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Antibacterial resistance in poultry from a One Health perspective

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ABSTRACT

Antibiotic resistance (ABR) development continues to be a major worldwide health concern. Poultry accounts for a significant amount of the world's consumption of antibiotics. Despite significant efforts in prevention and management, bacterial illnesses such as avian pathogenic *Escherichia coli,* causing colibacillosis, and *Clostridium perfringens*, causing necrotic enteritis, continue to pose significant challenges for poultry producers in terms of economic losses and market limits. Antibiotics have been used to promote growth in addition to treating and preventing these illnesses. Consequently, these practices have been linked to the selection and dissemination of antibiotic-resistant bacteria. Producers that raise poultry are trying to reduce the administration of antibiotics (ABU) in an attempt to battle ABR. In this article, we will discuss antibacterial resistance, its mechanisms, and its impact on the environment, humans, and other animals. We will also discuss the challenges posed by ABR and its alternatives for the future.

Keywords: poultry, antibiotic resistance, one-health-program, resistant genes, economic losses

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Introduction

Chemicals known as antibiotics are either created by a variety of microorganisms, such as bacteria and fungi, or synthesized in laboratories [1]. In the intensive poultry industry, they enhance intestinal health and lower subclinical illnesses, which boosts output and feed conversion efficiency. Growth-promoting antibiotics (GPA) use is the practice of administering antibiotics to animals that are healthy for longer than 14 days at a dosage less than 200 grams per ton of feed. This subtherapeutic dosage stabilizes the bacterial community, allowing the bird to utilize greater quantities of nutrients from its food and boosting animal output [2]. Antibiotics can thicken the gut, leading to improved food absorption. Thus, by reducing host-pathogen rivalry and minimizing microbial adherence and penetration of the gut wall, it can protect the host's essential nutrients. It also decreases the production of toxic amines, preventing stress in birds [3]. Antibiotics vary in their chemical, physical, and pharmacological characteristics, in addition to their antibacterial spectrum and mode of action. Bacteriocidal activities include preventing the activity of (1) the production of proteins, (2) cell wall creation, (3) DNA wrapping, (4) the production of DNA, or (5) plasma membrane development [4].

ABR is described as a microorganism's ability to live and reproduce in the presence of antimicrobial agents [5]. Because it restricts the treatment of bacterial illnesses and raises the possibility of mortality and morbidity from resistant bacteria, ABR continues to pose a serious threat to the health of both humans and animals. A significant concern for both human and veterinary health is ensuring that antimicrobials are effective in treating infections caused by bacteria [6]. Although it is believed that the widespread administration of medicines in animals bred for food is an essential component of resistance to antibiotics in humans, the specific impacts on the health of people are not fully understood. People may contract resistant bacteria by indirect environmental exposure, interaction with other foods, or ingestion of raw or undercooked food. In Quebec, a Canadian province, the application of ceftiofur in chickens was connected to human-resistant illnesses, suggesting that touching raw meat was the mode of transmission. Transmission straight from livestock to farm workers has also been a source of concern. ABR poses a threat to human, animal, and environmental health worldwide. According to Rahman and Hollis (2023), ABR necessitates a coordinated, interdisciplinary, and multisectoral strategy to address health issues at the human-animal-environment interaction that fall within the One Health concept [7].

Use of antibiotics in poultry systems

Poultry flocks are frequently raised in intensive circumstances with high concentrations of antibiotics to promote growth and prevent and treat disease [8]. The majority of traditional broiler feeds are made from grains and are usually prepared according to the stages of growth (the starter, the grower, and the finisher). Antibiotics are supplemented with vitamins, minerals, and protein for nutritional reasons. The primary antibiotics found in chicken feed are aminoglycosides (gentamicin, neomycin, spectinomycin, and streptomycin), tetracyclines, sulfonamides, and β-lactams (penicillin and amoxicillin) [9].

Mechanism of ABR in poultry

There are various ways that bacterial populations become resistant to antibiotics. The environment, cell physiology, bacterial biology, and population dynamics all influence how quickly a single gene mutates to produce an antibiotic resistance phenotype. Furthermore, because the antimicrobial targets are genetically diverse, mutations in a large number of genes are required for full resistance to appear. The target genes for fluoroquinolones are parA, parC, gyrA, and gyrB; they are the primary examples of that; they all serve as targets of the antibiotic fluoroquinolone and all need mutations to develop phenotypes of total resistance [10]. Antimicrobial resistance genes can also be acquired by bacteria via lateral or horizontal gene transfer. Bacteria engage in horizontal gene transfer events through transposons, which are genetic elements that confer a selected phenotype flanked by two insertion sequences. What makes transposons special is that they possess the capacity to relocate from one genetic locus to another, whether they are found in the same bacteria or in bacteria belonging to different taxa [11]. Conjugation, transformation, and transduction are the three processes that can all be used to transfer transposons. Because transposons frequently contain integron gene sequences, which mediate antibiotic resistance, they are important in the development of antimicrobial resistance. It is believed that integrons are crucial to the quick spread of antibiotic resistance in bacteria [12].

