Infectious diseases in a warming world: A call for action

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Significance:

Climate change risks triggering epidemics of emerging and re-emerging diseases across the world with disastrous consequences. Climate change impacts are typically discussed with long-term consequences in mind, but when it comes to climate effects on infectious diseases, the future is already here. Combatting the complex effects of climate change on infectious diseases requires a collaborative effort from governments, scientists, public health officials, and the private sector. We should view the response to climate change as an opportunity to invest in robust health care and outbreak response systems. However, we must act now to mitigate the impending global public health crisis for a healthier future for all.

Introduction

As the world begins to recover from the COVID-19 pandemic, it is crucial to recognise that another looming crisis demands our immediate attention. Human-induced climate change is frequently discussed in terms of its impact in the mid- to long-term future with gradual long-term shifts in global climate patterns. However, current events show the devastating consequences of climate change from extreme weather events. A recent example being the compounding effects of heat waves and long-term drought driving wildfires in the Brazilian Pantanal[1], damaging up to 9% of the world's largest wetland[2]. Closer to home, several regions of South Africa have been battered by floods over recent years, resulting in thousands of people injured and displaced and several fatalities.[3] The physical damage caused by these climate events burdens healthcare systems, but, regrettably, amidst these challenges, there is another impending threat to our health that requires urgent attention – the intricate interaction between climate change and infectious diseases.[4]

Climate-triggered disease outbreaks

We are facing a new era of global health with outbreaks of endemic, emerging and re-emerging pathogens triggered by climate and global change, and swiftly spread by global connectivity.[5] A recent review has revealed that climate change has the potential to aggravate almost 60% of known human pathogens.[6] Warming effects, changes in precipitation levels and floods are the most prominent climate hazards that predominantly stimulate vector-borne, waterborne, and airborne diseases. For example, West Nile virus, a vector-borne virus of African origin[7] spread by mosquitoes, has taken on an almost global distribution within the last two decades, facilitated by climate effects[8], with devastating outbreaks in Europe and the USA. The incidence of diarrhoea, particularly among children in low- and middle-income countries of Africa, South America and South Asia, increases during floods and floods preceded by drought[9] as these events reduce the quality of drinking water sources and contaminate them with pathogenic agents[10]. Additionally, changes in temperature and rainfall have been shown to affect human social behaviour, as people favour indoor activities over outdoor activities during unfavourable weather conditions, and, depending on indoor ventilation rates, this may facilitate the transmission of airborne diseases like COVID-19.[11]

Mechanisms of disease aggravation

There are three main mechanisms by which climate hazards stimulate infectious disease transmission:

Gradual environmental change

The slow but consistent increase in global temperatures is enabling climate-sensitive disease vectors, such as mosquitoes and ticks, to expand their geographical ranges into new territories and reproduce at a faster rate, consequently increasing their ability to transmit diseases.[12] Altered rainfall patterns can create breeding grounds for mosquitoes, which escalates the incidence of vector-borne diseases. Such increases in these diseases have been noticed around the world. For example, in 2023, there was a large outbreak of chikungunya virus (CHIKV) in South America with over 120 000 confirmed cases and 51 deaths.[13] Of those deaths, 46 occurred in Paraguay, causing substantial health disruptions as the virus spread to all corners of the country. This was the largest outbreak of CHIKV ever recorded in Paraguay and coincided with the highest average reported temperatures in the country's history.[14] In 2023, there was an extremely high global risk of contracting dengue virus, with an estimated 40% of the population at risk, partly attributed to the El Niño phenomenon and humanitarian crises.[15] At this time, 15 countries within the World Health Organization's (WHO) African region had reported cases of dengue with the number of infections in the region nine-fold higher than in 2019.[15]

