

Antimicrobial resistance in animal-origin foods: One Health context

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Abstract

Antimicrobial resistance (AMR) is a growing global threat to human, animal, and environmental health. The food chain is a major source and pathway for resistant microorganisms and their genes. The use of antimicrobials in livestock production for treatment, prevention, and growth promotion encourages the growth of resistant bacteria. These bacteria can persist during the slaughter, processing, and handling of animal products, such as meat, milk, and dairy products. Major resistant pathogens, including *Escherichia coli*, *Salmonella* spp., *Campylobacter* spp., *Brucella* spp., *Mycobacteria* spp., *Shigella* spp., *Staphylococcus aureus*, and *Listeria monocytogenes*, pose significant public health risks to humans. They can transfer resistance genes to the commensal or pathogens and the pathogens may cause infections difficult to treat. Global and national programs are working to track resistance trends. The impact of AMR on public health, economy, and trade is significant. Prevention and control efforts focus on the careful use of antimicrobials, better hygiene, vaccination, alternatives to antibiotics, stewardship programs, and coordinated global monitoring through the One Health approach. Strengthening international cooperation on AMR monitoring in food chains is essential to reduce the spread of resistant pathogens and maintain the effectiveness of antimicrobials for future generations.

Keywords: Antimicrobial resistance, Food chain, Meat, Milk, One Health

Highlights

- Even after processing treatments like pasteurization, meat, milk, and dairy products remain important sources of antimicrobial-resistant bacteria and resistance genes.
- AMR transmission risks to consumers are greatly increased by biofilm formation, poor hygiene, and cross-contamination in slaughterhouses.
- The persistence and horizontal gene transfer of resistance determinants are facilitated by environmental reservoirs, including soil, water, manure, and aquaculture systems.
- Strengthening the surveillance, stewardship, and One Health-based interventions is essential to reduce AMR burden in animal-origin food.

INTRODUCTION

Given the significant threat posed by antimicrobial resistance (AMR) to global health, it is crucial to understand its origins, particularly in agriculture, where the use of antimicrobials may generate antimicrobial resistant bacterial strains. Since resistant strains do not consider geographical borders or species barriers, AMR is seen as a true One Health issue that deeply affects human, animal, plant and environmental health (Manyi-Loh et al., 2018). It weakens disease treatment, harms animal welfare, and threatens the livelihoods of people who rely on livestock and animal products for their livelihood. The food chain is a dynamic reservoir of antimicrobial resistance. It includes foodborne pathogens, commensals, and the wider microbiome, which together create a resistome that can hold and share resistance genes (Samtiya

et al., 2022). Additionally, the mixing of microbes across animals, humans, and the environment increases the chances of gene transfer, making the food chain a key area for the rise and spread of AMR (Van Boeckel et al., 2015). Foods, even those deemed microbiologically safe, can harbour bacteria, bacteriophages, mobile genetic elements, and resistance genes. This creates a “pool” of antimicrobial resistance determinants. Research has shown that raw foods specially from animal origin, generated from a low-biosecurity farm and handled under poor hygiene conditions, often contain multidrug-resistant bacteria. This highlights the food chain as a crucial factor in the emergence and spread of AMR (Karumathil et al., 2016). Key foodborne pathogens like *Salmonella*, *Escherichia coli*, *Campylobacter*, *Staphylococcus* spp., *Enterococcus* spp., and ESBL-producing

