ONE HEALTH APPROACH IN CONTROLLING ANTIMICROBIAL RESISTANCE: INTERACTIONS BETWEEN ANIMAL, HUMAN AND ENVIRONMENTAL HEALTH

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REVIEW ARTICLE

Abstract

Antimicrobial resistance (AMR) represents one of the greatest global threats to public health, affecting humans, animals, and the environment. The One Health approach recognizes the interconnectedness of these three domains and the need for integrated strategies to control antimicrobial resistance. This review synthesizes current literature on the mechanisms of AMR, the role of each sector (human, animal, and environmental), and the interactions between them. Surveillance strategies, intervention measures, and global policies are analysed, highlighting the importance of interdisciplinary collaboration. The findings emphasize the need for coordinated global actions to limit the spread of AMR.

Keywords: AMR, One Health, antibiotic, animal production
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INTRODUCTION

Antimicrobial resistance (AMR) has become a critical global public health issue, associated with increased mortality, rising healthcare costs, and treatment failures in infectious diseases (Laxminarayan et al., 2013). According to the report led by O'Neill (2016), failure to implement effective measures may result in millions of deaths annually by 2050. The One Health concept provides an integrative framework for understanding and combating AMR, highlighting the connections between human, animal, and environmental health (McEwen & Collignon, 2018; Robinson et al., 2017). The aim of this review is to analyze these interactions and to identify effective control strategies.

MATERIAL AND METHOD

This study is based on a comprehensive literature review focused on sustainable animal nutrition and its implications for environmental sustainability and human health within the One Health framework (McEwen and Collignon, 2018; Robinson et al., 2017; Singh, 2022; Khan et al., 2025). Relevant peer-reviewed scientific articles, review papers, and international reports were selected based on their scientific relevance, methodological rigor, and year of publication, with emphasis on recent research (Aslam et al., 2022; Velazquez-Meza et al., 2023;; O'Neill, 2016).

The literature analysis included studies addressing alternative feed resources, feed additives for methane mitigation, circular economy approaches in livestock feeding, precision feeding strategies, and the relationship between animal nutrition, environmental impact, and human health (Nudda and Pulina, 2020; Van Boeckel et al., 2019; Gheorghe-Irimia, 2024). Particular attention was given to studies evaluating greenhouse gas emissions, nutrient efficiency, animal productivity, and product quality (Berendonk et al., 2015; Holmes et al., 2016; Kraemer et al., 2019).

In order to evaluate environmental impacts, studies using life cycle assessment (LCA) methodology were included, as this method allows the assessment of environmental impacts associated with feed production, animal production, and processing stages (Hendriksen et al., 2023; Li et al., 2026). Environmental indicators considered included greenhouse gas emissions, land use, water use, and nutrient losses (Van Boeckel et al., 2015; Tang et al., 2017).

The collected information was systematically analyzed, compared, and synthesized in order to identify the main sustainable nutritional strategies and their effects on animal productivity, environmental sustainability, and food quality (Economou and Gousia, 2015; Effendi et al., 2023; Mouiche et al., 2019). The results were interpreted within the One Health approach, which integrates animal health, human health, and environmental protection (Nadimpalli et al., 2020; Sonea et al., 2024; Șonea et al., 2025).

All measurements and data reported in the analyzed studies were expressed using the metric system and International System of Units (SI). Abbreviations such as LCA (life cycle assessment), GHG (greenhouse gas), and FAO (Food and Agriculture Organization) were defined when first introduced according to scientific writing standards.

RESULTS AND DISCUSSIONS

Livestock production systems face significant sustainability challenges, mainly due to the competition between feed and food resources, greenhouse gas emissions, and environmental impacts associated with intensive production systems (Van Boeckel et al., 2015; Berendonk et al., 2015; Laxminarayan et al., 2013). Several studies indicate that conventional livestock feeding relies heavily on human-edible feed resources such as cereals and soybean meal, which contributes to land use pressure and environmental degradation (Economou and Gousia, 2015; Tang et al., 2017).

Animal nutrition plays a crucial role in environmental sustainability because feed composition directly influences methane emissions, nitrogen and phosphorus excretion, and overall production efficiency (Holmes et al., 2016; Kraemer et al., 2019; Hendriksen et al., 2023). High-fiber diets in ruminants are associated with increased enteric methane emissions, while excessive protein diets lead to increased nitrogen excretion and environmental pollution (Nudda and Pulina, 2020; Effendi et al., 2023). Therefore, optimizing feed composition represents one of the most effective strategies for reducing environmental impact (Van Boeckel et al., 2019; Berendonk et al., 2015).

