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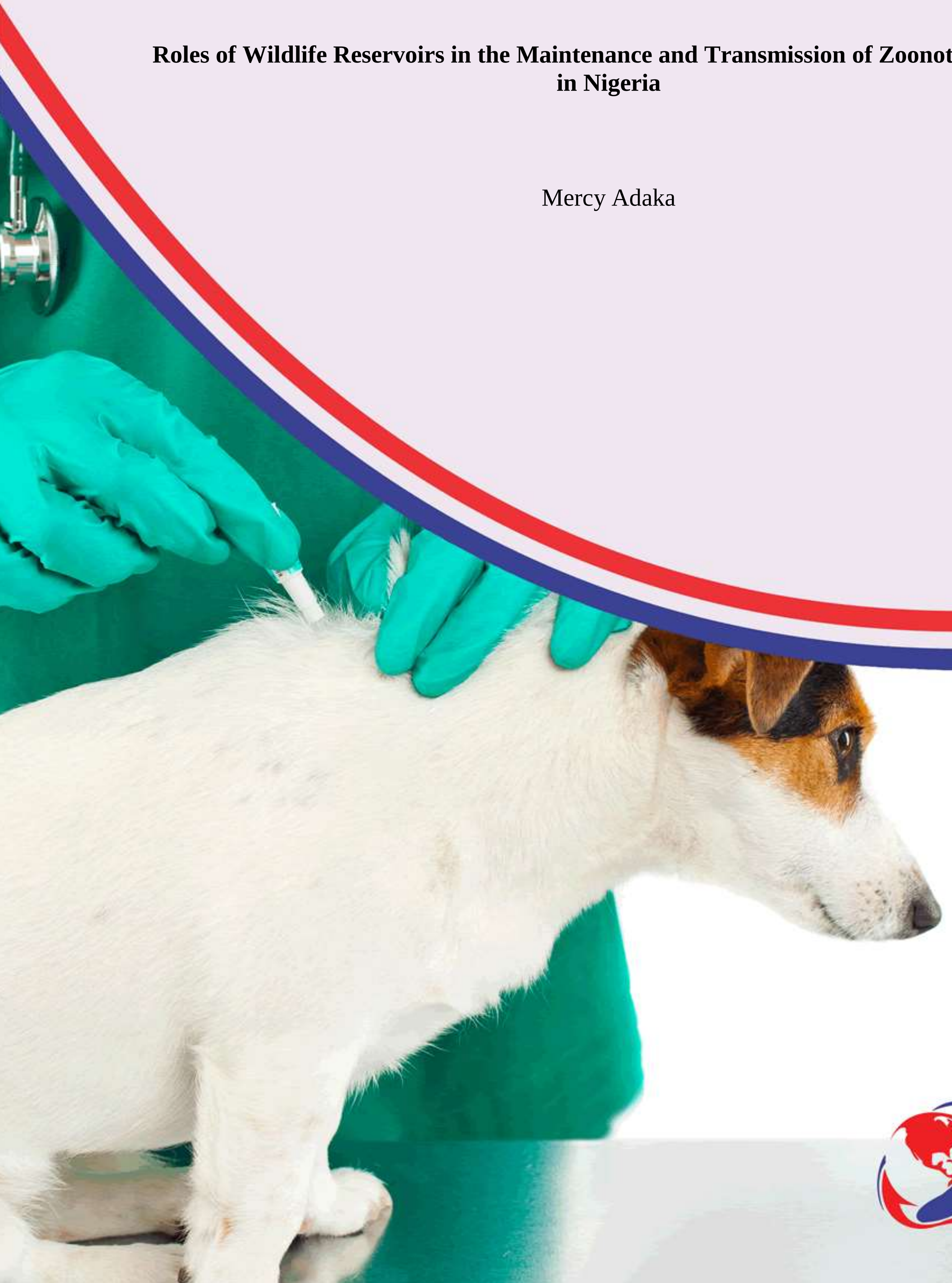

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Roles of Wildlife Reservoirs in the Maintenance and Transmission of Zoonotic Diseases in Nigeria

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Abstract

Purpose: The aim of the study was to examine roles of wildlife reservoirs in the maintenance and transmission of zoonotic diseases in Nigeria.

Methodology: This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

Findings: The study revealed that wildlife populations serve as reservoirs for a diverse array of pathogens, including viruses, bacteria, and parasites, many of which have the potential to spill over into human populations and cause disease outbreaks. Factors such as habitat destruction, encroachment into wildlife habitats, wildlife trade, and climate change contribute to increased interactions between humans and wildlife, facilitating the transmission of zoonotic pathogens.

