

Review Article

Review on Addressing Antimicrobial Resistance in Livestock Through a One Health Approach

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Abstract

Antimicrobial resistance (AMR) has emerged as one of the most pressing global health threats of the 21st century, jeopardizing the effective treatment of infectious diseases across humans, animals, and the environment. In livestock production, antimicrobials are widely used for therapeutic, prophylactic, and growth-promoting purposes. Therefore, the objective of this review is to examine the application of One Health approaches in addressing AMR in livestock and to identify key challenges and opportunities for their effective implementation. The inappropriate and excessive use of antimicrobials in animals has accelerated the emergence and spread of resistant pathogens. These resistant bacteria can be transmitted to humans through direct contact, food consumption, and environmental contamination, posing significant risks to public health, food security, and economic stability. Addressing AMR from a single-sector perspective has proven inadequate. A One Health approach which recognizes the interdependence of human, animal, and environmental health offers a more sustainable and effective solution. Despite growing global and national advocacy for One Health strategies, implementation remains inconsistent, particularly in the livestock sector. In many low- and middle-income countries, antimicrobial use in animals is poorly regulated, data on usage and resistance patterns are limited, and cross-sectoral collaboration is weak. Although One Health frameworks exist, their operationalization in livestock systems is hindered by gaps in policy, coordination, and technical capacity. In conclusion, AMR in livestock is a complex issue that requires a collaborative, multisectoral response. Strengthening the One Health approach is essential to tackle AMR at its source. As a key recommendation, countries should establish a national One Health coordination platform that brings together stakeholders from human, animal, and environmental health sectors to implement harmonized surveillance, promote responsible antimicrobial use, and support education and capacity building. Strong political commitment and sustained investment are crucial for achieving long-term impact.

Keywords

Antimicrobial Resistance, Microorganisms, One Health

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1. Introduction

Antimicrobial resistance (AMR) has to become as one of the most very important and needing immediate attention global health threats of the 21st century, endangering the effective treatment of infectious diseases across humans, animals, and the environment [41].

When infectious agents (bacteria, viruses, fungi, and parasites) alter over time and fail to react to medications, it is known as antimicrobial resistance (AMR). This makes infections more difficult to cure and raises the possibility of disease transmission, serious illness, and death. It is not always the case that bacteria as a species or group are equally susceptible or resistant to any given antimicrobial agent [29]. In livestock production systems, antimicrobials are commonly used for therapeutic, prophylactic, and growth-promotion purposes [10].

Thus one of the main causes of the resistance is the overuse and misuse of antibiotics; other causes include the conditions that encourage the local and international transmission of resistant bacteria and their genes. Within and between humans, animals, and the environment, bacteria and their genes can travel quite freely. Any other sector will exhibit microbial adaptations to antimicrobial usage and other selection pressures [38].

The interconnectedness of humans, animals, and the environment necessitates a more integrated strategy through a One Health approach but Addressing AMR solely from a human or animal health perspective has proven insufficient [4].

Antimicrobial resistance is a global public health issues that threatens our ability to successfully treat bacterial infections. here ever antimicrobials are used, there are reservoirs of resistance, including within humans and the local environments of hospitals and the community, as well as in animals and the farm and aquaculture environments, but also in water, soil, wild- life, and many other ecological niches, due to pollution by sewage, pharmaceutical industry waste, and manure runoff from farms [20].

Despite global and national initiatives promoting One Health strategies, gaps remain, particularly in the livestock sector. Many existing programs focus heavily on human health, with less emphasis on animal agriculture and environmental interfaces where AMR often originates or amplifies [19].

the use of antimicrobials in livestock remains largely unregulated, data on usage patterns and resistance trends are limited, and cross-sectoral collaboration is weak In many low- and middle-income countries, the use of antimicrobials in many low- and middle-income countries [12]. Furthermore, practical guidance on operate One Health principles in to livestock management and veterinary practice is still under-developed [21].

Given the tending to point out errors and careful role out in livestock, food security, livelihoods, and public health [34]. There is an urgent need to comprehensively review how One

Health approaches can be effectively applied to address AMR in animal production systems.

