Trends in Health Sciences

Article

https://doi.org/10.47626/ths-2025-0004

Extreme climate events, such as flooding in Rio Grande do Sul: the potential contribution of primary health care to building climate-resilient communities

As enchentes no Rio Grande do Sul e o aumento de eventos climáticos extremos: a potencial contribuição da atenção primária para a construção de comunidades resilientes ao clima

Andy Haines[1]
https://orcid.org/0000-0002-8053-4605

Anya Gopfert[2]
https://orcid.org/0000-0002-1678-4773

ABSTRACT | Climate change is increasing the frequency and intensity of extreme events such as heatwaves, floods, and droughts around the world. The recent flooding in the state of Rio Grande do Sul, Brazil, in April-May 2024 broke all previous records and had profound implications for the health and well-being of the population. Flooding can lead to an increase in deaths, infectious diseases, and injuries; it can also disrupt health care delivery and worsen noncommunicable diseases, including contributing to a rise in mental health conditions. In this article, we outline how primary health care (PHC) can reduce the health risks associated with flooding through its role in prevention, preparedness, response, and recovery. We discuss the key role of PHC in addressing the health impacts of climate change and present interventions that can help protect population health. We also emphasize the need to recognize the PHC workforce as a key actor in responding to the climate emergency.

Keywords | Climate change; flooding; climate resilient health systems; mental health; communicable diseases; extreme events; climate adaptation.

RESUMO | As mudanças climáticas estão aumentando a frequência e a intensidade de eventos extremos, como ondas de calor, enchentes e secas no mundo todo. As recentes enchentes no estado do Rio Grande do Sul, entre abril e maio de 2024, bateram todos os recordes anteriores, com profundas implicações para a saúde e o bem-estar da população. As enchentes podem aumentar o número de mortes, doenças infecciosas e lesões, além de prejudicar a prestação de serviços de saúde e agravar doenças crônicas, inclusive problemas de saúde mental. Neste artigo, delineamos como a Atenção Primária à Saúde (APS) pode reduzir os riscos das enchentes para a saúde humana, por meio de ações de prevenção, preparação, resposta e recuperação. Também discutimos o papel fundamental da APS na preparação e resposta aos impactos das mudanças climáticas na saúde, destacando intervenções essenciais para a proteção da saúde da população. Por fim, enfatizamos a necessidade de reconhecer a força de trabalho da APS como um ator-chave no enfrentamento da emergência climática.

Palavras-chave | Mudanças climáticas; inundações, sistemas de saúde resilientes ao clima; saúde mental; doenças transmissíveis; eventos extremos; adaptação climática.

[1] Professor of Environmental Change and Public Health, Centre on Climate Change and Planetary Health, London School of Hygiene and Tropical Medicine, London, United Kingdom.
[2] South West Deanery, Health Education England, London, United Kingdom.

Submitted Jul 19 2024. Accepted Jan 02 2025.

Correspondence: Andy Haines
E-mail: Andy.Haines@lshtm.ac.uk

How to cite this article: Haines A, Gopfert A. Extreme climate events, such as flooding in Rio Grande do Sul: the potential contribution of primary health care to building climate-resilient communities. Trends Health Sci. 2025;67(1):e20250004.

Introduction

The decade from 2015 to 2024 is the warmest on record. Between January and September 2024, the global mean surface air temperature was 1.54 °C above the pre-industrial average, driven in part by an El Niño event (1) (Figure 1). Temperature increases have generally been faster over land than over oceans. Since the early 1980s, the rate of temperature rise has been more than three times faster than the average rate since the beginning of the 20th century (2) Despite unequivocal evidence that climate change is caused by greenhouse gas (GHG) emissions — primarily from the burning of fossil fuels, as well as from agriculture, food systems, and land use — the emissions of the three main GHGs (carbon dioxide, methane, and nitrous oxide) continue to rise (1).

The failure of international negotiations to deliver meaningful cuts in GHG emissions means that temperatures are expected to continue rising for the foreseeable future, with projections of up to a 3.4 °C increase in the global average temperature compared to pre-industrial levels by 2100 (3). However, decisive climate action — resulting in deep reductions in GHG emissions — could still keep the global average temperature increase below 2 °C.

