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Societal Impacts of Zoonotic Diseases: Wildlife and Public Health Interactions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This article reviews the complex relationships between zoonotic diseases, wildlife, and public health while taking cognizance of how human activities such as habitat encroachment, climatic changes, and international trade amplify outbreaks. Zoonotic diseases, or diseases caught from animals, are a significant global challenge in public health. Over 60% of emerging infectious diseases come from wildlife, so zoonotic transmission is a significant threat to society. Diseases can be transferred from a wildlife species to humans directly, indirectly by acting as a carrier of pathogens, contacting humans or consuming animal products. Some of the recently notable examples include COVID-19, avian influenza, and Ebola. Such diseases have dramatically affected health, economic, and social aspects. In addition to the direct health impact, zoonotic disease transmission has profound social

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implications. Outbreaks cause billions of dollars in economic loss and really do affect industries through trade, tourism, or agriculture. On a societal level, these diseases can disrupt daily life, intensify inequalities, and strain healthcare systems, especially in resource-limited regions. This article highlights the importance of international cooperation, robust public health systems, and sustainable development practices in mitigating the risk of zoonotic disease transmission. By examining available literatures and assessing current policies, we provide recommendations for reducing the societal and public health impacts of wildlife-related zoonotic diseases in a rapidly changing world. This paper critically examines the multifaceted societal impacts of zoonotic diseases, delving into the complex interplay between wildlife, human behavior, and public health systems. It underscores the urgent need for integrated strategies to address the escalating threats posed by human-wildlife interactions and their public health implications.

Keywords: Zoonotic diseases; public health; wildlife; disease transmission; societal impact; sustainable development; COVID-19.

1. INTRODUCTION: ZOONOTIC DISEASES AND PUBLIC HEALTH

The human factor, animals, and environment together play an important role in the causation of as well as in transmitting a variety of infectious diseases. A number of infections which afflict human are essentially of animal origin (Woods, et al., 2019). It has been mentioned by the report of “Asia Pacific strategy for emerging diseases: 2010,” All these newly emerging diseases in human subjects within the last two decades had an animal origin and a direct association with food of animal origin. The term “Zoonoses” is derived from the Greek word “Zoon”, meaning animal, and “nosos”, meaning illness. (Woods, et al, 2019). According to WHO, any disease or infection that is naturally transmissible from vertebrate animals to humans or from humans to animals is classified as a zoonosis. Among the human pathogens, about 61% are zoonotic in nature. Zoonoses are a severe public health concern and pose a direct human health threat that might even cause deaths. These major zoonoses were very impactful on low- and middle-income livestock workers across the world. These diseases mainly damage the health of animals and lower the output of livestock (Woods, et al., 2019).

Improved sanitation, vaccines, and antimicrobial treatments significantly reduced infectious disease burdens in the developed world by the 1970s. However, the emergence of new diseases like toxic shock syndrome, Legionnaire’s disease, and the spread of HIV/AIDS in the 1980s redirected global health policies toward managing Emerging infectious diseases (McArthur, 2019). Zoonotic diseases—those transmissible between animals and humans—became especially concerning due to their rapid spread, high fatality rates, as seen in Ebola, and the lengthy processes often required for vaccine or treatment development, as with HIV/AIDS. In the 1990s, patterns of zoonotic disease emergence became evident, with many linked to pathogens originating from tropical wildlife, alongside environmental and human behavioural changes (Cupertino et al, 2020). Reports from the Institute of Medicine, such as Emerging Infections in 1992 and a 2003 update, highlighted microbial threats, propelling zoonotic disease into public awareness (Cupertino et al., 2020). Challenges continue to arise because zoonoses often deal with both public health and animal health jurisdictions, which can create "turf" problems and delays in the fund and policy. Diseases such as avian influenza affect two sectors but normally face funding and regulatory barriers because of the jurisdictional complexity. Zoonotic diseases pose a real danger in the public health arena, particularly in low- and middle-income countries, and are particularly hazardous for people working in livestock. Recent major outbreaks, including SARS, MERS, and COVID-19, stemmed from zoonotic pathogens often linked to wildlife trade and intensive animal production (Woods et al., 2019). Approximately 60% of newly emerging infections in humans are zoonotic, with over 70% of these traced to wildlife sources, underscoring the interconnected nature of human, animal, and environmental health. Cross-species transmission, as seen with SARS-CoV-2, poses new health risks as pathogens adapt in animal hosts and potentially return to humans in altered forms. Influenza is another example of this dynamic, having crossed between humans and swine repeatedly, complicating vaccine efforts.

