Companion Animals as Reservoirs for Antimicrobial Resistance Genes: Implications for Human Health

Policy Paper

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Abstract

Antimicrobial resistance (AMR) is a pressing global health challenge, with companion animals increasingly recognised as reservoirs for resistant bacteria and resistance genes. The close contact between pets and humans, combined with the misuse and overuse of antibiotics in veterinary practice, facilitates the emergence and spread of resistance across species barriers. This policy paper explores the key mechanisms behind AMR transmission from companion animals, outlines the risk factors within clinical and domestic settings, and identifies critical areas for intervention.

The IVSA Pathology Network (PN) brings this paper forward to highlight the often-overlooked diagnostic and surveillance role of veterinary pathologists in identifying and monitoring AMR. As specialists at the intersection of clinical medicine, microbiology, and disease investigation, veterinary pathologists are uniquely positioned to detect resistance trends early and contribute valuable data to national and international AMR surveillance systems. While AMR is inherently a One Health issue, this paper specifically emphasises the need for greater recognition of the contributions and responsibilities of veterinary pathology in tackling this threat.

The paper calls for strengthened antimicrobial stewardship, improved infection control in veterinary settings, and targeted investment in surveillance and research. Coordinated action across veterinary, public health, and policy sectors is essential to safeguard the effectiveness of antimicrobial treatments for both animal and human health. This entails:

1. **Promoting** responsible use of antimicrobials;
2. **Implementation** of strict infection control procedures;
3. **Strengthening** of surveillance and monitoring;
4. **Raising awareness** among pet owners;
5. **Investing** in research on alternatives;
6. **Reinforcing** veterinary guidelines for antimicrobial use;
7. **Global collaboration** and regulation.

Introduction

The International Veterinary Students' Association (IVSA) is a global non-profit and non-governmental organisation dedicated to uniting veterinary students worldwide. It is the largest veterinary student organisation in the world, with 190 member organisations across 84 countries and approximately 38,000 members. The IVSA's mission is to: "*Benefit the animals and people of the world by harnessing the potential and dedication of veterinary students to promote the international application of veterinary skills, education, and knowledge*".

The IVSA Pathology Network (PN), IVSA's latest Network, serves as a platform dedicated to veterinary students who are enthusiastic about veterinary pathology, complementing the global network of IVSA members. By facilitating collaborations with specialists, the PN aims to present the diverse interdisciplinary aspects of veterinary pathology and enhance significant youth engagement in this field, fostering a strong engagement between veterinarians. In doing so, the PN actively contributes to the IVSA's diversity by introducing the first Network focused on the paraclinical field of Veterinary Medicine. The IVSA Pathology Network aims to raise awareness about Veterinary Pathology and help veterinary students explore potential career paths. The Pathology Network does so by connecting like-minded IVSA members and providing collaboration and knowledge exchange opportunities.

In line with its mission to foster professional development and promote interdisciplinary collaboration, the IVSA Pathology Network brings forward this policy paper to address the underrecognised role of companion animals in the spread of antimicrobial resistance (AMR). While AMR is commonly discussed in the context of livestock or human medicine, companion animals, due to their close contact with humans and frequent exposure to antimicrobials, serve as important reservoirs and vectors of resistance genes. With a unique perspective grounded in diagnostic pathology and veterinary education, the PN highlights the specific risks and responsibilities within companion animal practice and pathology that require urgent policy attention. This paper outlines the key mechanisms behind AMR transmission in pets, the role of companion animals as reservoirs for resistance genes, reviews current evidence, and proposes targeted policy recommendations to improve surveillance, antibiotic stewardship, and public awareness in the veterinary field.

Materials and Methods

This policy paper is based on a review of peer-reviewed literature, expert opinions, and official reports from IVSA Global partners.

This knowledge was compiled into a comprehensive policy paper draft. The draft was subsequently revised by IVSA Global Officials to ensure the position presented is representative of the collective perspective.

1. Background

1.1. Overview of AMR

Antimicrobial resistance (AMR) refers to the ability of microorganisms, including bacteria, fungi, viruses, and parasites, to withstand the effects of drugs that once killed or inhibited them. AMR is a natural phenomenon that occurs over time through mutations in the genetic makeup of microbes, but the overuse and misuse of antibiotics and other antimicrobial agents in both human and veterinary medicine have accelerated this process. The emergence of resistant microorganisms poses a significant challenge to the treatment of infections, as previously effective antimicrobial drugs become less useful or ineffective. This issue is further compounded by the limited development of new antimicrobial drugs and the widespread use of antimicrobials in agriculture and veterinary practices. In companion animals, the routine administration of antibiotics for treatment and prevention, as well as for growth promotion in some regions, plays a central role in the development and spread of AMR [1,2].

In the context of bacterial infections, this means that the bacteria can grow and multiply even in the presence of drugs that would normally suppress or eradicate them. Resistant bacteria can be transmitted between animals and humans, and they are often harder to treat, requiring more potent or alternative medications that may have more side effects or be less effective. The significance of AMR lies in its potential to undermine modern medicine and public health, making routine surgeries, cancer treatments, and even simple infections much riskier and potentially fatal. According to the World Health Organization (WHO), AMR is one of the top 10 global health threats, with implications for the future of health care, food safety, and economic stability. Given the interconnected nature of resistant bacteria transmission across humans, animals, and the environment, it is crucial to understand and address the role of companion animals in this global health issue [1-4].

AMR affects countries regardless of their income levels, and borders. Contributing factors include lack of access to clean water, sanitation and hygiene (WASH) for both humans and animals; poor infection and disease prevention and control in homes, healthcare facilities and farms; partial access to quality and affordable vaccines, diagnostics and medicines; lack of awareness and knowledge; and lack of enforcement of relevant legislation. People living in low-resource settings and vulnerable populations are especially impacted by both the drivers and consequences of AMR [1-4].

