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The Burden of Antimicrobial Resistance in Livestock and Its Transmission to Humans

Aakifa Maryam[1], Syeda Kousar Fathima[2], Syed Baker[1], Niranjan Raj. S[1]*

[1] Department of Studies in Microbiology, Karnataka State Open University, Mysore.

[2]Department of Botany and Microbiology, Government College of Women, Mandya.

Corresponding author.
Correspondence: Niranjan Raj. S
E-mail: niruraj@gmail.com

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Abstract
Antimicrobial resistance (AMR) is a growing global health threat that poses significant challenges to both human health and the agricultural sector. The overuse and misuse of antibiotics in livestock farming are key drivers of AMR, as they promote the development and spread of resistant bacteria, which can subsequently be transmitted to humans through direct contact, consumption of contaminated animal products, and environmental pathways. The impact of AMR is far-reaching, leading to more difficult-to-treat infections, prolonged hospital stays, increased healthcare costs, and higher mortality rates. This paper explores the role of livestock in the emergence and transmission of AMR, the mechanisms by which resistant bacteria develop in animals, and the transmission routes through which these pathogens reach humans. It also discusses the implications of AMR for human health, including its economic burden and the challenges it poses to medical treatments and procedures. Finally, the paper reviews potential strategies to mitigate the spread of AMR, such as reducing antibiotic use in livestock, improving animal husbandry practices, and implementing better regulatory frameworks. By addressing AMR in livestock farming, this paper emphasizes the need for a comprehensive approach involving collaboration across sectors to combat the growing threat of antibiotic resistance.

INTRODUCTION

Antimicrobial resistance (AMR) has emerged as one of the most urgent and challenging public health threats in the 21st century. The widespread and often unchecked use of antibiotics in various sectors, particularly in healthcare and agriculture, has led to the development of resistant pathogens that are difficult, if not impossible, to treat with standard medications (Niño-Vega et al., 2025). While human healthcare is often the primary focus of AMR discussions, the agricultural sector, particularly livestock farming, plays a significant and sometimes underestimated role in the development and transmission of resistant bacteria. In livestock farming, antibiotics are used not only to treat infections but also as a preventative measure and to promote growth in healthy animals (Burnham, 2025). This

widespread, sometimes indiscriminate use creates an ideal environment for the evolution of antibiotic-resistant bacteria. These resistant microorganisms can then spread through a variety of pathways—such as direct contact with animals, consumption of contaminated food, and environmental exposure—eventually reaching humans and contributing to the increasing burden of AMR worldwide (Rosa et al., 2025).

The impact of AMR on human health is severe, as infections caused by resistant pathogens are more difficult to treat, often requiring more expensive and toxic drugs, prolonged treatment periods, and resulting in higher rates of morbidity and mortality (Shayista et al., 2024). In addition to these health implications, the economic consequences are significant, placing a strain on healthcare systems and increasing the cost of medical treatments (Imai et al., 2022). Moreover, resistant infections complicate even routine medical procedures like surgery and organ transplants, where the risk of post-operative infections is high. The spread of AMR from livestock to humans is not only a public health issue but also an economic, environmental, and societal one, impacting food safety, food security, and economic stability (Pinto et al., 2025).

Addressing the AMR burden in livestock is complex, requiring a multifaceted approach. This includes enforcing stricter regulations on antibiotic use in agriculture, encouraging alternative disease control methods like vaccines and probiotics, improving farming practices, and increasing public awareness about the risks of overusing antibiotics in both animal and human health (Berman et al., 2023). This paper will explore the significant role that livestock farming plays in the emergence and transmission of AMR, the mechanisms through which resistance develops, and the strategies that can be implemented to mitigate its spread from animals to humans. By focusing on these interconnected issues, we aim to highlight the critical need for a coordinated global effort to combat AMR in livestock and safeguard both public health and food security for future generations.