Additionally, in the face of climate change and land-use change, in order to survive, many animal species will need to move their home ranges along with the environment as it changes. Such local and large-scale movements of animals will cause new species to interact with one another, potentially stimulating novel pathogen-sharing events and disease emergence in wildlife.[16] These pathogen-sharing events have the potential to be globally devastating, just as the SARS-CoV virus jumped from bats into civets which enabled infections of humans and caused a mini-pandemic in 2002–2003.[17]

Extreme climate disasters

Extreme climate events are sudden and severe weather conditions such as floods, cyclones and wildfires that devastate communities, agriculture and natural ecosystems. These events are increasingly causing or amplifying

disease outbreaks by contaminating drinking water[18], displacing people and animals from their homes[19], disrupting social services, destroying crops and creating conditions of malnourishment such that affected communities are less capable of naturally fighting off disease[20]. These disasters often unfold quickly, catching countries off guard with limited time to prepare treatment facilities or interrupt disease transmission. Arguably, one of the most devastating infectious diseases triggered by extreme climate events is cholera. According to the WHO, as of mid-2021, we are in the midst of an acute upsurge of the seventh global cholera pandemic.[21] This pandemic has been characterised by multiple large outbreaks, spread of the bacteria to previously cholera-free areas, and alarmingly high mortality rates. Two such epidemics are worth noting. In 2022, Pakistan experienced extreme flooding, resulting in hundreds of thousands of infections (https://who-global-cholera-and-awd-dashboard-1-who.hub.arcgis.com/). The strain responsible for the outbreak in Pakistan was also associated with the deadliest cholera epidemic in Malawi's history, with over 57 000 confirmed cases and 1733 deaths during the 2022/2023 outbreak.[22]

Climate-induced migration

The above-mentioned gradual changes in temperature and rainfall also have indirect effects on disease transmission via their impacts on food production and water availability. Long-term droughts are causing crop failures and raising issues of food insecurity[23], while desertification fosters conflict over water access[24]. Disrupted access to food and water prompts both people and animals to migrate in search of these basic resources as well as new economic opportunities.[25] Regional and international movement of people may stimulate outbreaks by the introduction of pathogens into non-endemic areas to naive populations, through susceptible migrants being exposed to new pathogens, or from overcrowding in informal settlements.[26] For example, there have been 12 recorded outbreaks of acute viral hepatitis in forcibly displaced peoples in sub-Saharan Africa since 2010, with at least 30 000 cases and over 600 deaths.[27] These outbreaks have been attributed to poor sanitation and overcrowding conditions[26], which are a consequence of climate-induced migration and displacement of people.

Call to action

Unfortunately, while countries in the Global South contribute less than 10% of greenhouse gas emissions (https://ourworldindata.org/co2-emissions-metrics), they are more at risk of climate-related health threats (https://ourworldindata.org/health-meta#burden-of-disease) and have less adaptive capacity to respond to these threats. As such, low- and middle-income countries are highly vulnerable to climate-induced hazards. In response to the Global South climate-health crisis, the Climate Amplified Diseases and Epidemics (CLIMADE) consortium has banded together leading scientists working to close knowledge gaps, improve disease surveillance tools and develop disease transmission interventions to decrease the impact of climate-amplified diseases (https://climade.health/). The CLIMADE consortium has highlighted five action points for governments, academic institutions, scientists, public health officials, private sector industries and health organisations to consider in order to collectively address the climate-health crisis.[28] Firstly, CLIMADE urges governments and health organisations to **report outbreaks timeously** and transparently, as it is crucial for global preparedness and outbreak response efforts. Secondly, relevant stakeholders, such as governments, academic institutions, and health organisations, must expand and **strengthen disease and genomic surveillance** capacity. Strong genomic surveillance programmes will equip nations to detect emerging pathogens and instate response strategies early on in outbreaks. Thirdly, globally, we need to **prioritise** the development of adequate health care, infrastructure, and disaster preparedness systems for **vulnerable populations,** as they are most affected by the crisis. Also, academic institutions and private sector industries should **promote climate resilience** within healthcare systems by developing solutions to prevent damage from extreme weather events and ensure the supply of essential medical supplies during crises. Lastly, CLIMADE calls on governments, private sector industries, and health organisations to **commit sustainable funding** for research, capacity-building, and community engagement in the fight against climate change related infectious diseases.