Respiratory infections originating from humans have even had devastating effects on endangered species like gorillas and chimpanzees (Meslin, 2006).

2. WILDLIFE AND SOURCE OF ZOONOTIC DISEASES

The term wildlife relates to wild animals and uncultivated plants. It refers to animals that include fish, amphibians, reptiles, mammals, and birds. Of the 1,415 identified human pathogens, 62% are zoonotic, that is, they come from animals (Altaf, 2020). They pass on to man. Wild life is a multi-purpose resource for man with implications for culture, medicine, aesthetics, and the ecosystem. At the same time, wild life can become a bio-indicator for the state of the environment. However, they interact with wild animals at the human end where close contact might expose them to zoonotic disease risks through pathogens which might be directly transmitted from the animals, droplets, or through vectors (Altaf, 2020). Zoonotic diseases, in fact, have moulded human health concerns. The disease leprosy caused by Mycobacterium leprae emerged as a pandemic and attacked regions including Greece, India, and the Middle East around 23 AD (Altaf, 2020). It is thought to have originated from armadillos, and leprosy had deep social impacts (Altaf, 2020). Tuberculosis, caused by Mycobacterium tuberculosis, has also posed a chronic threat, recognized as "king's evil" in Europe and tied to animal vectors like elephants. Spanish influenza in 1918, which was associated with the H1N1 virus, began in the U.S. and resulted in approximately 50 million deaths worldwide, demonstrating how viruses borne by animals can be transmitted with devastating effects (Altaf, 2020). In the not-too-distant past, cases like MERS, which originated from camels in 2012, and SARS, which originated from bats in 2003, have demonstrated the potential of zoonotic diseases to be transmitted directly to humans, thereby posing enormous health risks (Altaf, 202). Ebola Virus Disease, which was first recognized in Africa in 1976, was characterized by very high case fatality rates and severe haemorrhagic fever (Altaf, 2020). This continues to be the potential of zoonoses, where new viruses continue to evolve and spread. MERS-CoV, transmitted by Arabian camels, has proven the potential for serious disease and human-to-human transmission with high case fatality rates (McCallum, 2005). SARS was the first identified in China; it spread very quickly by human contact but was contained through quarantine measures, limiting further transmission (Altaf, 2020). At the end of 2019, a new SARS-CoV-2 virus emerged. This virus causes COVID-19 and has zoonotic origins from bats and possibly pangolins with mutations that have enhanced transmissibility between humans. It is a different pathogen from SARS, since COVID-19 has more transmissibility and less immediate pathogenicity, hence it has resulted in a pandemic involving wide spread in the community (Altaf, 2020). Studies suggest SARS-CoV-2 may have arisen through recombination between bat and pangolin coronaviruses, which over time adapted to enable cross-species transmission (Altaf, 2020). Like many zoonotic diseases, pathogens often evolve for centuries through natural adaptations and mutations. However, though SARS and MERS were previously identified with relatively mild respiratory conditions, the evolution of such viruses toward higher virulence requires that surveillance of wildlife reservoirs take place to detect early-emerging pathogens. Preventive measures like health monitoring in humans and wildlife can prevent zoonotic threats. Disease prevention in animals and environmental hygiene are essential in reducing the risk of transmission of zoonotic pathogens from wildlife to humans, thereby safeguarding public health and ecosystem stability (Meslin, 2006).

