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Research Article

Review of Climate Change and Its Impact on Zoonotic Disease Transmission: The Need for One Health Interventions

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Abstract

Climate change is increasingly recognized as a major driver of shifts in zoonotic disease transmission dynamics. These diseases, which are transmitted between animals and humans, pose a serious threat to global health, economies, and food security. This paper aims to review the impact of climate change on the transmission of zoonotic diseases and explore the significance of the One Health approach in mitigating associated risks. Rising global temperatures, changes in precipitation patterns, and the increasing frequency of extreme weather events are altering ecosystems and the behavior, distribution, and interactions of both animal hosts and pathogens. These environmental changes influence the emergence and re-emergence of zoonotic diseases in various regions. The One Health approach, which integrates human, animal, and environmental health disciplines, is increasingly seen as essential for addressing the complex interconnections among these sectors. This approach promotes interdisciplinary collaboration, timely surveillance, early detection, and effective response to outbreaks. It also helps identify high-risk areas and practices, improving preparedness and resilience to climate-related health threats. This paper provides a comprehensive overview of how climate change affects zoonotic disease transmission and highlights the need for integrated research and coordinated action. Challenges such as limited data, weak health systems, and lack of awareness are discussed alongside opportunities for innovation and cross-sectoral partnerships. The paper concludes with policy recommendations designed to enhance One Health interventions in response to climate-related health risks, emphasizing the importance of global cooperation, resource mobilization, and sustainable solutions in a rapidly changing world.

Keywords

Climate, Zoonotic, Disease, Transmission, Importance, One Health, Interventions, Strategies

1. Introduction

1.1. Background of Climate Change

Climate change refers to the long-term alteration of temperature and typical weather patterns in a place [9]. This phenomenon has become more pronounced over the past century, largely due to human activities such as deforestation, industrialization, and the burning of fossil fuels, which have led to an increase in greenhouse gases (GHGs) in the atmosphere [5]. The Intergovernmental Panel on Climate Change (IPCC) reports that global temperatures have risen

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by approximately 1.1 ℃ since pre-industrial times, with significant regional variations [10]. These temperature increases are associated with more frequent extreme weather events, rising sea levels, and disruptions to ecosystems, all of which can have profound effects on human and animal health.

1.2. Overview of Zoonotic Diseases

Zoonotic diseases are infections that are transmitted from animals to humans, either directly or through vectors such as mosquitoes, ticks, or fleas. These diseases can be viral, bacterial, or parasitic and are responsible for a significant portion of infectious diseases worldwide. Zoonotic diseases have been responsible for some of the deadliest pandemics in history, including the Black Death, and more recently, the COVID-19 pandemic [4]. Zoonoses are often linked to environmental factors, and as climate change alters habitats and migration patterns of animals, the spread of these diseases becomes more unpredictable. For instance, warmer temperatures can expand the habitats of vectors such as mosquitoes and ticks, allowing them to spread to new areas and increase the incidence of diseases like malaria, dengue, and Lyme disease [7].

1.3. Significance of One Health Approach

The One Health approach is an integrated framework that recognizes the interconnection between human, animal, and environmental health [9]. It emphasizes the need for coordinated efforts across multiple sectors to effectively manage health risks, particularly those posed by zoonotic diseases. The One Health approach is critical in addressing the challenges posed by climate change, as it allows for a comprehensive understanding of the factors influencing disease transmission across species and ecosystems [8]. By integrating human health, veterinary medicine, and environmental science, One Health enables more effective surveillance, prevention, and response to zoonotic disease outbreaks [10].

1.4. Objectives of the Study

The main objectives of this study are to:

1) Review the relationship between climate change and zoonotic disease transmission.
2) Explore the importance of adopting the One Health approach in mitigating the risks posed by climate change-induced zoonotic outbreaks.
3) Identify the barriers and challenges to implementing One Health interventions.
4) Provide policy recommendations for improving One Health strategies in response to climate change.