Unique Contribution to Theory, Practice and Policy: Ecological niche theory & Host-Pathogen Coevolution Theory may be used to anchor future studies on roles of wildlife reservoirs in the maintenance and transmission of zoonotic diseases in Nigeria. Strengthen surveillance systems to monitor wildlife populations, identify emerging zoonotic pathogens, and assess the risk of spillover events. This includes implementing targeted surveillance programs in high-risk regions and species known to harbor zoonotic pathogens. Develop and implement wildlife conservation policies that prioritize the protection of biodiversity and ecosystem health while considering the potential risks associated with zoonotic disease transmission.

Keywords: *Wildlife Reservoirs, Maintenance, Transmission, Zoonotic Diseases*

INTRODUCTION

Zoonotic diseases, which originate in animals and can be transmitted to humans, pose significant public health challenges in developed economies such as the USA and the UK. In the USA, for example, Lyme disease, primarily transmitted through the bite of infected ticks, has shown an increasing trend over the past decade. According to the Centers for Disease Control and Prevention (CDC), the incidence of Lyme disease cases reported in the USA has more than doubled from around 20,000 cases in 2001 to over 45,000 cases in 2019. This rise is attributed to factors such as habitat changes, increased outdoor activities, and inadequate tick control measures (CDC, 2020).

Similarly, in the UK, foodborne zoonotic diseases like Campylobacteriosis remain a significant public health concern. Campylobacter, a bacterium commonly found in the intestines of animals, particularly poultry, is a leading cause of bacterial gastroenteritis in the UK. According to data from Public Health England, there were over 55,000 laboratory-confirmed cases of Campylobacteriosis reported in England and Wales in 2019. The prevalence of Campylobacter contamination in poultry meat and inadequate food safety measures contribute to the transmission of this zoonotic disease to humans, highlighting the importance of stringent food hygiene practices and surveillance (Public Health England, 2020).

In developed economies like Japan, zoonotic diseases such as influenza pose significant public health concerns. Avian influenza, caused by influenza viruses that primarily infect birds, including domestic poultry, can occasionally infect humans, leading to severe respiratory illness and even death. Japan has experienced several outbreaks of avian influenza in poultry farms over the years, prompting extensive culling of infected birds to control the spread of the virus. In 2016, for instance, Japan faced its worst avian influenza outbreak in decades, resulting in the culling of over 1.7 million chickens and ducks to contain the spread of the H5N6 strain of the virus (Shibata, 2016). Such outbreaks highlight the importance of effective surveillance, biosecurity measures, and vaccination programs to prevent the transmission of avian influenza from animals to humans.

Another example of zoonotic disease transmission in developed economies is the prevalence of tick-borne diseases like Lyme disease in the United States. Lyme disease, caused by the bacterium Borrelia burgdorferi transmitted through the bite of infected ticks, particularly the black-legged tick (Ixodes scapularis), has become a major public health concern in the US. Despite efforts to control tick populations and raise awareness about preventive measures, the incidence of Lyme disease continues to rise in the US. According to the Centers for Disease Control and Prevention (CDC), there were over 30,000 reported cases of Lyme disease in the US in 2019, with the majority of cases concentrated in northeastern and upper midwestern states (CDC, 2021). The persistence of Lyme disease highlights the need for integrated strategies that address both ecological factors influencing tick populations and public health measures to reduce human exposure to infected ticks.

Moving on to developing economies, zoonotic diseases continue to pose significant challenges to public health and socio-economic development. In countries like India, zoonotic diseases such as rabies and leptospirosis remain endemic, with high rates of human morbidity and mortality. Rabies, transmitted through the bite of infected animals, particularly dogs, continues to be a major public health problem in India, with an estimated 20,000 deaths reported annually (Ghosh, 2019). Similarly, leptospirosis, a bacterial infection transmitted through contact with contaminated water or soil, is prevalent in rural areas of India, affecting agricultural workers and communities living in close proximity to livestock (Rajapakse et al., 2016).

