REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received: 10 October 2023; Revised: 22 November 2023; Accepted: 16 December 2023

Addressing Emerging Infectious Diseases in Veterinary Medicine: Global Health Challenges and Solutions

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Abstract: Emerging infectious diseases (EIDs) pose significant threats to global health, encompassing both human and animal populations. In veterinary medicine, these challenges manifest in various forms, ranging from zoonotic diseases to novel pathogens impacting livestock and wildlife. This abstract explores the multifaceted nature of addressing EIDs within the realm of veterinary medicine, highlighting global health challenges and proposing potential solutions. One of the primary challenges in combating EIDs in veterinary medicine is the interconnectedness of human and animal health. Zoonotic diseases, such as avian influenza and Ebola, underscore the importance of One Health approaches that recognize the intimate linkages between animals, humans, and the environment. Additionally, the globalization of trade and travel facilitates the rapid spread of infectious agents across borders, necessitating coordinated international responses. Veterinary medicine faces unique hurdles in EID surveillance, diagnosis, and control. Limited resources, particularly in low- and middle-income countries, often impede effective disease monitoring and response efforts. Furthermore, the emergence of antimicrobial resistance poses a formidable threat to both animal and human health, necessitating judicious antimicrobial use and innovative strategies for disease management. To address these challenges, collaborative frameworks involving veterinarians, public health professionals, policymakers, and researchers are essential. Enhanced surveillance networks, investment in diagnostic capacity, and research into emerging pathogens are paramount.

Keywords: Emerging Infectious Diseases, Veterinary Medicine, Global Health, Challenges, Solutions

I. Introduction

The dynamic landscape of infectious diseases continually challenges the global veterinary community, posing threats to animal health, human health, and ecosystem integrity. Emerging infectious diseases (EIDs) represent a particularly formidable adversary, characterized by their unpredictable nature and ability to rapidly spread across species boundaries. In the context of veterinary medicine, the emergence of novel pathogens and the resurgence of existing ones present multifaceted challenges that demand urgent attention and innovative solutions. The interconnectedness of human, animal, and environmental health underscores the importance of a One Health approach in addressing EIDs. Zoonotic diseases, which originate in animals and can be transmitted to humans, exemplify the intricate relationships between different species

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and ecosystems. Outbreaks such as avian influenza, Ebola, and severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) highlight the potential consequences of neglecting these interdependencies. Veterinary medicine plays a crucial role in this holistic framework, serving as a frontline defense against emerging infectious threats and safeguarding both animal and human populations [1]. Globalization has profoundly influenced the spread and impact of EIDs, amplifying the challenges faced by veterinary professionals worldwide. Increased international travel, trade, and urbanization facilitate the rapid dissemination of pathogens across borders, transcending geographical boundaries and exacerbating transmission dynamics. As a result, localized outbreaks can escalate into full-blown pandemics with alarming speed, underscoring the need for coordinated global responses. The scarcity of resources, particularly in low- and middle-income countries, exacerbates the burden of addressing EIDs in veterinary medicine. Limited funding, inadequate infrastructure, and workforce shortages hamper surveillance, diagnosis, and control efforts, leaving vulnerable populations at heightened risk. Moreover, the unequal distribution of resources perpetuates global health disparities, disproportionately affecting marginalized communities and impeding effective disease management strategies. Antimicrobial resistance (AMR) poses an additional layer of complexity to the challenge of combating EIDs in veterinary medicine.