AMR is not only a critical issue in human health but also poses a growing concern in animal health. Resistant infections in companion animals are increasingly common, with pets being treated for conditions like skin and urinary tract infections, and pneumonia using antibiotics that may no longer be fully effective due to resistance. As companion animals are in close contact with humans, the transmission of resistant bacteria between pets and their owners becomes a significant risk factor for human health. Studies have shown that certain strains of resistant bacteria, such as

Methicillin-resistant Staphylococcus aureus (MRSA) and *Escherichia coli*, can be transmitted between animals and humans, often causing infections in both groups. For instance, MRSA infections in animals were sporadic in the late 1990s and were mostly brought on by close contact between animals and people. The kind of clones found in the cats and dogs were similar to the ones in humans of the same region. This can be seen in different strains such as HA-MRSA(ST239-III), which was reported to have been found in domestic dogs that were infected by MRSA in Australia. Similarly, MRSA strains found in canines in Portugal and UK are linked to the region's pre-dominant healthcare strain[Epidemic MRSA(EMRSA)-15,ST22-IV]. Similar to this, 50% of MRSA infections in pets being treated at veterinary clinics in midwestern and northeastern America were the most prevalent HA-MRSA strain in hospitals in America (USA100, ST5-II) [Source 5, 6].

The potential for zoonotic transmission means that the emergence of AMR in pets can directly affect human health, particularly in households with vulnerable individuals such as the elderly, children, and immunocompromised persons. Additionally, veterinarians and animal caretakers may be at increased risk of exposure to resistant bacteria, further emphasizing the need for comprehensive monitoring and responsible antimicrobial use in both veterinary and human medicine [2,4-7].

1.1.1 AMR in veterinary medicine

In recent years, antimicrobial resistance (AMR) has become an increasingly urgent concern in veterinary medicine. While much of the focus has historically been on agricultural settings and livestock, companion animals, such as dogs, cats, and other pets, have emerged as key players in the development and transmission of AMR. Companion animals are frequently treated with antibiotics for various medical conditions, ranging from infections to preventive care such as prophylactic treatments during surgeries. However, the overuse and misuse of antibiotics in these animals can significantly contribute to the emergence of resistant pathogens, which may then be transmitted to humans [1,2,7].

Companion animals can harbour bacteria that are resistant to commonly used antibiotics. including antibiotics prescribed for infections, skin conditions, or preventive measures such as flea treatments or prophylactic use in surgery. While the use of antibiotics in companion animals is essential for treating infections and improving animal welfare, inappropriate or excessive use can promote the development of AMR. For instance, the frequent administration of broad-spectrum antibiotics, such as tetracyclines or fluoroquinolones, can disrupt the balance of the microbiota in animals, encouraging the selection of resistant bacterial strains [4-8].

Studies have demonstrated that companion animals can harbor a wide range of resistant pathogens, including *Methicillin-resistant Staphylococcus aureus* (MRSA), *Escherichia coli*, and *Enterococcus spp*. These resistant bacteria are often associated with common infections in pets, such as urinary tract infections, skin infections, and respiratory conditions. Furthermore, companion animals often share living spaces with humans, increasing the likelihood of zoonotic transmission, where resistant bacteria are passed between animals and their owners, potentially complicating the treatment of human infections [5-8].

The relationship between AMR and the misuse or overuse of antibiotics in companion animals is well-established. Misuse refers to both the overprescription of antibiotics (e.g., for conditions where they are not needed, for instance viral infections, mild self-limiting illnesses, or inflammation without bacterial involvement) and the inappropriate administration of the wrong antibiotic for the wrong infection. One example is the overuse of broad-spectrum antibiotics, which are often prescribed in cases of respiratory or skin infections in companion animals without first confirming the presence of bacterial pathogens. The use of antibiotics in situations where they are not necessary, such as for viral infections or minor conditions that resolve on their own, contributes to the development of resistant bacteria [4-8].

Additionally, incomplete courses of antibiotics or failure to follow proper dosing guidelines can promote resistance. For example, if a pet's antibiotic treatment is cut short because the animal's symptoms seem to improve, the bacteria may not be fully eradicated. This incomplete treatment can lead to the survival of partially resistant bacteria, which may evolve into fully resistant strains. Similarly, when antibiotics are used inappropriately in veterinary practices (e.g., using antibiotics to treat viral infections), it accelerates the development of resistance [4-8].

Antimicrobial stewardship, which emphasises the careful and judicious use of antibiotics, is a critical component of veterinary medicine. Efforts to reduce unnecessary antibiotic use in companion animals include promoting proper diagnostic procedures, such as bacterial cultures and sensitivity testing, to ensure that antibiotics are only prescribed when necessary and the correct antibiotic is selected for the identified pathogen. Furthermore, educating pet owners about the risks of overusing antibiotics and ensuring they follow veterinary advice on dosage and duration of treatment are key to reducing the spread of AMR in companion animals. Thus, AMR in veterinary medicine is not an isolated concern but one that directly impacts human health, underscoring the importance of a One Health strategy [2,7,8].

1.2 One Health Approach (OHA)

The One Health Approach (OHA) is a multidisciplinary framework that recognises the interconnectedness of human, animal, and environmental health. It emphasizes collaboration across sectors to address global health challenges, including antimicrobial resistance (AMR). Given that resistant bacteria can circulate between humans, animals, and the environment, a One Health perspective is essential for developing effective strategies to mitigate AMR [9-11].

One Health is based on the principle that the health of humans, animals, and ecosystems is deeply interdependent. The increasing interaction between these domains, through food production, pet ownership, and environmental contamination, necessitates a coordinated response to health threats. In the context of AMR, this means integrating veterinary, medical, and environmental sciences to ensure responsible antimicrobial use and to monitor the emergence and spread of resistance [9-11].

AMR spreads across species and environments through multiple pathways. Resistant bacteria from animals, including companion animals, can be transmitted to humans through direct contact, contaminated food, or shared environments. Wastewater and soil contaminated with antimicrobial residues further contribute to the persistence and dissemination of resistant pathogens. Addressing AMR under the One Health framework involves reducing unnecessary antibiotic use in both human and veterinary medicine, strengthening surveillance systems, and promoting hygiene and biosecurity measures to minimize cross-species transmission [9-11].

A collaborative approach involving veterinarians, physicians, policymakers, and environmental scientists is crucial for mitigating AMR. By integrating strategies across these disciplines, the One Health framework offers a comprehensive and sustainable solution to one of the most pressing global health challenges. Understanding the pathways of transmission from pets to humans is therefore essential for implementing effective AMR containment policies [9-11].

1.3. Resistance Genes Mechanisms and Bacteria

Antimicrobial resistance (AMR) is primarily driven by the presence and transmission of resistance genes, which enable bacteria to survive antimicrobial treatments and proliferate despite drug exposure. These resistance genes can be intrinsic (naturally occurring within a bacterial species) or acquired through various genetic mechanisms. Understanding the nature of resistance genes and their transmission is essential to addressing the spread of AMR in both veterinary and human medicine [2,7,12].