Therefore, the objectives of these papers are;

- 1) To review the application of One Health approaches in addressing antimicrobial resistance in livestock and identify key challenges and opportunities.
- 2) By embracing the One Health approach, stakeholders can work together to implement comprehensive strategies that address the multifaceted nature of AMR, ensuring Sustainable health outcomes for people, animals, and ecosystems.

2. Literature Review

2.1. The Burden of AMR in Livestock

Animal welfare, output, and health are all seriously threatened by infectious illnesses. Depending on the pathogen's characteristics, production settings, mitigation techniques used, and market conditions, there may be significant economic lost [15].

Given the socioeconomic importance of animals to farmers' livelihoods and the production of safe and reasonably priced food, viral diseases in livestock can have wider detrimental effects on society, including sustainable development. Livestock zoonotic infections are also a direct public health concern [5].

This importance is recognized at a societal level. It underpins public investments in animal health surveillance and disease control programmers [15]. Antimicrobials are an important part of the tool kit to mitigate the impact of infectious diseases at the farm level. They are used in livestock to prevent and treat infections and, in some countries, for growth promotion. From an economic perspective, antimicrobials represent an input to animal production and a cost incurred to maximize production outputs by minimizing infectious disease losses while enhancing animal and public health and As a production input, antimicrobials have a specific characteristic important to its economic framing: they are drivers for AMR, meaning that the beneficial use of antimicrobials and their positive effects in infection mitigation may negatively affect their effectiveness in the long run [19]. When thinking about AMR in livestock, the detrimental externalities on the environment and human health are important contextual considerations [43].

2.2. Impact of AMR on Livestock Health, Productivity and Food Safety

Antimicrobials extensively used for food-producing animals in different counties of the world are beta-lactams, tetracycline, macrolides, sulfonamides, aminoglycosides, fluo-

roquinolone, lincosamide, and cephalosporins groups. The use of large amounts of antimicrobial drugs could result in the deposition of antibiotics as residues in animal products [44]. Milk, meat, and other dairy products containing drug residues beyond the MRL may produce serious health problems to the consumers [5]. Although good quality milk, meat, and other related products are a prime need for maintaining proper public health [32]. The presence of antimicrobial residues in these food items and their subsequent consumption may cause serious health problems to consumers including the development of AMR, hypersensitivity reaction, and cancer [14]. The consequences of such resistance are even more threatening where antibiotics become ineffective clinically for the treatment of illness. Food and Agriculture Organization (FAO) and World Health Organization (WHO) reported that antibiotic residues in edible animal products have grown beyond the permissible levels in developing countries [23].

2.3. Economic Impacts of Antimicrobial Resistance in Livestock

The economic cost of AMR is narrowly defined as the incremental cost of treating patients with resistant infections as compared with sensitive ones, and the productivity losses due to excess mortality attributable resistant infections [18].

In contrast to treating a susceptible strain of the pathogen, the term "direct economic cost" describes the direct medical costs involved in treating a resistant illness. Ineffective infection and inadequate treatment can result in more severe or long-lasting illness, increased risk of death, reduced work productivity, and adverse effects on people's livelihoods and food security [33].

The indirect impacts of AMR extend beyond health risks or reduced productivity, and include higher costs for treatment and health care, and drain national and global economies conference. The health consequences and economic costs of AMR are estimated at 10 million annual human fatalities and a 2 to 3.5 percent decrease in global Gross Domestic Product (GDP), or 100 trillion USD by 2050. Although real consequences of AMR remain unpredictable because of higher disease incidence, these falls will affect low income countries more severely, with a predicted rise of 6.2 to 18.7 million the number of extremely poor people by 2030 [26].

3. One Health Concept and Its Relevance to AMR

One Health is described as "the collaborative effort of multiple health science professions, together with their related disciplines and institutions working locally, nationally, and globally [21]. The persistence and spread of resistant microbial species and this association of determinants at the human-animal-environment interface can alter microbial genomes, resulting in resistance super bugs or strains that are

resistant to most of the medications commonly used to treat the infections they cause in various niches. When bacteria acquire resistance to antimicrobial they also acquire greater ability to proliferate in animals, humans.

