The impact of veterinary antimicrobial usage on human health

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1. Introduction

Antimicrobial resistance (AMR) is not only a threat to public health but also a complex, ancient, and naturally occurring phenomenon driven by the presence of antibiotic-producing microorganisms in the environment. While the selection and spread of resistant bacteria are exacerbated by any sort of antimicrobial use (AMU) and environmental contamination with antimicrobial residues, AMR exists independently of modern antibiotic practices. Nonetheless, food-producing animals account for most global antimicrobial use (AMU), including for prophylactic and growth-promoting purposes. This widespread use creates selective pressure that poses potential risks to human health. Specifically, antimicrobial-resistant bacteria and genes can be transmitted from farms to community and clinical settings through the food chain or direct contact with animals, potentially contributing to treatment failures, increased mortality, and higher healthcare costs.

AMR poses a dual threat via the food chain: the direct transmission of resistant pathogens and the indirect spread of resistance genes. However, quantifying the contribution of veterinary AMU to AMR in human infections remains highly challenging due to complex ecological interactions, geographical variations, and evolving usage and AMR patterns. This complexity is further compounded by co-selection - a phenomenon in which AMR genes are maintained or amplified through exposure to chemically unrelated antimicrobials or non-antibiotic substances, such as heavy metals - making risk management even more challenging than risk assessment.

This presentation reviews evidence of veterinary AMU's impact on human health, with a focus on AMU in food animals and foodborne transmission of AMR, including both zoonotic and opportunistic pathogens. AMU in companion animals and AMR transmission at the household level are covered in another lecture at this conference.

2. Evidence for the impact of veterinary AMU on human health

Once antimicrobial resistance (AMR) emerges in an animal reservoir, it can impact human health through two primary pathways: direct transmission of zoonotic pathogens and horizontal transfer of resistance genes via commensal bacteria.

1.1 Direct infection by zoonotic pathogens

There is strong evidence linking veterinary AMU to AMR in zoonotic pathogens such as *Campylobacter* and *Salmonella*. For instance, the use of fluoroquinolones in poultry has been closely associated with the emergence of ciprofloxacin-resistant *Campylobacter jejuni*, a major foodborne pathogen. Both field and experimental studies have shown that treatment with enrofloxacin selects for resistant *C. jejuni* within the intestinal microbiota of

poultry, which usually mirrors high rates ciprofloxacin resistance in human clinical isolates. Although this resistance is clearly linked to antimicrobial use in animals and foodborne transmission is relatively common, its impact on human health is limited, as most foodborne infections are self-limiting and rarely require antimicrobial treatment.

Similar evidence exists for livestock-associated methicillin-resistant *Staphylococcus aureus* (LA-MRSA), which also has a well-documented animal origin. However, its impact on public health remains relatively limited, primarily affecting regions with intensive livestock production and low background prevalence of MRSA in the human population [1]. Another potential contributor to this pathway of AMR transmission is uropathogenic *Escherichia coli* (UPEC). Growing evidence suggests that a subset of clinical *E. coli* isolates causing urinary tract infections in humans, particularly extensively multidrug-resistant ST131 strains that carry allele 30 of the *fimH* type 1 fimbrial adhesin gene, may originate from animal reservoirs, indicating a possible zoonotic link [2].

2.2 Horizontal gene transfer via commensal bacteria of animal origin

In contrast, evidence linking veterinary AMU to AMR in commensal opportunistic pathogens via horizontal gene transfer is less consistent and often contradictory. Experimental data have shown that small amounts of exogenous *E. coli* of poultry origin can readily transfer plasmids to the human fecal microbiota, provided that the exogenous strain is able to survive the transit through the gastric environment [3]. Despite the high prevalence of ESBL-producing *E. coli* in animals and their potential for gene transfer via conjugative plasmids, large-scale epidemiological studies have found limited overlap between human and animal ESBL genotypes. For instance, a Dutch meta-analysis of >27,000 samples across 35 studies found no strong epidemiological connection between livestock farms and the general population [4]. Another Dutch study estimated that only 19% of community ESBL colonization could be attributed to food consumption, while 60% originated from human-to-human transmission [5]. Several recent studies conclude that only a limited proportion of human infections caused by ESBL-producing *E. coli* are attributable to food. Among food sources, seafood appears to be a notable reservoir of ESBL types of high clinical relevance, such as CTX-M-15 [6]. However, the origin of these bacteria in seafood remains unclear and is not necessarily linked to veterinary AMU but may result from human faecal contamination of water in the aquaculture environment (pre-harvest) or during processing (post-harvest).

It is important to note that much of the evidence supporting limited foodborne transmission of ESBL-producing bacteria comes from EU countries and may not be generalizable to other regions or all types of AMR. For example, in China, the use of colistin—a critically important antimicrobial—as a growth promoter in livestock led to the emergence and rapid spread of mcr-1-mediated colistin resistance in *E. coli*. Following a national ban on colistin use in animal production in 2017, the prevalence of colistin-resistant *E. coli* declined significantly in both animals and humans. This provides strong evidence of a direct link between veterinary colistin use and resistance in human infections and highlights the effectiveness of targeted policy interventions [7]. Another association between AMU in animals and AMR in humans has been recently observed for aminopenicillins in *E. coli* in Europe. According to a recent EU report [8], aminopenicillin use in livestock correlates with resistance not only in animal *E. coli* commensal isolates but also in human invasive infections. Although not classified as critically important, aminopenicillins are widely used in primary care, and resistance can impact many patients, posing a notable public health concern.

3. Conclusion

While there is strong evidence linking AMU in food animals to the emergence of AMR in foodborne pathogens isolated from human infections, the impact of indirect transmission via horizontal gene transfer appears more limited than previously thought and varies by region, depending on local AMU practices. Nonetheless, even if only a small fraction of human deaths is attributable to veterinary AMU, a precautionary approach is justified. Mitigation efforts, including national and international regulations, are essential to curb the global spread of AMR via food exports. In this context, the European Commission has recently enacted a regulation banning the use of certain antimicrobials, including growth promoters, in animals or animal products destined for the EU [9]. This rule will apply to all third-country exporters from September 2026 and is expected to significantly influence global veterinary AMU practices.

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