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Antimicrobial Resistance in Livestock: A One Health Review

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ABSTRACT

Antimicrobial resistance (AMR) in livestock is a global health concern in the modern era. AMR in food-producing animals poses a threat to human health and the resilience of food systems. Antibiotic use in livestock is on the rise worldwide, particularly in low- and middle-income nations. Large-scale use of antibiotics in livestock animals leads to the selection of resistant bacteria and resistance genes, which spread through the environment, food, and direct contact. Human resistant infections are also linked to the use of antibiotics on farms. This complicated problem, which affects the health of people, animals, and the environment, is known as a "one health issue." The burden and causes of animal AMR, the main routes of transmission, the effects on human health and the food chain, and intervention techniques that include environmental controls, biosecurity, and diagnostics are all covered in this review.

Keywords: Antimicrobial resistance, livestock, one health

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Introduction

With an estimated 4.95 million deaths (1.27 million attributable) in 2019, AMR is already a major threat to global health [1]. One of the biggest global consumers of antibiotics is the production of food animals. According to global modeling, the amount of antibiotics used in food animals was estimated at 63,151 tons in 2010 and expected to rise by 67% by 2030 due to intensification of swine and poultry production in emerging economies [2]. Updated analyses continue to identify geographical "hotspots" of antimicrobial use (AMU) that correspond with rapidly increasing production [3].

How Antimicrobial Use Selects for Resistance in Livestock

Selection pressure from routine and metaphylactic use promotes resistance across commensal and enteric flora [4]. Modeled AMU intensities (mg/kg) in pigs and poultry are higher than in cattle, potentially leading to the emergence of resistance [2].

The plasmid-mediated colistin resistance gene mcr-1, discovered in 2015 in *E. Coli* from pigs, retail meat, and humans in China, serves as a sentinel example illustrating mobility of last-resort resistance and rapid global spread [5].

Animal-to-Human Transmission Pathways

a) The Food Chain

Contamination during slaughter and processing enables transmission of resistant pathogens and genes to consumers. Policy evidence supports that the 2005 U.S. withdrawal of enrofloxacin in poultry reduced fluoroquinolone-resistant Campylobacter, demonstrating the link between poultry AMU and human infections [6].

b) Direct Contact at Work

Livestock-associated MRSA (LA-MRSA), particularly clonal complex CC398, colonizes people with high animal contact. Genomic studies show a human-to-animal host jump, acquisition of tetracycline/methicillin resistance in livestock, and spillback to humans [7].

c) The Environment (Soil, Water, Manure)

Manure management spreads antibiotics, resistant bacteria, and antibiotic resistance genes (ARGs) across agro-ecosystems. Manure-amended soils consistently appear as ARG hotspots [8], while metagenomic studies of Chinese swine farms report diverse and abundant ARGs across manure and amended soils [9].

Evidence Linking Human AMR Outcomes to Animal AMU

Campylobacter and Fluoroquinolones

Both observational and natural-experiment evidence link poultry fluoroquinolone use to human fluoroquinolone-resistant Campylobacter infections; resistance persisted even after restrictions, showing its entrenchment once established [6,10].

LA-MRSA CC398

Epidemiology and genomics document animal-to-human transmission dynamics and elevated colonization risk among swine and veal-calf workers [7,11].

Colistin and mcr-1

Mobile colistin resistance demonstrates how agricultural practices can compromise last-resort human therapies. Emergence occurred simultaneously in animals, food, and patients [5,12].

Implications for Food Systems and Food Security

Animal AMR destabilizes protein supplies, increases treatment costs, and threatens productivity via mortality, morbidity, and reduced feed conversion [13]. Intensification without parallel improvements in husbandry and vaccination increases infection pressure and antibiotic dependence [3]. Projections through 2030 emphasize separating productivity from routine antibiotic inputs [2].

Evidence-Based Interventions

a) Stewardship for Medically Important Drugs

Limiting group treatments to evidence-based indications and avoiding prophylactic use of critically important antimicrobials (fluoroquinolones, polymyxins) are key strategies. Natural experiments on fluoroquinolone withdrawal in poultry demonstrate public health benefits, reinforcing early action [6,10].

b) Biosecurity, Vaccination, and Husbandry

Improved biosecurity and herd management reduce disease pressure and AMU in swine and poultry. Systematic reviews confirm that hygiene and biosecurity measures reduce microbial loads and antimicrobial use [14].

c) Targeted Therapy and Diagnostics

Although farm-level RCTs remain limited, rapid diagnostics and culture-guided treatment shorten duration and narrow spectra, reducing selection pressure [15].

d) Environmental Controls for Effluents and Manure

Composting and anaerobic digestion can reduce antibiotic residues, ARGs, and ARB compared to lagoon storage, though field-scale consistency varies [8].

Conclusion

Extensive antibiotic use in livestock selects resistant bacteria and genes that spread to humans through food, environment, and direct contact, as demonstrated by peer-reviewed evidence. Sentinel events such as mcr-1 emergence and LA-MRSA CC398 show how agricultural practices can undermine last-resort therapies and alter pathogen ecology. Effective mitigation requires decisive stewardship, improved husbandry and vaccination, diagnostics, and improved management of manure and wastewater—implemented early enough to prevent resistant strains from becoming entrenched.

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