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Gram-negative bacteria are recognized as major contributors to antimicrobial resistance. Their importance lies in the strong connection between antimicrobial use in livestock production and the presence of resistant strains that can cause disease in humans (Bandyopadhyay & Samanta, 2020). International trade in animal-derived foods also promotes the spread of resistant organisms across borders. A noted example is *Salmonella typhimurium* DT104, which first appeared in the United Kingdom as a multidrug-resistant strain, quickly spread worldwide, and later developed resistance to key drugs, such as fluoroquinolones and cephalosporins (Leekitcharoenphon et al., 2016). Food processing can affect the risk of antimicrobial resistance transmission in humans. Treatments such as heat, pasteurization, freezing, and acidification usually lower bacterial counts and the risk of AMR gene transfer. Moreover, microorganisms intentionally added to foods, such as starter cultures and probiotics, can also carry resistance genes. This underscores the need for monitoring to evaluate potential public health risks in the future. Antimicrobial resistance has been found in both domestic and wild animal meat products, indicating that resistance is influenced not only by antimicrobial use but also by environmental pressure. According to a recent longitudinal study, bacterial populations in a meat processing factory can survive for months and develop biofilms on both food-contact and non-food-contact surfaces. These enduring colonies are a constant source of microbiological contamination that can infect meat products (Xu et al., 2025). This highlights the necessity of good manufacturing and hygiene practices.

Sources of antimicrobial resistant bacteria in food chain

The growing demand for meat and milk has led to rapid intensification of livestock and poultry farming worldwide, where antibiotics are extensively used not only for therapeutic purposes but also to enhance productivity and maintain animal welfare (Islam et al., 2024). In many developing countries, antibiotics are routinely administered as preventive measures to control disease outbreaks to compensate poor biosecurity, inadequate nutrition, and limited vaccination coverage as evidenced in smallholder farms in West Bengal (Arnold et al., 2021; Hennessey et al., 2025). Although antimicrobial use in livestock is a major driver of antimicrobial resistance (AMR), its exact contribution to resistance patterns in humans remains complex and not yet fully quantified (Samanta

& Bandyopadhyay, 2019).

However, the extensive use of antimicrobials in intensive farming creates selective pressure that promotes the emergence of resistant bacterial strains that can enter the food chain and cause human diseases. Slaughterhouses and meat processing facilities are significant entry points for antimicrobial-resistant (AMR) bacteria in the food chain. This largely occurs through cross-contamination and not through direct animal carriage. During slaughter, critical processes such as scalding, de-feathering, and evisceration in poultry, along with poor inspection and contaminated equipment in pig and cattle processing, allow bacteria from the gut and environment to contaminate carcasses (Wu et al., 2022). Recent farm-level studies from India demonstrated that 41% of livestock and 54% of poultry harboured ESBL-producing *E. coli* with widespread multidrug resistance and mobile resistance genes, underscoring the serious One Health concerns that come from animal agricultural settings (Malik et al., 2025).

It is also vital to consider milk and dairy products as another crucial pathway, emphasizing the diverse vectors through which resistant bacteria can infiltrate into the food chain. Milk serves as a rich medium for bacteria such as *Staphylococcus aureus*, *Streptococcus* spp., and *Escherichia coli*. The misuse of antimicrobials on dairy farms leads to the development of plasmid-mediated resistance genes in commensals carried by the milk, increasing the likelihood of horizontal gene transfer (Cheng et al., 2019). While pasteurization and ultra-heat treatment reduce commensal or pathogenic bacterial loads, resistance genes can still persist in processed milk, making milk handling a key control point in managing AMR (James et al., 2021).

Food contamination poses a serious public health threat, causing an estimated 600 million illnesses and 420,000 deaths annually worldwide, with roughly 1 in 10 diarrheal cases linked to contaminated food (Fung et al., 2018). Several studies from developing countries, including raw meat samples in Poland (Rybak et al., 2022) and raw milk samples in India, have reported the presence of antimicrobial-resistant bacteria and foodborne pathogens (Batabyal et al., 2018). High levels of contamination in milk and meat are often associated with poor hygiene, unpasteurized products, inadequate storage and cooling, and unsanitary equipment (Kakati et al., 2021). Close contact with animals, contaminated food, and the environment further facilitates the transmission of zoonotic bacteria, while antimicrobial use in humans

and animals, together with environmental resistance reservoirs, drives the selection and spread of antimicrobial resistance (Samanta & Bandopadhyay, 2022).