Climate change is increasing the frequency and intensity of extreme events such as heatwaves, floods, and droughts around the world (4), with profound implications for health,

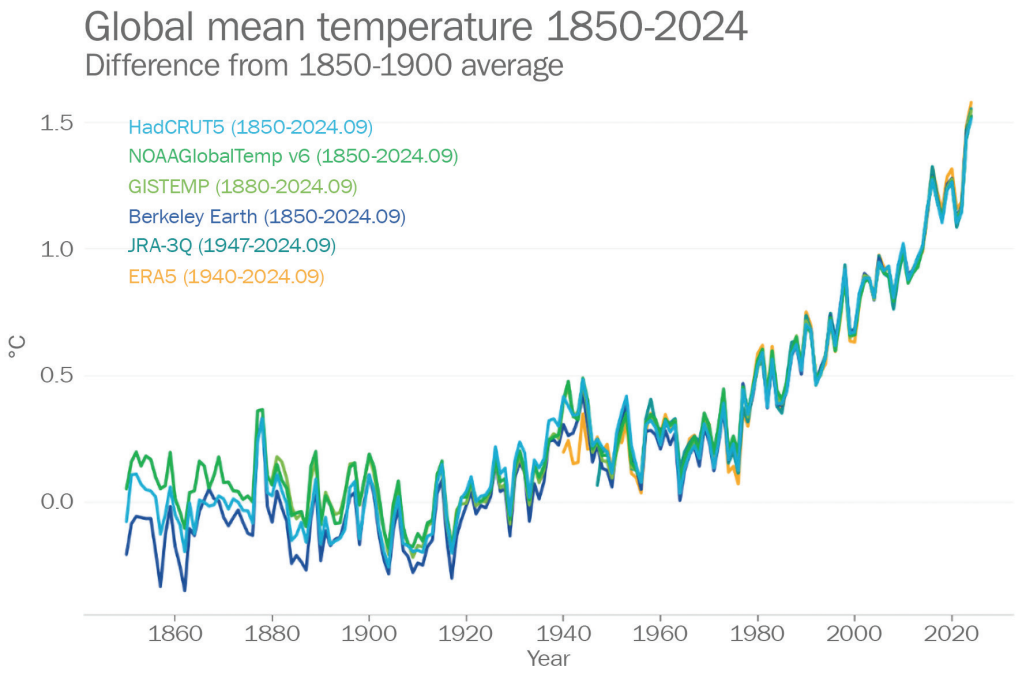

Figure 1. Adapted from World Meteorological Organization (WMO) State of the Climate 2024 Update for the 29th Meeting of the Conference of the Parties (COP) (1).

well-being, and the development prospects of billions of people. The health effects of climate change include physical and mental health impacts from extreme events, increases in respiratory illnesses following wildfires, changes in the distribution and transmission of infectious diseases, rising undernutrition, poverty, population displacement, and potentially conflict (5,6).

Primary health care (PHC) is on the frontline of the response to climate-related events, but it is also vulnerable to disruption. Learning from recent flooding events is therefore essential to increasing the resilience of health care systems to climate change and strengthening their capacity to prevent and manage the health impacts of flooding.

Health effects of flooding in Rio Grande do Sul

The extreme flooding that affected 90% of the state of Rio Grande do Sul in April–May 2024 broke all previous records (7). An analysis by an international team of scientists attributed the floods to a combination of climate change, El Niño, and infrastructure failures (8). The floods displaced more than 580,000 people, with informal settlements, Indigenous villages, and predominantly *quilombola* communities particularly affected. By late May, over 200 people had been reported dead or missing (9). A lack of investment in flood protection played a significant role, as the system reportedly began to fail at a floodwater depth of 4.5 m — despite its stated capacity to withstand up to 6 m.

More than 8 million Brazilians live in areas at risk of landslides, floods, and other climate-related disasters, including over 270,000 in Rio Grande do Sul (10). The magnitude of the recent flooding suggests that these 2010 estimates will need to be revised upward due to increasing climate risks. Approximately 3,000 health facilities — including clinics, hospitals, pharmacies, and doctors' offices — were affected by the May 2024 floods (11).

Flood-related deaths in Brazil caused by extreme rainfall have increased over the decade leading up to 2022, with about 25% of these deaths occurring in 2022 alone (12). Deaths during floods are caused by drowning, trauma from landslides or solid debris, hypothermia, electrocution, and carbon monoxide poisoning from the unventilated combustion of fuel used for heating and cooking (12). Flooding also increases the transmission of infectious diseases such as leptospirosis, hepatitis A, hepatitis E, and typhoid (12,13).