2. Climate Change: An Overview

2.1. Definition and Causes

Climate change refers to significant changes in temperature, precipitation, and other atmospheric conditions over extended periods. It is primarily driven by the accumulation of greenhouse gases (GHGs) in the atmosphere, particularly carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), which trap heat and cause the planet's surface temperatures to rise. These gases are primarily emitted through human activities such as burning fossil fuels for energy, deforestation, and industrial processes [3].

2.2. Historical Trends and Projections

Over the past century, global temperatures have increased by approximately 1.1 ℃, and this trend is expected to continue unless significant mitigation efforts are undertaken [10]. Projections for the future show that, under current emissions scenarios, global temperatures could rise by 1.5 ℃ to 5 ℃ by the end of the century. These temperature changes are expected to have profound impacts on weather patterns, ecosystems, and biodiversity, all of which are interrelated with the dynamics of zoonotic diseases [9]. Rising temperatures are also predicted to increase the frequency and intensity of extreme weather events, such as heatwaves, floods, and hurricanes, which can disrupt ecosystems and affect the distribution of zoonotic pathogens and their hosts.

2.3. Climate Change and Biodiversity

Climate change is one of the leading threats to global biodiversity. As temperatures rise and precipitation patterns shift, ecosystems are altered, and many species are forced to migrate or adapt to new conditions [4]. These ecological shifts often result in changes in the geographic range of zoonotic pathogens, their vectors, and their animal hosts. For example, warmer temperatures can extend the range of mosquitoes that carry diseases like malaria and dengue, leading to increased risk in regions that were previously unaffected [6]. The loss of biodiversity, especially in ecosystems that act as buffers against disease spread, can also increase the vulnerability of both humans and animals to emerging zoonotic threats [7].

3. Zoonotic Diseases as Global Perspective

3.1. Definition and Classification

Zoonotic diseases are diseases that can be transmitted from animals to humans. These diseases can be viral, bacterial, or parasitic and can be transmitted through direct contact with animals, through the consumption of contaminated animal

products, or through vectors like ticks and mosquitoes [4]. Zoonotic diseases are classified into several categories based on the mode of transmission:

Direct transmission: Diseases like rabies, which are transmitted through direct contact with infected animals.

Vector-borne diseases: Diseases like malaria and Lyme disease, which are transmitted through vectors such as mosquitoes and ticks.

Foodborne diseases: Diseases like Salmonella, which are transmitted through the consumption of contaminated animal products [9].

3.2. Statistics and Incidence Rates

Zoonotic diseases are a significant cause of morbidity and mortality worldwide. The World Health Organization (WHO) estimates that zoonotic diseases account for over 60% of all infectious diseases that affect humans. For example, rabies causes approximately 59,000 deaths annually, with the majority of cases occurring in Africa and Asia [9]. Additionally, diseases like Ebola, Zika, and COVID-19 have highlighted the potential for zoonotic diseases to cause widespread global health crises [5]. As climate change alters the distribution of animal species and their habitats, the risk of zoonotic diseases spreading to new regions is expected to increase.

3.3. Major Zoonotic Diseases and Their Hosts

Some of the major zoonotic diseases include:

Rabies: Caused by the rabies virus and transmitted through the bite of an infected animal, typically dogs [9].

Influenza: A viral disease that is transmitted from animals to humans, often through contact with infected birds or pigs [4].

Lyme disease: Caused by Borrelia burgdorferi bacteria, transmitted through the bite of infected ticks [9].

Ebola: A viral hemorrhagic fever transmitted from fruit bats to humans through direct contact with infected animals [9].

These diseases are often linked to environmental factors, and as climate change reshapes ecosystems, the transmission dynamics of these diseases are also changing. Warmer temperatures, changes in rainfall, and altered migration patterns all contribute to the spread of zoonotic diseases [2].