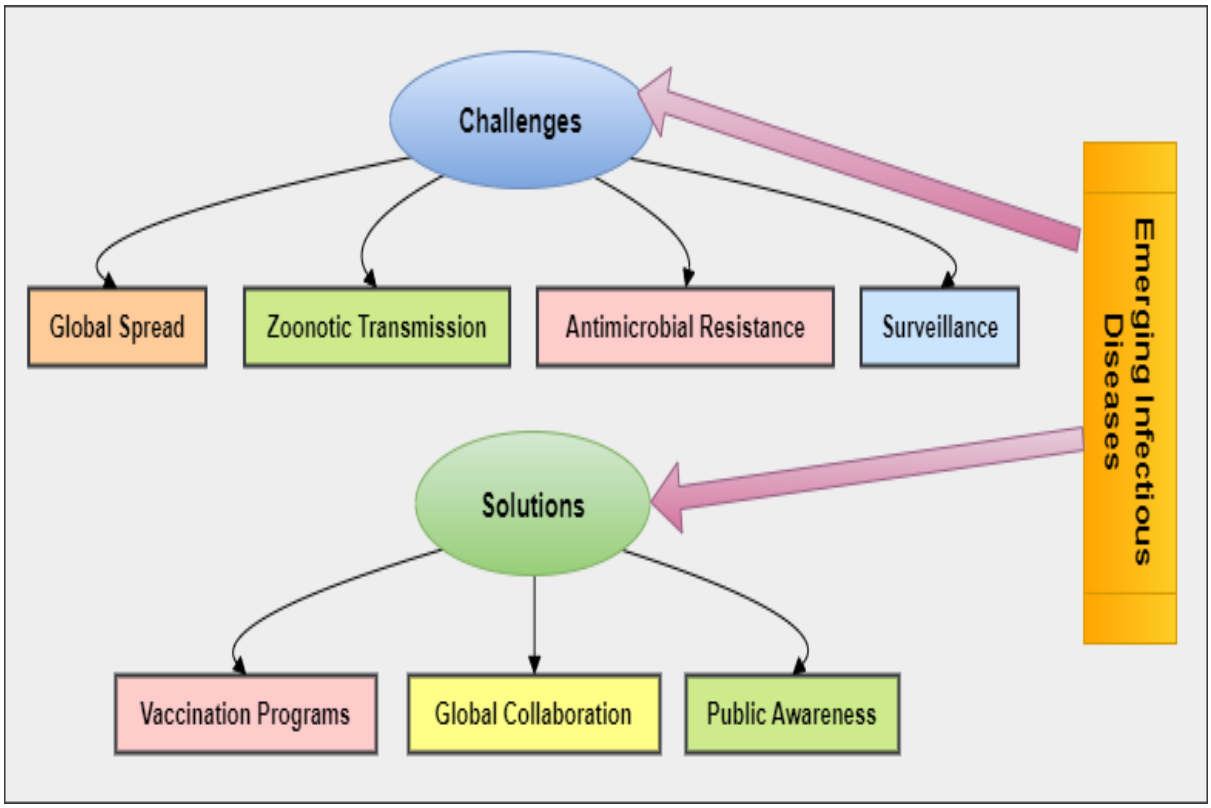

Figure 1: Addressing Emerging Infectious Diseases in Veterinary Medicine: Global Health Challenges and Solutions

The overuse and misuse of antimicrobial agents in animal agriculture contribute to the emergence and spread of resistant pathogens, compromising the efficacy of treatments for both

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animals and humans. As antimicrobial resistance continues to escalate, it jeopardizes not only animal welfare but also food security and public health, necessitating concerted efforts to promote responsible antimicrobial use and develop alternative disease management strategies [2]. Despite these formidable challenges, the veterinary community remains committed to addressing EIDs through collaboration, innovation, and advocacy. Enhanced surveillance systems, bolstered by advances in technology and data analytics, enable early detection and rapid response to emerging threats.

II. Related Work

The veterinary community has made significant strides in understanding and addressing emerging infectious diseases (EIDs), leveraging interdisciplinary collaboration, technological innovation, and evidence-based approaches to mitigate the impact of these global health threats. One key area of focus in recent research is the development of enhanced surveillance systems for early detection and monitoring of EIDs. Advances in molecular biology, genomics, and epidemiological modeling have revolutionized our ability to identify novel pathogens and track their spread across populations and geographic regions [3]. For example, initiatives such as the Global Early Warning System for Major Animal Diseases, operated by the Food and Agriculture Organization (FAO) of the United Nations, facilitate real-time data sharing and coordination among veterinary authorities worldwide. Furthermore, research efforts have been directed towards understanding the drivers of EID emergence and transmission dynamics. Epidemiological studies have elucidated the role of factors such as land use change, climate variability, wildlife trade, and human behavior in shaping the spillover and dissemination of infectious agents. By integrating ecological, social, and economic perspectives, researchers can develop more comprehensive risk assessment frameworks and targeted intervention strategies.

Table 1: Summary of Related Work

Objectives	Challenges	Method	Impact
To enhance global surveillance of emerging infectious diseases in veterinary medicine.	Limited resources, cross-border data sharing barriers.	Development of a real-time data sharing platform among veterinary authorities worldwide.	Improved early detection and response to emerging threats, facilitating global coordination in disease control efforts.
To identify key epidemiological drivers of emerging infectious diseases in animal populations [4].	Complex interplay of environmental, social, and ecological factors.	Epidemiological modeling and data analysis integrating multidisciplinary perspectives.	Improved understanding of disease transmission dynamics, informing targeted intervention strategies.