Leptospirosis can be transmitted directly through contact with rat urine or indirectly through exposure to contaminated soil, food, or water. Other rodent-borne diseases, such as hantavirus, may also increase after floods (12). By late May 2024, 141 cases of leptospirosis had been confirmed in Rio Grande do Sul, with seven reported deaths (14). In Santa Catarina, the incidence of leptospirosis between 2000 and 2015 was associated with the number of rainy days, maximum temperatures, flash floods, and river flooding (15). The risk of diarrheal disease may also rise due to the consumption of contaminated food or drinking water, especially when compounded by failures in water treatment systems or disruptions in electricity supply. Respiratory infections can increase as a result of crowding in shelters and pneumonia following prolonged immersion in floodwaters. The effects of flooding on vector-borne diseases are mixed: flash floods may wash away mosquito breeding sites, while standing water left behind can provide ideal conditions for mosquitoes that transmit diseases such as

dengue. In 2023, Rio Grande do Sul reported 1,649,144 dengue infections and 1,179 related deaths. By June 2024, infections had surged to 6,148,161, with 4,207 deaths (16).

Flood victims and rescuers may experience dermal, respiratory, and systemic toxic effects from exposure to chemicals released during flooding. These may include the release of flammable hydrocarbons from storage depots, toxic mining waste from flooded coal mines or dam failures, runoff from waste storage sites, and pesticide, herbicide, and fertilizer residues from agricultural runoff (17).

A study of mortality following floods in 761 communities across 35 countries or territories found that the risks of all-cause, cardiovascular, and respiratory mortality increased for up to 60 days after flood exposure. The associations were stronger in communities with low socioeconomic status and a high proportion of older individuals (18). Overall, up to 0.10% of all-cause deaths, 0.18% of cardiovascular deaths, and 0.41% of respiratory deaths were attributed to flooding in the affected communities.

Pregnant women may be particularly vulnerable to the impacts of flooding. An analysis of pregnancy loss records from 33 low- and middle-income countries found that gestational exposure to flooding was associated with an increased risk of pregnancy loss (odds ratio of 1.08, 95% confidence interval 1.04-1.11), with annual excess pregnancy losses rising consistently from 2010 to 2020. Women outside the peak reproductive age range (<21 or >35 years), as well as those in the mid- or late stages of pregnancy, were at particularly high risk. Lower income and education levels further increased the likelihood of adverse outcomes (19).

Flood exposure also has pervasive and long-lasting effects on mental health, including anxiety, depression, post-traumatic stress disorder, and psychosomatic symptoms such as headaches and body pain. These impacts stem from multiple factors, including the disruption of community networks, economic and physical insecurity, gender-based violence, loss of personal belongings, limited access to health and social services, and interruptions in education (20). The flooding in Rio Grande do Sul had a major impact on agricultural productivity and the state's economy, which is expected to worsen poverty levels.

Disruptions to health care systems and supply chains for essential medicines, increased poverty due to reduced income and uninsured losses, and population displacement all contribute to breaks in care for a range of chronic conditions. Studies have documented, for example, increased risks of uncontrolled hypertension and cognitive decline in older adults following floods (12).

The role of PHC in reducing the health impacts of flooding

PHC can reduce the health risks associated with flooding through its roles in prevention, preparedness, response, and recovery. Primary prevention includes efforts to reduce the greenhouse gases driving climate change by advocating for an accelerated transition to clean, renewable energy; promoting more sustainable transport systems; encouraging healthy, plant-based diets; and supporting the decarbonization of the health care sector. These actions can also deliver near-term health benefits by reducing air pollution, increasing physical activity, and improving dietary quality (21).

Nature-based solutions — such as investing in green infrastructure, restoring wetlands and floodplains, and preventing construction in flood-prone areas — can help reduce flood risk (12). The PHC workforce can support local communities in advocating for such preventive measures. Improving preparedness requires the development of processes and protocols to respond to flood risk. This includes increasing awareness of flood vulnerability and establishing early warning systems that connect weather forecasting with health care systems and other relevant sectors. Such approaches also require enhanced staff training on the health effects of climate extremes, emergency evacuation procedures, and continuity-of-care planning during crises. Critical equipment — including backups of electronic medical records, pharmaceutical supplies, and vaccines — should be stored in locations not prone to flooding. Nearby health facilities should be equipped with additional resources to accommodate an increased number of patients.

PHC services play a vital role in responding to and recovering from floods, working in close collaboration with other sectors at the local level. PHC facilities should coordinate with regional and national teams to develop response plans, such as deploying mobile health units until healthcare infrastructure is restored and implementing telemedicine services when electricity is available. Enhanced surveillance for communicable diseases can enable early detection and timely interventions during outbreaks, but this requires careful planning and staff training. Community health workers can assist in providing clean water, as well as promoting sanitation and hygiene practices — including handwashing with soap — and supporting vector control programs, such as those aimed at preventing the spread of dengue. Maintaining the continuity of preventive services — such as vaccination, nutrition programs, and antenatal care — as well as ensuring the supply of essential medicines for patients with chronic conditions, are key priorities for the PHC workforce. Early diagnosis of respiratory and other infections is also critical during and after flood events.