The One Health approach is defined as a joint effort of various disciplines that come together to provide solutions for human, animal, and environmental health [43]. AMR is linked to each of these three components due to the irresponsible and excessive use of antimicrobials in various sectors (agriculture, cattle raising, and human medicine) [19]. When bacteria acquire resistance to antimicrobials, they also acquire a greater ability to proliferate in animals, humans, and the natural world [21]. Mismanagement of antimicrobials, inadequate infection control, agricultural debris, contaminants in the environment, and migration of people and animals infected with resistant bacteria facilitate the spread of resistance [21].

The One Health approach is fully integrated in to global efforts to address the problem of AMR. Among them any obstacles to overcome are the competing interests of multiple economic sectors and organizations involved in animal, human, and environmental health [36].

These sectors must align on key priorities for action, the best methods to monitor AMR and control infections, and policies governing antimicrobial use [24]. Key strategies to address AMR through the One Health approach include launching a global public awareness campaign to educate society about the dangers of overusing and misusing antimicrobials, which can help reduce unnecessary prescriptions [36]. Improving hygiene practices and healthcare infrastructure is also essential for preventing infections and decreasing the demand for antimicrobials, thus limiting the rise of resistant strains [25]. In agriculture and aquaculture, where most antimicrobials are used, reducing misuse and environmental contamination is critical [36]. Additionally, enhancing global surveillance systems will provide better insights into antimicrobial consumption and resistance trends, enabling scientists and healthcare professionals to predict and address emerging threats more effectively [24].

Promoting the development and use of vaccines and alternatives is another key strategy. The development of vaccines targeting antibiotic-resistant bacteria that cause serious infections will reduce the need for antimicrobial treatment [36]. Investments are also needed to develop alternatives to antimicrobials, such as phage therapy, probiotics, antibodies, and lysins [25]. Furthermore, increasing the number of professionals working with infectious diseases is vital. Addressing AMR requires experts such as microbiologists, pharmacists, infectious disease specialists, nurses, infection control specialists, veterinarians, and epidemiologists [36]. Therefore, countries must invest in training these professionals. Finally, building a global coalition for real action against AMR is crucial for making significant progress in the fight against antimicrobial resistance [24].



Figure 1. AMR is a critical global problem that affects human, environmental, and animal health [21].

4. Key Factor of Antimicrobial Resistance

Antimicrobial resistance (AMR) in livestock is a serious threat to the health of both humans and animals and is caused by a number of important causes. The overuse and abuse of antibiotics in animal husbandry is one of the main causes, especially when the drugs are regularly used for illness prevention or growth promotion rather than therapy. Selective pressure is created by non-therapeutic use [41].

4.1. Misuse and Overuse of Antimicrobial

The use of antimicrobial, even when used appropriately, creates a selective pressure for resistant organisms. However, there are additional societal pressures that act to accelerate the increase of antimicrobial resistance [31]. In appropriate use Selection of resistant microorganisms is exacerbated by inappropriate use of antimicrobials. Sometime health care providers will prescribe antimicrobials inappropriately, wishing to placate an insistent patient who has a viral infection or an as-yet undiagnosed condition [16].

4.2. Inadequate Diagnostics

More often, health care providers misuse incomplete or imperfect information to diagnose an infection and thus prescribe an antimicrobial just-in-case or prescribe a broad spectrum antimicrobial when a specific antibiotic might be better. These situations contribute to selective pressure and accelerate antimicrobial resistance [30].