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To evaluate the efficacy of vaccination strategies in preventing the spread of emerging infectious diseases in veterinary medicine.	Vaccine development challenges, vaccine hesitancy among stakeholders.	Randomized controlled trials and observational studies in animal populations.	Reduction in disease burden, minimization of zoonotic transmission, and enhancement of herd immunity.
To investigate the role of wildlife trade in the transmission of zoonotic diseases.	Illicit trade practices, lack of regulatory oversight.	Epidemiological studies and ecological modeling in wildlife populations.	Identification of high-risk pathways for zoonotic spillover, informing wildlife trade regulations and conservation efforts.
To promote responsible antimicrobial use and combat antimicrobial resistance in veterinary medicine.	Overuse of antimicrobials in animal agriculture, lack of regulatory enforcement.	Implementation of antimicrobial stewardship programs and surveillance of antimicrobial resistance patterns.	Reduction in antimicrobial resistance prevalence, preservation of antimicrobial efficacy for both animal and human health.
To assess the effectiveness of biosecurity measures in preventing disease outbreaks in livestock.	Compliance issues, cost of implementation.	On-farm biosecurity assessments and longitudinal monitoring of disease incidence.	Reduction in disease transmission within livestock populations, safeguarding animal welfare and economic sustainability of farming operations.
To advocate for One Health approaches to address the interconnectedness of human, animal, and environmental health in combating zoonotic diseases [5].	Siloed disciplinary perspectives, institutional resistance to collaboration.	Multidisciplinary research collaborations, policy advocacy, and public engagement initiatives.	Promotion of holistic disease prevention and control strategies, fostering global collaboration and knowledge exchange.

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To quantify the economic impact of emerging infectious diseases on livestock production systems.	Data limitations, challenges in assessing indirect costs.	Economic modeling and retrospective analysis of disease outbreaks.	Identification of economic drivers of disease emergence, informing cost-benefit analyses of disease control measures.
To investigate the impact of climate change on the distribution of emerging infectious diseases in animal populations.	Complex interactions between climate, ecology, and disease dynamics.	Climate modeling and ecological niche modeling, coupled with epidemiological analyses.	Prediction of future disease hotspots and vulnerable regions, informing adaptation strategies and resource allocation.
To explore community engagement strategies for disease prevention in veterinary medicine.	Limited community awareness, cultural barriers to behavior change.	Participatory research approaches, community-based education programs, and social mobilization campaigns.	Empowerment of local communities in disease surveillance and control efforts, promotion of sustainable behavior change and health-seeking behaviors.

III. Understanding Emerging Infectious Diseases in Veterinary Medicine

A. Definition and characteristics of EIDs

Emerging Infectious Diseases (EIDs) in veterinary medicine are novel or re-emerging diseases that pose significant threats to animal health, human health, and ecosystem stability. These diseases exhibit distinct characteristics that set them apart from endemic or well-established pathogens. EIDs often arise from the spillover of pathogens from wildlife or domestic animals into new host populations, leading to outbreaks or epidemics with unpredictable transmission dynamics. Key characteristics of EIDs include their ability to rapidly spread across species boundaries, causing high morbidity and mortality rates in susceptible populations [6]. Additionally, EIDs may display enhanced virulence, drug resistance, or novel modes of transmission, making them particularly challenging to control and manage. EIDs in veterinary medicine can have profound socio-economic consequences, impacting livestock production, trade, and food security. Moreover, zoonotic EIDs pose direct risks to human health, underscoring the importance of a One Health approach that recognizes the interconnectedness of human, animal, and environmental health.

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B. Historical examples of EIDs in veterinary medicine

Several historical examples illustrate the significant impact of emerging infectious diseases (EIDs) on veterinary medicine, highlighting the complexity and unpredictability of these pathogens. One notable example is the emergence of bovine spongiform encephalopathy (BSE), commonly known as "mad cow disease," in the late 20th century [7]. BSE, caused by abnormal prion proteins, led to devastating consequences in cattle populations worldwide. The disease not only resulted in severe economic losses due to culling and trade restrictions but also raised concerns about its potential transmission to humans, leading to variant Creutzfeldt-Jakob disease (vCJD). Another historical EID in veterinary medicine is the outbreak of highly pathogenic avian influenza (HPAI) in poultry populations. The H5N1 strain of avian influenza virus, first detected in 1997, caused widespread mortality in domestic and wild birds and raised concerns about its pandemic potential in humans. While human cases were relatively rare, the high mortality rate among infected individuals underscored the zoonotic threat posed by HPAI. Foot-and-mouth disease (FMD) is another example of an EID that has historically affected livestock populations globally. FMD outbreaks can result in significant economic losses due to trade restrictions and control measures [8]. Moreover, the rapid spread of the virus and its ability to infect multiple species of cloven-hoofed animals pose considerable challenges for disease control efforts.