Recent research highlights several sustainable animal nutrition strategies (Velazquez-Meza et al., 2023; Mouiche et al., 2019). One important strategy is the use of alternative feed resources, including agro-industrial by-products, former food products, insects, and algae (Effendi et al., 2023; Gheorghe-Irimia, 2024). These alternative feed sources contribute to circular economy systems by reducing food waste and decreasing the use of conventional feed crops.

Another important strategy is the use of feed additives such as methane inhibitors, essential oils, tannins, probiotics, and encapsulated oils, which can reduce enteric methane emissions and improve feed digestibility and nutrient utilization efficiency (Nudda and Pulina, 2020; Singh, 2022). Precision feeding is also an important strategy, as it allows the adjustment of feed intake according to the nutritional requirements of animals, reducing nutrient losses and improving production efficiency (Van Boeckel et al., 2019; Kraemer et al., 2019).

Circular crop–livestock systems represent another sustainable approach, where crop residues are used as animal feed and animal manure is used as fertilizer, thus reducing the need for synthetic fertilizers and improving nutrient recycling (Berendonk et al., 2015; Robinson et al., 2017; Șonea et al,. 2024).

From a human health perspective, animal nutrition directly influences the nutritional quality of animal-derived products such as meat, milk, and eggs (Nudda and Pulina, 2020; Velazquez-Meza et al., 2023). Feeding strategies can improve the content of beneficial fatty acids, vitamins, and antioxidants in animal products, contributing to improved human nutrition (Economou and Gousia, 2015).

However, there are also trade-offs between productivity, environmental impact, and animal health (McEwen and Collignon, 2018; Nadimpalli et al., 2020). Intensive production systems are more productive but may have higher environmental impacts and increased risks of disease transmission, while extensive systems have lower environmental impact but reduced productivity (Robinson et al., 2017; Sonea et al., 2024).

Statistical data from the reviewed studies show that sustainable feeding strategies can significantly reduce greenhouse gas emissions, improve feed efficiency, and reduce nutrient losses, while maintaining animal productivity

(Van Boeckel et al., 2019; Kraemer et al., 2019; Mouiche et al., 2019). These findings support the implementation of sustainable animal nutrition strategies within the One Health framework, where animal nutrition is considered a key factor linking environmental sustainability and human health (Singh, 2022; Khan et al., 2025; Șonea et al., 2025).

CONCLUSIONS

In summary, the emergence and spread of resistance are the result of both adaptive biological mechanisms—such as genetic mutations and horizontal gene transfer—and anthropogenic factors, particularly the excessive and inappropriate use of antimicrobials in human medicine and animal production (Holmes et al., 2016; Aslam et al., 2022; Laxminarayan et al., 2013).

Within this context, the One Health approach proves indispensable, as it provides a comprehensive framework for understanding the interconnected pathways through which resistant microorganisms and resistance genes circulate across sectors (McEwen and Collignon, 2018; Robinson et al., 2017; Nadimpalli et al., 2020; Khan et al., 2025). The movement of these determinants through the food chain, environmental reservoirs, and global travel further emphasizes the need for coordinated, cross-sectoral action (Wellington et al., 2013; Wallace et al., 2020).

Effective mitigation of AMR relies on the implementation of integrated strategies, including robust surveillance systems, antimicrobial stewardship programs, and the rationalization of antibiotic use (Dyar et al., 2025; Hendriksen et al., 2023; Sonea et al., 2024). Improvements in genomic technologies have significantly enhanced our ability to monitor resistance patterns and track transmission pathways, offering valuable tools for targeted interventions (Hendriksen et al., 2023; Li et al., 2026). At the same time, the development of alternative therapies and innovative solutions represents a promising avenue for reducing dependence on conventional antibiotics (Velazquez-Meza et al., 2023; Effendi et al., 2023).

In conclusion, tackling AMR requires a sustained, collaborative, and multidisciplinary effort grounded in the principles of One Health (Singh, 2022; Khan et al., 2025; Șonea et al., 2025). Only through the alignment of policies, the strengthening of surveillance and prevention measures, and the promotion of responsible antimicrobial use can the global community effectively curb the spread of resistance and prevent a future public health crisis (O'Neill, 2016; Wallace et al., 2020).

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