Antibiotics in Veterinary Medicine and Livestock Production

Overview of Antibiotic Resistance through the One Health Approach

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Abstract

Antibiotic resistance is a major global health threat, with livestock production playing a key role in its spread. Extensive and often inappropriate antibiotic use in veterinary medicine has accelerated the emergence of resistant bacteria, which threaten animal, human, and environmental health. Resistance develops through bacterial mutations and horizontal gene transfer, allowing bacteria to survive antibiotics and share resistance genes across species. Humans can be exposed via contaminated food, direct contact with animals, or environmental pathways, highlighting the One Health connection. While antibiotics are used therapeutically, prophylactically, metaphylactically, and historically for growth promotion, preventive and group treatments in large herds increase resistance risks. Contributing factors include suboptimal dosing, prolonged exposure, and the gut microbiome acting as a reservoir for resistance genes. Resistant infections lead to treatment failures, higher mortality, increased costs, and reduced productivity. Addressing this requires stewardship, education, targeted therapies, alternative interventions, and improved farm management under a One Health framework.

According to the World Health Organization, antibiotic resistance is the greatest public health threat that humanity faces. Particularly, the misuse of antibiotics in livestock represents a major source of antibiotic-resistant bacteria. This issue is an urgent threat affecting humans, animals, and environmental health.

What is Antibiotic Resistance?

Antibiotic resistance is a natural process in bacteria. After antibiotic treatment, resistant genes can emerge and spread, giving bacteria protection against future antibiotic exposure. The excessive use of antibiotics accelerates this process, leading to the emergence of antibiotic-resistant bacteria that threaten both health and economic systems. To preserve the effectiveness of antibiotics, regulatory measures are being implemented to reduce and limit their use.

Take away points

Antibiotic resistance in livestock is a multifactorial challenge that demands coordinated One Health actions. Here are the key points:

- Livestock antibiotic use is a major driver of global resistance
- Antibiotic resistance undermines animal health and farm economics
- Resistant infections lead to treatment failures, higher veterinary costs, productivity losses, and, in severe cases, depopulation and long-term production disruptions.
- Improved biosecurity, nutrition, housing, precision livestock farming, vaccines, probiotics, and other alternatives can significantly reduce reliance on antibiotics while maintaining animal welfare and productivity
- Beyond drug development, pharma actors influence responsible use through education, targeted products, diagnostics, and alignment with global antimicrobial policies..

How Does Antibiotic Resistance Occur in Livestock?

Antibiotic resistance in veterinary medicine lies at the intersection of animal health, food safety, and public health. In many countries, livestock use more antibiotics than humans, accounting for roughly 50% of global antibiotic consumption. This extensive use in animal agriculture fuels the global antibiotic resistance crisis.

What Are the Mechanisms of Antibiotic Resistance?

- **Mutations**: Natural changes in bacterial DNA that can make antibiotics less effective. These changes may alter the drug's target, increase efflux pumps (which push antibiotics out of the cell), or reduce cell permeability, preventing the drug from entering.
- **Horizontal gene transfer**: Bacteria can share resistance genes through mobile genetic elements (plasmids, transposons, and integrons). This process allows resistance to move between harmless and harmful bacteria, as well as between bacteria from animals and humans.

Transmission Pathways of Antibiotic Resistance

Antibiotic resistance in livestock illustrates the One Health concept, which recognizes the connection between human, animal, and environmental health.

Resistant bacteria from livestock can enter the human population through multiple pathways:

- **Contaminated Food Products**: Contaminated meat, dairy products, and eggs represent the most direct pathway for resistant bacteria to reach consumers.
- **Occupational Contact**: Farmers, veterinarians, slaughterhouse

workers, and others with direct animal contact face a higher risk of acquiring antibiotic-resistant bacteria.

- **Environmental Contamination**: The application of manure to agricultural land, runoff from livestock facilities, and contaminated water sources distribute resistant bacteria into the broader environment.
- **Horizontal Gene Transfer to Human Pathogens:** Antibiotic-resistant bacteria in livestock can transfer to human pathogens.

What are the Uses of Antibiotics in Veterinary Medicine?

Since the 1940s, antimicrobial growth promoters have been used to boost livestock productivity and improve production efficiency. The misuse promotes the development of antibiotic resistance genes, leading to increased resistance to available treatments.

- **Therapeutic Use:** Treatment of diagnosed bacterial infections in individual animals or small groups. This is the most medically justified application of antibiotics in veterinary medicine.
- **Prophylactic Use:** Prevention of infections in healthy animals, common during high-risk periods such as weaning, transport, or when introducing animals to new environments.
- **Metaphylactic Use:** Treatment of entire herds or flocks to prevent spread, when some members show signs of infection.
- Growth Promotion: In the past, sub-therapeutic antibiotics were added to animal feed to boost growth and feed efficiency, but this practice is regulated in several countries.