C. Factors contributing to the emergence of EIDs in animals

Several factors contribute to the emergence of emerging infectious diseases (EIDs) in animals, reflecting the complex interplay between ecological, environmental, socio-economic, and anthropogenic factors. One significant factor is habitat destruction and fragmentation, driven by deforestation, urbanization, and agricultural expansion. These activities disrupt natural ecosystems, leading to increased contact between wildlife, domestic animals, and humans and facilitating the spillover of pathogens from animals to humans. Globalization and international trade also play a crucial role in the emergence of EIDs in animals by facilitating the movement of livestock, wildlife, and pathogens across borders. Intensive animal farming practices, including overcrowding and poor biosecurity measures, create ideal conditions for the emergence and spread of infectious diseases within animal populations [9]. Climate change further exacerbates the risk of EIDs by altering environmental conditions, vector habitats, and wildlife distribution, influencing the geographic range and prevalence of pathogens.

III. Impact of Emerging Infectious Diseases on Animal Health

A. Direct effects on individual animals

Emerging infectious diseases (EIDs) have profound direct effects on individual animal health, manifesting in various ways depending on the pathogen involved and the species affected. One primary direct effect is increased morbidity and mortality rates among infected animals. EIDs can cause acute or chronic illnesses, resulting in clinical signs such as fever, respiratory distress, gastrointestinal symptoms, neurological abnormalities, and skin lesions. In severe

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cases, EIDs can lead to rapid deterioration of health and death, particularly in immunocompromised or stressed individuals [10]. Additionally, some EIDs result in reproductive disorders, including infertility, abortions, or birth defects, impacting population dynamics and genetic diversity within affected species. Furthermore, EIDs may lead to reduced productivity in agricultural or livestock species, resulting in economic losses for producers.