One of the main AMR reservoirs and transmission routes is the environment. Through aquaculture waste, agricultural runoff, and inappropriate pharmaceutical disposal, antibiotics and their residues find their way into soil, water, and food systems, where they exert selective pressure in favour of resistant strains (Khan, 2023). Humans can be exposed to resistant bacteria and antibiotic resistance genes (ARGs) through aquaculture products, contaminated water, and crops fertilised with manure (Koutsoumanis et al., 2021). The application of manure and sewage sludge containing antibiotics and resistant bacteria enriches agricultural soils with ARGs, which can persist over time and spread to microorganisms linked with plants or humans (Zalewska et al., 2021). Antibiotics from hospital waste, agricultural runoff, and waste water discharge are also accumulated by aquatic ecosystems, such as rivers, lakes, and coastal waters, which encourages the growth of resistant strains (Nguyen & Huynh, 2023; Shigei et al., 2021). Because residues and ARGs cannot be completely eliminated by wastewater treatment, they persist in moving across interconnected ecosystems (Reddy et al., 2022). Earlier studies showed that livestock farm environment carried the ESBL-producing bacteria in absence of direct antibiotic usage (Samanta et al., 2018).

Aquaculture exacerbates this issue, as antibiotics such as tetracyclines, aminoglycosides, macrolides, oxytetracycline, and florfenicol are often used for disease prevention and treatment (Avendaño Herrera et al., 2022). Antibiotic residues accumulate in sediments and water, supporting resistant bacterial populations and aiding the transfer of ARGs to human pathogens through seafood or contaminated water (Yu et al., 2021). Sustainable aquaculture practices, including vaccination, probiotics, and better management, are vital for reducing antibiotic use and slowing the spread of AMR (World Health Organization [WHO], 2021). The use of lower levels of antimicrobials in livestock and aquaculture leads to the selection and persistence of resistant bacteria that can transfer ARGs through gene transfer (Von Wintersdorff et al., 2016).

Humans can acquire these bacteria through contaminated food, water, or direct contact with animals (Gomes et al., 2023). Additionally, antimicrobial residues in animal feed, aquaculture systems, and crops lead to environmental

contamination, encouraging the spread of AMR along the food chain (Gomes et al., 2023). Food handling and processing are also essential for spreading AMR. Poor hygiene and cross-contamination by food handlers can transfer resistant bacteria to ready-to-eat foods (Samtiya et al., 2022). Although preservation methods such as pasteurization, heat treatment, high-pressure processing, and ionizing radiation can kill bacteria, some AMR strains may survive or release resistance genes into the environment (Samtiya et al., 2022). Surviving AMR bacteria retain their resistance traits. Although direct evidence of gene transfer from heat-treated foods is limited (James et al., 2021), this possibility highlights the urgent need for strict hygiene and safety measures during food processing and handling.

Major resistant bacteria in animal food products

Meat and meat products often contain mesophilic and psychrotrophic bacteria. Many of these bacteria can be transmitted to humans through food (Nespolo, 2021). Animal-based foods, including meat, milk, and dairy products, are significant sources of zoonotic pathogens that can infect humans. Several of these pathogens have developed antibiotic resistance. These resistant bacteria pose serious risks to public health and food safety because they can persist in the food chain and cause infections that are difficult to treat. The key resistant bacteria found in animal-derived foods include *Escherichia coli*, *Salmonella* spp., *Campylobacter* spp., *Shigella* spp., *Listeria monocytogenes*, *Yersinia enterocolitica*, *Brucella abortus*, and *Mycobacterium bovis*.

***Escherichia coli*:** *Escherichia coli* is a gram-negative, rod-shaped bacterium that is part of the normal gut flora in humans and animals (Tuo et al., 2020). Resistant bacteria and genes, such as ESBL-producing *E. coli*, can enter the human food chain through animals, contaminated water, food reservoirs, and environmental elements, creating a complex network of transmission pathways between humans, animals, and the environment (Sharmila et al., 2024) (Table 1). This pathogen can survive in intermediate environments, such as the food matrix and natural settings, which improves its longevity and adaptability (Vidovic & Korber, 2016).

