

Effects of climate-related risks and extreme events on health outcomes and health utilization of primary care in rural and remote areas: a scoping review

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Background: Rural populations are at risk of climate-related impacts due to ecological and geographical determinants, potentially leading to greater morbidity and health utilization. They are often highly dependent on primary care services. However, no rural- or primary care specific synthesis of these issues has ever been conducted. This review aimed to identify, characterize, and summarize existing research on the effects of climate-related events on utilization and health outcomes of primary care in rural and remote areas and identify related adaptation strategies used in primary care to climate-related events.

Methods: A scoping review following PRISMA-ScR guidelines was conducted, examining peer-reviewed English-language articles published up to 31 October 2022. Eligible papers were empirical studies conducted in primary care settings that involved climate-related events as exposures, and health outcomes or utilization as study outcomes. Two reviewers independently screened and extracted relevant information from selected papers. Data were analysed using content analysis and presented using a narrative approach.

Results: We screened 693 non-duplicate papers, of those, 60 papers were analysed. Climate-related events were categorized by type, with outcomes described in terms of primary, secondary, and tertiary effects. Disruption of primary care often resulted from shortages in health resources. Primary care may be ill-prepared for climate-related events but has an important role in supporting the development of community.

Conclusions: Findings suggest various effects of climate-related events on primary care utilization and health outcomes in rural and remote areas. There is a need to prepare rural and remote primary care service before and after climate-related events.

Key words: adaptation strategies, climate change, health care utilization, health outcomes, primary health care, rural health

Background

Climate change, largely attributable to human emissions, poses a great threat to human health. It affects social and environmental determinants of health, e.g. clean air, safe drinking water, food systems, and secure shelter.¹ Climate change is predicted to cause 250,000 extra deaths annually, with total estimated direct health costs of USD\$ 2–4 billion per year by 2030.¹

The changing climate has led to increases in climate-related risks and extreme events that can directly or indirectly affect human health.² For example, through reduced water availability and agricultural production, changes to human settlements and distributions of disease vectors, environmental disasters, and loss of ecosystem resources.^{1,3,4} Floods can cause fatalities in place and bodily trauma,⁵ but also can lead to disruption of food and clean water supply posing greater risk for gastrointestinal infections and malnutrition among children.^{3,6,7} Increasing ambient temperature along with bushfire events may lead to heat-related illnesses, cardiovascular and respiratory hospitalization,^{8,9} mental health issues¹⁰ or can increase transmission of vector-borne diseases.^{11,12} Extreme

events associated with changing climate can also institute social and economic disruptions,^{3,6,7,13} food insecurity,³ and disruption of access to health care.^{14–16}

Climate-related risks and extreme events are often more visible in low- and middle-income countries (LMICs), where adaptation capacities are limited, further exacerbating health inequities between rich and poor countries.^{1,4} The existing social, environmental, and economic pressures experiencing by LMICs, such as increasing poverty levels and food insecurity, land degradation, deforestation, rapid urbanization, water shortages, and limited public health and primary care capacity, all contribute to increased vulnerability to climate-related risks and extreme events.^{1,4}

Similarly, some social and environmental characteristics of rural and remote communities can increase vulnerability to climate-related risks and extreme events. Many rural and remote areas are heavily reliant on climate-sensitive resources, particularly water and food.¹⁷ They are also at higher risk of exposure to effects of multiple extreme events such as prolonged drought or floods,¹⁸ and resultant reductions in agricultural production. In turn, these events may increase the burden of chronic illness, infectious disease, unintentional

Key messages

- Climate-related events impact health outcomes and health utilization, and these effects may be exacerbated in rural populations.
- Rural primary care providers are crucial during immediate responses to extreme events, and in managing climate-related risks.
- Primary care mitigation and adaptation strategies are essential, though many providers and services may be under-prepared.
- Disaster management planning and risk mitigation strategies should incorporate community perspective and vulnerabilities.
- Primary care providers in rural areas have an important role in supporting community resilience development.

injury and death, and poor mental health.^{19,20} Rural and remote populations in various countries face ongoing issues associated with access to quality health care and higher burden of disease,^{20–26} meaning residents have limited capacity to mitigate health-related outcomes. Given that rural and remote populations already experience disadvantages associated with geographical isolation and reduced access to health services, they may also be at greater risk of adverse outcomes from climate-related risks and extreme events than urban settings. Such hazards further exacerbate many of the social, economic, health, and environmental inequities already experienced by rural population.¹⁸

The backbone of rural and remote health service delivery is ambulatory primary care providers (PCPs), with essential personnel ranging from medical doctors, nurses, and technicians to community health workers and allied health professionals.¹⁷ Some areas are also supported by rural and regional hospitals with variable access to specialist services, but with limited scale and capacity relative to their metropolitan counterparts.^{27,28} Rural and remote populations commonly rely on PCPs to mitigate and address health impacts of climate-related risks, including preparing for and responding to disasters and extreme weather events, providing care for health-related sequelae, and dealing with indirect and long-term consequences.²⁹ Additionally, primary care may also play a significant role in mitigating climate-related risks by promoting environmentally sustainable health care services.³⁰

The increasing number of publications examining health effects of climate change³¹ suggest it may be timely to review the available literature to identify the effects of climate-related risks and extreme events on health outcomes and health care utilization among rural and remote populations, in light of potential differences. There is also a case for considering these issues with specific reference to primary care settings, and their role in response and adaptation to climate-related effects on health. Previous reviews have focussed on mental health²⁰ or examined impacts on health which are not specific either to primary care or to rural areas.^{1,3,6,19} This paper presents findings from a scoping review, which aimed to (i) identify, characterize, and summarize existing research on the effects of climate-related events on health outcomes and health utilization of primary care in rural and remote areas globally and (ii) identify adaptation strategies used in primary care in response to climate-related events in rural and remote areas. Findings from this review can be used to identify research gaps and inform policy formulation related to primary care preparedness in disaster management in rural and remote areas.

