PERSPECTIVE

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Special Topic: Climate Change and Health

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Climate Change Is Reshaping the Global Patterns of Infectious Disease

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Climate change is rapidly reshaping the spatiotemporal dynamics of infectious diseases. As global warming breaks down ecological barriers, pathogens and their hosts are expanding toward higher latitudes and elevations, while seasonal transmission periods are becoming prolonged. This mounting environmental instability may contribute to a rise in compound disasters involving extreme climate events and epidemic outbreaks. In these scenarios, the associated health risks may extend beyond simple additive effects, potentially triggering severe global public health crises. This Perspective highlights the urgent need to address the global expansion of pathogen distributions and the potential emergence of sustained year-round transmission, and calls for climate-informed infectious disease governance to become a core component of global climate adaptation and health security planning.

One of the most direct effects of climate warming on infectious diseases is the reconfiguration of their geographic ranges. As warming weakens climatic constraints on vector survival and transmission, some disease vectors that were previously concentrated primarily in tropical and subtropical regions are expanding toward higher latitudes and elevations, creating increasingly favorable conditions for the local

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transmission of associated pathogens in newly suitable environments [1]. For example, an analysis of more than 500,000 spatiotemporal occurrence records for 22 malaria-vector Anopheles species across Africa reveals that the southern limits of their observed ranges are shifting poleward (southward) at a mean velocity of 4.7 km/year, while simultaneously undergoing upslope displacement to higher altitudes at a rate of 6.5 m/year [2]. Concurrently, over the past century, the distribution of the common vampire bat (Desmodus rotundus) has shifted significantly northward in North America [3]. At the northernmost extent of its range, temperature seasonality at vampire bat capture sites has declined over time. This northward shift may increase the risk of rabies spillover at the wildlife-livestock-human interface [3]. By 2070, climate- and land-use-driven redistribution of mammalian ranges is projected to generate new species assemblages, particularly at high elevations, in biodiversity hotspots, and in densely populated regions of Asia and Africa, resulting in an estimated 4,000 cross-species viral sharing events and potentially facilitating zoonotic spillover [4]. Moreover, climate change can reshape the geography of infectious diseases through coupled shifts in ecological suitability, human exposure, and population susceptibility. For example, climate-driven displacement and changes in settlement patterns can reorganize the spatial distribution of human exposure, while overcrowding, disruption of water and sanitation systems, and reduced access to healthcare may further increase infection risk and population vulnerability in newly affected areas [5]. In China, dengue transmission risk is increasingly shaped by the combined effects of climate change, urbanization, and human connectivity, with projections indicating a northward expansion of climatically suitable and high-risk areas that is further amplified by population density, urban connectivity, and social vulnerability [6-7]. More broadly, assessments of urban infection susceptibility show that climatic conditions interact with human activity and societal capacity, including population density, urban connectivity, and healthcare accessibility, to shape both the risk of infection and the capacity to prevent and contain disease transmission [8].

Beyond altering the geographic distribution of infectious diseases, climate change is increasingly recognized as a major driver of changes in the timing and duration of

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transmission. In temperate regions, cold winters have historically constrained vector-borne diseases by limiting vector survival and activity and slowing pathogen development. As winters become milder, this thermal constraint can weaken, allowing vector activity to begin earlier in spring and persist later into autumn. Mechanistic models of dengue, Zika and chikungunya, for example, indicate that transmission is generally possible between approximately 18-34 °C and peaks at 26-29 °C, suggesting that warming can lengthen periods of climatic suitability in cooler regions [9]. More importantly, prolonged transmission seasons may also modify the ecological and evolutionary conditions experienced by pathogens by increasing opportunities for replication and circulation. Experimental evolution of West Nile virus demonstrated that repeated viral passage under warmer conditions increased genetic diversity, accumulated more nonsynonymous mutations, and produced variants with greater replicative fitness across different temperatures, suggesting that elevated temperatures can influence viral adaptation and evolutionary potential [10]. Meanwhile, extreme weather events can further alter seasonal timing through different mechanisms. In California, extreme spring drought was associated with a 2.8-week earlier onset of the coccidioidomycosis transmission season, while autumnal drought was associated with a 0.69-week later cessation, corresponding to an approximately 1-month longer period of elevated risk [11]. These spatial and temporal changes point to a common pattern: climate change is eroding the climatic constraints that have historically limited where and during which seasons infectious disease transmission can occur.