Based on mode of transmission, Emerging infectious diseases among wild animals fall broadly into three categories. Of course, these would consist of spill overs, human-related, and unlinked Emerging infectious diseases involving domestic and human hosts directly, respectively. Wild animal hosts often serve as reservoirs for many pathogens from some mammals and birds to certain diseases that infect both animals and humans (Meslin, 2006). This dual role underlines two important biological implications: wild animals are primary reservoirs for a wide range of pathogens that can threaten both domestic animals and human health, and Emerging infectious diseases in wildlife significantly threaten biodiversity worldwide. Viruses, bacteria, and parasites spread through wild animals (McCallum, 2005). Such species include those that are associated with Ebola (EBOV) (Leroy et al., 2005) as the reservoir and SARS and Nipah virus (NiV). Characterization of the dynamics of transmission has been described as frequent contact between animals and humans; therefore, zoonotic epidemiology should be known in high-risk areas. Studies underscore the need to monitor these interfaces to prevent pandemics before they happen, especially in light of the global health burdens such diseases impose. Zoonotic diseases, estimated at over a billion cases per year, are an increasingly pressing challenge for densely populated regions and ecosystems with significant wildlife presence.

3. BIOSECURITY AND SURVEILLANCE MECHANISMS

Biosecurity and surveillance are among the tools applied in managing zoonotic diseases. This includes preventing and controlling entry of pathogens into populations or between animals and humans. It includes activities that might include hygiene practices by animal farms, proper disposal of waste products, proper and controlled movements of animals, vaccination, and using PPE among individuals involved with animals. It ensures that farms and borders where animals are reared for export and in the wildlife, habitat do indeed reduce risk since no infection takes place from a transmission of pathogens (Sharan et al, 2023). The surveillance mechanisms for zoonotic diseases are equally important as they facilitate early detection, monitoring, and response to potential outbreaks. Surveillance refers to the process of gathering, analysing, and interpreting data from sources such as veterinary clinics, livestock farms, and wildlife reserves. There are two types-primary active and passive surveillance. Active surveillance requires intentional taking of samples from animals and humans in high-risk sites to detect diseases before its spread. Passive surveillance has relied on reports of animals' clinical symptoms or mortality, mainly as they present themselves. Both help bring out disease patterns and risk to public health. With the advancement in technology, such as gene sequencing and real-time data analysis, these mechanisms of surveillance have improved the detection and identification of zoonoses and their response (Sharan et al, 2023). A global surveillance network is now set up by the collaboration of WHO and FAO with national governments to observe outbreaks, trace contacts, and issue timely warnings in advance. Because such collaborations link biosecurity practices with advanced surveillance mechanisms that prevent epidemics and safeguard animal and human health, there is a reduced risk of zoonotic diseases (Cupertino et al, 2020).