With the world already grappling with climate-induced disease outbreaks, we need immediate and concerted action to address the complex challenges posed by the intersection of climate and health. Building global capacity, improving surveillance, and developing climate-resilient healthcare systems are critical steps in safeguarding communities from further harm. The window to act is narrowing; we need to work collectively to mitigate potential public health losses and build a more resilient, equitable future for all.

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Declarations

We have no competing interests to declare. We have no AI or LLM use to declare. All authors read and approved the final manuscript.

References

1. Calim Costa M, Marengo JA, Alves LM, Cunha AP. Multiscale analysis of drought, heatwaves, and compound events in the Brazilian Pantanal in 2019-2021. Theor Appl Climatol. 2024;155(1):661–677. https://doi.org/10.1007/s00704-023-04655-2
2. MapBiomas Brasil [webpage on the Internet]. No date [cited 2024 Sep 12]. Available from: https://brasil.mapbiomas.org/en/2024/07/05/ate-25-da-vegetacao-nativa-do-brasil-pode-estar-degradada/
3. Eloff H. Climate change wreaks havoc: Major floods in KwaZulu-Natal and Eastern Cape. NSRI 2024 June 27 [cited 2024 Sep 12]. Available from: https://www.nsri.org.za/2024/06/climate-change-wreaks-havoc-major-floods-in-kwazulu-natal-and-eastern-cape/
4. De Oliveira T, Tegally H. Will climate change amplify epidemics and give rise to pandemics? Science. 2023;381(6660), eadk4500. https://doi.org/10.1126/science.adk4500
5. Baker RE, Mahmud AS, Miller IF, Rajeev M, Rasambainarivo F, Rice BL, et al. Infectious disease in an era of global change. Nat Rev Microbiol. 2022;20(4):193–205. https://doi.org/10.1038/s41579-021-00639-z
6. Mora C, McKenzie T, Gaw IM, Dean JM, von Hammerstein H, Knudson TA, et al. Over half of known human pathogenic diseases can be aggravated by climate change. Nat Clim Chang. 2022;12(9):869–875. https://doi.org/10.1038/s41558-022-01426-1
7. Mencattelli G, Ndione MHD, Silverj A, Diagne MM, Curini V, Teodori L, et al. Spatial and temporal dynamics of West Nile virus between Africa and Europe. Nat Commun. 2023;14(1), Art. #6440. https://doi.org/10.1038/s41467-023-42185-7
8. Erazo D, Grant L, Ghisbain G, Marini G, Colón-González FJ, Wint W, et al. Contribution of climate change to the spatial expansion of West Nile virus in Europe. Nat Commun. 2024;15(1), Art. #1196. https://doi.org/10.1038/s41467-024-45290-3
9. Wang P, Asare EO, Pitzer VE, Dubrow R, Chen K. Floods and diarrhea risk in young children in low- and middle-income countries. JAMA Pediatr. 2023;177(11):1206–1214. https://doi.org/10.1001/jamapediatrics.2023.3964
10. Jung Y-J, Khant NA, Kim H, Namkoong S. Impact of climate change on waterborne diseases: Directions towards sustainability. Water. 2023;15(7), Art. #1298. https://doi.org/10.3390/w15071298
11. Shenoy A, Sharma B, Xu G, Kapoor R, Rho HA, Sangha K. God is in the rain: The impact of rainfall-induced early social distancing on COVID-19 outbreaks. J Health Econ. 2022;81, Art. #102575. https://doi.org/10.1016/j.jhealeco.2021.102575
12. De Souza WM, Weaver SC. Effects of climate change and human activities on vector-borne diseases. Nat Rev Microbiol. 2024;22(8):476–491. https://doi.org/10.1038/s41579-024-01026-0
13. World Health Organization. Disease Outbreak News: Geographical expansion of cases of dengue and chikungunya beyond the historical areas of transmission in the region of the Americas. Geneva: World Health Organization; 2023.

