Climate change and pandemics: a call for action

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Climate change is expected to impact macroecological processes and adaptive responses of wildlife, thereby increasing cross-species viral transmission and elevating the risks of zoonotic pathogen spillover to humans.[1] More than 1000 pathogen transmission pathways are exacerbated by climatic hazards, accounting for approximately half of all known human diseases.[2] The increasing risk of zoonotic outbreaks—from spillover to viral epidemics and pandemics—driven by climate change, poses a significant concern.[3]

We reviewed research examining the impact of climate change on zoonotic infections. 76.5% of studies focus on climate-sensitive, vector-borne diseases in humans (malaria, dengue, Zika, Lyme disease) and the associated impacts on vectors. This emphasis is likely to reflect the high disease burden and climate-sensitivity of ectothermic vectors and their pathogens (figure). The existing body of evidence includes the spatial and temporal patterns of vector-borne disease cases in humans, the distribution and abundance of vectors, their lifecycle, phenology, survival, vector competence, and host-pathogen interactions in relation to climate and thermal biology, and prevalence and spread in animal reservoirs. These insights have prompted public health organisations to invest in early warning systems for vector-borne diseases.

By contrast, comparatively less scientific attention has been directed towards the climate-sensitive nature of cross-species spillover and non-vector-borne zoonotic disease risks such as Ebola, Hendra, Nipah, and rabies viruses. Nevertheless, the pandemic potential of viral zoonotic pathogens is well established,[3] as evidenced by the substantial economic and health impacts of SARS-CoV-2 and monkeypox virus.

The discrepancy in publication output, and by extension, research efforts between vector-borne and non-vector-borne zoonotic diseases is unlikely to reflect a weaker association between climate change and cross-species viral transmission or spillover to humans. This discrepancy might instead result from the challenges in studying the more complex pathways involved in cross-species viral sharing and spillover. These pathways are mediated by underlying interactions at the interface between the affected communities and ecosystems,[4] which are influenced by various environmental and anthropogenic factors, as well as dynamic adaptive responses of these systems to climate change.

Climate change is already exerting profound effects on the biological and ecological systems, affecting the human–animal–environment interface.[5] The effects include shifts in biodiversity, relocation of species to more suitable areas, disruptions to food webs, altered seasonal lifecycle events in plants, vectors, and animals,[6] and climate adaptation of animal farming systems.[7] Collectively, these processes cause novel biotic interactions that influence infectious disease ecology and alter disease risks for humans and animals.[1] These changes have been shown to increase the likelihood of zoonotic spillover events.[8] However, the role of climate change in influencing these underlying drivers and the emergence and spread of zoonotic pathogens, remains understudied. In the absence of increased research efforts and insights on how climate change-driven processes affect zoonotic spillover events and associated pathways, evidence will be scarce to inform comprehensive pandemic prevention and preparedness.

Failing to integrate climate change with pandemic prevention and preparedness actions risks overlooking important health benefits and unintended consequences. Climate change mitigation can aid primary pandemic prevention by lowering the likelihood of a spillover event.[9] However, current efforts prioritise pandemic preparedness through early warning systems, outbreak detection, case ascertainment, and pharmaceutical interventions, representing adaptation strategies and preparedness for climate-driven risks of infections. Pandemic prevention and preparedness policies are increasingly recognising climate change as a potential driver of emerging infectious diseases.[3] However, these policies often remain general and lack detailed guidance and certainly do not get translated into action.