1.3.1. Introduction to resistance genes

Antimicrobial resistance genes (ARGs) are segments of genetic material that encode proteins capable of neutralizing or evading the effects of antimicrobial agents. These genes may produce enzymes that degrade antibiotics, alter drug targets, enhance efflux mechanisms to expel antibiotics, or modify bacterial cell permeability to prevent antibiotic penetration. ARGs can be found on bacterial chromosomes, plasmids, transposons, or integrons, which allows their transmission both within and between bacterial species. Resistance genes may be classified into two main categories [13-15]:

1. Intrinsic resistance genes
   Naturally present in a bacterial species, providing an inherent resistance to certain antibiotics. For example, Pseudomonas aeruginosa possesses efflux pumps that confer resistance to multiple drugs.
2. Acquired resistance genes

Gained through genetic exchange mechanisms such as horizontal gene transfer (HGT), enabling previously susceptible bacteria to become resistant. Acquired resistance poses a significant challenge in both veterinary and human medicine, as it facilitates the spread of AMR across bacterial populations and environments.

The spread of resistance genes is largely facilitated by horizontal gene transfer (HGT), a process by which bacteria exchange genetic material independently of reproduction. This allows resistance traits to disseminate rapidly across bacterial populations, including between commensal and pathogenic bacteria. The primary mechanisms of HGT include [13-15]:

1. Transformation
   Involves the uptake of free DNA from the environment. Some bacteria, such as Streptococcus pneumoniae and Neisseria spp., have natural competence, allowing them to incorporate exogenous genetic material, including resistance genes, into their genome.
2. Transduction
   Occurs when bacteriophages (viruses that infect bacteria) transfer resistance genes from one bacterial cell to another. This process allows AMR genes to spread between bacteria that do not normally interact, bypassing environmental barriers.
3. Conjugation
   The most significant mechanism of resistance gene transfer, involving direct cell-to-cell contact. Conjugation is mediated by plasmids—small, self-replicating DNA molecules that carry resistance genes. Through the formation of a pilus, plasmids can be transferred between bacteria of the same or different species, promoting rapid dissemination of AMR genes.
4. Mobile Genetic Elements (MGEs)
   Include plasmids, transposons (jumping genes), integrons, and insertion sequences that facilitate the movement of resistance genes within and between genomes.
   Plasmids play a crucial role in conjugation and can carry multiple resistance genes, making them central players in multidrug resistance (MDR).
   Transposons are DNA segments capable of moving within a genome, often carrying resistance genes. They can integrate into plasmids or chromosomes, increasing bacterial adaptability.
   Integrons are genetic elements that capture and express gene cassettes, including ARGs, allowing bacteria to acquire and maintain resistance traits efficiently.

The combination of these mechanisms creates a highly dynamic and adaptable resistance landscape, allowing bacteria to evolve rapidly in response to selective pressure from antibiotic use. In companion animals, close contact with humans and frequent antimicrobial exposure in clinical settings facilitate the transfer of resistance genes between animal and human-associated bacterial populations. Understanding these genetic exchange mechanisms is vital to designing strategies for AMR containment and mitigation [13-15].

1.3.2. Focus on specific bacteria

The presence of antimicrobial resistance (AMR) in bacterial populations associated with companion animals is a growing concern due to its implications for both veterinary and human medicine. Certain bacterial species act as reservoirs for resistance genes, facilitating their spread within and beyond animal populations. Among these, *Escherichia coli* (*E. coli*) is one of the most well-documented carriers of AMR genes. However, other bacterial species commonly found in pets, including *Staphylococcus pseudintermedius*, *Enterococcus spp.*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*, have also been identified as significant contributors to the spread of AMR. Understanding the mechanisms and prevalence of AMR in these bacteria is crucial in mitigating the risks associated with the transmission of resistant pathogens between animals and humans [4, 7, 8, 16, 17].

1.3.2.1. Escherichia coli, a common carrier of resistance genes

Escherichia coli is a gram-negative, facultatively anaerobic bacterium that is a natural part of the gastrointestinal microbiota in both humans and animals. While commensal strains are generally harmless, pathogenic variants can cause a range of infections, including urinary tract infections, enteric diseases, and systemic infections. In recent years, *E. coli* has gained attention for its ability to acquire and disseminate antimicrobial resistance genes, making it a key indicator of resistance trends in both human and veterinary medicine [16,17].

One of the most pressing concerns regarding AMR in *E. coli* is its role in the spread of extended-spectrum beta-lactamases (ESBLs), enzymes that confer resistance to third-generation cephalosporins and monobactams. ESBL-producing *E. coli* strains have been isolated from both healthy and diseased companion animals, raising concerns about their zoonotic potential. Studies have demonstrated that ESBL genes, such as *blaCTX-M*, can be transferred between bacteria through horizontal gene transfer, increasing the risk of resistance spreading within microbial communities [16-18].

In addition to ESBLs, *E. coli* has been implicated in the dissemination of plasmid-mediated quinolone resistance genes (*qnr*), which reduce susceptibility to fluoroquinolones, a class of antibiotics widely used in veterinary practice. The recent emergence of colistin resistance, conferred by the *mcr-1* gene, is particularly alarming, as colistin is considered a last-resort antibiotic for treating multidrug-resistant infections. The detection of *mcr-1* in *E. coli* isolates from companion animals highlights the potential for resistant strains to be transmitted between pets and their owners, complicating treatment options for bacterial infections [16-19].

The zoonotic transmission of resistant *E. coli* strains is an increasing concern, particularly in households where pets receive frequent antibiotic treatments. Several studies have reported genetic similarities between *E. coli* isolates from pets and those found in their owners, suggesting a bidirectional exchange of bacteria. This underscores the importance of responsible antibiotic use in veterinary medicine, as well as the need for stringent infection control measures to prevent the spread of AMR in both animal and human populations [16-19].

1.3.2.2. Emerging resistance genes in other bacteria relevant to companion animals

While *E. coli* is a well-established model for studying AMR, several other bacterial species commonly associated with companion animals have also developed significant resistance patterns. These emerging resistant bacteria pose additional challenges in veterinary and human healthcare [16-20].