14. Giovanetti M, Vazquez C, Lima M, Castro E, Rojas A, Gomez de la Fuente A, et al. Rapid epidemic expansion of chikungunya virus east/central/south African lineage, Paraguay. Emerg Infect Dis. 2023;29(9):1859–1863. https://doi.org/10.3201/eid2909.230523

15. WHO African Region. Multi-country outbreak of dengue. Consolidated Regional Situation Report # 001. Brazzaville: WHO African Region; 2023.

16. Carlson CJ, Albery GF, Merow C, Trisos CH, Zipfel CM, Eskew EA, et al. Climate change increases cross-species viral transmission risk. Nature. 2022;607(7919):555–562. https://doi.org/10.1038/s41586-022-04788-w

17. Cherry JD. The chronology of the 2002-2003 SARS mini pandemic. Paediatr Respir Rev. 2004;5(4):262–269. https://doi.org/10.1016/j.prrv.2004.07.009

18. Rieckmann A, Tamason CC, Gurley ES, Rod NH, Jensen PKM. Exploring droughts and floods and their association with cholera outbreaks in sub-Saharan Africa: A register-based ecological study from 1990 to 2010. Am J Trop Med Hyg. 2018;98(5):1269–1274. https://doi.org/10.4269/ajtmh.17-0778

19. Choi SH, Beer J, Charrow A. Climate change and the displaced person: How vectors and climate are changing the landscape of infectious diseases among displaced and migrant populations. Int J Dermatol. 2023;62(5):681–684. https://doi.org/10.1111/ijd.16636

20. El Samra GH. Climate change, food security, food safety and nutrition. Egypt J Occup Med. 2017;41(2):217–236.

21. World Health Organization. Disease Outbreak News: Cholera – Global situation. Geneva: World Health Organization; 2023.

22. Chabuka L, Choga WT, Mavian CN, Moir M, Tegally H, Wilkinson E, et al. Genomic epidemiology of the cholera outbreak in Malawi 2022-2023 [preprint]. medRxiv. 2023 Aug 24. https://doi.org/10.1101/2023.08.22.23294324

23. Ngcamu BS, Chari F. Drought influences on food insecurity in Africa: A systematic literature review. Int J Environ Res Public Health. 2020;17(16), Art. #5897. https://doi.org/10.3390/ijerph17165897

24. Eswaran H, Reich P, Beinroth F. Global desertification tension zones. In: Stott DE, Mohtar RH, Steinhardt GC, editors. Sustaining the global farm. Selected papers from the 10th International Soil Conservation Organization Meeting; 1999 May 24; USA. 2001;29:24–28.

25. Wetlands International. Water shocks: Wetlands and human migration in the Sahel. Ede: Wetlands International; 2017.

26. Tsui J, Pena R, Moir M, Inward R, Eduan W, San JE, et al. Impacts of climate change-induced human migration on infectious diseases. Nat Clim Change. 2024;14:793–802. https://doi.org/10.1038/s41558-024-02078-z

27. Desai AN, Mohareb AM, Elkarsany MM, Desalegn H, Madoff LC, Lassmann B. Viral hepatitis E outbreaks in refugees and internally displaced populations, sub-Saharan Africa, 2010-2020. Emerg Infect Dis. 2022;28(5):1074–1076. https://doi.org/10.3201/eid2805.212546

28. CLIMADE Consortium. Summary for policymakers: COP28. In: de Oliveira T, Baxter C, editors. Climate change and epidemics 2023. Stellenbosch: CLIMADE Consortium; 2023. p. 1–23.