4. The Link Between Climate Change and Zoonotic Diseases

4.1. Mechanisms of Transmission

Climate change influences zoonotic disease transmission in several ways. Changes in temperature and precipitation patterns affect the distribution of animal hosts and vectors, which in turn influences the spread of zoonotic pathogens [13]. For example, rising temperatures can accelerate the development of larvae in mosquitoes, leading to an increase in the number of disease-carrying mosquitoes [7]. Additionally, altered precipitation patterns can create standing water, providing breeding grounds for mosquitoes and other disease vectors [12].

4.2. Environmental Changes Affecting Zoonotic Pathogens

Environmental changes due to climate change, such as deforestation and land-use change, can also facilitate the spread of zoonotic diseases. For example, the destruction of forests can force wild animals to move into urban areas, increasing the likelihood of contact between animals and humans and thereby increasing the risk of disease transmission [5]. Additionally, warmer temperatures and shifting rainfall patterns can alter the availability of food and water for animals, leading to changes in migration patterns and interactions between species [2].

4.3. Case Studies of Climate-Induced Zoonotic Outbreaks

Several case studies highlight the role of climate change in the emergence of zoonotic diseases:

Zika Virus: The spread of Zika virus in the Americas was accelerated by increased temperatures, which expanded the range of Aedes mosquitoes [7].

Lyme Disease: Warmer temperatures have allowed ticks to survive at higher altitudes and latitudes, increasing the incidence of Lyme disease in previously unaffected areas [9].

Malaria: Changes in rainfall patterns have altered the distribution of Anopheles mosquitoes, increasing the risk of malaria transmission in regions where the disease was previously uncommon [7].

5. The Need for One Health Interventions

5.1. Concept and Principles of One Health

The One Health approach is a holistic framework that recognizes the interconnectedness of human, animal, and environmental health. It emphasizes the need for collaboration between various sectors, including human health, veterinary medicine, environmental science, and agriculture, to effectively manage zoonotic diseases. One Health is particularly relevant in the context of climate change, as it provides a comprehensive approach to understanding and addressing the complex factors influencing disease transmission [5].

5.2. Integration of Human, Animal, and Environmental Health

The integration of human, animal, and environmental health is essential for managing zoonotic diseases in the face of climate change. This integration allows for more effective surveillance of disease outbreaks, early detection of new pathogens, and coordinated response strategies [13]. For example, a One Health approach to avian influenza involves monitoring both wild bird populations and domestic poultry to detect potential outbreaks and prevent the spread of the disease to humans [9].

5.3. Examples of Successful One Health Initiatives

GOARN (Global Outbreak Alert and Response Network): The Global Outbreak Alert and Response Network (GOARN) is an example of a successful One Health initiative that coordinates international efforts to respond to infectious disease outbreaks [23]. This network integrates expertise from multiple sectors, including health, veterinary, and environmental sciences, and is instrumental in tackling zoonotic diseases, particularly those with the potential for global spread like Ebola, Zika, and COVID-19 [9].

Ebola Outbreak Response: The 2014 Ebola outbreak in West Africa demonstrated the importance of a One Health approach [11]. By combining efforts from health professionals, wildlife conservationists, and local communities, authorities were able to control the outbreak, investigate wildlife reservoirs, and prevent further human-to-human transmission [22]. This integrated response emphasized the role of environmental factors, such as deforestation and hunting practices, in the spread of the virus [6].

Ebola Preparedness (*Rwanda One Health Strategic Plan):* Rwanda developed a national One Health strategic plan to address zoonotic diseases, food safety, and antimicrobial resistance. It integrates ministries of health, agriculture, environment, and education, finally institutionalized One Health into national planning with an improved coordination during disease outbreaks (i.e., Ebola preparedness) [21].

PREDICT Project (Global): Led by USAID, the PREDICT project focused on detecting emerging zoonotic viruses in wildlife and building local capacity, been discovered over 1,000 new viruses, including coronaviruses, and Trained thousands of professionals in over 30 countries in surveillance techniques [16].