4.3. Biosecurity and Farm Management Gaps

Farm management practices play a crucial role in its

emergence and spread. One of the major gaps in farm management is the overuse and misuse of antibiotics, often administered without proper veterinary supervision, not only for treating diseases but also for growth promotion and disease prevention in healthy animals. This inappropriate use accelerates the development of resistant bacteria [35]. Another critical issue is the lack of effective biosecurity measures; many farms fail to implement adequate controls on animal movement, visitor access, and quarantine procedures, which increase the risk of disease transmission and subsequent antibiotic use [10]. Additionally, poor record-keeping practices hinder the monitoring of antibiotic usage and make it difficult to identify patterns of misuse [41]. Farmer awareness and training also remain inadequate in many regions, leading to low understanding of AMR and the importance of judicious antibiotic use. Furthermore, substandard infection prevention measures, such as poor sanitation, overcrowding, and inadequate nutrition, contribute to increased disease burden and reliance on antimicrobials [17]. Scientists also believe that the practice of adding antibiotics to agricultural feed promote s drug resistance. However, there is still much debate about whether drug-resistant microbes in animals pose a significant public health burden [39].

5. Intervention and Strategies for AMR Mitigation

Mitigating antimicrobial resistance (AMR) necessitates a multipronged strategy that includes clinical tactics, public health, legislation, and agricultural practices. Implementing antimicrobial stewardship programs (ASPs) in veterinary and healthcare settings is one of the main strategies to maximize antibiotic use and minimize needless prescriptions. To track resistance trends and direct policy-making, surveillance systems like the WHO's Global Antimicrobial Resistance Surveillance System are crucial. The spread of resistant diseases is considerably decreased by infection prevention and control (IPC) strategies, such as immunization, sanitation, and hand hygiene [41].

5.1. Infection Prevention and Control

Reducing the incidence of infections is a fundamental step in curbing antimicrobial use and, consequently, the selection pressure for resistance [41]. Effective IPC practices, particularly hand hygiene, are paramount [27]. demonstrated that a hospital-wide hand hygiene program, using alcohol-based hand rub, led to a significant reduction in nosocomial infections and MRSA transmission. Improved sanitation, access to clean water, and robust vaccination programs are also essential. Furthermore, implementing stringent environmental cleaning and isolation protocols within healthcare facilities helps to minimize the spread of resistant organisms [7].

5.2. Antimicrobial Stewardship (AMS)

Antimicrobial stewardship programs design to enhance antimicrobial use, ensuring appropriate treatment while minimizing collateral damage. These programs typically involve implementing evidence-based prescribing guidelines, restricting the use of broad-spectrum antimicrobials, and conducting audits with feedback to prescribers [1]. Several studies have highlighted the significant effectiveness of AMS interventions in substantially reducing the use of antimicrobials across various healthcare settings [6]. The development of rapid and accurate diagnostic tests is critical to guide antimicrobial prescribing and reduce unnecessary use [24].

5.3. Public Awareness and Education

Increasing public awareness and promoting responsible antimicrobial use are essential for fostering behavior change [9]. Public education campaigns, training programs for healthcare professionals and integration of AMR education into school curricula can all contribute to raising awareness [45].

5.4. Policies and Regulations

Supportive policies and regulations are needed to create an enabling environment for AMR mitigation. National action plans, antimicrobial regulation, and strengthened collaboration between human health, animal health, and environmental sectors are critical [41].

5.5. Environmental Controls

The environmental spread of AMR is a growing concern, necessitating strategies to minimize contamination [28]. Improving wastewater treatment to remove antimicrobials and resistance genes, implementing responsible practices for managing animal waste, and monitoring antimicrobial levels in the environment are important steps [3].

6. Challenges and Opportunities of AMR in Application of One Health

Antimicrobial resistance (AMR) is a major global threat to health, food security, and development. It leads to longer illnesses, higher medical costs, and greater mortality, largely driven by the misuse and overuse of antibiotics in medicine and agriculture, worsened by poor regulation and low public awareness. The slow development of new drugs and weak infection control and surveillance systems, especially in low- and middle-income countries, allow resistant strains to spread. AMR also strains healthcare systems and poses a serious economic risk [42].