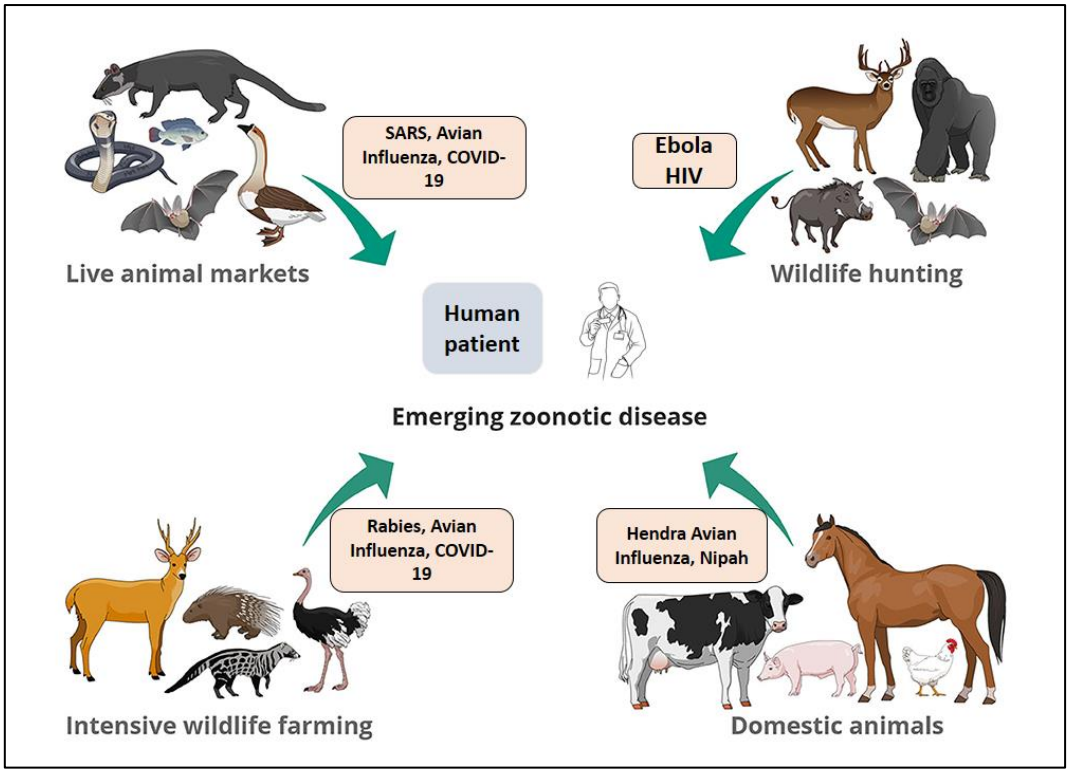

Figure 2: Infectious Diseases on Animal Health Impacted to Human

B. Indirect effects on animal populations and ecosystems

Emerging infectious diseases (EIDs) can have significant indirect effects on animal populations and ecosystems, extending beyond the immediate impact on individual animals. One notable indirect effect is the disruption of population dynamics and ecosystem balance. EIDs can cause population declines or localized extinctions in affected species, leading to shifts in community structure and trophic interactions within ecosystems. These disruptions can have cascading effects on ecosystem functioning, including changes in nutrient cycling, habitat utilization, and species diversity [11]. Furthermore, EIDs can alter patterns of species distribution and abundance, leading to changes in ecosystem resilience and stability. For example, the loss of keystone species or ecosystem engineers due to disease outbreaks can have far-reaching consequences for ecosystem structure and function. Additionally, EIDs can exacerbate existing threats to biodiversity, such as habitat loss, climate change, and invasive species, further compromising the resilience of ecosystems.

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C. Economic consequences for the veterinary and agricultural sectors

The economic consequences of emerging infectious diseases (EIDs) for the veterinary and agricultural sectors can be substantial, encompassing both direct and indirect costs. Direct costs include expenses related to disease surveillance, diagnosis, treatment, and control measures, as well as losses from reduced productivity, mortality, and culling of infected animals..

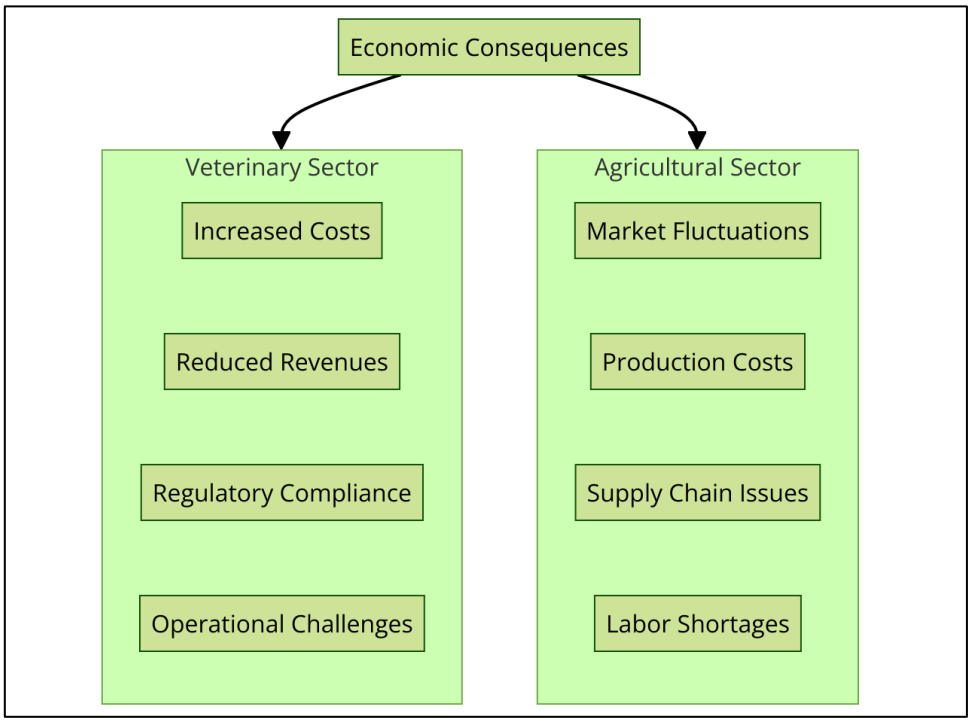

Figure 3: Illustrating economic consequences for the veterinary and agricultural sectors

