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ONE HEALTH APPROACHES TO PREVENTING AND CONTROLLING ZOONOTIC DISEASES: INTEGRATING HUMAN, ANIMAL, AND ENVIRONMENTAL HEALTH FOR SUSTAINABLE GLOBAL HEALTH SECURITY

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ABSTRACT

Zoonotic diseases—those transmissible between animals and humans—pose significant threats to global public health, food security, and economic stability. Emerging pathogens such as SARS-CoV-2, Ebola virus, avian influenza, and antimicrobial-resistant bacteria underscore the urgency of coordinated interventions. The One Health approach emphasizes the interconnectedness of human, animal, and environmental health to mitigate zoonotic risks. This review examines the epidemiology of zoonotic diseases, identifies key drivers of emergence, evaluates surveillance and mitigation strategies, and highlights case studies demonstrating successful One Health interventions. Integrating multidisciplinary approaches enhances early detection, risk assessment, and response capacity, providing a sustainable pathway to reduce zoonotic disease burden and prevent future pandemics.

Keywords: methane mitigation; ruminants; nitrate supplementation; seaweed; sustainable livestock; dairy cattle

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INTRODUCTION

Zoonotic diseases account for over 60% of all human infectious diseases and approximately 75% of emerging infectious diseases (Taylor et al., 2001; Jones et al., 2008). Factors such as habitat loss, urbanization, intensive livestock production, wildlife trade, and climate change accelerate the emergence and spread of pathogens. The One Health concept recognizes the inseparable links between human, animal, and environmental health, advocating interdisciplinary collaboration to prevent, detect, and respond to zoonotic threats. The COVID-19 pandemic highlighted vulnerabilities in health systems and demonstrated the consequences of delayed recognition of zoonotic spillover events. Beyond pandemic preparedness, One Health strategies also support food safety, antimicrobial stewardship, and biodiversity conservation, providing multifaceted benefits for global health security (Destoumieux-Garzón et al., 2018).

This article explores the One Health approach in zoonotic disease prevention, examines major drivers of pathogen emergence, and evaluates practical strategies for integrated surveillance, risk mitigation, and policy implementation.

EPIDEMIOLOGY OF ZOONOTIC DISEASES

Classification of Zoonoses

Zoonotic diseases can be categorized based on their

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transmission pathways:

- **Direct zoonoses**: Transmitted through direct contact with infected animals (e.g., rabies, brucellosis).
    - **Vector-borne zoonoses**: Transmitted via arthropod vectors such as mosquitoes and ticks (e.g., Lyme disease, West Nile virus).
    - **Foodborne zoonoses**: Resulting from
    - consumption of contaminated animal products (e.g., Salmonella, E. coli O157:H7).
    - **Environmental zoonoses**: Linked to pathogen presence in soil, water, or ecosystems (e.g., leptospirosis, anthrax) (WHO, 2023). (n = 8 per group):

TABLE 1. COMMON ZOONOTIC DISEASES AND THEIR CHARACTERISTICS

Disease	Causative Agent	Primary Animal Reservoir	Mode of Transmission	Human Impact
Rabies	Rabies virus	Dogs, bats	Bite	Fatal if untreated
Avian Influenza	Influenza A virus	Wild birds, poultry	Respiratory droplets	Severe respiratory illness
Brucellosis	*Brucella* spp.	Cattle, goats, sheep	Direct contact, ingestion	Chronic fever, joint pain
Ebola	Ebola virus	Bats, primates	Contact with bodily fluids	Hemorrhagic fever, high mortality
Leptospirosis	*Leptospira* spp.	Rodents, livestock	Contaminated water	Fever, kidney/liver damage

DRIVERS OF ZOONOTIC EMERGENCE

Zoonotic spillover is driven by multiple interacting factors:

1. **Human–animal interface**: Intensive farming, deforestation, and wildlife trade increase human exposure to pathogens.
2. **Environmental change**: Climate change affects vector distribution, pathogen survival, and wildlife migration patterns.
3. **Globalization and travel**: International trade and human mobility facilitate rapid disease spread.
4. **Antimicrobial resistance (AMR)**: Overuse of antibiotics in humans and livestock accelerates resistant pathogen emergence (O'Neill, 2016).
5. **Socioeconomic and cultural factors**: Traditional hunting, wet markets, and food handling practices can elevate zoonotic risk.

