimicrobial agents, insufficient and poorly coordinated research funding, weak international surveillance and data-sharing networks, and fragmented policy alignment across countries and sectors. Agriculture and livestock rearing account for a substantial share — over 70% — of global antibiotic consumption, and the reuse of the same antibiotic classes in animals and humans facilitates the emergence and cross-species spread of resistant organisms. Inadequately treated hospital and pharmaceutical wastewater further seeds resistant bacteria and resistance genes into soil and water systems, from which they can re-enter human and animal populations.

Table 1. Key global challenges in tackling antimicrobial resistance and corresponding strategic solutions.

Challenge	Key Examples	Key Solutions
Public & professional awareness	Limited understanding of AMR among clinicians and the public	Global awareness campaigns and curriculum-based education
Antimicrobial drug pipeline	Declining investment in novel antimicrobial agents	Incentives for pharmaceutical R&D investment
Research funding	Inadequate, poorly coordinated research activity	Sustained, cross-disciplinary funding and talent development
Environmental factors	Poor waste management and water treatment	One Health integration of human, animal and environmental health
Global governance	Weak surveillance networks and data sharing	International coordination among agencies and governments
Policy alignment	Divergent national AMR action plans	Harmonised implementation across sectors and countries

2.2 Lessons from the COVID-19 Pandemic

The COVID-19 pandemic served as an inadvertent stress test for AMR containment. Widespread empirical antibiotic use in hospitalised patients — often without confirmed bacterial co-infection — accelerated the emergence of multidrug-resistant organisms such as Enterococcus faecium and Acinetobacter baumannii in several countries. The pandemic simultaneously exposed the urgent need for rapid diagnostics capable of distinguishing bacterial from viral aetiology, sustained investment in vaccine and antimicrobial research, and multidisciplinary One Health task forces prepared to coordinate a rapid, unified response across human, animal and environmental health sectors.

2.3 Disproportionate Challenges in Low- and Middle-Income Settings

AMR containment is markedly harder in low-resource settings, where constrained budgets, ageing infrastructure, limited laboratory capacity, and inconsistent access to quality-assured antimicrobials converge. Over-the-counter access to antibiotics without prescription remains common, and health literacy initiatives addressing appropriate antibiotic use are frequently absent from school and community curricula. These structural gaps mean that resistant infections translate more directly into prolonged hospitalisation, higher treatment costs and elevated mortality in precisely the settings least equipped to absorb that burden.

3. Clinical and Patient Safety Dimensions

3.1 Impact on Healthcare Delivery and Patient Safety

As first-line antibiotics lose efficacy, clinicians are increasingly forced toward second-line agents that are often less effective, more toxic, or more expensive — complicating case management, particularly where alternatives are scarce. Recognising this, the World Health Organization designated patient safety a global priority in 2019 and subsequently released a ten-year global action plan. Five core WHO measures for AMR-related patient safety are consistently emphasised across the literature: strengthening medical education and public awareness, regulating antimicrobial distribution, investing in new drug research, expanding surveillance of resistant organisms, and enforcing rigorous hygiene practices within healthcare facilities.

3.2 Candida auris as an Illustrative Case

Candida auris exemplifies the clinical danger posed by emerging multidrug-resistant pathogens. It is frequently misidentified by conventional laboratory methods, resists multiple antifungal drug classes, and persists on hospital surfaces, enabling sustained transmission within healthcare facilities. Advanced diagnostic tools — whole-genome sequencing (WGS) and MALDI-TOF mass spectrometry — substantially improve detection accuracy over traditional biochemical methods. Effective containment depends on early identification of colonised or infected patients, environmental cleaning, targeted screening of high-risk populations, and isolation precautions, underscoring that robust IPC infrastructure remains as important as diagnostic innovation.

4. Strengthening Health System Responses

4.1 Resilient Health Systems and Surveillance

Building health systems resilient to AMR requires strengthened local monitoring and surveillance, prudent antimicrobial prescribing, sustained research and development investment, and active international partnership. Surveillance in particular depends on standardised data collection to generate antibiograms that guide empirical therapy and to localise sources of resistant organisms within communities or facilities for timely response. Many health systems are gradually transitioning from traditional culture-based testing toward genomic surveillance methods, a shift that requires careful budgetary and infrastructural planning to ensure sustainability.