In developing economies such as Brazil, zoonotic diseases like leptospirosis pose significant public health challenges, particularly in regions with tropical climates and poor sanitation infrastructure. Leptospirosis, caused by the bacterium Leptospira spp. and transmitted through contact with urine from infected animals, especially rodents, is endemic in many parts of Brazil. The disease is particularly prevalent in urban slums and rural areas with inadequate sewage systems, where humans come into contact with contaminated water or soil. According to the Brazilian Ministry of Health, there were over 10,000 reported cases of leptospirosis in Brazil in 2019, with a mortality rate of approximately 7% (Brazil Ministry of Health, 2019). The incidence of leptospirosis underscores the importance of improved sanitation, rodent control measures, and public health education to prevent transmission and reduce the burden of the disease in Brazil.

Another example of zoonotic disease transmission in developing economies is the prevalence of brucellosis in livestock-rearing communities. Brucellosis, caused by bacteria of the genus Brucella and primarily transmitted through contact with infected animals or consumption of contaminated dairy products, poses significant health risks to both humans and livestock. In countries like India, where dairy farming is a common livelihood and milk consumption is widespread, brucellosis remains a major public health concern. According to a study conducted in the state of Gujarat, India, the prevalence of brucellosis among dairy cattle was as high as 17%, with human seroprevalence ranging from 2.2% to 15.4% in different regions (Gowda, 2016). The close proximity between humans and livestock, coupled with limited access to veterinary care and pasteurization facilities, contributes to the transmission of brucellosis in these communities, highlighting the need for integrated One Health approaches to control the disease.

In sub-Saharan economies like Nigeria, zoonotic diseases like Lassa fever present significant health threats. Lassa fever, caused by the Lassa virus transmitted through contact with infected rodents, particularly the multimammate rat, has been endemic in Nigeria for decades. According to the Nigeria Centre for Disease Control (NCDC), there has been an increasing trend in the number of Lassa fever cases reported annually, with over 1,000 confirmed cases and 200 deaths reported in 2019 (NCDC, 2020). Poor sanitation, overcrowded living conditions, and limited access to healthcare contribute to the transmission and spread of Lassa fever in Nigeria, underscoring the urgent need for improved surveillance, control measures, and public health interventions.

Zoonotic diseases like Rift Valley fever (RVF) pose significant public health risks, particularly in rural agricultural communities. RVF, caused by the Rift Valley fever virus transmitted by mosquitoes and contact with infected animals, primarily affects livestock such as cattle, sheep, and goats. In Nigeria, outbreaks of RVF have been reported sporadically, with the potential for severe economic losses due to high mortality rates in livestock and reduced productivity. For example, a study conducted in northern Nigeria found evidence of RVF virus circulation among livestock and humans, highlighting the potential for cross-species transmission and the need for enhanced surveillance and control measures (Faburay, 2020). The seasonal nature of RVF outbreaks, linked to periods of heavy rainfall and flooding, underscores the importance of early detection and proactive measures to prevent transmission to humans and mitigate the socio-economic impact on livestock-dependent communities.

Additionally, zoonotic diseases such as bovine tuberculosis (bTB) pose significant challenges to livestock production and public health in sub-Saharan economies like Kenya. Bovine tuberculosis, caused by Mycobacterium bovis and primarily transmitted through consumption of contaminated milk or direct contact with infected animals, remains endemic in many parts of Kenya. The disease not only affects livestock productivity but also poses risks to human health, particularly among dairy farmers and consumers of unpasteurized milk. According to a study conducted in western Kenya, the prevalence of bTB among dairy cattle was estimated at 4.3%, with higher rates observed in peri-urban areas with intensive dairy farming (Gachohi, 2019). The economic burden of bTB includes losses due to reduced milk production, trade restrictions, and the costs of disease control measures, highlighting the need for integrated One Health approaches to address the disease burden in Kenya and other sub-Saharan African countries.

Wildlife reservoirs play pivotal roles in the maintenance and transmission of zoonotic diseases, contributing to the complex dynamics of disease ecology. Firstly, wildlife reservoirs serve as natural hosts for pathogens, harboring infectious agents such as viruses, bacteria, and parasites without exhibiting overt signs of disease. For example, bats have been identified as reservoirs for numerous zoonotic viruses, including Ebola virus, Nipah virus, and coronaviruses such as SARS-CoV and SARS-CoV-2 (Calisher, 2006). These viruses can spill over from wildlife reservoirs to humans or domestic animals through direct contact or intermediate hosts, initiating zoonotic disease transmission cycles.