2. THE ROLE OF ANTIMICROBIALS IN LIVESTOCK FARMING

Antimicrobials, including antibiotics, are widely used in livestock farming to control and prevent diseases, promote growth, and ensure the health of animals. In many agricultural systems, antibiotics are routinely administered to healthy animals to prevent disease outbreaks, often at sub-therapeutic doses (Hosain et al., 2021). This practice, known as prophylactic use, is intended to boost animal productivity but also accelerates the development of resistance (Okaiyeto et al., 2024). In addition to preventing diseases, antibiotics are often used for growth promotion, increasing the efficiency of feed conversion, and leading to faster weight gain. While antibiotics can be essential for controlling disease in intensive farming systems, their overuse is a key driver of AMR (Okaiyeto et al., 2024). The types of antibiotics used in livestock include those classified for human medical use, such as penicillins,

tetracyclines, and cephalosporins, which increases the risk of cross-resistance between animal and human pathogens (Burnham, 2025). In many countries, there is little regulation of antibiotic use in livestock farming, leading to inconsistent and often inappropriate practices. Greater oversight and regulation are crucial to limit antibiotic use in livestock and prevent further amplification of resistant bacteria. Efforts to reduce reliance on antibiotics in agriculture are essential to preserve the effectiveness of these drugs in human medicine (Burnham, 2025).

3. MECHANISMS OF AMR DEVELOPMENT IN LIVESTOCK

Bacteria develop resistance to antibiotics through several mechanisms, which can be further exacerbated by the overuse and misuse of antimicrobials in livestock (Bava et al., 2024). Resistance can arise through mutation, where a random genetic change makes the bacteria less susceptible to a drug. This mutation can be naturally selected if the antibiotic is present, enabling the resistant bacteria to survive and proliferate (Baran et al., 2023). Another key mechanism is horizontal gene transfer (HGT), where bacteria exchange genetic material, including resistance genes, with other bacteria (Baker et al., 2023). This allows even unrelated bacterial strains to acquire resistance traits. In livestock, the use of antibiotics creates a selective pressure that encourages the survival of resistant bacteria, which can multiply rapidly (Neidhöfer et al., 2023). Plasmids, small DNA molecules that carry resistance genes, play a critical role in transferring resistance between bacteria. Additionally, the environmental factors in farms, such as animal waste, contaminated water, and the use of antibiotics in feed, provide ideal conditions for the spread of resistance genes. When animals are raised in close quarters, with frequent use of antibiotics, bacteria have ample opportunities to exchange resistance genes, which are then passed on to other animals or to humans. The widespread presence of these resistant bacteria in animal populations poses a significant public health risk (Pinto et al., 2025).

4. TRANSMISSION PATHWAYS OF AMR FROM LIVESTOCK TO HUMANS

AMR pathogens can be transmitted from livestock to humans through multiple pathways. One of the most direct transmission routes is direct contact, which occurs when farm workers, veterinarians, or individuals who handle livestock come into contact with animals or animal products contaminated with resistant bacteria. This can happen through skin contact, inhalation of dust, or accidental ingestion of contaminated materials (Pinto et al., 2025). Consumption of animal products, such as meat, milk, and eggs, is another significant route for AMR transmission. If these products are undercooked or improperly handled, resistant bacteria can be transferred to humans. Contaminated water sources, which may be exposed to animal waste containing resistant bacteria, also serve as a conduit for the spread of AMR (Burnham, 2025). Furthermore, environmental pathways such as

agricultural runoff can carry resistant bacteria from farms to surrounding ecosystems, contaminating soil, water, and crops, which can then be consumed by humans. The global trade of live animals and animal products further facilitates the movement of AMR pathogens, increasing the potential for cross-border transmission (Pinto et al., 2025). Understanding these transmission routes is crucial for developing strategies to reduce the spread of AMR and protect human health (Baker et al., 2020).

5. IMPACT OF AMR FROM LIVESTOCK ON HUMAN HEALTH

The emergence of antimicrobial-resistant pathogens in livestock poses a significant threat to human health (Syed et al., 2018). Resistant bacteria that originate in animals can cause foodborne illnesses, leading to infections in humans that are harder to treat due to their resistance to antibiotics. Common pathogens such as Salmonella, Campylobacter, and Escherichia coli can acquire resistance through exposure to antibiotics in animals, making infections more difficult to treat (Shahrivar et al., 2025). Additionally, zoonotic diseases (diseases that can be transmitted from animals to humans) caused by resistant bacteria can complicate the management of infections (Kaur et al., 2024). Infections such as tuberculosis and brucellosis, which are prevalent in livestock, can also become more challenging to treat as resistance develops. The economic burden of AMR is substantial, as it results in longer hospital stays, more expensive treatments, and increased mortality rates. It also puts a strain on healthcare systems, particularly in low-resource settings where access to alternative treatments is limited (Ahmed et al., 2024). Furthermore, as resistant infections become more common, the effectiveness of medical procedures such as surgeries, cancer treatments, and organ transplants diminishes, as infections following these procedures become harder to manage (Niño-Vega et al., 2025). As AMR continues to grow, it threatens the progress made in modern medicine and the sustainability of healthcare systems worldwide (Baker & Perianova, 2019; Syed et al., 2019).