6.1. Challenges in Food Chain and Economical Aspect

Overuse of antibiotics in the agricultural sector has resulted in the emergence of new strains of antibiotic-resistant bacteria. It is undeniable that antibiotics are widely used in the livestock to promote faster growth, better yield and prevent infection [37]. Antibiotics are also used as herbicides and pesticides for vegetations to control weeds and pests that infest the cultivated plants [37]. Theoretically, the antibiotics used above are ingested by humans as food [37]. and therefore, there are chances that the resistant genes may be transferred from the animal through zoonotic diseases or as a direct exposure from the food. The transfer of resistant bacteria from animal to human is not new as it has been identified in the 80's itself [2]. Indeed, scientists have thought that new dangerous superbugs and viruses are triggered by overuse of antibiotics in the agriculture [13].

6.2. Economic / Financial Aspects

This situation is a widespread threat to developing countries, particularly in Southeast Asia and Africa, where the burden of communicable diseases is high and financial resources are limited. It often requires the use of second- or third-line antibiotics, which are expensive, and not easily accessible [8, 11]. The obstacles to acquire an appropriate treatment also occur in the form of inadequate infrastructure, diagnostic tools and insufficient number of trained personnel [22, 40]. These difficulties occasionally delay the treatment and possibly a global mutual partnership between the developing and developed countries as well as world organizations may mitigate these hurdles.

While antimicrobial resistance (AMR) poses significant threats, it also presents critical opportunities to strengthen global health systems, innovation, and policy. One major opportunity lies in the advancement of research and development of new antimicrobials, vaccines, and rapid diagnostic tools. These innovations not only help combat resistant pathogens but also improve overall infectious disease management. AMR has also prompted global collaboration and policy reforms, encouraging countries to implement national action plans and improve surveillance systems [42].

There is a significant opportunity to enhance antimicrobial stewardship by focusing on public education, professional training for healthcare providers, and ensuring antibiotics are used more responsibly in both agriculture and human healthcare. The growing threat of antimicrobial resistance (AMR) has driven greater investment in healthcare infrastructure, improved hygiene, and stronger infection prevention measures, which collectively strengthen public health far beyond just addressing AMR. Ultimately, the challenge posed by AMR is acting as a powerful motivator for building more resilient health systems and fostering a better-informed global community [25].

7. Conclusion and Recommendations

Antimicrobial resistance (AMR) in livestock presents growing threats to public health, animal health, environmental integrity. The misuse and over use of (AMR) in animal production have facilitated the emergence of resistant pathogen. To combat AMR, it is important to support “One Health” approach (human, animal, plant, and environmental health). AMR can be reduced when antimicrobial are used only as a treatment, Antimicrobial resistance (AMR) in livestock presents a growing threats to public health, animal health, environmental integrity. The misuse and over use of (AMR) in animal production have facilitated the emergence of resistant pathogen and rarely for prophylaxis, and never as growth promoters. Success will require strict and efficient control of the types and amounts of antimicrobial used in medical practice and monitoring and Controlling the proliferation of resistant bacteria that spread to the environment. Challenges associated with bacterial infection associated diseases are due to the current shortage of effective therapies, lack of successful prevention measures, and lack of new antibiotics, which require development new treatment options and alternative antimicrobial therapies. It results in economic lose and health problems.

Based on the above conclusion the following recommendations are forwarded:

- 1) Awareness and understanding of Antimicrobial Resistance should be improve through effective communication, education.
- 2) Enhance veterinary antimicrobial stewardship programs by providing updated training, resources, and clear guidelines for responsible antimicrobial use among animal health professionals and farmers.
- 3) Veterinarians should be the key part to play in the fight against antimicrobial resistance, through regulating and supervising the use of antimicrobials, offering professional advice to farmers and animal owners and collaborating with human health sector.
- 4) Strengthen the implementation of Ethiopia’s National One Health Strategic Plan, with specific focus on antimicrobial resistance in the livestock sector.

Abbreviations

ABR	Antibiotic Resistance
AMR	Antimicrobial Resistance
AMRB	Antimicrobial Resistance Bacteria
MIC	Minimum Inhibitory Concentration
ASP	Antimicrobial Stewardship Program
FAO	Food and Agriculture Organization
IPC	Infection Prevention and Control
WB	World Bank
WHO	World Health Organization

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Conflicts of Interest

The authors declare no conflicts of interest.

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