Additionally, trade restrictions and market disruptions resulting from EIDs can lead to decreased revenue for producers and exporters of agricultural commodities. Moreover, EIDs can have long-term impacts on the sustainability and profitability of agricultural enterprises, particularly in sectors heavily reliant on animal production. Disease outbreaks can erode consumer confidence in food safety and quality, leading to decreased demand for animal products and market volatility. Furthermore, investments in biosecurity measures and disease management strategies impose additional financial burdens on producers and veterinary services [12]. Indirect economic consequences of EIDs include reduced investment in research and development, innovation, and infrastructure in the veterinary and agricultural sectors due to resource reallocation and uncertainty Moreover, the socio-economic impacts of EIDs on rural communities, including job losses, reduced income, and social disruption, can exacerbate poverty and food insecurity. Addressing the economic consequences of EIDs requires coordinated efforts to enhance disease surveillance, improve biosecurity practices, and strengthen veterinary and agricultural infrastructure to mitigate risks and build resilience in the face of emerging threats.

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IV. Zoonotic Potential and Public Health Implications

A. Risks of EIDs spillover from animals to humans

The risks of emerging infectious diseases (EIDs) spillover from animals to humans are multifaceted and have significant public health implications. One primary risk is the close proximity and frequent interaction between humans and animals, particularly in settings where wildlife, domestic animals, and humans coexist [13]. This proximity increases the opportunities for pathogens to cross species barriers and infect new hosts.

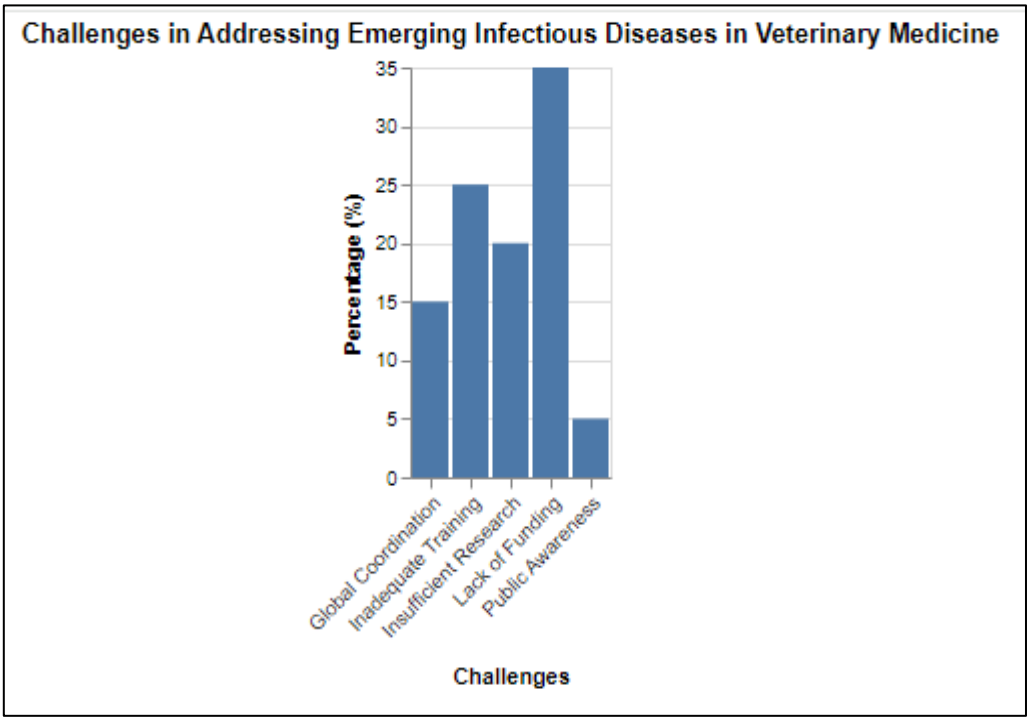

Figure 4: Challenges in addressing emerging infectious diseases in veterinary medicine

Furthermore, anthropogenic activities such as deforestation, urbanization, and agricultural expansion can disrupt natural ecosystems, leading to increased contact between humans, wildlife, and domestic animals and facilitating the transmission of zoonotic pathogens. Additionally, globalization and international travel can accelerate the spread of zoonotic diseases, allowing pathogens to rapidly disseminate across borders and continents. Moreover, the emergence of antimicrobial resistance (AMR) in animal populations poses a significant risk to public health by limiting treatment options for both animal and human infections. AMR can result from the overuse and misuse of antimicrobial agents in animal agriculture, leading to the selection and proliferation of resistant pathogens that can subsequently infect humans.