ONE HEALTH APPROACH

Conceptual Framework

The One Health framework integrates expertise from human medicine, veterinary medicine, environmental sciences, epidemiology, public policy, and social sciences. Core components include:

- Surveillance and early detection: Coordinated monitoring of humans, livestock, and wildlife to identify emerging threats.
- Risk assessment and modeling: Predictive models for zoonotic spillover events and outbreak scenarios.
- Intervention strategies: Vaccination, biosecurity, sanitation, vector control, and responsible antimicrobial use.
- Policy and governance: Regulatory mechanisms that support cross-sector collaboration and information sharing.

Surveillance Systems

Effective surveillance requires:

- Integrated human–animal disease reporting networks.
- Wildlife pathogen monitoring, especially in high-risk interfaces.

- Genomic epidemiology to track pathogen evolution.
- Community engagement to improve reporting and compliance.

Case Study: In Uganda, the integration of livestock, wildlife, and human health surveillance reduced Rift Valley Fever outbreaks by enabling early interventions and vaccination campaigns (Bird et al., 2017).

PREVENTION AND MITIGATION STRATEGIES

Vaccination

Vaccination remains a cornerstone in preventing zoonoses. Examples include:

- **Rabies vaccination** for dogs reduces human cases by >90%.
- **H5/H7 avian influenza vaccines** in poultry prevent spillover to humans.

Biosecurity and Hygiene

- Farm-level biosecurity, quarantine, and sanitation reduce transmission.
- Proper food handling and cooking practices limit foodborne zoonoses.

Environmental Management

- Habitat conservation and controlled wildlife interactions minimize spillover risks.
- Vector control through environmental management reduces arboviral disease transmission.

Antimicrobial Stewardship

- Prudent antibiotic use in livestock reduces AMR emergence.
- Cross-sector guidelines ensure coordinated human and veterinary drug policies.

CASE STUDIES OF ONE HEALTH SUCCESS

H5N1 Avian Influenza, Southeast Asia

Integrated surveillance of poultry, wild birds, and humans, combined with targeted vaccination and culling, reduced H5N1 outbreaks and limited human cases (FAO, 2018).

Rabies Elimination Programs, Latin America

Coordinated mass dog vaccination campaigns, public education, and human post-exposure prophylaxis led to a dramatic decline in rabies incidence (WHO, 2019).

Ebola Virus Outbreaks, West Africa

Community engagement, wildlife monitoring, safe burial practices, and rapid diagnostics exemplified a One Health approach to outbreak containment (CDC, 2016).

Challenges and Future Directions

Despite its promise, One Health faces challenges:

- Fragmented governance and insufficient cross-sector collaboration.
- Limited funding for integrated surveillance in low-resource regions.
- Data sharing constraints and incompatible reporting systems.
- Balancing ecosystem conservation with agricultural development.

Future priorities include:

1. Global data integration platforms to allow real-time zoonotic surveillance.
2. Predictive modeling using artificial intelligence to forecast spillover events.
3. Community-driven approaches to enhance compliance and awareness.
4. Sustainable livestock and wildlife management to reduce pathogen emergence.

CONCLUSION

Zoonotic diseases represent a persistent threat to global health, food security, and economic stability. A One Health approach—integrating human, animal, and environmental health—offers a sustainable and effective framework for preventing, detecting, and controlling zoonotic outbreaks. Coordinated surveillance, vaccination, biosecurity, environmental

management, and antimicrobial stewardship are critical components of this approach. Strengthening governance, investing in multidisciplinary research, and fostering international collaboration will enhance global preparedness for future zoonotic threats and pandemics.

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