Rabies Elimination in the Philippines (Bohol Province): Multi-sectoral initiative including animal vaccination, human post-exposure prophylaxis, and community education, and Achieved zero human rabies deaths for several years with reduced animal rabies cases by over 90% [10].

Kenya Zoonotic Disease Unit (ZDU): Joint unit between Kenya's Ministry of Health and Ministry of Agriculture to prevent and control zoonoses, and Effective coordination of Rift Valley Fever and anthrax responses has been made besides to national frameworks for zoonotic disease surveillance program development [14].

Bangladesh One Health Hub: Cross-ministerial platform integrating surveillance and response to antimicrobial resistance and zoonotic diseases, and One Health AMR surveillance strategy development has been made with Enhanced collaboration among public health, livestock, and environmental sectors [16].

6. Challenges and Barriers to One Health Implementation

6.1. Institutional and Political Barriers

Despite the growing recognition of One Health, there are significant institutional and political barriers to its widespread implementation [24]. Different sectors, human health, animal health, and environmental health, often operate in silos, with separate funding streams, regulatory frameworks, and policy agendas [9]. Overcoming these institutional barriers requires significant political will and leadership to align the efforts of diverse sectors and stakeholders [8]. Moreover, One Health interventions often require changes to existing health infrastructure and regulations, which can be met with resistance due to bureaucratic inertia or lack of resources.

6.2. Socioeconomic Factors

Socioeconomic factors, including poverty, lack of education, and inadequate access to healthcare, can exacerbate the risks of zoonotic diseases [23], particularly in vulnerable communities. People living in close proximity to wildlife or engaging in high-risk activities such as hunting and animal husbandry are often at greater risk of contracting zoonotic diseases [15]. Climate change can worsen these challenges by increasing the frequency and intensity of natural disasters, which disproportionately affect low-income populations [2]. Additionally, communities with limited access to resources for disease prevention, such as vaccines or medical care, are less able to effectively mitigate the risks posed by zoonotic diseases.

6.3. Public Awareness and Education

Public awareness and education are critical components of effective One Health interventions. Many zoonotic diseases are preventable with proper knowledge of how they are transmitted and how to mitigate risk factors [6]. However, in many regions, especially rural areas, there is limited understanding of the link between human, animal, and environmental health. Raising awareness through education campaigns that focus on hygiene, vaccination, and responsible animal handling practices can play a crucial role in preventing

zoonotic disease outbreaks [3]. Engaging local communities in One Health programs and decision-making processes can enhance the success of these initiatives.

7. Policy Recommendations

7.1. Strategic Framework for One Health Interventions

To effectively address the challenges posed by climate change and zoonotic diseases, a comprehensive strategic framework for One Health interventions is necessary. This framework should prioritize:

Strengthening intersectoral collaboration: Governments, international organizations, and local communities must work together to align health systems, policies, and surveillance networks.

Building capacity for surveillance and early detection: Investment in surveillance systems that monitor zoonotic diseases in humans, animals, and the environment is critical for early detection and rapid response.

Enhancing climate change mitigation: Reducing greenhouse gas emissions through policies that promote renewable energy, sustainable agriculture, and deforestation prevention will help slow the impacts of climate change on zoonotic disease transmission.

7.2. Role of International Organizations

International organizations, such as the World Health Organization (WHO), the World Organisation for Animal Health (OIE), and the United Nations Environment Program (UNEP), play a crucial role in fostering global cooperation on One Health [12]. These organizations can facilitate the sharing of information, best practices, and resources among countries, particularly in response to emerging zoonotic threats [17]. Additionally, they can support the development of international guidelines and frameworks for zoonotic disease management in the context of climate change [9].