***Salmonella* spp.:** *Salmonella* spp. are gram-negative, rod-shaped, non-spore-forming bacteria that include *S. enterica* and *S. bongori*. The most dangerous serotypes belong to *S. enterica* (Guerrini et al., 2021).

Table 1. Major foodborne pathogens associated with AMR – characteristics, reservoirs and recent AMR trends

Pathogen	Key Characteristics	Major Reservoirs	Recent AMR Trends	Key References
<i>Escherichia coli</i>	Gram-negative rod; commensal and pathogenic	Animals, contaminated waters, food, environment, raw meat, milk	Enterobacteriaceae from food and livestock have a pooled ESBL prevalence of approximately 20% (high variability). Plasmid-mediated qnr/tet/sul genes and an increase in CTX-M ESBLs have been extensively documented in pigs and poultry.	Rahaman et al., 2025; Que et al., 2025; Lemlem et al., 2024.
<i>Salmonella</i> spp.	Gram-negative, non-spore forming; many serotypes, biofilm production	Food Animals, humans, environment, eggs	Reported resistance rates to fluoroquinolones & 3rd-gen cephalosporins in food isolates vary by region (recent reports 7–16% for key drug classes in some studies). Rising MDR clones (Typhimurium DT/monophasic variants) remain a concern.	Barrientos-Villegas et al., 2025; Niu et al., 2025
<i>Campylobacter</i> spp.	Gram-negative; low infectious dose	Food animals, humans, contaminated water, raw milk, poultry (Main Reservoir)	Meta-analysis (India, 2025) found 40-60% resistance to ciprofloxacin & cefotaxime in chicken meat isolates.	Ayoub et al., 2025
<i>Shigella</i> spp.	Gram-negative, non motile	Humans, non-human primates, contaminated water and food	Rapid emergence of XDR <i>Shigella</i> (resistant to ciprofloxacin, azithromycin and 3rd-gen cephalosporins) reported since ~2015 and expanding 2019-2024	Lefèvre et al., 2023
<i>Listeria</i> <i>Monocytogenes</i>	Gram positive bacillus; Psychrotrophic	Soil, water, animals, food processing environment, meat, dairy	Persistent biofilms on processing equipment; increasing reports of disinfectant tolerance and occasional detection of resistance determinants (tetracycline/macrolide genes) in isolates from food chains	Silva et al., 2024; Sutton et al., 2025
<i>Yersinia enterocolitica</i>	Gram negative coccobacillus	Swine, pork, environment, contaminated water, milk	Generally susceptible to many drugs but intrinsic resistance to aminopenicillins is common; sporadic reports of β -lactam/tetracycline resistance and regionally variable MDR	Seakamela et al., 2022; Koskinen et al., 2022
<i>Brucella</i> spp.	Gram negative coccobacilli; intracellular	Raw milk, unpasteurized dairy, livestock	Overall low frequency of antimicrobial resistance but small increases in tetracycline/ other resistances reported in	Shahrabi et al., 2023

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Pathogen	Key Characteristics	Major Reservoirs	Recent AMR Trends	Key References
<i>Mycobacterium bovis</i>	Acid-fast bacillus	Cattle and buffalo, meat, unpasteurized milk	some surveillance studies; careful monitoring required due to intracellular niche. Multidrug-resistant <i>M. bovis</i> strains have been reported regionally; MDR/Mac resistance documented in several studies - important One Health concern though population-level prevalence data are sparse.	Borham et al., 2022; Vazquez-Chacon et al., 2015

These pathogens can also have various virulence factors and the ability to form biofilms, which makes them among the most hazardous foodborne pathogens affecting humans (Mondal et al., 2024) (Table 1). They are among the leading causes of foodborne illnesses worldwide (Abd El-Aziz et al., 2021).