The close intertwining between climate change and infectious diseases has further contributed to the increasing transition of global hazard from isolated, single-factor threats to extreme weather-epidemic compound disasters (EWED) [12]. EWED disasters are complex hazard systems that are coupled, synergized, or secondarily triggered by extreme weather and climate events (e.g., floods, droughts, heat waves, cold waves etc.) and infectious disease outbreaks or transmission [12]. The systemic shocks arising from the compounding of multiple crises may place additional pressure on existing social governance systems and public health infrastructure. As the spatiotemporal patterns of infectious diseases continue to change rapidly, the frequency

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of such compound disasters may also increase, with their impacts extending across broader geographic areas. The widespread flooding across New Orleans caused by Hurricane Katrina in 2005 provides a representative example of such a compound disaster. In the directly affected areas of Louisiana and Mississippi, cases of West Nile neuroinvasive disease increased rapidly following landfall. Multiple factors may have contributed to this increase, including greater human-mosquito contact resulting from extensive housing damage, prolonged outdoor exposure during evacuation, the creation of new mosquito breeding habitats in post-storm standing water, and increased outdoor reconstruction activities. Together, these conditions were associated with West Nile virus disease incidence in 2006 that was more than twice the historical average [13]. Meanwhile, large-scale population displacement may have provided an additional pathway for disease transmission. For example, more than 27,000 evacuees were temporarily accommodated at the Reliant Park megashelter in Houston, where severe crowding, inadequate sanitation and hand-washing facilities, increased contact with contaminated environmental surfaces, and delays in environmental decontamination may have collectively contributed to widespread norovirus transmission. During the 11-day outbreak, more than 1,000 cases of gastroenteritis received clinical care, accounting for 17% of all clinic visits at the shelter. Although intensified control measures were rapidly implemented, transmission was not completely interrupted, and the outbreak placed substantial additional demands on already strained local healthcare resources [14]. Recently during the 2025 chikungunya outbreak in Foshan, heat-wave conditions were associated with a net 76% increase in confirmed cases, potentially involving accelerated viral replication and changes in human behavior. Meanwhile, increased effective precipitation was associated with a 205% increase in mosquito abundance and a 10.5% increase in viral transmission [15]. Therefore, interactions among multiple hazards may amplify the public health consequences of compound disasters, giving rise to cascading impacts that further exacerbate disease transmission and associated health risks. As the spatiotemporal distribution of infectious diseases continues to shift, such compound disasters may increasingly pose systemic threats characterized by wider geographic reach, prolonged impacts, and greater public health burdens.

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Overall, climate change is no longer merely an external environmental factor, but has emerged as a major driver reshaping the distribution and transmission risks of infectious diseases, potentially contributing to pathogen range expansion into higher elevations and longer seasonal windows of disease transmission (Fig. 1). Building on existing public health governance frameworks, greater integration, adaptability, and cross-sectoral coordination may contribute to more effective responses to compound crises arising from the complex interactions between climate change and public health. Integrating climate information into public health early-warning and governance frameworks, together with the development of spatiotemporal monitoring, prediction, and early-warning systems, could therefore help reduce the public health risks posed by such complex crises. Such systems should operate as integrated surveillance-to-action frameworks comprising three interconnected components: bio-environmental surveillance, multi-source data integration, and risk-informed prediction and decision support. First, surveillance should extend beyond clinical case detection through multi-tiered sentinel networks spanning human populations, vectors, animal hosts, and the environment. These networks could integrate environmental surveillance of airborne and wastewater samples with vector monitoring, thereby facilitating the early detection and characterization of both known and emerging pathogens. Second, multi-source surveillance data should be spatially and temporally integrated with high-resolution meteorological observations and forecasts, Earth-observation data, ecological indicators, and sociodemographic information, including population density, human mobility, vulnerability, and healthcare capacity. These heterogeneous observations could then be assimilated into infectious-disease transmission models using observation operators, error-covariance estimation, and data-assimilation methods, allowing both observed and latent epidemiological states to be dynamically updated as new information becomes available. Finally, risk-prediction frameworks should jointly account for climatic precursors, ecological change, pathogen circulation, and population connectivity. For example, we propose that such systems should incorporate parameterization schemes that capture seasonal variation, population aggregation, and government interventions, which could help improve the accuracy of infectious-disease

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forecasts and provide a stronger scientific basis for public health decision-making [16]. In summary, the changing global distribution and seasonality of infectious diseases call for a closer integration of climatological and epidemiological perspectives. Climate-informed infectious disease governance could therefore play an increasingly important role in global climate adaptation and health security planning, helping to reduce the growing health burden of climate change and safeguard populations worldwide.