4. ZOONOTIC DISEASE MANAGEMENT: LEGAL AND ETHICAL DIMENSIONS

Emerging Infectious Diseases control is determined by context, alignment of stakeholder values, and public trust. For a liberal democracy, the overall agreement on what the public interest is and which values will drive that interest should be achieved (Sharan, et al, 2023). What this kind of previous experience has taught was the deep disagreement on competing values of personal liberties and collective good, the economic cost of controlling it, and the right of health professionals to detain against personal security. Such divisions will lead to public fear and mistrust, misinformation, resistance to health directives, hence making EID responses; such as a One Health approach, address such ethical issues and balance competing priorities leading to effective, fair solutions (van Herten et al, 2020). Policy effectiveness also hinges on public alignment; if not, competing values might block implementation. Public interest, therefore, needs to be clarified and defined early on in policy work. Legal frameworks for EID responses add further complexity, as they are complex and vary within jurisdictions. National, state, and local approaches also often require 'soft law' through executive or international mandates, such as IHR, rather than tough 'hard law' statutes (Cupertino et al, 2020). This layering often hinders regulatory clarity and can impede response efficiency and underscores the continued importance of sovereign states in the governance of EID, in spite of global governance trends. Public health laws primarily concern cross-border transmission and community outbreaks without addressing the root conditions of Emerging infectious diseases that consist of environmental degradation and intensive agriculture (Degeling et al., 2015). Environmental laws could more effectively respond to these root conditions, but restrictions on development may raise global health inequalities in these emerging economies and may modify health outcomes. These tensions need to be resolved through open identification of the beneficiaries and cost-bearers of One Health strategies. Clear legal frameworks outlining the interlinked roles played by policymakers, health professionals, and biosecurity authorities will establish coordination and supportive structures for a combined unified and effective response against all EID threats. Legally clear frameworks constitute fundamental building blocks in shaping all-inclusive infrastructure for health security and sustainable development on all EID management areas (Degeling et al., 2015).

5. CONTRIBUTING FACTORS TO THE EMERGENCE OF ZOONOTIC DISEASE

The emergence of zoonotic diseases is influenced by a combination of ecological, environmental, and human behavioral factors. Deforestation, urbanization, and habitat destruction disrupt natural ecosystems, increasing interactions between humans and wildlife, thereby facilitating the spillover of pathogens (Tran, Kassié, & Herbreteau, 2016). Agricultural expansion, illegal wildlife trade, and wet markets further intensify these risks. Climate change alters the habitats of vectors such as mosquitoes and ticks, expanding the geographic reach of zoonotic pathogens. Once transmitted to humans, zoonotic diseases often spread through direct contact with infected animals, consumption of contaminated animal products, or secondary human-to-human transmission (van Herten, Buikstra, Bovenkerk, & Stassen, 2020). The impacts are profound, affecting human health by causing outbreaks with high morbidity and mortality rates. Economically, these diseases burden healthcare systems, disrupt trade, and cause significant losses in livestock industries. Societal structures are strained as outbreaks exacerbate inequalities, disrupt social cohesion, and highlight gaps in public health preparedness and response systems.

6. RESULTS AND ANALYSIS

The studies reviewed suggest that mammals, particularly bats and primates, are significant reservoirs for zoonotic diseases. The most common pathogens that are found are viruses, which have a greater ability to recombine and thereby an increased chance of mutation; meaning, therefore the appearance of strains that have a greater virulence (Ferreira et al., 2021). Some of the examples of the bat viruses include coronaviruses, arenaviruses, and filoviruses, which have the potential of recombining and possibly making new pathogens. This ability of recombining is a significant factor for the rise of new, potentially more virulent disease strains, such as in SARS-CoV and Ebola outbreaks (Menachery et al., 2015). There have been documented recombination events among viruses in bats and other wild animals in recent outbreaks (Wang & Crameri, 2014). A prime example is the 2014 outbreak of Ebola in Africa, resulting in more than 8,600 deaths. In this respect, the COVID-19 pandemic has also focused attention on the zoonotic origin of such outbreaks. Wet markets in China have become a hub where animals, often stressed to near-extreme conditions, come together-an ideal situation for viral recombination and transmission to humans. Birds and other animals, including camels and rodents, became disease reservoirs where pathogens were disseminated by migratory patterns across regions. Such conclusions are reverberating the need for continuous vigilance and watchfulness, which is supposed to be more targeted towards the high-risk zones to prevent the spread of diseases initiated and facilitated by both environmental and anthropogenic factors.