One such bacterium is *Staphylococcus pseudintermedius*, a commensal and opportunistic pathogen in dogs that frequently causes skin infections, otitis, and postoperative wound infections. In recent years, methicillin-resistant *S. pseudintermedius* (MRSP) has emerged as a veterinary counterpart to methicillin-resistant *Staphylococcus aureus* (MRSA) in humans. MRSP carries the *mecA* gene, which encodes an altered penicillin-binding protein (PBP2a) that confers resistance to β-lactam antibiotics. The increasing prevalence of MRSP in companion animals is concerning because these strains often exhibit multidrug resistance, limiting treatment options for infected animals [20,21].

Another bacterial genus of concern is *Enterococcus*, which includes species such as *Enterococcus faecium* and *Enterococcus faecalis*. These bacteria are commonly found in the intestines of animals and humans and can act as opportunistic pathogens, causing urinary tract infections and wound infections. A major concern in enterococcal AMR is the emergence of vancomycin-resistant enterococci (VRE), which harbor the *vanA* and *vanB* genes. These resistance genes enable enterococci to survive treatment with vancomycin, an antibiotic that is often used as a last resort in human medicine. VRE strains have been isolated from companion animals, raising concerns about their potential for zoonotic transmission and the role of pets as reservoirs of resistant bacteria [22,23].

Pseudomonas aeruginosa is another bacterium that has developed significant antimicrobial resistance mechanisms, particularly in veterinary settings. This gram-negative opportunistic pathogen is commonly associated with chronic otitis externa, respiratory infections, and wound infections in dogs and cats. *P. aeruginosa* is inherently resistant to multiple antibiotics due to its low outer membrane permeability and the presence of efflux pumps that expel antibiotics from bacterial cells. However, in recent years, carbapenem-resistant *P. aeruginosa* (CRPA) has been identified in veterinary patients. These strains often carry metallo-β-lactamase genes such as *blaVIM* and *blaIMP*, which confer resistance to carbapenems, a class of antibiotics reserved for severe infections. The spread of CRPA in companion animals poses a significant therapeutic challenge, as carbapenem resistance severely limits treatment options [24,25].

Klebsiella pneumoniae is another gram-negative bacterium that has been increasingly recognized for its role in AMR. This pathogen is known to cause pneumonia, urinary tract infections, and soft tissue infections in both humans and animals. *K. pneumoniae* has been identified as a carrier of ESBL genes as well as carbapenemase genes, such as *KPC* and *NDM*, which confer resistance to nearly all β-lactam antibiotics. Recent studies have detected multidrug-resistant *K. pneumoniae* in companion animals, further highlighting the role of pets as potential reservoirs of AMR genes that can spread to human populations [24, 26].

The presence of antimicrobial resistance genes in bacterial species associated with companion animals is a growing public health concern. While *E. coli* remains one of the most prominent carriers of resistance genes, the emergence of multidrug-resistant *Staphylococcus pseudintermedius, Enterococcus spp., Pseudomonas aeruginosa,* and *Klebsiella pneumoniae* underscores the need for continuous surveillance and intervention strategies. The potential for zoonotic transmission of these resistant bacteria highlights the importance of antimicrobial stewardship in veterinary medicine, as well as the need for a One Health approach to combat the spread of AMR across animal, human, and environmental ecosystems. Addressing AMR in companion animals requires a multifaceted effort that includes responsible antibiotic use, improved diagnostic capabilities, and stringent infection control measures to minimize the risk of resistance spreading between animals and humans [16-26].

2. Companion Animals as Reservoirs for Resistance Genes

The role of companion animals as potential reservoirs for antimicrobial resistance (AMR) genes is an increasingly relevant concern in veterinary and human medicine. Due to their close interactions with humans and frequent exposure to antibiotics, pets such as dogs and cats can harbor resistant bacteria that may contribute to the spread of AMR within households and communities. Understanding the reservoir concept and the mechanisms by which companion animals acquire, maintain, and transmit resistance genes is essential for developing effective mitigation strategies [2-7,12, 16-26].

2.1. Understanding the reservoir concept

In the context of antimicrobial resistance, a reservoir is defined as any population or environment that supports the persistence and transmission of resistant bacteria and their associated genes. These reservoirs play a crucial role in the epidemiology of AMR, acting as sources from which resistance genes can spread to other bacteria, hosts, or ecosystems [2-7,12, 16-26].

Reservoirs of AMR can be categorized into biological and environmental sources. Biological reservoirs include humans, animals, and microbial communities that naturally harbor resistant bacteria. Environmental reservoirs encompass water bodies, soil, food, and surfaces contaminated with antibiotic-resistant organisms. Within these reservoirs, bacteria can exchange resistance genes through horizontal gene transfer mechanisms, including conjugation, transformation, and transduction, thereby facilitating the dissemination of AMR across different species and ecological niches [2-7,12, 16-26].

Companion animals serve as biological reservoirs for AMR due to their exposure to antibiotics, close contact with humans, and the presence of commensal and pathogenic bacteria capable of acquiring resistance genes. Pets may asymptomatically carry multidrug-resistant organisms (MDROs), which can be transmitted to humans through direct contact, shared environments, or contaminated surfaces [2-7,12, 16-26].

2.2. Role of companion animals

The interaction between companion animals and humans creates multiple opportunities for the exchange of antimicrobial-resistant bacteria. Unlike livestock, which are typically housed in controlled environments, pets share living spaces with their owners, increasing the likelihood of bacterial transmission [27,28].

Pets and their owners often engage in close physical contact, including petting, licking, and sharing furniture or bedding. Studies have demonstrated that resistant bacteria, such as methicillin-resistant *Staphylococcus aureus* (MRSA) and extended-spectrum beta-lactamase (ESBL)-producing *Escherichia coli*, can be isolated from both pets and their owners, suggesting bidirectional transmission. Additionally, resistant bacteria can persist on pet fur, saliva, and feces, acting as a potential source of environmental contamination [27,28].

Common household surfaces, including floors, furniture, food bowls, and litter boxes, can also serve as reservoirs for resistant bacteria. Pets that roam freely outdoors may introduce resistant strains from the environment into the home, further complicating AMR control efforts [27,28].

The overuse and misuse of antibiotics in veterinary medicine play a significant role in the development and persistence of antimicrobial resistance (AMR) in companion animals. Several common practices contribute to this issue, often stemming from both veterinary prescribing habits and pet owner behaviors [27,28].