During the recovery phase, recognizing the mental health impacts of flood exposure can support early diagnosis and facilitate community-based interventions. The PHC workforce can also play a role in addressing misinformation and disinformation about climate change, which are expected to become more prevalent in the future (22,23). Through evaluative research capturing lessons from the prevention, preparedness, response, and recovery phases, PHC facilities and staff can contribute to building the evidence base for effective interventions.

PHC can also enhance resilience to other hazards such as extreme heat, wildfires, droughts, intense storms, and food insecurity (24,25). Ensuring that PHC is adequately funded and fully integrated into national climate adaptation and mitigation plans is of paramount importance (26). Building capacity to meet these challenges also requires access to training and educational resources — such as those provided by the World Organization of Family Doctors (27) — alongside strengthened research capabilities to evaluate the effectiveness of PHC interventions.

Regrettably, climate change will continue to pose an increasing threat to health due to insufficient mitigation and adaptation efforts. The active engagement of health

professionals is essential to raise the level of ambition in climate action at local, national, and international levels. The PHC workforce should be recognized as a key actor in responding to the climate emergency.

DISCLOSURE: Dr. Andy Haines reports the following potential conflicts of interest: Principle Investigator Pathfinder Initiative 2020-present; co-investigator Sustainable Healthy Food Systems research programme 2017-2023; co-investigator Complex Urban Systems for Sustainability and Health (CUSSH) 2017-2023; collaborator on several other climate change and health projects all funded by the Wellcome Trust, with additional funding from the Oak Foundation for the Pathfinder initiative; reports royalties from Cambridge University Press; has received travel support from WHO and Human Frontiers Science Program; 2022-24 member of Cool roofs trial steering committee Nouna Research Centre, Burkina Faso/ University of Heidelberg; 2023-24 Co-chair of the International Advisory Committee, NIHR Clean-Air (Africa) Global Health Research Unit; 2023 member of the Independent Advisory Group, Collaboration for the Establishment of an African Population Cohort Consortium (CE-APCC); Co-chair InterAcademy Partnership, Climate change and health working group 2019-2022; US National Academy of Medicine Climate Grand Challenge Steering Committee 2023-present; Chair of the Office of National Statistics SOSCHI Expert Advisory Group 2023-present; Co-director of the WHO Collaborating Centre on Climate Change, Health and Sustainable Development between 2020-2024 and is currently scientific advisor to the WHO Pan-European Commission on climate change and health.

Anya Gopfert reports no conflicts of interest.

References

1. World Meteorological Organization [Internet]. State of the Climate 2024 Update for COP29. 2024 Nov 11 [cited 2024 Dec 27]. Available: https://wmo.int/publication-series/state-of-climate-2024-update-cop29
2. Lindsey R, Dahlman L. Climate.gov [Internet]. Climate Change: Global Temperature. 2024 Jan 18 [cited 2024 Dec 29]. Available: https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature
3. Climate Analytics [Internet]. Warming Projections Global Update. 2024 Nov [cited 2024 Dec 27]. Available: https://climateactiontracker.org/documents/1277/CAT_2024-11-14_GlobalUpdate_COP29.pdf
4. World Weather Attribution [Internet]. When Risks Become Reality: Extreme Weather In 2024. 2024 Dec 27 [cited 2024 Dec 27]. Available: https://www.worldweatherattribution.org/when-risks-become-reality-extreme-weather-in-2024/
5. Cissé G, McLeman R, Adams H, Aldunce P, Bowen K, Campbell-Lendrum D, et al. Health, Wellbeing, and the Changing Structure of Communities. In: Pörtner HO, Roberts DC, Tignor M, Poloczanska ES, Mintenbeck K, Alegría A, et al., eds. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press; 2022. p. 1041–170.
6. Haines A, Ebi K. The Imperative for Climate Action to Protect Health. N Engl J Med. 2019;380:263-73.
7. Clarke B, Barnes C, Rodrigues R, Zachariah M, Alves LM, Haarsma R, et al. [Internet] Climate change, El Niño and infrastructure failures behind massive floods in southern Brazil. 2024 Jun 3 [cited 2024 Dec 28]. Available: https://spiral.imperial.ac.uk/entities/publication/90f8beda-e5b7-43a0-b878-7f82abe695c6
8. Governo do Estado do Rio Grande do Sul [Internet]. Defesa Civil atualiza balanço das enchentes no RS - 29/5, 9h. 2024 May 29 [cited 2024 Dec 27]. Available: https://estado.rs.gov.br/defesa-civil-atualiza-balanco-das-enchentes-no-rs-29-5-9h
9. Instituto Brasileiro de Geografia e Estatística [Internet]. População em áreas de risco no Brasil. 2018 [cited 2024 Dec 28]. Available: https://www.ibge.gov.br/apps/populacaoareasderisco/#/home
10. Tokarnia M. Agência Brasil [Internet]. Floods have affected 3,000 health care units in Rio Grande do Sul. 2024 May 20 [cited 2024 Dec 28]. Available: https://agenciabrasil.ebc.com.br/en/geral/noticia/2024-05/floods-have-affected-3000-health-care-units-rio-grande-do-sul
11. Confederação Nacional de Municípios. Agência CNM de Notícias [Internet]. Mais de 25% das mortes por chuvas no Brasil nos últimos 10 anos ocorreram em 2022. 2022 May 31 [cited 2024 Dec 28]. Available: https://cnm.org.br/comunicacao/noticias/mais-de-25-das-mortes-por-chuvas-no-brasil-nos-ultimos-10-anos-ocorreram-em-2022