Australia possesses a healthy security system that detects and responds to zoonotic diseases through a holistic approach involving both the human, animal, and environmental health sectors (Woods et al.,2019). Anchored on One Health commitment, the system has recognized that these sectors connect with one another, wherein most emerging infectious diseases initially originate from wildlife before they reach human. This structure coordinates disease surveillance with more than 30 partner organizations and employs Wildlife Health Information System (eWHIS) [Grillo et al,2016) a real-time web-enabled database to monitor the health of wildlife across Australia. Australia's biosecurity strategy is implemented at several levels: pre-border, border, and post-border and is characterized by a huge emphasis on early detection and rapid response (Tajudeen et al., 2022). The operation of this structure is governed by a national biosecurity business plan whose top priority is surveillance on wildlife diseases especially those threatening public health, agriculture, biodiversity, and trade. Further, Australia's international partnership enhances its health security system; the WHO and the World Organisation for Animal Health (OIE) (Stafford & Mellor, 2009) have recognized Australia's integration between human and animal health (Woods et al.,2019). The Australian Chief Veterinary Officer works closely with the OIE and national health agencies to ensure that they share knowledge and data reporting internationally just like on GenBank, but there are numerous challenges for Australia to track wildlife diseases (Zhang, Guo, & Lv, 2024). Data is limited, and there is variability in surveillance, along with inadequate standardized indicators to measure success (Damborg et al., 2016). These gaps will be addressed through targeted workforce development, especially in recruiting much-needed specialized professionals, including disease ecologists (Woods et al.,2019). Environmental issues, for example, climate change alter disease trends, and Australia has set the Chief Environmental Biosecurity Officer (ACEBO)(woods et al., 2019) position to enhance the integration of environment into the works of biosecurity. Technological innovations, including genomic sequencing, become increasingly critical in monitoring pathogens, for instance, Avian Influenza Wild Bird Surveillance Program, which employs genetic data to understand the likelihood of zoonosis (Wang & Crameri, 2014). Some of the recommendations that may likely emanate from the WHO's Joint External Evaluation include special zoonosis committee development, standardization of laboratory practices, and a National Action Plan for Health Security. These would see the country move a step closer to conformed world standards as the inter-sectoral collaboration is also enhanced. Australia will be an example of integrated health security when it has been proactive and set to innovation and collaboration (Cunningham, Daszak, & Wood, 2017). The nation extends on wildlife surveillance; promotes workforce capacity; and employs genomics in enhancing preparation towards zoonotic diseases, and Australia sets an example for international public health resilience (Wang & Crameri, 2014).

Global ecosystems with their biodiversity are highly degrading due to increased anthropogenic activities like urbanization, industrialization, and pollution. Such disturbances are not only impacting the local environment but are also bringing humans into increased interaction with wildlife, increasing the chance of zoonotic disease transmission. Emerging infectious diseases, which have been increasing in the past two decades, are a particular cause for concern (Cupertino et al, 2020). These diseases have been a result of known pathogens adapting to new hosts or of novel pathogens like West Nile Virus, SARS, MERS-CoV, and most recently, COVID-19, in a global health-begone worldwide threat. The association of these diseases with wildlife requires the investigation of how wild animals serve as reservoirs for infectious agents that amplify and disseminate them across ecological boundaries into humans under favorable ecological conditions (Sharan, et al, 2023).

7. FUTURE DIRECTIONS AND RECOMMENDATIONS

Emerging technologies and innovative solutions have tremendous potential for increasing the monitoring and response systems for zoonotic diseases. However, these advancements solely hold great potential, but further research is required as well as practical applications in their fullest effectiveness in the prevention and management of diseases (Hayman et al., 2013).

- **Big Data Analytics**

Big data analytics allows improving zoonotic disease surveillance through processing massive numbers of complex data from different sources. According to the "five Vs" — volume, variety, velocity, veracity and value — (Dhamodharavadhani et al., 2018) it enables real time management of data from such sources as animal health records, environmental sensors, human health statistics, and social media. By using advanced analytics, patterns or anomalies can be discovered, thus tenoting a possible outbreak (Milich & Morse, 2024). For instance, through social media and health reports, public health officials with timely insights into unusual clusters of symptoms or diseases that could have zoonotic characteristics (Godfroid, 2017). Ensuring data accuracy, confidentiality, and interoperability between systems, however, is very challenging. Overcoming these challenges will help unlock big data to support swift response and prediction in the management of zoonotic disease[s] (Di Bari et al., 2023).