Pasteurella multocida, Gallibacterium anatis, Salmonella Pullorum/Gallinarum, E. Coli, and Klebsiella species are the poultry pathogens that have acquired ABR. Because of the intricacy of their cell surface, Gram-negative bacteria are naturally resistant to a variety of medications. Gram-negative bacteria can be effectively combated by antibiotics such as cephalosporins, carbapenems, and fluoroquinolones; nevertheless, there have been reports of gram-negative bacteria that are resistant to these drugs. Gram-negative bacteria can develop innate or acquired resistance [13].

Gram-positive bacteria that can be either helpful or harmful, such as enteric bacteria organisms, *Staphylococcus* organisms, and *C. perfringens,* are commonly found in poultry. According to a public meta-analysis, the most frequently utilised antibiotics among humans over the previous 30 years have mostly been used to treat Gram-positive bacteria. These bacteria compensate for the lack of an outer membrane by having a more dense (30–100 nanometres) peptidoglycan cell wall. Major ABR Gram-positive bacteria of concern *include vancomycin-resistant E. faecium (VRE), MDR Streptococcus pneumoniae, vancomycin-resistant Staphylococcus aureus (VRSA), and methicillin-resistant S. aureus (MRSA).* Several gram-positive pathogens resistant to multiple drugs have been found in the traditional, naturally produced, and ABF poultry industries. [13].

The relation between poultry production systems and ABR

Many studies have looked into AMU in food animals and how it affects ABR in foodborne bacteria. The impacts of standard and different methods of production on ABR are examined here in order to allay worries regarding the transition from traditional to ABF or natural production and the ensuing impact on ABR in poultry and their products [9]. It is commonly known that conventional production has an effect on ABR; however, it is less clear how

natural or ABF production affects ABR. ABR investigations in ABF and natural systems are scarce.

Challenges and future perspectives

As the post-antibiotic era approaches, this becomes even more concerning because there aren't many new antimicrobials being developed, and even fewer have been licensed for use. Additionally, there are few possibilities and funds for research, particularly in poor nations like Kenya, and thus, a large portion of Africa, where opposition seems to be widespread; so, international cooperation and coordination are required [14].

Therefore, in order to lessen the over-reliance on antimicrobial medicines, alternative treatments for poultry diseases must be used. At every stage of the production of poultry, rational antimicrobial treatment should be encouraged. Alternative therapies like phage therapy could be taken into account. To improve the overall health and well-being of poultry, attention must also be directed towards the use of probiotics and/or prebiotics in poultry farming. This will lessen the need for antimicrobial medications to cure illnesses or stimulate development [15].

Probiotics are live microbial feed additives that support the host's health by preserving gut microbial equilibrium. Several Streptococcus thermophilus, Lactobacillus species, Bacillus subtilis, and Enterococcus faecium, along with E. faecalis in the poultry sector, were among the commonly used probiotics reviewed by Khan and Naz. They work by using competitive exclusion to prevent harmful bacteria from colonizing the gut. Furthermore, numerous studies linking probiotic administration to increased humoral and cellular immune responses have demonstrated that Probiotics strengthen the immune system by increasing the production of anti-inflammatory cytokines, T cells, CD+, and B cells. Prebiotics are carbohydrate-based polymers, including mannanoligosaccharides (MOS), galactooligosaccharides, and fructooligosaccharides (FOS), which help the gut's good bacteria, facilitate digestion, and prevent harmful bacteria from colonising the area [13].

Conclusion

The market and consumer demand are driving the poultry industry's rapid growth. However, because of ABR concerns, it is essential to implement alternate poultry production methods to enhance bird performance and health while lowering the ABU. Even though there are links between ABU and ABR, various environmental and genetic factors may have a role in the frequency and dissemination of ABR in chicken production systems. Many vaccinations and antibiotic substitutes are currently being used in ABF and organic poultry production. The cost-effective advantages of the majority of antibiotic substitutes for poultry have not yet been determined. These substitute compounds appear to exhibit pleotropic effects, including antioxidant, antimicrobial, immune-stimulatory, and anti-inflammatory qualities, but further investigation is required to determine their mode of attack towards bacterial cells, especially their ABR profiles, as well as birds. Overall, this analysis shows that although ABR was found in antibacterial-free chicken production systems, its prevalence was much lower than that of conventional poultry. However, further research is required to examine ABR in the production of organic and ABF poultry. Additionally, knowing how feeding programs affect pathogenic bacteria, commensal gut microbiota, and ABR can assist in direct dietary and bird health management strategies. In order to stop the establishment and spread of ABR in poultry, intensive efforts utilising integrated One Health techniques are necessary.

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