The One Health Joint Plan of Action (2022–26) and the UN Environment Programme report Preventing the Next Pandemic both acknowledge the role of climate change in zoonotic disease emergence, re-emergence, and spread. However, other key frameworks, such as the World Organisation for Animal Health. Wildlife Health Framework and the WHO's Global Strategy on Health, Environment, and Climate Change fail to address the connection between climate change and zoonotic disease

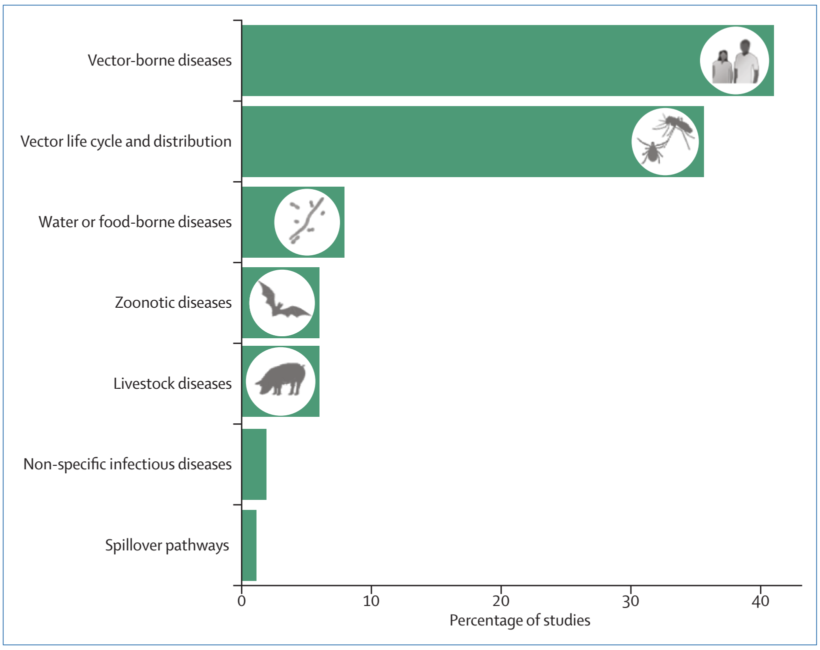

Figure: **Research publications examining the effect of climate change on infectious diseases (PubMed, from Jan 1, 2010, to Sept 20, 2024, N=1014, see appendix p 1)**
Note: The vector-borne disease bar represents the percentage of the studies reporting climate dependencies of vector-borne disease in humans; the vector lifecycle and distribution bar represents the percentage of the studies reporting climate-sensitivity of vectors only.

See Online for appendix

emergence. The Pandemic Fund of the World Bank focuses on outbreak preparedness and detection without integrating upstream preventive measures related to climate. The WHO member states have recently adopted the Pandemic Agreement, which endorses implementing the One Health approach in surveillance, prevention, and control actions. This action presents considerable progress in a global approach to pandemic risk reduction.[10] However, the integration of climate change considerations remains unclear. Notably, the International Health Regulations have not yet incorporated climate considerations and climate services information within their monitoring and evaluation framework.

Nonetheless, the health implications of climate change have been recognised in climate negotiations since the 28th session of the Conference of the Parties to the UN Framework Convention on Climate Change in 2023, with the climate crisis now deemed a public health emergency. The World Health Assembly in 2024 adopted the Global Action Plan on Climate Change and Health for 2025–28, acknowledging the impact of climate change on pandemic risk and the necessity for adaptive measures.

To inform policy development, we call for increased research on the impact of climate change on biological and ecological systems and the spatiotemporal risk of zoonotic disease emergence and transmission. Key research areas include climate change impacts on 1) wildlife pathogen interactions, including population dynamics and microorganisms; 2) ecosystem functioning, biodiversity, and pathogenic risks; 3) microorganism prevalence and sharing between humans, domestic animals, wildlife and the environment; and 4) associated pathogen survival, adaptation, and evolution with climate change. Such research is essential to establish quantitative and mechanistic evidence linking climate change to the emergence and spread of zoonotic diseases, particularly those with pandemic potential. Historical and projected climate data can improve the prediction of climate-driven changes in zoonotic processes and aid prevention, preparedness, and response strategies. Studies on climate change mitigation can additionally identify zoonotic health co-benefits. A deeper understanding of the impacts of climate change on zoonotic disease risk will further support the integration of primary prevention and climate change mitigation into international health regulations.

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