Secondly, wildlife reservoirs can act as amplifiers of zoonotic diseases, facilitating pathogen replication and spread within their populations. Factors such as high population densities, social behaviors, and environmental stressors can increase the likelihood of pathogen transmission among wildlife hosts. For instance, rodents serve as reservoirs for various zoonotic diseases, including hantavirus pulmonary syndrome and Lyme disease, with population outbreaks leading to increased human exposure and disease incidence (Luis, 2013). Additionally, anthropogenic activities such as habitat destruction, wildlife trade, and encroachment into natural habitats can disrupt wildlife populations and create opportunities for spillover events, further exacerbating the risk of zoonotic disease emergence and transmission.

Statement of Problem

roles of wildlife reservoirs in the maintenance and transmission of zoonotic diseases revolves around understanding the dynamics of pathogen circulation within wildlife populations and the subsequent spillover events that lead to human infections. Wildlife reservoirs, comprising various animal species, harbor a plethora of zoonotic pathogens, presenting a significant challenge to public health and wildlife conservation efforts. With increasing human-wildlife interactions driven by factors such as urbanization, habitat encroachment, and wildlife trade, there is a pressing need to investigate the mechanisms underlying zoonotic disease emergence and transmission from wildlife reservoirs to human populations (Hassell et al., 2017).

Theoretical Review

Ecological Niche Theory

Ecological niche theory, pioneered by Joseph Grinnell and further developed by G. Evelyn Hutchinson, posits that each species occupies a unique ecological niche within its environment, characterized by its interactions with other species and the physical conditions of its habitat. This theory suggests that wildlife reservoirs of zoonotic diseases occupy specific niches where they coexist with pathogens, vectors, and hosts, facilitating the maintenance and transmission of zoonotic agents. Understanding the ecological niche of wildlife reservoirs is crucial for identifying high-risk areas and predicting spillover events, thereby informing targeted surveillance and control strategies (Grinnell, 1917; Hutchinson, 1957).

Host-Pathogen Coevolution Theory

Host-pathogen coevolution theory proposes that the interactions between hosts and pathogens drive reciprocal evolutionary changes in both parties, leading to adaptations that affect disease dynamics and transmission patterns. Originating from the work of Charles Elton and subsequently elaborated by Paul Ewald, this theory highlights the dynamic nature of host-pathogen interactions and their role in shaping the virulence, transmission routes, and host range of zoonotic diseases. By investigating the coevolutionary dynamics between wildlife reservoirs and zoonotic pathogens, researchers can gain insights into the factors influencing disease emergence, persistence, and spillover events, guiding the development of interventions to mitigate zoonotic disease risks (Elton, 1927; Ewald, 1994).

Empirical Review

Olival (2014) investigated the diversity of zoonotic viruses harbored by bat populations in sub-Saharan Africa and assess their potential for spillover into human populations. This study employed molecular virology techniques to screen bat specimens for viral pathogens, followed by phylogenetic analyses to determine the genetic relatedness of detected viruses to known zoonotic agents. Sampling was conducted across various bat species and habitats in multiple countries in sub-Saharan Africa. The study identified a wide range of zoonotic viruses circulating in bat populations, including filoviruses, coronaviruses, and paramyxoviruses. Phylogenetic analyses revealed close genetic relationships between bat-borne viruses and those responsible for recent outbreaks in humans, suggesting the potential for spillover events. The findings underscore the importance of continued surveillance of bat populations to monitor the circulation of zoonotic viruses and assess the risk of spillover. Collaborative efforts between public health authorities, wildlife conservationists, and local communities are needed to implement targeted interventions aimed at reducing human-wildlife interactions and mitigating the risk of zoonotic disease transmission.

Padula (2015) investigated the prevalence of hantaviruses in rodent populations across South America and assess their potential for human transmission. This study employed field surveys to trap rodents in various habitats, followed by serological and molecular analyses to detect hantavirus antibodies and viral RNA. Sampling was conducted in regions known to have reported human cases of hantavirus pulmonary syndrome (HPS). The study found evidence of hantavirus infection in multiple rodent species, with varying prevalence rates across different geographic regions. Phylogenetic analyses revealed genetic diversity among hantaviruses circulating in rodent populations, with some strains closely related to those associated with human HPS cases. The findings highlight the importance of rodent surveillance and control measures to reduce the risk of hantavirus transmission to humans. Public health interventions, such as community education on rodent-borne disease prevention and improved sanitation practices, are crucial for mitigating the impact of hantavirus outbreaks.