7.3. Community Engagement and Participation

Community involvement is essential for the success of One Health interventions [21]. Local communities, especially those most at risk of zoonotic diseases, should be engaged in the development and implementation of health strategies [19]. This can be achieved through community-based surveillance, education programs, and participatory decision-making processes. By empowering communities to take an active role in disease prevention, the effectiveness of One Health initiatives can be significantly enhanced [6].

8. Future Directions and Research Needs

8.1. Gaps in Current Research

Although there has been significant progress in understanding the link between climate change and zoonotic diseases, there are still important gaps in research [20]. One of the major gaps is the lack of comprehensive models that can predict how climate change will impact the distribution of zoonotic diseases [9]. More research is needed to understand the interactions between climate variables, host populations, and pathogens, and how these interactions vary across different regions and ecosystems [1]. Furthermore, there is a need for longitudinal studies that track the long-term effects of climate change on zoonotic disease transmission [11].

8.2. Importance of Interdisciplinary Studies

As climate change influences zoonotic diseases in complex ways, interdisciplinary research is crucial for developing effective strategies to mitigate these risks [16]. Collaboration between climatologists, epidemiologists, ecologists, and social scientists is necessary to gain a holistic understanding of the factors driving zoonotic disease emergence [13]. By incorporating diverse perspectives, interdisciplinary studies can offer more comprehensive solutions that address the root causes of zoonotic disease outbreaks [4].

8.3. Innovations in Surveillance and Response

Innovative technologies, such as remote sensing, geographic information systems (GIS), and genomics, can play a key role in improving surveillance and response to zoonotic diseases. Remote sensing can be used to monitor environmental changes, such as deforestation and changes in temperature, that may affect the distribution of zoonotic pathogens. GIS can help track the movement of animals and vectors and predict areas at high risk of zoonotic disease outbreaks. Genomic tools can be used to identify new pathogens and track their evolution, enabling more accurate forecasting of potential disease outbreaks [8].

9. Conclusion

Climate change is a significant driver of the emergence and spread of zoonotic diseases. Rising temperatures, altered rainfall patterns, and habitat disruptions are creating new opportunities for zoonotic pathogens and their hosts to expand their geographic ranges. The One Health approach provides an integrated framework for addressing the complex interactions between human, animal, and environmental health. However, significant challenges remain in implementing One Health interventions, including institutional barriers, socioeconomic factors, and public awareness gaps. A strategic framework for One Health interventions, strengthened inter-

national collaboration, and community engagement are key to mitigating the risks posed by climate change-induced zoonotic diseases.

Addressing the impact of climate change on zoonotic diseases requires collaborative action at local, national, and global levels. By adopting the One Health approach, strengthening surveillance systems, and investing in research, we can better understand the dynamics of zoonotic diseases and develop more effective strategies to prevent and control outbreaks. The integration of human, animal, and environmental health is essential for achieving long-term health security in the face of climate change.

Abbreviations

CDC	Centers for Disease Control and Prevention
WHO	World Health Organization
FAO	Food and Agriculture Organization
OIE	World Organisation for Animal Health
UNEP	United Nations Environment Program
GHG	Greenhouse Gases
EID	Emerging Infectious Disease
COVID-19	Coronavirus Disease 2019
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
HPAI	Highly Pathogenic Avian Influenza
EVD	Ebola Virus Disease
PHEIC	Public Health Emergency of International Concern
IPCC	Intergovernmental Panel on Climate Change
R&D	Research and Development
NGO	Non-Governmental Organization
LMICs	Low- and Middle-Income Countries

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Conflicts of Interest

The author declares no conflicts of interest.