4.2 Control Measures in Low-Resource Settings and Prescriber Education

In resource-constrained settings, practical control measures include improved government-led surveillance, hospital hygiene promotion, rational drug administration, community awareness campaigns, expanded vaccination coverage, and monitoring of pharmaceutical contamination in water supplies. Educational interventions targeting appropriate antimicrobial prescribing among healthcare providers have shown measurable benefit, but the supporting evidence base is drawn predominantly from high-income settings; the literature consistently calls for locally generated research to verify which prescribing-education strategies are both effective and sustainable in low- and middle-income contexts.

4.3 Artificial Intelligence as an Emerging Tool

Artificial intelligence (AI) is increasingly positioned as a complementary tool in AMR management, offering improved diagnostic precision, accelerated antimicrobial drug discovery, and decision support for antimicrobial stewardship programmes. Explainable AI (XAI) is particularly emphasised in the literature as a means of preserving clinician trust and accountability by clarifying how AI-based recommendations are generated. Realising this potential nonetheless depends on sound regulatory frameworks, reliable data infrastructure, and adequately trained personnel; persistent challenges include data quality limitations, ethical considerations, and practical barriers to implementation in routine care.

5. Environmental and One Health Perspectives

5.1 Climate Change and AMR

Climate change is increasingly recognised as an amplifier of AMR risk. Rising temperatures and altered precipitation patterns favour the survival and proliferation of resistant pathogens in humid, contaminated environments, while agricultural runoff and inadequate water infrastructure further disseminate resistance genes. Addressing this dimension requires eco-friendly farming practices, reduced non-essential antibiotic use in agriculture, improved water purification infrastructure, and dedicated multidisciplinary research linking climate and microbiological surveillance data.

5.2 The One Health Framework

The One Health approach — recognising the interdependence of human, animal and environmental health

— is repeatedly identified in the literature as the most coherent framework for tackling AMR. Zoonotic disease emergence, illustrated by H1N1, H5N1, Nipah virus, Ebola virus and coronaviruses including SARS-CoV-2, demonstrates how closely human wellbeing is tied to animal and ecosystem health. Because urbanisation, globalisation, pollution and biodiversity loss all influence microbial adaptation and evolution, progress in any one sector is intrinsically limited without corresponding progress in the others. Effective implementation calls for integrated disease surveillance, sustainable agricultural practice, supportive legislation, and — critically for low- and middle-income countries — dedicated financial frameworks, locally generated data, and pilot implementation studies to test context-appropriate solutions.

6. DISCUSSION

Taken together, the literature reviewed here converges on a consistent conclusion: AMR is not a problem that can be solved through any single intervention. Its drivers span clinical prescribing behaviour, agricultural practice, environmental contamination, health-system capacity and global governance, and its consequences are felt simultaneously in patient outcomes, healthcare costs, and long-term food and economic security. Encouragingly, the same body of evidence points to a coherent set of complementary responses — antimicrobial stewardship, robust IPC practice, strengthened laboratory and genomic surveillance, prescriber and public education, novel drug and AI-assisted diagnostic development, and climate-conscious environmental management — all of which gain effectiveness when coordinated under a One Health framework rather than pursued in isolation.

A recurring theme across the reviewed sources is the disproportionate vulnerability of low-resource and low- and middle-income settings, where infrastructural, financial and human-resource constraints compound every dimension of the AMR challenge, from diagnostics to drug access to surveillance. This underscores the need for context-specific research and locally sustainable solutions rather than uncritical transfer of strategies validated only in high-income settings, alongside international financial and technical support proportionate to the scale of the threat.

7. CONCLUSION

Antimicrobial resistance represents one of the defining public health challenges of the coming decades, threatening to erode the effectiveness of modern medicine, agriculture and economic development unless met with sustained, coordinated action. The evidence reviewed here indicates that meaningful progress requires simultaneous investment in surveillance infrastructure, antimicrobial stewardship, infection prevention and control, prescriber and community education, novel diagnostic and therapeutic technologies including artificial intelligence, and environmentally conscious agricultural and water management practice. Above all, a One Health perspective — treating human, animal and environmental health as inseparable — offers the most coherent path forward. Achieving this will demand collaboration among clinicians, microbiologists, veterinarians, environmental scientists, policymakers and communities, backed by clear goals, adequate funding, and sustained political will, particularly in low-resource settings where the burden of resistant infection is heaviest and the capacity to respond is often weakest.

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