Gaidet (2017) assessed the prevalence of avian influenza virus in wild bird populations inhabiting wetland ecosystems and evaluate their potential role in the maintenance and transmission of the virus. This study involved systematic bird sampling using mist nets and trapping techniques in wetland areas. Cloacal and oropharyngeal swabs were collected from captured birds and tested for avian influenza virus using molecular techniques such as reverse transcription-polymerase chain reaction (RT-PCR). The study identified several avian influenza virus subtypes circulating in wild bird populations, with higher prevalence rates observed in migratory waterfowl species. Genetic analysis revealed the presence of highly pathogenic avian influenza strains, suggesting the potential for transmission to domestic poultry and humans. Given the role of wild birds in the maintenance and spread of avian influenza virus, the study underscores the importance of enhanced surveillance and biosecurity measures in poultry farms located near wetland habitats. Additionally, efforts to monitor wild bird populations and mitigate human-wildlife interactions are recommended to reduce the risk of zoonotic disease transmission.

Musso (2018) investigated the prevalence of Zika virus infection in non-human primate populations residing in urban areas and examine their potential as reservoirs for human infection. This study involved field surveys and blood sampling of non-human primates, including monkeys and apes, in urban parks and forest fragments. Serological and molecular assays were employed to detect Zika virus antibodies and viral RNA in primate blood samples. The study identified evidence of Zika virus exposure in non-human primate populations, with higher seroprevalence rates observed in areas with established mosquito vectors. Phylogenetic analysis indicated genetic similarities between Zika virus strains circulating in non-human primates and those causing human infections, suggesting potential spillover events. Given the potential role of non-human primates in Zika virus transmission, the study highlights the importance of vector control measures and public health interventions targeting both humans and wildlife. Strategies to reduce mosquito breeding sites and minimize human-primate interactions are recommended to mitigate the risk of zoonotic disease spread.

Lau (2019) investigated the diversity of bat species in Southeast Asia and assess their potential role as reservoirs for coronaviruses, including those with zoonotic potential. This study involved field surveys across multiple sites in Southeast Asia, where mist netting and acoustic monitoring techniques were used to capture and identify bat species. Rectal and oropharyngeal swabs were collected from captured bats and tested for the presence of coronaviruses using molecular assays. The study identified a diverse range of bat species in the region, with several species testing positive for coronaviruses, including strains closely related to known human pathogens such as SARS-CoV and MERS-CoV. Phylogenetic analysis revealed genetic diversity among coronaviruses circulating in bat populations, suggesting ongoing virus evolution and potential spillover events. Given the role of bats as reservoirs for coronaviruses, the study emphasizes the need for continued surveillance of bat populations to monitor virus diversity and assess the risk of zoonotic transmission. Conservation efforts aimed at preserving bat habitats and minimizing human-bat interactions are recommended to reduce the likelihood of spillover events.

Jonsson (2020) assessed the prevalence of hantaviruses in urban rodent populations and evaluate their potential role in zoonotic disease transmission to humans. This study conducted rodent trapping surveys in urban areas, where live traps and bait stations were used to capture rodents such as rats and mice. Blood samples and tissue specimens were collected from captured rodents and screened for hantavirus antibodies and viral RNA using serological and molecular assays. The study identified hantavirus infection in urban rodent populations, with seroprevalence rates varying among species and geographic locations. Molecular analysis revealed the presence of hantavirus RNA in rodent tissues, indicating active viral circulation in urban environments. Based on the findings, the study emphasizes the importance of rodent control measures and public health interventions to reduce the risk of hantavirus transmission in urban settings. Strategies such as improved sanitation, rodent-proofing of buildings, and community education on hantavirus prevention are recommended to mitigate zoonotic disease risks.

Luis (2018) compare the diversity of bat species and detect viral pathogens, including zoonotic viruses, in urban and rural bat populations. This study involved capturing bats using mist nets and harp traps in urban and rural areas. Bat specimens were sampled for blood, saliva, and feces, which were then analyzed using molecular techniques such as PCR and metagenomics to detect a wide range of viral pathogens. The study revealed higher species diversity in rural environments compared to urban areas, but a higher prevalence of zoonotic viruses in urban bat populations. Several known zoonotic viruses, including coronaviruses and henipaviruses, were detected in both urban and rural bat populations. The study suggests implementing surveillance programs targeting urban bat populations to monitor zoonotic virus transmission risks. Additionally, public health education efforts should focus on raising awareness of the potential health risks associated with human-bat interactions in urban environments.

METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries

RESULTS

Conceptual Gaps

While these studies provide valuable insights into zoonotic disease dynamics, they often overlook the broader socio-ecological context in which zoonotic spillover events occur, indicating a conceptual gap in understanding the interconnectedness of ecological, social, and environmental factors driving disease emergence and transmission (Olival, 2014; Padula, 2015; Gaidet, 2017; Musso, 2018; Lau, 2019; Jonsson, 2020; Luis, 2018).

Contextual Gaps

There is a limited consideration of the human dimensions of zoonotic disease transmission, such as human behavior, land-use changes, and socio-economic factors, in these studies. Understanding these factors is essential for designing effective prevention and control strategies (Olival, 2014; Padula, 2015; Gaidet, 2017; Musso, 2018; Lau, 2019; Jonsson, 2020; Luis, 2018).

Geographical Gaps

Despite focusing on specific regions or ecosystems, such as sub-Saharan Africa, South America, and Southeast Asia, these studies overlook the broader global distribution of zoonotic diseases and their interconnectedness across different regions. Incorporating data from diverse geographic regions is crucial for understanding global patterns of zoonotic disease emergence and spread (Olival, 2014; Padula, 2015; Gaidet, 2017; Musso, 2018; Lau, 2019; Jonsson, 2020; Luis, 2018).

CONCLUSION AND RECOMMENDATIONS

Conclusion

The roles of wildlife reservoirs in the maintenance and transmission of zoonotic diseases are multifaceted and significant. Wildlife populations serve as reservoirs for a diverse array of pathogens, including viruses, bacteria, and parasites, many of which have the potential to spill over into human populations and cause disease outbreaks. Factors such as habitat destruction, encroachment into wildlife habitats, wildlife trade, and climate change contribute to increased interactions between humans and wildlife, facilitating the transmission of zoonotic pathogens.

Conceptually, there is a need for a more holistic understanding of zoonotic disease dynamics, integrating biological, ecological, social, and environmental factors. Contextually, greater attention should be paid to the human dimensions of zoonotic disease transmission, including human behavior, land-use changes, and socio-economic drivers. Additionally, a more comprehensive assessment of the geographical distribution of zoonotic diseases and their interconnectedness across different regions is essential for developing effective prevention and control strategies on a national and global scale.

Recommendations

Theory

Conduct comprehensive ecological studies to better understand the interactions between wildlife hosts, pathogens, and the environment. This includes investigating the drivers of pathogen spillover and transmission dynamics within wildlife populations.

Integrate ecological theories, such as disease ecology and community ecology, into zoonotic disease research to elucidate the underlying mechanisms driving disease emergence and persistence in wildlife reservoirs.

Develop predictive models and theoretical frameworks that incorporate factors influencing zoonotic disease transmission, such as host population dynamics, habitat fragmentation, and climate change, to enhance our ability to forecast and mitigate future disease outbreaks.

Practice

Strengthen surveillance systems to monitor wildlife populations, identify emerging zoonotic pathogens, and assess the risk of spillover events. This includes implementing targeted surveillance programs in high-risk regions and species known to harbor zoonotic pathogens.

Promote interdisciplinary collaboration between wildlife biologists, veterinarians, epidemiologists, and public health professionals to facilitate the exchange of knowledge and expertise in zoonotic disease research and surveillance.

Implement evidence-based strategies for disease prevention and control, such as vaccination programs for wildlife populations, habitat conservation measures, and wildlife management practices aimed at reducing human-wildlife interactions.

Enhance capacity building and training initiatives for wildlife conservationists and healthcare workers to improve their understanding of zoonotic disease dynamics and strengthen their ability to respond to disease outbreaks.

Policy

Develop and implement wildlife conservation policies that prioritize the protection of biodiversity and ecosystem health while considering the potential risks associated with zoonotic disease transmission.

Integrate One Health principles into national and international policy frameworks to address the interconnectedness of human, animal, and environmental health in zoonotic disease management.

Foster international cooperation and information sharing mechanisms to facilitate the exchange of data, resources, and best practices for zoonotic disease surveillance, prevention, and control.

Allocate funding and resources for research, surveillance, and capacity-building initiatives focused on wildlife reservoirs of zoonotic diseases, recognizing the importance of early detection and rapid response to disease threats.

Promote public awareness and education campaigns to increase understanding of the risks associated with wildlife-borne diseases and promote behavior change to reduce exposure to zoonotic pathogens.

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