Campylobacter spp.: *Campylobacter jejuni* and *C. coli* are the leading causes of Campylobacteriosis, with poultry as the main reservoir (Table 1). A very low dose (500–800 cells) can cause an infection, often linked to undercooked meat and unpasteurized milk (Royden et al., 2021). Increasing resistance to fluoroquinolones and macrolides limits the treatment options (Chen et al., 2021).

Shigella spp.: *Shigella* is spread through the feco-oral route and food contamination, causing bacillary dysentery (Lee et al., 2020). Widespread multidrug resistance, especially to fluoroquinolones, cephalosporins, and ampicillin, has been reported (Yang et al., 2015).

Listeria monocytogenes: This pathogen thrives at refrigeration temperatures. It is often associated with ready-to-eat meat, seafood, and dairy products (Kayode et al., 2021; Ranasinghe et al., 2021).

Yersinia enterocolitica: Yersiniosis, which is usually mild, typically originates from contaminated meat, milk, and water (Table 1). It can be severe in immunocompromised individuals (Karlsson et al., 2021). Resistant strains that show resistance to β -lactam and tetracycline have emerged (Shoaib et al., 2019).

Brucella spp.: *B. abortus*, *B. suis*, and *B. melitensis* infect humans through raw milk and direct contact with

animals (Ali et al., 2018; Yawoz et al., 2021). Treatment is challenging because of their ability to persist inside cells, and there is growing concern about resistance to rifampicin and tetracyclines (Schaeffer et al., 2021).

Mycobacterium bovis: *M. bovis* causes bovine tuberculosis and spreads through contaminated milk and meat (Jabeen et al., 2021). Multidrug-resistant strains resistant to isoniazid and rifampicin present a major One Health challenge (Duffy et al., 2020).

Molecular studies have shown that transferable resistance genes, such as tet(A) (tetracycline resistance), qnrB and qnrS (quinolone resistance), and blaTEM (β -lactam resistance), are found in *Escherichia coli*, *Salmonella*, and *Staphylococcus aureus*. These genes are often carried on mobile genetic elements, allowing for the rapid transfer and spread of resistance throughout the food chain (Kagambèga et al., 2023). The widespread presence of multidrug-resistant bacteria in fresh meat highlights a significant food safety challenge, especially in areas with limited diagnostic resources and high misuse of antibiotics in livestock rearing. Improved AMR surveillance, careful antibiotic use in animals, and strict hygiene practices during meat production and processing are essential for reducing transmission to humans.

AMR's wider One Health impact is highlighted by the fact that multidrug-resistant bacteria in animal-derived foods present significant public health risks due to their ability to persist along the food chain and cause difficult-to-treat infections, gene transfer, and gut colonisation.

Public health implications of AMR in food products

Antimicrobial resistance (AMR) in foodborne pathogens is a significant global public health concern. While earlier data (2019) showed that 26% of

160 reporting countries used antibiotics for growth promotion, more recent analysis (2025) indicates that about 22% of countries still permit growth-promoting antibiotic use, suggesting both a slow decline and the continued prevalence of the practice worldwide (Centers for Disease Control and Prevention [CDC], 2019; World Organisation for Animal Health [WOAH], 2025). The CDC estimates that 2.8 million people in the U.S. are infected with AMR bacteria annually (CDC, 2019). Globally the burden is even more substantial. Approximately 4.95 million of the 7.7 million bacterial infection-related deaths that occur worldwide each year are linked to drug-resistant organisms, and 1.27 million are directly related to resistance (Okeke et al., 2024). Contaminated food is a major route of exposure to these pathogens. The WHO estimates that there are 420,000 annual deaths worldwide from foodborne diseases. Diarrheal illnesses are the second leading cause of death among children under five years of age, with 40% linked to unsafe food (Savelli et al., 2019). In the U.S., foodborne infections affect 48 million people annually, causing 128,000 hospitalizations and 3,000 deaths. If not managed, AMR could result in 10 million deaths per year by 2050, which is one death every three seconds (WHO, 2015).