Acknowledgments

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References

1. Wu Y, Huang C. Climate change and vector-borne diseases in China: a review of evidence and implications for risk management. Biology 2022; 11: 370.
2. Carlson CJ, Bannon E, Mendenhall E et al. Rapid range shifts in African Anopheles mosquitoes over the last century. Biol Lett 2023; 19: 20220365.
3. Van de Vuurst P, Qiao H, Soler-Tovar D et al. Climate change linked to vampire bat expansion and rabies virus spillover. Ecography 2024; 2024: e06714.
4. Carlson CJ, Albery GF, Merow C et al. Climate change increases cross-species viral transmission risk. Nature 2022; 607: 555-562.
5. Tsui JL-H, Pena RE, Moir M et al. Impacts of climate change-related human migration on infectious diseases. Nat Clim Chang 2024; 14: 793-802.
6. Cai W, Zhang C, Zhang S et al. The 2025 China report of the Lancet Countdown on health and climate change: empowering cities for synergistic action. Lancet Public Health 2025; 10: e1066.
7. Guang X, He Y, Geng M et al. Climate and socioeconomic factors drive heterogeneous dengue risk escalation in the Chinese population. Commun Med 2026; 6: 382.
8. Yan W, Huang J, Lian X et al. The urban infection susceptibility index and its application in cities of China. Biosaf Health 2026; 8: 55-62.
9. Mordecai EA, Cohen JM, Evans MV et al. Detecting the impact of temperature on transmission of Zika, dengue, and chikungunya using mechanistic models. PLoS Negl Trop Dis 2017; 11: e0005568.

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10. Fay RL, Ngo KA, Kuo L et al. Experimental evolution of West Nile virus at higher temperatures facilitates broad adaptation and increased genetic diversity. Viruses 2021; 13: 1889.
11. Camponuri SK, Head JR, Collender PA et al. Prolonged coccidioidomycosis transmission seasons in a warming California: a Markov state transition model of shifting disease dynamics. J R Soc Interface 2025; 22: 20240821.
12. Huang J, Lian X, Wang H et al. An overview of extreme weather-epidemic compound disasters. Sci Bull 2025; 70: 2868.
13. Caillouët KA, Michaels SR, Xiong X et al. Increase in West Nile neuroinvasive disease after Hurricane Katrina. Emerg Infect Dis 2008; 14: 804.
14. Yee EL, Palacio H, Atmar RL et al. Widespread outbreak of norovirus gastroenteritis among evacuees of Hurricane Katrina residing in a large 'megashelter' in Houston, Texas: lessons learned for prevention. Clin Infect Dis 2007; 44: 1032.
15. Yan W, Huang J, Hu S et al. Influence of heat wave and precipitation on chikungunya transmission. Geophys Res Lett 2026; 53: e2026GL123990.
16. Huang J, Zhang L, Chen B et al. Development of the second version of Global Prediction System for Epidemiological Pandemic. Fundam Res 2024; 4: 516.

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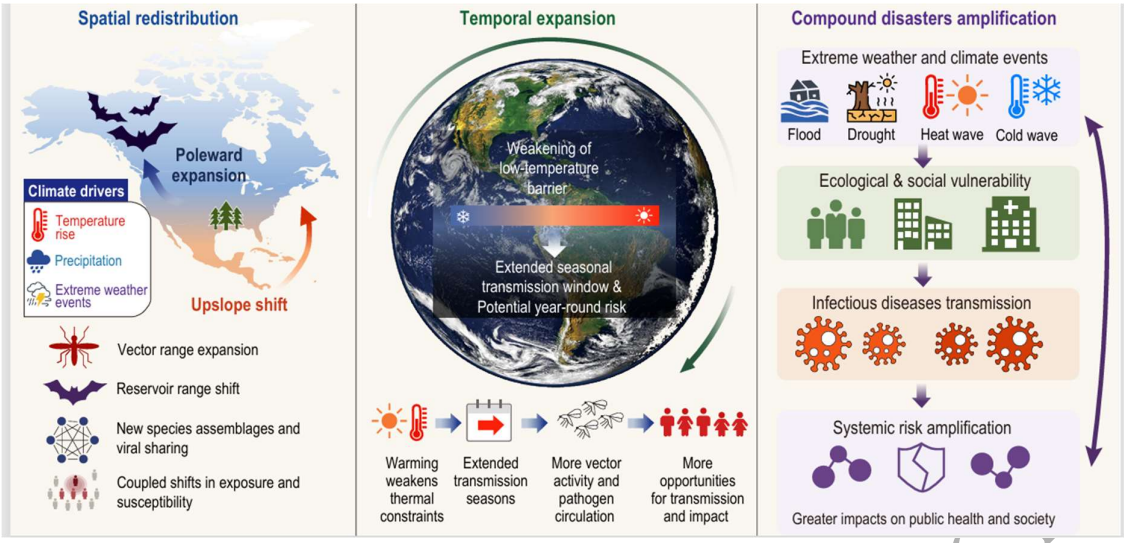


Figure 1. Schematic diagram of climate change-driven spatiotemporal dynamics of infectious diseases

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