Appendix

Table 1. *List of Glossary of Terms [16, 18].*

Term	Definition
Zoonotic Diseases	Diseases that are transmitted from animals to humans, either directly or indirectly.
Reservoir Host	An animal species that harbors a pathogen without being affected by the disease, serving as a source of infection.
Vector	An organism, often an insect or arthropod, that transmits a pathogen from one host to another.
Climate Change	Long-term shifts in temperatures and weather patterns, primarily due to human activities like burning fossil fuels.
Global Warming	The observed and projected increase in the average temperature of Earth's atmosphere and oceans.
One Health	A collaborative approach that integrates human, animal, and environmental health for optimal health outcomes.
Emerging Infectious Diseases (EIDs)	New or previously unrecognized infections that are increasing in incidence or geographic range.
Re-emerging Diseases	Diseases that were once controlled but are now showing a resurgence due to various factors, including climate change.
Vector-borne Disease	A disease transmitted by vectors such as mosquitoes, ticks, or fleas (e.g., malaria, Lyme disease).
Host	An organism that supports the survival and growth of a pathogen.
Pathogen	A biological agent that causes disease or illness to its host.

Term	Definition
Ecosystem Disruption	Alteration of natural habitats and ecosystems due to environmental changes, often affecting disease transmission dynamics.
Anthropogenic	Originating from human activity (e.g., pollution, deforestation, greenhouse gas emissions).
Interdisciplinary Approach	Combining knowledge from multiple academic fields to address complex issues such as zoonotic disease transmission.
Surveillance	Systematic collection, analysis, and interpretation of health data for planning, implementation, and evaluation of public health practice.

Table 2. *List of major zoonotic diseases and their hosts [15, 18, 19].*

Zoonotic Disease	Hosts
Rabies	Dogs, Bats, Foxes, Raccoons
Influenza (H5N1, H1N1)	Birds (especially poultry), Pigs
Lyme Disease	Ticks, Rodents, Deer
Leptospirosis	Rodents, Cattle, Dogs, Wildlife
Tuberculosis	Cattle, Goats, Sheep, Deer
Malaria	Anopheles Mosquitoes, Humans
Ebola Virus	Bats, Primates, Forest Antelopes
Zika Virus	Aedes Mosquitoes, Humans
Toxoplasmosis	Cats, Sheep, Goats, Pigs
Anthrax	Cattle, Sheep, Goats, Horses
Hantavirus	Rodents, Deer, Bats
Brucellosis	Cattle, Sheep, Goats, Dogs, Bison
SARS-CoV-2 (COVID-19)	Bats, Pangolins (suspected)
West Nile Virus	Culex Mosquitoes, Birds, Horses
Bubonic Plague	Fleas, Rats, Prairie Dogs

Table 3. *List of Zoonotic Diseases and Their Reservoirs [16, 17, 20].*

Zoonotic Disease	Primary Reservoir(s)
Rabies	Dogs, Bats, Wild Canines (e.g., foxes)
Anthrax	Soil (spore-forming), Livestock (Cattle, Sheep)
Brucellosis	Cattle, Sheep, Goats, Pigs
Leptospirosis	Rodents (especially rats), Livestock, Dogs
Ebola Virus Disease	Fruit Bats (natural host), Primates
Hantavirus	Wild Rodents (deer mice, cotton rats)
Plague (Yersinia pestis)	Wild Rodents (rats, prairie dogs), Fleas
Toxoplasmosis	Domestic Cats (definitive host)
Salmonellosis	Poultry, Reptiles, Amphibians, Livestock

Zoonotic Disease	Primary Reservoir(s)
Q Fever (Coxiella burnetii)	Goats, Sheep, Cattle
Avian Influenza (H5N1, H7N9)	Wild Birds (ducks, geese), Poultry
Swine Influenza (H1N1)	Domestic and Wild Pigs
Zika Virus	Primates, Humans (amplifying hosts)
COVID-19 (SARS-CoV-2)	Bats (natural reservoir), Possibly Pangolins
West Nile Virus	Wild Birds (especially Corvids), Mosquitoes
Lyme Disease	Deer, Rodents (White-footed mice), Ticks
Nipah Virus	Fruit Bats (Pteropus spp.), Pigs

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