In livestock, AMR could cost USD 2.5 billion per year by 2030 (European Centre for Disease Prevention and Control [ECDC], 2017). AMR infections can lead to treatment failures, longer illnesses, and higher death rates. They also reduce the number of effective antibiotics and weaken infection control efforts (CDC, 2023). These findings highlight AMR as a One Health crisis. It calls for global cooperation, careful antibiotic use in food animals, and improved surveillance to protect human health. The use of antimicrobials in both human medicine and food animal production creates selective pressure, promoting the emergence and spread of antimicrobial-resistant bacteria (ARB) and antimicrobial resistance genes (ARGs) throughout the food supply chain (Kenyon, 2021). AMR spreads through two main routes: (1) the transmission of resistant bacteria, and (2) the horizontal gene transfer (HGT) of resistance genes among microbial populations (Antunes et al., 2020). Humans can be exposed to ARB and ARGs at various stages—from farms and slaughterhouses to processing facilities, manufacturing plants, and retail foods. Studies show similarities between ARB found in food animals and those in humans who handle them, suggesting cross-species transmission within the food chain (Collineau et al., 2019). This suggests that the food chain is an important exchange point for resistant

microorganisms and their genetic material between animal and human populations. For foodborne AMR to affect public health, several conditions must be met: resistant bacteria or genes must be present and survive food preparation or cooking. They then need to colonize or infect the consumer or transfer resistance genes to human pathogens or gut bacteria (Antunes et al., 2020). When such infections do not respond to antimicrobial treatment, they pose a direct risk to human health. While the presence of resistant microbes and ARGs in food products is well-documented, there is still uncertainty about their overall contribution to the AMR burden in humans (Kenyon, 2021). However, the increasing evidence of foodborne transmission highlights the need for better surveillance and source attribution studies. These are critical for accurately assessing the human health risks from AMR in the food chain. Having outlined the key resistant bacteria prevalent in animal-derived foods and public health implications we now turn our attention to critical role of detection and monitoring techniques in understanding and combating AMR.

Economics and trade burden of antimicrobial resistance in the food-animal and public health sectors

Infectious diseases in livestock cause substantial economic losses influenced by pathogen type, production conditions, and control measures, while also affecting sustainable development and farmers' livelihoods (Kappes et al., 2023). Although antimicrobials remain vital for preventing and treating infections, their use can drive antimicrobial resistance diminishing long-term treatment efficacy and creating societal costs (Lhermie et al., 2017). AMR and the resulting decline in antimicrobial effectiveness are therefore considered negative externalities of antimicrobial use (Innes et al., 2020). According to WOAH's EcoAMR modelling, failure to address AMR could increase global healthcare costs by up to USD 159 billion annually by 2050 and threaten the food security of more than two billion people (World Organisation for Animal Health [WOAH], Animal Industry Data (AID), Center for Global Development (CGD), Institute for Health Metrics and Evaluation (IHME), & RAND Europe, 2024)

The economics and health costs of AMR are expected to rise globally, especially in developing countries. In livestock sectors, the growing burden of AMR leads to more sickness and death, decreasing productivity and overall efficiency in food production (Pokharel et al., 2020). Livestock production could

decline by roughly 11% in low-income nations and 6-9% in middle and high nations by 2050 due to AMR, posing significant risks to food security (World Bank, 2017). From a trade perspective, resistant strains or antibiotic residues in food animals pose a serious risk to international trade. Contaminated products are often turned away by importing nations, resulting in major economic losses and reduced market access (Pokharel et al., 2020). AMR also raises the cost of treatment and monitoring efforts in both animal and human health. Resistant infections require more expensive medications, longer treatment periods, and additional diagnostic testing (Vollset et al., 2024).