One major factor is the overprescription and inappropriate use of antibiotics. Veterinarians frequently prescribe antibiotics as a precautionary measure, even in cases where a bacterial infection has not been confirmed. This is particularly common when diagnostic tests are not performed to identify the causative agent of an illness. As a result, broad-spectrum antibiotics are often administered unnecessarily, creating selective pressure that favors the survival and proliferation of resistant bacterial strains. Additionally, antibiotics are sometimes prescribed for conditions that are primarily viral or inflammatory, where they offer no therapeutic benefit. This practice not only increases resistance in the animal receiving treatment but also contributes to the overall spread of AMR within the household and community [29,30].

Another contributing factor is the prolonged or incomplete use of antibiotic courses. Pet owners do not always follow the prescribed treatment duration, either by discontinuing the medication too soon when symptoms improve or by extending the course without veterinary supervision. When antibiotics are stopped prematurely, some bacteria may survive, allowing partially resistant populations to persist and multiply. On the other hand, prolonged use without medical justification further selects for resistant bacteria, increasing the risk of treatment failure in future infections [29,30].

The use of critically important antibiotics in pets is another concerning practice. Some antibiotics that are considered essential for treating severe infections in human medicine, such as fluoroquinolones and third-generation cephalosporins, are also used in veterinary settings. While these drugs can be highly effective, their misuse in companion animals accelerates the development of resistance, potentially compromising their efficacy in human patients. The emergence of resistance to these antibiotics in bacteria carried by pets poses a significant public health concern, as resistant strains may be transmitted to humans through direct contact or environmental contamination [29,30].

Finally, veterinary clinics and grooming facilities can act as reservoirs for resistant bacteria, facilitating their spread among animals. Inadequate infection control measures, such as poor hand hygiene, insufficient sterilization of equipment, and improper handling of infected animals, contribute to the transmission of resistant organisms. Overcrowding in veterinary hospitals, boarding facilities, and pet salons further increases the risk of bacterial exchange between animals and humans. These environments can harbor multidrug-resistant bacteria, which may persist on surfaces, equipment, and even veterinary staff, creating opportunities for cross-species transmission [29,30].

Companion animals act as important reservoirs for antimicrobial-resistant bacteria, with direct and indirect transmission pathways to humans. Their close physical proximity to owners, frequent exposure to antibiotics, and interactions with veterinary environments create multiple opportunities for the spread of AMR genes. Addressing these issues requires a multifaceted approach, including improved diagnostic practices, stricter antibiotic stewardship, better education for pet owners on responsible antibiotic use, and enhanced biosecurity measures in veterinary and pet care facilities. Recognising and mitigating these risk factors is crucial in the fight against AMR in companion animals and its potential spillover to humans [29,30].

3. Implications for Human Health

Antimicrobial resistance (AMR) in companion animals is not only a veterinary concern but also a significant public health threat. Resistant bacteria and their associated genes can be transmitted between animals and humans, contributing to the growing challenge of antibiotic-resistant infections.

Understanding the pathways of transmission, the potential health impacts, and the necessity of a One Health approach is crucial in addressing this issue [1-4, 9-11, 31].

3.1. Transmission pathways

Companion animals can serve as reservoirs and vectors for resistant bacteria, facilitating their transmission to humans through multiple routes. The most direct transmission pathway is close physical contact between pets and their owners. Many pet owners allow their animals to sleep in their beds, lick their faces, or share household spaces, increasing the likelihood of bacterial exchange. Hands-on interactions such as petting, grooming, and cleaning up after pets further contribute to microbial transmission [1-8, 12, 16-31].

Another significant route is environmental contamination. Companion animals can shed resistant bacteria into their surroundings through feces, saliva, and skin contact. Contaminated surfaces, bedding, food bowls, and even water sources can serve as indirect transmission points. Veterinary clinics, pet grooming salons, and dog parks can also act as hubs where resistant bacteria circulate between animals and humans [1-8, 12, 16-31].

In some cases, AMR transmission occurs through zoonotic bacterial infections, where pathogens capable of infecting both humans and animals develop resistance. Certain strains of Escherichia coli, Salmonella spp., and Staphylococcus aureus (including methicillin-resistant S. aureus or MRSA) have been documented in both pets and their owners, highlighting the risk of cross-species infection. These resistant bacteria can enter the human body through minor cuts, inhalation, ingestion of contaminated food or water, or direct mucosal contact [12-31].

3.2. Potential health impacts

The presence of antimicrobial-resistant bacteria in companion animals poses serious health risks to humans, particularly vulnerable populations such as young children, the elderly, and immunocompromised individuals. One of the most pressing concerns is the increased difficulty in treating infections. If a person acquires a resistant bacterial strain from their pet, common antibiotics may be ineffective, leading to prolonged illness, increased healthcare costs, and higher morbidity and mortality rates [2-7, 12, 16-31].

Beyond individual health risks, AMR in companion animals has broader implications for healthcare systems and public health policies. The spread of resistant bacteria from pets to humans can contribute to the growing burden of antibiotic-resistant infections in hospitals and community settings. This can lead to an increased reliance on last-resort antibiotics, which are often more expensive, less effective, or associated with severe side effects [32-33].

Estimates by global health agencies, such as the WHO and the World Bank, suggest that antimicrobial resistance could cost the global economy up to US$ 1 trillion additional healthcare costs by 2025, if left unchecked, due to longer hospital stays, lost productivity, and the need for costly treatments. While figures vary by region, even conservative estimates show significantly higher treatment costs for resistant infections [32-33].

Additionally, veterinary antibiotic use may indirectly impact human medicine by accelerating the overall evolution of resistant bacteria, reducing the effectiveness of key antimicrobial treatments [2-7, 12, 16-31].

Addressing these risks requires thoughtful policy measures that account for complex trade-offs, such as restricting antibiotic use while ensuring effective treatment remains available in both veterinary and human medicine. These tensions underscore the need for coordinated, evidence-based approaches that align public health goals with practical realities [2-7, 12, 16-31].

3.3. One Health perspective and interdisciplinary collaboration to tackle AMR

Addressing AMR requires a One Health approach, which recognizes the interconnectedness of human, animal, and environmental health. Tackling AMR effectively demands collaboration between veterinarians, medical professionals, microbiologists, epidemiologists, policymakers, and environmental scientists [9-11, 31].