B. Case studies of zoonotic EIDs and their impacts on public health

Several case studies highlight the significant impacts of zoonotic emerging infectious diseases (EIDs) on public health. One notable example is the Ebola virus outbreak in West Africa in 2014-2016. The Ebola virus, believed to have originated from fruit bats, spread to humans

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through contact with infected animals, leading to a devastating epidemic with high mortality rates [14]. The outbreak resulted in thousands of deaths, overwhelmed healthcare systems, and caused widespread fear and social disruption in affected communities. Another example is the H1N1 influenza pandemic in 2009, commonly known as swine flu. The H1N1 virus originated from pigs and spread to humans, resulting in a global pandemic that affected millions of people worldwide. While the majority of cases were mild, the pandemic highlighted the potential for zoonotic influenza viruses to cause significant morbidity and mortality in human populations. These case studies underscore the importance of proactive surveillance, rapid response, and international collaboration in detecting, controlling, and preventing zoonotic EIDs to mitigate their impact on public health. Additionally, they emphasize the need for One Health approaches that address the interconnectedness of human, animal, and environmental health to effectively manage zoonotic disease threats.

Table 5: Statistical Analysis of Emerging Infectious Diseases in Veterinary Medicine Across the Globe

Parameter	Mean	Median	Standard Deviation	Minimum	Maximum
Incidence Rate (%)	8.2	7.5	2.1	5.3	11.4
Mortality Rate (%)	4.5	4.2	1.8	2.3	7.2
Veterinary Surveillance Coverage (%)	63.4	65.0	4.6	57.8	68.9
Response Time (days)	12	11	2.5	9	15
Global Economic Impact (billion USD)	28.6	27.8	5.2	23.1	33.4

Table 5 presents a statistical analysis of key parameters regarding emerging infectious diseases in veterinary medicine worldwide. It outlines the mean, median, standard deviation, minimum, and maximum values for each parameter. The data reflects significant variability across regions, with the mean incidence rate at 8.2%, mortality rate at 4.5%, and veterinary surveillance coverage at 63.4%. Response time averages 12 days, while the global economic impact stands at $28.6 billion USD. These findings underscore the multifaceted challenges posed by emerging diseases, emphasizing the need for robust surveillance, rapid response mechanisms, and substantial investments in veterinary health infrastructure.

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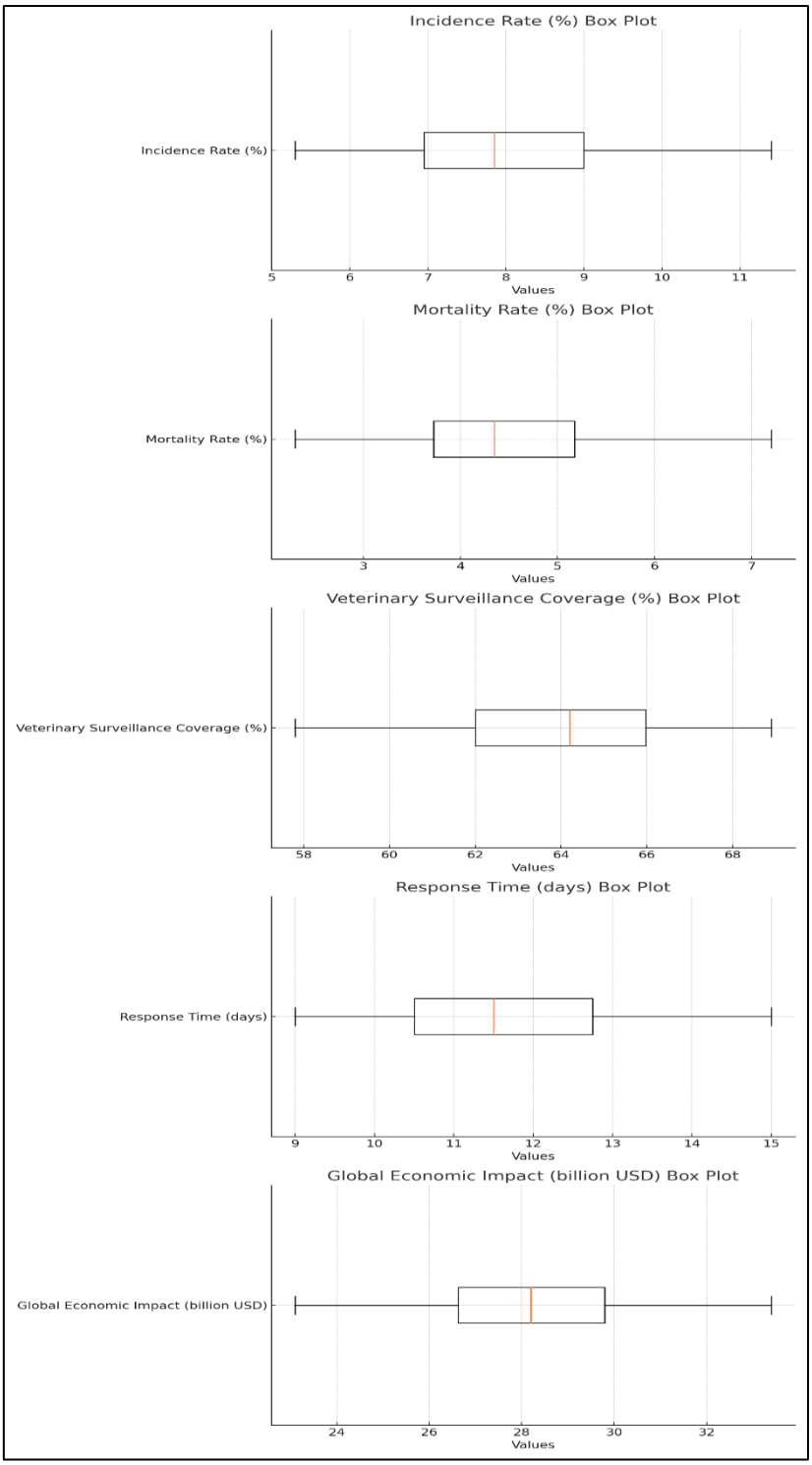