12. Wu Y, Wen B, Gasevic D, Patz JA, Haines A, Ebi KL, et al. Climate Change, Floods, and Human Health. N Engl J Med. 2024;391:1949-58.
13. Martins-Filho PR, Croda J, Araújo AAS, Correia D, Quintans-Júnior LJ. Catastrophic Floods in Rio Grande do Sul, Brazil: The Need for Public Health Responses to Potential Infectious Disease Outbreaks. Rev Soc Bras Med Trop. 2024;57:e006032024.
14. Governo do Estado do Rio Grande do Sul [Internet]. Mais dois óbitos por leptospirose são confirmados no Estado. 2024 May 29 [cited 2024 Dec 28]. Available: https://www.estado.rs.gov.br/mais-dois-obitos-por-leptospirose-sao-confirmados-no-estado-6657c7768dd44
15. Silva AEP, Latorre MDRDO, Chiaravalloti Neto F, Conceição GMS. Temporal trends in leptospirosis incidence and association with climatic and environmental factors in the state of Santa Catarina, Brazil. Cien Saude Colet. 2022;27:849-60.
16. Varzim CS, Dilly J, Pfeifer AO, Rosa LD, Silva CE, Silva OS. Um enorme risco de surtos de Dengue após as enchentes de outono de 2024 no sul do Brasil. Res Soc Dev. 2024;13:e19131046880.
17. World Health Organization. Chemical releases caused by natural hazard events and disasters – information for public health authorities. Geneva: World Health Organization; 2018.
18. Yang Z, Huang W, McKenzie JE, Xu R, Yu P, Ye T, et al. Mortality risks associated with floods in 761 communities worldwide: time series study. BMJ. 2023;383:e075081.
19. He C, Zhu Y, Zhou L, Bachwenkizi J, Schneider A, Chen R, et al. Flood exposure and pregnancy loss in 33 developing countries. Nat Commun. 2024;15:20.
20. Alderman K, Turner LR, Tong S. Floods and human health: a systematic review. Environ Int. 2012;47:37-47.
21. Whitmee S, Green R, Belesova K, Hassan S, Cuevas S, Murage P, et al. Pathways to a healthy net-zero future: report of the Lancet Pathfinder Commission. Lancet. 2024;403:67-110.
22. Piatek SJ, Haines A, Larson HJ. We need to tackle the growing threat of mis- and disinformation about climate change and health. BMJ. 2024;387:q2187.
23. Falce E. Time to talk to patients about climate change. BMJ. 2024;387:q2444.
24. Xie E, de Barros EF, Abelsohn A, Stein AT, Haines A. Challenges and opportunities in planetary health for primary care providers. Lancet Planet Health. 2018;2:e185-7.
25. Haines A, Kimani-Murage EW, Gopfert A. Strengthening primary health care in a changing climate. Lancet. 2024;404:1620-2.
26. Brazilian Government [Internet]. BRAZIL'S NDC National determination to contribute and transform. 2024 Nov [cited 2024 Dec 29]. Available: https://unfccc.int/sites/default/files/2024-11/Brazil_Second%20Nationally%20Determined%20Contribution%20%28NDC%29_November2024.pdf
27. Wonca [Internet]. WONCA Working Party: Planetary Health. [cited 2024 Dec 29]. Available: https://www.globalfamilydoctor.com/groups/WorkingParties/PlanetaryHealth.aspx