Interdisciplinary cooperation can help in several ways. First, enhancing antibiotic stewardship in both human and veterinary medicine ensures that antibiotics are prescribed responsibly, reducing unnecessary use and minimizing resistance development. Second, strengthening surveillance systems for tracking resistant bacteria across species can help identify emerging threats early and inform targeted interventions. Finally, promoting public awareness and education about AMR, responsible pet ownership, and hygiene practices can help mitigate transmission risks at the community level [9-11, 31].

The One Health framework emphasizes that AMR is not confined to human or veterinary medicine alone; it is a shared challenge that requires a unified global response. Implementing coordinated strategies at the intersection of human, animal, and environmental health is essential to combat the rise of resistant infections and safeguard public health [9-11, 31].

4. Actions and Recommendations

Addressing antimicrobial resistance (AMR) in companion animals requires a multifaceted approach that includes responsible antibiotic use, improved infection prevention measures, and strong policy interventions. By implementing targeted strategies at the veterinary, public health, and policy levels, the spread of resistant bacteria can be mitigated, protecting both animal and human health [1-11, 27-31].

4.1. Strategies to reduce AMR in companion animals

A key strategy for reducing AMR in companion animals is responsible antibiotic use in veterinary medicine. Veterinarians play a crucial role in ensuring that antibiotics are only prescribed when necessary and based on proper diagnostic evidence. This includes performing bacterial cultures and antimicrobial susceptibility testing before initiating treatment, rather than relying on empirical prescriptions. Additionally, veterinary professionals should prioritize narrow-spectrum antibiotics over broad-spectrum ones whenever possible, reducing the likelihood of selecting for resistant bacterial strains [27-31].

Another critical aspect is educating pet owners about responsible antibiotic use. Many cases of antibiotic misuse stem from owners' misconceptions, such as prematurely discontinuing treatment when symptoms improve or administering leftover antibiotics without veterinary guidance. Clear communication from veterinarians about treatment adherence, the risks of misuse, and the importance of completing prescribed courses is essential in minimizing resistance development [27-31].

Beyond antibiotic stewardship, infection prevention measures in veterinary practice are fundamental in controlling the spread of resistant bacteria. Clinics, hospitals, and grooming facilities should implement strict hygiene protocols, including proper sterilization of equipment, routine handwashing, and disinfection of surfaces. Staff should receive training on infection control measures, and isolation procedures should be enforced for animals with known or suspected resistant infections [27-31].

The role of vaccination and preventive healthcare should also not be overlooked. Reducing the incidence of bacterial infections through effective vaccination programs can lower the need for antibiotic treatments. Routine health checks, parasite control, and appropriate husbandry practices further contribute to overall animal health, reducing the risk of infections that might otherwise require antimicrobial treatment [27-31].

Additionally, monitoring and surveillance of AMR trends in companion animals should be strengthened. By establishing national and international databases tracking resistance patterns in veterinary settings, researchers and policymakers can identify emerging threats early and adapt intervention strategies accordingly [27-31].

4.2. Policy recommendations

The growing threat of antimicrobial resistance (AMR) necessitates a comprehensive policy response that addresses both the regulation of antimicrobial use in veterinary medicine and the need for international cooperation under the One Health framework. Policies should aim to reduce unnecessary antimicrobial use, promote stewardship programs, enhance surveillance systems, and foster global collaboration to mitigate the risks associated with resistant pathogens. Given the close relationship between companion animals and humans, effective regulations and coordinated international efforts are essential to limit the spread of resistance and ensure the continued efficacy of antimicrobial treatments [1-11,31,34].

4.2.1. Regulation of antimicrobial use in veterinary settings

One of the most significant contributors to AMR in companion animals is the overuse and misuse of antibiotics. This often occurs due to the overprescription of antimicrobials by veterinarians, self-administration by pet owners, and the lack of diagnostic confirmation before treatment. To address these issues, stringent regulations must be established to control the availability, distribution, and administration of antimicrobials in veterinary medicine [27-34].

A critical step in antimicrobial regulation is restricting the use of critically important antibiotics (CIAs) for human medicine in veterinary practice. Certain classes of antimicrobials, such as third- and fourth-generation cephalosporins, fluoroquinolones, and polymyxins (including colistin), play a vital role in treating multidrug-resistant infections in humans. The use of these antibiotics in companion animals should be strictly limited to cases where no viable alternatives exist, and only after laboratory-confirmed bacterial infections indicate their necessity. Several countries have already implemented policies restricting the veterinary use of CIAs, and further international standardization is needed to prevent resistance development [27-35].

Another essential measure is ensuring that all antimicrobial prescriptions in veterinary medicine are issued exclusively by licensed veterinarians. Over-the-counter sales of antibiotics should be prohibited, as easy accessibility encourages self-medication by pet owners without proper veterinary oversight. Additionally, veterinarians should be required to provide a clinical justification for prescribing antimicrobials, including documentation of infection type, suspected pathogen, and treatment rationale. To further support responsible prescribing practices, the implementation of diagnostic-driven antimicrobial therapy should be encouraged. Whenever possible, bacterial culture and antimicrobial susceptibility testing (AST) should be performed before prescribing antibiotics to ensure targeted therapy, rather than the empirical use of broad-spectrum agents [27-35].

In addition to regulatory control, antimicrobial stewardship programs (ASPs) should be integrated into veterinary practice to promote the responsible use of antibiotics. Such programs provide veterinarians with guidelines on appropriate antimicrobial selection, optimal dosing strategies, and treatment duration recommendations to minimize resistance development. Continuing education and training on antimicrobial resistance should be mandatory for veterinary professionals, ensuring they remain informed about emerging resistance patterns and alternative treatment strategies [27-36].

Another crucial aspect of antimicrobial regulation is the establishment of national and regional surveillance systems to monitor antibiotic use and resistance trends in companion animals. Reliable data on antimicrobial prescribing habits and resistance prevalence would enable policymakers to adjust regulations accordingly, ensuring that interventions are evidence-based and responsive to emerging threats. National authorities should collaborate with veterinary clinics, diagnostic laboratories, and academic institutions to collect and analyze this data, with findings used to inform future policy decisions [27-36].

4.2.2. International cooperation under the One Health framework

The issue of AMR extends beyond national borders, requiring a coordinated global response under the One Health framework. Because resistant bacteria and genes can spread between animals, humans, and the environment, policies addressing AMR in companion animals must be harmonised at the international level to be effective. Global collaboration is essential for sharing data, standardizing regulations, and ensuring equitable access to resources that support responsible antimicrobial use [27-37].