Increase Factors of Antibiotic Resistance in Livestock

- **Population Size**: Large herds or flocks create vast bacterial populations where resistant bacteria can easily appear and spread.
- **Suboptimal Dosing**: Underdosing, poor absorption, or prolonged exposure kill sensitive bacteria but allow resistant ones to survive.
- **Duration of Exposure**: Preventive and group treatments expose animals to antibiotics for long periods, increasing the chances of antibiotic resistance developing.
- **Commensal Reservoirs**: The normal gut microbiome acts as a “gene bank” where resistance genes can form and later move to harmful bacteria.

Importance of Antibiotic Resistance in Veterinary Medicine

Antibiotic resistance poses a significant daily challenge in veterinary medicine. Once effective treatments, they now fail to cure infections. This translates into prolonged illness, increased mortality, and higher healthcare costs.

The Economic Burden of Antibiotic Resistance in Livestock

Antimicrobial resistance in livestock represents a significant economic burden on animal agriculture. Resistant infections are challenging because they often require more expensive antibiotics and longer treatments. These challenges translate directly into productivity losses.

Also, managing herd health becomes complex when resistant pathogens emerge. Some measures may include depopulation, stricter biosecurity protocols, and interruptions to production cycles.

The pharmaceutical industry must acknowledge the measures needed to protect the antimicrobial tools that it relies on.

Veterinary Pharma Role in Antibiotic Resistance Crisis

Veterinary pharmaceutical companies play a vital role in combating antibiotic resistance. Their contributions extend far beyond producing antibiotics as they shape how these tools are used, monitored, and supplemented with innovative alternatives.

Development of responsible antibiotic portfolios

Pharmaceutical companies should promote their antibiotics with a focus on stewardship to reduce misuse and improve clinical outcomes. This can be addressed through:

- Promoting responsible dosing and label clarity
- Supporting narrow-spectrum or targeted-action products
- Avoiding marketing practices that encourage overuse
- Investing in research on resistance mechanisms and drug efficacy
- By aligning with global policies and One Health standards, companies build long-term trust with veterinarians and regulators.

Support for the use of antibiotics in veterinary medicine

Pharma partners can empower veterinarians by offering:

- Educational materials and training programs
- Stewardship guidelines tailored to species and production systems
- Digital tools for monitoring antibiotic use
- Access to rapid diagnostics or partnerships with labs

Alternatives to Face the Antibiotic Resistance Crisis

As pressure increases to reduce antimicrobial use, the demand for effective alternatives is also rising. These innovations aim to support long-term reductions in antibiotic resistance.

- **Antimicrobial peptides:** Small natural proteins that kill bacteria by breaking their cell membranes. They work against many bacteria, but cost, delivery, and large-scale production are still challenges.
- **Vaccination Srategies**: Better vaccines help prevent infections that would otherwise need antibiotics. Vaccines for common livestock diseases lower illness rates and reduce antibiotic use.

- **Probiotics and Competitive Exclusion:** Probiotics are beneficial microbes that improve gut health, boost immunity, and help keep harmful bacteria out.
- **Prebiotics and Immunomodulators**: These compounds support the immune system or encourage the growth of good gut bacteria, helping animals resist infections and reducing antibiotic needs
- **Bacteriophage Therapy:** Phages are viruses that attack specific bacteria. They can target pathogens without harming helpful microbes. However, regulations for use in food animals are still limited, and concerns exist about phage resistance.

How to prevent antibiotic resistance in livestock?

To face antibiotic resistance in livestock, the focus should be on animal welfare and better farm management.

Good practice guide to prevent antibiotic resistance in livestock

- **Biosecurity**: Preventing pathogen introduction and transmission through improved facility design, traffic control, sanitation protocols, and quarantine measures.
- **Nutrition**: Optimized feeding programs that support immune function and gut health reduce infection risk.
- **Optimized housing**: Appropriate stocking densities, ventilation, temperature control, and environmental enrichment reduce stress and disease pressure.
- **Precision livestock farming**: Sensors, monitoring systems, and data analytics enable early disease detection and targeted interventions, reducing reliance on mass medication.

A One Health Roadmap for the Future

Antibiotic resistance poses a significant global health threat that affects both humans and animals. Stakeholders in the veterinary pharmaceutical market need to implement a coordinated plan of action.

Key strategies should include antimicrobial stewardship, improved farm management practices, advancements in diagnostics, and development of alternatives.

By embracing One Health principles and practicing responsible antibiotic use, stakeholders can safeguard animal welfare and promote the sustainability of global agriculture. This approach will contribute to a safer, healthier, and more resilient future for everyone.

References

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