6. STRATEGIES FOR MITIGATING AMR IN LIVESTOCK

There are several strategies that can be employed to mitigate the rise of AMR in livestock. One key approach is to reduce the use of antibiotics in animal farming. This can be achieved by implementing alternative methods for disease prevention, such as the use of vaccines, probiotics, or immunostimulants that enhance the animals' natural defenses without relying on antibiotics (Manju et al., 2023). Improved husbandry practices, including better sanitation, biosecurity, and animal welfare, can also reduce the need for antibiotics by preventing infections from occurring in the first place (Adams et al., 2023). Regulatory measures are another crucial aspect of mitigating AMR. Governments can enforce policies that restrict the use of antibiotics for growth promotion and prophylaxis and ensure that antibiotics are only used when necessary for the treatment of diagnosed

infections (Sutton & Ashley, 2024). Additionally, surveillance programs to monitor antibiotic use and the presence of resistant bacteria in livestock can help identify and control outbreaks before they spread. International cooperation is also essential, as AMR is a global issue, and efforts to reduce antibiotic resistance in livestock must be aligned across borders (Zhao et al., 2024). These strategies, combined with public awareness campaigns, can help limit the spread of AMR from livestock to humans and preserve the efficacy of antibiotics for future generations.

7. THE ROLE OF PUBLIC AWARENESS AND EDUCATION

Public awareness and education play a crucial role in addressing the issue of AMR, particularly in livestock farming. Farmers need to be educated about the dangers of overusing antibiotics in animals and the importance of responsible antibiotic use to preserve their effectiveness. Training programs can teach farmers about alternative practices, such as improved hygiene, biosecurity, and disease prevention strategies, that reduce the reliance on antibiotics (Ajayi et al., 2024). Consumers also need to be informed about the risks of consuming undercooked or contaminated animal products and the importance of food safety practices, such as proper cooking and handling of meat. Public health campaigns can help raise awareness about the role of agriculture in the development of AMR and encourage people to support policies that promote sustainable farming practices (Seyoum et al., 2024). Governments and health organizations must work together to foster an understanding of AMR among the general public, particularly in regions with high levels of antibiotic use in agriculture. Educational initiatives targeting schoolchildren, consumers, and healthcare professionals can play a significant role in changing behaviors and promoting a more sustainable approach to antibiotic use (Marvasi et al., 2021).

8. CONCLUSION

The burden of antimicrobial resistance (AMR) in livestock farming and its subsequent transmission to humans represents a critical public health challenge that demands immediate attention. As antibiotics are widely used in agriculture, not only for treating infections but also for disease prevention and growth promotion, this practice creates an environment conducive to the development of resistant pathogens. These resistant bacteria can be transmitted to humans through direct contact with animals, the consumption of contaminated animal products, or environmental exposure. The consequences of AMR are profound, with infections caused by resistant pathogens leading to increased morbidity and mortality, prolonged hospital stays, and higher healthcare costs.

Addressing the spread of AMR from livestock to humans requires a multifaceted and coordinated approach. A significant aspect of this strategy involves reducing the unnecessary and overuse of

antibiotics in agriculture through stronger regulations and better farming practices. Encouraging the use of alternatives to antibiotics, such as vaccines, probiotics, and improved biosecurity measures, will further help limit the reliance on antibiotics and reduce the risk of resistance. Additionally, there must be stronger surveillance systems in place to monitor the emergence and spread of resistant bacteria, along with increased awareness and education on the risks of AMR among farmers, consumers, and healthcare professionals. Collaboration between governments, international organizations, farmers, the healthcare sector, and consumers is essential for implementing these measures effectively. Only through these combined efforts can we curb the spread of AMR, ensure food safety, and protect both public health and the effectiveness of antibiotics for future generations. Given the interconnectedness of human, animal, and environmental health, a One Health approach is critical in tackling the global threat of antimicrobial resistance. By taking decisive action now, we can mitigate the impact of AMR and safeguard the ability to treat infections in both humans and animals, ensuring a healthier, more resilient future for all.

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