One of the most important aspects of international cooperation is the development and strengthening of global AMR surveillance networks. Organizations such as the World Organisation for Animal Health (WOAH, formerly OIE) and the World Health Organization (WHO) have established antimicrobial use and resistance monitoring programs, but these systems need further expansion to include comprehensive data on companion animals. The integration of veterinary AMR surveillance with human and environmental health monitoring is critical for identifying transmission pathways and potential outbreak sources [1-4, 37].

Harmonization of antimicrobial use policies across different countries is another key component of global AMR mitigation. Disparities in antibiotic regulations can lead to inconsistent prescribing practices, facilitating the cross-border spread of resistant bacteria. For example, while some countries have banned the use of certain antimicrobials in veterinary medicine, others continue to allow their widespread use. To address this issue, international organisations should develop standardized veterinary antimicrobial guidelines that are legally enforceable at the national level. By establishing universal principles for responsible antibiotic use, countries can work together to reduce AMR without creating loopholes that allow resistance to persist [27-37].

Knowledge-sharing and capacity-building efforts should also be prioritized in international cooperation initiatives. Many regions lack the infrastructure, expertise, or financial resources needed to effectively regulate antimicrobial use in veterinary medicine. High-income countries should support lower-income nations by providing training programs, research funding, and technical assistance to strengthen their AMR mitigation capabilities. International conferences, workshops, and online platforms can serve as valuable tools for exchanging knowledge and best practices between veterinarians, researchers, and policymakers worldwide [27-37].

Pharmaceutical companies play a crucial role in antimicrobial stewardship and should be held accountable for ethical antibiotic production and distribution. The marketing of veterinary antimicrobials should be regulated to prevent financial incentives from driving overprescription. Additionally, drug manufacturers should be encouraged to invest in the development of novel antimicrobial alternatives, such as bacteriophage therapy, probiotics, and vaccines, which could reduce reliance on antibiotics in companion animals. Governments and international organisations should collaborate with the pharmaceutical industry to promote research initiatives that focus on these innovative solutions [27-37].

Another vital policy recommendation under the One Health framework is the promotion of alternative therapies and preventive measures that reduce the need for antibiotic use in companion animals. Vaccination programs, improved hygiene standards, and the implementation of infection prevention protocols in veterinary clinics can significantly lower the incidence of bacterial infections, thereby decreasing antibiotic consumption. Encouraging pet owners to practice responsible animal care, such as maintaining proper nutrition, avoiding unnecessary antibiotic use, and seeking regular veterinary check-ups, can further contribute to AMR mitigation efforts [9-11, 27-37].

In conclusion, effective policy measures to combat AMR in companion animals require a dual approach: stringent regulation of antimicrobial use in veterinary settings and enhanced international cooperation under the One Health framework. By implementing stricter controls on antibiotic prescriptions, promoting antimicrobial stewardship programs, and strengthening surveillance systems, national authorities can reduce the misuse of antimicrobials in veterinary medicine. Simultaneously, global collaboration is essential to ensure consistent regulations, facilitate knowledge-sharing, and support the development of alternative therapies. A unified policy response, grounded in scientific evidence and interdisciplinary cooperation, is necessary to address the growing threat of AMR and protect both animal and human health for future generations [1-4, 9-11, 27-37].

Discussion

The findings presented in this policy paper underscore the often-overlooked but critical role of companion animals in the global challenge of antimicrobial resistance. Through frequent antimicrobial exposure and close contact with humans, companion animals have been positioned as reservoirs and transmission vectors for resistant bacteria, posing a direct threat to human health. These resistant strains have the potential to cross species barriers and contribute to human infections, particularly among high-risk populations such as children, the elderly, and immunocompromised individuals [1-26].

Inappropriate antibiotic use in veterinary medicine, including overprescription and lack of diagnostic confirmation, has increased the emergence of resistance in companion animal populations. Veterinary practices, while essential for the welfare of companion animals, have contributed to the rise of this threat by overuse of antibiotics, wrong diagnosis or lack of diagnostic information, and relying on broad-spectrum antibiotics altogether fuel the selection of resistant bacterial strains. Furthermore, veterinary clinics, animal shelters, and pet grooming facilities can act as hubs for the persistence and spread of resistant bacteria if infection control measures are not applied. This highlights the need for better biosecurity-biosafety practices, improved hygiene protocols, and improving the education of pet owners, veterinary staff, and other related individuals [1-26].

While the contribution of livestock to AMR is widely acknowledged, the role of companion animals has received less policy attention. This gap is partly due to the perception that the smaller population size and more regulated setting of companion animal medicine reduce the risk of large-scale resistance transmission. However, emerging research demonstrates that resistant pathogens, including MRSA, ESBL-producing *E. coli*, and carbapenem-resistant organisms, can be carried by dogs and cats and transmitted through direct contact, shared environments, or contaminated surfaces. In this light, everyday practices in small animal clinics, shelters, and grooming facilities must be re-evaluated for their potential role in AMR propagation [2-7,12, 16-26].

Critics may argue that the evidence for zoonotic transmission from pets to humans remains limited or inconsistent, suggesting that human-to-human or foodborne routes remain more significant. While this may hold true in terms of sheer numbers, the One Health paradigm emphasises that even less frequent transmission events can be clinically relevant, especially when involving pathogens with limited treatment options. Moreover, the increasing reliance on broad-spectrum antimicrobials in veterinary settings, often in the absence of culture and sensitivity testing, exacerbates selection pressure and risks amplifying resistance reservoirs within household environments [1-11, 27-31].

Another counterargument posits that companion animals receive relatively high-quality veterinary care, including supervised antibiotic use, which should limit the risk of resistance. Yet studies continue to report high rates of inappropriate prescription practices, including unnecessary antibiotic administration for viral infections, empirical prescribing without diagnostics, and prolonged treatment courses. These behaviours persist in part due to client expectations, diagnostic cost limitations, and time constraints in busy clinical settings. As a result, even high-income countries with advanced veterinary infrastructure are not exempt from AMR risks originating from companion animal care [2-7, 12, 16-33].