- **Artificial Intelligence (AI) and Machine Learning (ML)**

AI and ML have transformed disease surveillance through the automatic examination of data, making it more End Forecasting skills as well as alerting for emerging threats (Liguori et al., 2023). ML, both supervised and unsupervised models learn complex patterns without explicit programming. For instance, supervised ML can predict outbreak hotspots using historical data but unsupervised ML may detect trends with no explanation that indicate new risks (Ajayi et al., 2024). ML models can even track wildlife behavior for an unusual pattern that may indicate zoonotic threats. Despite these promises, AI/ML integration raises challenges that need attention on data quality, algorithmic bias, and ethical considerations. Surrounding healthcare data privacy (Zhang, Guo, & Lv, 2024). These new technologies must be set within clear regulatory frames to enable them to effectively support zoonotic disease surveillance and response (Awaidy & Al Hashami, 2020).

- **Internet of Things (IoT) and Sensors**

IoT networks link sensor-enabled devices, which ensure continuous, real-time data acquisition and monitoring. In zoonotic disease surveillance, IoT sensors monitor biological, environmental, and health parameters in the wildlife, livestock, and human populations (Rahman et al., 2020). For example, biosensors in livestock facilities monitor the key health and environmental indicators associated with disease transmission (Crozier & Schulte-Hostedde, 2014). The IoT system should raise an alert if there is an abnormal reading or trend of the vectors, climate, or movements of animals (Kruse, Kirkemo, & Handeland, 2004). However, full exploitation of IoT to detect the disease at early stages and continuous surveillance are hindered by cybersecurity risks, data management, and logistical issues in deploying sensors in remote areas [Sharan et al, 2023].

- **Geographic Information Systems (GIS)**

GIS may track zoonotic diseases through the collection, processing, and spatial analysis to represent a comprehensive geographic pattern of disease distribution. It can also trace vector-borne diseases like mosquitoes or wildlife that keep on approaching people. For instance, GIS has been instrumental in mapping the regions of yellow fever and cholera. Moreover, GIS can make an early warning of such outbreaks (Mengistu et al, 2017). Now, modern GIS tools encompass predictive models that account for environment changes, animal migration, and urbanization. This has equipped the prevention of diseases (Gwenzi et al., 2022). Issues related to interoperability of data, spatial resolution, and privacy need to be sorted out so that GIS can perform its optimum role in public health decision-making (Di Lorenzo et al, 2023].

- **Satellite Imagery and Remote Sensing**

Remote sensing technologies take information regarding environmental determinants of zoonotic disease dynamics by using satellite and aerial sensors (Amman et al., 2015). This method captures real-time images and enables the quantification of variables like vegetation, temperature, and water, which can influence the vectors' habitats. In this regard, seasonality monitoring assists in predicting when the mosquito will breed, which is an essential aspect for controlling malaria [Tran et al, 2016]. The improvement in thermal and infrared sensors enhances the strength of disease surveillance by monitoring the movement and irregularities of animals. However, remote sensing is influenced by climatic conditions as well as spatiotemporal limits. Despite all these, early detection incorporation with remote sensing data enhances proactive public health responses to zoonotic risks [Ajayi et al, 2024).

- **Molecular Technologies**

Molecular technologies are pivotal to quick detection and characterization of zoonotic pathogens. Techniques such as Polymerase Chain Reaction (PCR) amplify DNA or RNA sequences, enabling the presence of pathogens to be detected at very high sensitivity levels such as Brucella and Leptospira in animals, and hence prompt intervention can be taken [Zhang et al, 2024]. Additional technologies include genome sequencing and multiplex real-time PCR that is very helpful for the detection of multiple pathogens at the same time, especially in areas with a wide range of diseases (González-Barrio, 2022). However, these are highly expensive technologies requiring special equipment and trained personnel. Improving access to mobile molecular devices and training will increase molecular surveillance and allow a faster response time to the zoonotic outbreaks, which may be remote or with limited resources (Rana et al, 2023).