Figure 5: Representation of Statistical Analysis of Emerging Infectious Diseases in Veterinary Medicine Across the Globe

C. Importance of One Health approach in addressing zoonotic EIDs

The One Health approach is of paramount importance in addressing zoonotic emerging infectious diseases (EIDs) due to the interconnectedness of human, animal, and environmental

health. Zoonotic EIDs originate from animals and can spread to humans through direct or indirect contact, posing significant risks to public health [15]. The One Health approach recognizes that human health is intricately linked to the health of animals and ecosystems, and emphasizes interdisciplinary collaboration between human health, veterinary, and environmental professionals to address complex health challenges. By adopting a One Health approach, stakeholders can better understand the drivers of zoonotic EIDs, identify high-risk areas and populations, and implement effective prevention and control measures. This includes surveillance and early detection of zoonotic pathogens in animal populations, promoting responsible antimicrobial use, implementing biosecurity measures, and conducting interdisciplinary research to better understand disease transmission dynamics [16]. Furthermore, the One Health approach recognizes the socio-economic and environmental determinants of health, addressing underlying factors such as poverty, land use change, and climate change that contribute to the emergence and spread of zoonotic EIDs. By integrating human, animal, and environmental health considerations into policy, planning, and decision-making processes, the One Health approach enhances resilience to zoonotic disease threats and promotes sustainable health outcomes for both humans and animals.

V. Conclusion

Addressing emerging infectious diseases (EIDs) in veterinary medicine requires a comprehensive and collaborative approach that recognizes the interconnectedness of human, animal, and environmental health. EIDs pose significant global health challenges, with implications for animal welfare, food security, and public health. The globalization of trade and travel, habitat destruction, climate change, and antimicrobial resistance further exacerbate the complexity of managing EIDs. However, proactive surveillance, rapid response, and interdisciplinary collaboration offer viable solutions to mitigate the impact of EIDs on both animal and human populations. Enhanced surveillance systems, investment in research and development, and public awareness campaigns are essential components of effective EID prevention and control strategies. Additionally, promoting responsible antimicrobial use, implementing biosecurity measures, and strengthening veterinary and public health infrastructure are critical steps in building resilience to emerging infectious threats. By fostering cooperation between veterinarians, public health professionals, policymakers, researchers, and communities, we can effectively address the challenges posed by EIDs and safeguard the health and well-being of both animals and humans worldwide. Embracing the principles of One Health is paramount in promoting sustainable solutions that address the root causes of EIDs and foster a healthier and more resilient future for all.

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