To address these challenges, greater investment is needed in antimicrobial stewardship programs tailored to companion animal practice. This includes improved clinical guidelines, access to rapid diagnostics, and continued professional education for veterinarians. In parallel, public outreach efforts are essential to align pet owners' expectations with responsible antimicrobial use. Infection prevention strategies, including routine hygiene protocols and environmental disinfection in clinics and pet facilities, must also be prioritised to prevent the spread of resistant organisms across animal-human interfaces [1-11,31,34].

Veterinary students, as future practitioners, researchers, and policymakers, play a pivotal role in changing the culture of antibiotic use within the profession. With training that integrates microbiology, pathology, pharmacology, and public health, veterinary students are uniquely positioned to advocate for evidence-based practices that reduce AMR risks. By recognising the companion animal sector as an important part of the broader AMR landscape, the veterinary community can take more effective and inclusive steps to protect both animal and human health [1-11,31,34].

The International Veterinary Students' Association (IVSA) recognises the importance of early intervention in tackling AMR. By emphasising the diagnostic and surveillance methods, and promoting responsible antimicrobial use, the IVSA seeks to mobilise the next generation of veterinarians to take leadership in the global response to AMR. Veterinary students, as future professionals in this field and policymakers, are in a crucial position to drive the changes needed within their profession and across health sectors [1-4, 9-11, 27-37].

Conclusion

Antimicrobial resistance (AMR) in companion animals is a growing public health concern with significant implications for both veterinary and human medicine. This paper has explored the mechanisms of resistance gene transfer, the role of companion animals as reservoirs for resistant bacteria, and the pathways through which AMR can be transmitted to humans. The close interaction between pets and their owners, combined with the overuse and misuse of antibiotics in veterinary medicine, has facilitated the emergence and spread of resistant bacteria [1-8, 12, 16-30].

Key findings highlight that inappropriate antibiotic prescription practices, prolonged or incomplete treatment courses, and the use of critically important antimicrobials in veterinary settings all contribute to AMR in companion animals. Additionally, veterinary clinics and pet care facilities serve as transmission hubs for resistant bacteria, further complicating infection control efforts. The evidence reviewed underscores the urgent need for responsible antibiotic use, improved infection prevention strategies, and strengthened surveillance systems to monitor resistance trends in animals [2-7, 12-37].

From a One Health perspective, the interconnection between human, animal, and environmental health necessitates a collaborative approach to tackling AMR. This includes international cooperation, stricter regulations on antibiotic use in veterinary medicine, and public awareness initiatives to educate both veterinary professionals and pet owners. By adopting these measures, the risk of resistant infections spreading between animals and humans can be reduced, safeguarding the effectiveness of antimicrobial treatments [1-4, 9-11, 27-37].

Addressing AMR in companion animals requires coordinated action at both local and global levels. Governments, veterinary organisations, researchers, and public health agencies must work together to enforce responsible antimicrobial stewardship and implement policies that limit the misuse of antibiotics in veterinary practice. Increased investment in surveillance programs, infection prevention measures, and research on alternative treatment options is also essential to mitigate the long-term consequences of AMR [1-4, 9-11, 27-37].

Without immediate and sustained intervention, AMR will continue to pose a major threat to human and animal health. A proactive, multidisciplinary approach rooted in the One Health framework is critical to ensuring that antibiotics remain effective for future generations [1-4, 9-11, 27-37].

This policy paper calls on veterinary organisations, policymakers, and global health actors to work together to harmonise antimicrobial use guidelines, improve regulatory oversight, and invest in alternatives to antibiotics. Through increased collaboration, research, and public engagement, the veterinary sector, especially its companion animal branch, can take a more proactive and accountable role in addressing AMR.

Ultimately, protecting the effectiveness of life-saving antimicrobial treatments requires urgent, collective action grounded in the One Health approach. Veterinary students and professionals alike must lead the change in culture and practice to safeguard both animal and public health for generations to come.

Call to action

The role of companion animals as reservoirs for antimicrobial resistance genes is a growing concern in the fight against AMR. The close interactions between pets and their owners, coupled with the increasing misuse and overuse of antibiotics in veterinary medicine, facilitate the spread of resistant bacteria. Addressing AMR requires a multifaceted approach that involves improving antibiotic stewardship in veterinary practices, enhancing infection control protocols in pet care settings, and expanding surveillance systems to monitor resistance patterns. The interconnectedness of human, animal, and environmental health underscores the importance of adopting a One Health approach to tackle this issue comprehensively. Without urgent action, the growing threat of AMR could compromise the effectiveness of antibiotics, making infections in both animals and humans harder to treat. To curb the rise of antimicrobial resistance in companion animals, decisive action is needed at local, national, and global levels.

This policy paper urges governments, organisations and relevant stakeholders to take swift action in addressing the role of companion animals as reservoirs for AMR resistance genes, safeguarding both animal and human health. This entails:

1. **Promoting** responsible use of antimicrobial drugs:
   Veterinary professionals must commit to the principles of antimicrobial stewardship, ensuring that antibiotics are used only when necessary and in the most appropriate manner.
2. **Implementation** of strict infection control procedures:
   Veterinary clinics and pet care facilities must adopt enhanced infection control measures to reduce the risk of AMR transmission within and between animals.
3. **Strengthening** of surveillance and monitoring:
   Governments, international organisations, and stakeholders must prioritise the establishment of global surveillance systems to track AMR trends in companion animals and identify emerging resistant pathogens.
4. **Raising awareness** among pet owners:
   Public education campaigns are essential in raising awareness about the dangers of AMR and encouraging responsible pet care practices, including proper antibiotic use.
5. **Investing** in research on alternatives:
   Research into alternative treatment options, such as vaccines and non-antibiotic therapies, must be prioritised to reduce the reliance on antibiotics in veterinary medicine.
6. **Reinforcing** veterinary guidelines for antimicrobial use:
   National and international veterinary bodies must update and enforce evidence-based guidelines to ensure consistent, prudent antimicrobial use across veterinary practices, particularly in the treatment of companion animals.
7. **Global collaboration** and regulation:

Policymakers, public health authorities, and veterinary organisations worldwide must coordinate efforts to harmonise regulations, share surveillance data, and support unified strategies to combat AMR at the international level.

Policymakers, public health authorities, human and veterinary health professionals, and their respective organisations worldwide must coordinate efforts to harmonise regulations, share surveillance data, and support unified strategies to combat AMR at the international level.

Decisive and coordinated action is urgently needed to combat the growing threat of antimicrobial resistance, preserve the effectiveness of life-saving treatments, and protect both animal and public health for the future.

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