- **Early Warning Systems**

Early warning systems are needed to pre-reckon and control zoonotic disease outbreaks in their early stages (World Health Organization, 2009). This system analyses data from IoT sensors, remote sensing, and health records, identifying risk increases before reaching the critical outbreak stage (Rupasinghe, Chomel, & Martínez-López, 2022). Early warning devices for poultry can alert people through distress calls on failing chickens, which leads to quick detection and intervention (Kshirsagar et al, 2013). Early warning systems minimize loss and diminish public health risks for the agricultural issues. The limitation of such a system is related to the absence of the integration of data with response mechanisms and the interconnection requirement with national and international health databases (Capps et al., 2015). All these problems are addressed towards improvement in the effectiveness of early warning systems in the mitigation of threats from zoonotic diseases (Kshirsagar et al, 2013).

8. CONCLUSION

Despite the identification of wildlife as a critical factor in disease transmission, significant knowledge gaps remain. The exact transmission pathways for certain diseases, such as MERS-CoV and COVID-19, are not fully understood, although bats and possibly other wild animals have been implicated. Studies indicate that while bats and snakes may host precursors to COVID-19, comprehensive molecular investigations are still needed. These gaps highlight the importance of improved global health strategies focusing on prevention, enhanced disease surveillance, and predictive epidemiology (Bag & Sengupta, 2024). The complexity of viral recombination and transmission in wild animals poses a unique challenge. Viruses coexisting in a single animal host can exchange genetic material, increasing the likelihood of emergent strains with unpredictable pathogenicity. This was exemplified in the H1N1 Influenza outbreak and newer strains of Hepatitis E found in wild boars. Additionally, environmental changes due to human activities—such as urbanization, deforestation, and climate change—further complicate the disease dynamics, creating favourable conditions for zoonotic spill over.

To address these challenges, health authorities must implement broader and more robust surveillance of disease reservoirs in wildlife. Ecological factors, including climatic variations and interactions within ecosystems, play a role in the emergence of new diseases, making it essential to monitor these components in tandem with disease prevention efforts. Strengthening the capacity for rapid response to outbreaks is critical, especially in high-risk interfaces where animal and human populations intersect frequently [Milich & Morse, 2024]. The role of wild animals in amplifying and spreading infectious diseases to humans is well-documented but remains an area requiring further research and targeted preventive strategies. Emerging and re-emerging zoonotic diseases have demonstrated the importance of monitoring animal reservoirs and understanding the ecological and environmental contexts in which these pathogens evolve. As seen in past outbreaks, such as those involving Ebola and COVID-19, wildlife trade, and other human activities that disrupt natural habitats, increase the probability of zoonotic disease transmission (Chua, 2003). Thus, surveillance systems must therefore be equipped to detect early signs of zoonotic spill over and monitor high-risk animal-human interfaces to mitigate future pandemics. Social, economic, and cultural factors play a critical role in mitigating zoonotic disease outbreaks and reducing their societal impact. Strengthening healthcare systems and ensuring equitable access to medical resources can curb the spread of diseases and protect vulnerable populations. Economically, investments in sustainable agriculture and regulated wildlife trade reduce human-wildlife interactions, a key factor in zoonotic spillovers. Culturally, public awareness campaigns tailored to local customs and beliefs can promote safer practices, such as improved hygiene, responsible animal handling, and dietary habits. Collaborative global efforts, such as the "One Health" approach, which integrates human, animal, and environmental health strategies, are essential for addressing the root causes of zoonotic diseases and minimizing their social and economic toll.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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