Treatment failures caused by infections with AMR pathogens not only increase hospitalization and healthcare costs but also reduce livestock productivity, as infected animals require longer care and may have lower growth rates or milk yields. Additionally, controlling AMR requires greater investment in monitoring and prevention strategies in livestock production, adding to economic burdens (World Bank, 2017; O'Neill, 2016). Overall, AMR poses a threat to both public health and the stability of international food trade. Its increasing prevalence not only undermines the effectiveness of medical and veterinary treatments but also erodes global market trust in animal-derived food products. The considerable economic and health burden of AMR underscores the urgency of implementing preventive measures. Coordinated international policies, careful antimicrobial use, and improved monitoring are crucial to reduce the serious economic and trade effects of AMR.

Prevention and control strategies

Grasping the patterns and trends of antimicrobial resistance (AMR) is essential for crafting effective control measures. Global surveillance efforts, like the Global Antimicrobial Resistance Surveillance System (GLASS), improve data collection, standardization, and international cooperation (Zhou et al., 2022). Responsible antimicrobial usage through stewardship initiatives optimizes antibiotic therapy, enhances diagnostics, and encourages measures for infection prevention and control (Alam et al., 2023). Campaigns aimed at educating and raising awareness among the public, healthcare workers, and policymakers are crucial for minimizing misuse and controlling resistance (Gandra et al., 2020).

Utilizing a “One Health” perspective-merging surveillance and actions across human, animal, and environmental domains-facilitates early identification

of resistance trends and fosters responsible antimicrobial stewardship in both veterinary and clinical contexts (Despotovic et al., 2023). In order to keep antibiotic-resistant bacteria and resistance genes out of the environment and away from human populations, wastewater must be properly treated before being released (La Rosa et al., 2025). At the consumer level, following guidelines for food hygiene, ensuring safe cooking and storage methods, practicing regular handwashing, and disposing of waste correctly are all critical for minimizing infection risks and halting the spread of resistance (Johnson & Hariharan, 2017).

Although existing control strategies are important, the swift development of AMR necessitates more holistic and innovative approaches. Enhancing global surveillance systems, improving molecular diagnostics, advocating for antimicrobial stewardship, and promoting international collaboration within the One Health framework will be essential for addressing AMR effectively in the future (Khare et al., 2021).

Conclusion

The One Health approach is highlighted by the essential intersection of human, animal, and environmental health represented by antimicrobial resistance (AMR) in food products obtained from animals. Antibiotic-resistant bacteria that may survive in meat, milk, and dairy products as a result of extensive use in cattle for growth promotion, disease prevention, and treatment may spread resistance genes to human pathogens. Food handling stages, slaughterhouses, and processing facilities are important control points where biofilm formation and cross-contamination allow AMR to spread. Antimicrobial residues and resistance genes make containment even more difficult, while resistant bacteria including *Salmonella* spp., *Campylobacter* spp., *Staphylococcus aureus*, *Listeria monocytogenes*, and *Escherichia coli* demonstrate the threats to the public's health. Phenotypic and genetic techniques are used for detection, and national and international surveillance systems help monitor resistance and direct policy. While the economic and trade ramifications include decreased cattle output and export limitations, the public health repercussions include treatment failures, longer illness, increased mortality, and greater healthcare expenses. Integrated approaches that include farm management, biosecurity, vaccination, alternative medicines, responsible use of antibiotics, good hygiene, and public awareness are necessary for effective prevention and control. To preserve antibiotic efficacy, safeguard human health,

and guarantee a secure, sustainable food supply, coordinated One Health surveillance, molecular diagnostics, data sharing, stewardship initiatives, and cutting-edge technology are crucial.

Conflict of interest: Authors have no conflicts of interest in this study.

Author's contribution: DS: Primary writing, data curation; KB, SD, SNJ: Editing and reviewing; SB, IS: Conceptualization critical evaluation and supervision

Data availability statement: Data set generated during

research need to be available from the corresponding author upon reasonable request.

Use of artificial intelligence tools: During preparation of this work, the author(s) used Zotero software for reference management and Quillbot for grammar checking. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

ACKNOWLEDGEMENT

The authors are thankful to the Hon'ble Vice Chancellor, West Bengal University of Animal and Fishery Sciences, Kolkata for providing necessary facilities and support to carry the present work.

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