Methods

This scoping review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-analysis Extension for Scoping Reviews (PRISMA-ScR).^{32,33} It also forms part of a broader living systematic review of ecological determinants of health care outcomes in rural and remote settings registered in the Open Science Framework (doi:10.17605/OSF.IO/GEPSJ).

Concepts and contexts

Definitions of rurality and remoteness differ internationally but generally encompass regions with relatively smaller populations outside major cities.^{21,27} In this review, the classification of rurality was based on a simple, inclusive categorization of *not urban*.

According to the World Health Organisation, primary care constitutes any health services that facilitates entry-level access to the health system and is primarily the first encounter of a person with a given health concern.³⁴ The primary care covers a broad range of health care; including health promotion, prevention, early intervention, treatment, and management of acute and chronic conditions; but is generally not related to hospital visits.

Climate-related risks and extreme events are defined as long-term alteration of temperatures and weather patterns observed across the globe.¹¹ In this review, these included bushfires, floods, storms/hurricanes, drought, and extreme heat. The effects on health are considered using 3 ‘pathways’: primary effects as the direct result of climate-related risks; secondary, as indirect effects in which changes to the physical environments subsequently impact health, and tertiary effects in which environmental changes disrupt social determinants of health and eventually impact health.²

Searching

The following databases were searched, without date restriction, for eligible studies on the 1 April 2022: PubMed, Web of Science Core Collection, Scopus, the Cochrane Library, ProQuest Dissertations and Theses, and WHO IRIS. In addition, hand searches of cited articles within eligible studies were also conducted. A follow-up search was conducted on the 31 October 2022.

Search terms included words associated with health outcomes, primary care service utilization, climate change, and rural and remote settings. An initial search strategy was developed in PubMed, combining Medical Subject Headings terms and specific terms, which were then adapted for the remaining databases. Pilot searches demonstrated that title and abstract

searches were satisfactory, returning sufficient relevant articles without retrieving excessive irrelevant results. **Table 1** displays employed search terms using a population, exposure, comparison, and outcome (PECO) approach.

Search results were exported to Endnote,³⁵ and duplicates were removed before importing to Covidence (Veritas Health Innovation, Melbourne, VIC, Australia) for screening. Titles and abstracts were screened, and studies outside the scope of the review were removed. Full-text screening of articles was undertaken against inclusion and exclusion criteria by 2 reviewers independently (SD and RK), and any disagreements were resolved by inviting a third reviewer (SHD and INS).

Inclusion criteria

The review included English-language, original research articles published in peer-reviewed journals that described the effects of climate-related risks and extreme events in geographically rural or remote areas. Eligible studies were conducted in primary care settings and identified at least 1 climate-related event as exposure and at least 1 outcome concerning health outcomes or health service utilization. Studies that used quantitative, qualitative, and mixed methods approaches were included, though we excluded study protocols, reviews, letters, editorials, and commentaries. Studies that did not directly address the effect of climate-related events on health outcomes or utilization were also excluded. This review also excluded studies that examined the impacts of health care utilization on ecological factors (e.g. the effect of telemedicine on greenhouse gas reduction).

Data extraction and analysing

A data charting form, aligned with review objectives, was used to extract information from included studies. The form was developed a priori and piloted on 5 randomly selected studies to ensure all relevant results were extracted and then iteratively updated. Critical information included authors, year of publication, country and region, study setting and

population, study design and aims, exposure, outcomes, and key findings.

Included studies were classified according to exposure (climate-related risks and extreme events) and outcome type (patient health outcomes, health care utilization). Study concepts, characteristics, and results were coded and analysed using summary statistics and qualitative descriptions where appropriate. Given the inclusion of both quantitative and qualitative findings and heterogeneous study designs, a narrative synthesis of the evidence was performed.³⁶ Results are presented both numerically and narratively as appropriate to map the evidence and identify gaps for future research.

Results

A total of 693 non-duplicate articles were identified through the search strategy; after screening, 60 articles from 49 individual studies were included in the analysis (**Fig. 1**). Studies were conducted from 2003 to 2022. Using the World Bank country classification,³⁷ 26 of the studies were undertaken in high-income countries (Australia, Canada, China, and the United States) and 23 studies were conducted in LMICs (Bangladesh, Guatemala, India, Iran, Namibia, Pakistan, Peru, Sri Lanka, Tanzania, Vietnam, Zimbabwe). All articles were observational designs, including quantitative ($n = 24$), qualitative ($n = 23$), and mixed methods ($n = 13$) approaches (see **Table 2**) (**Supplementary Material**).

Specific climate-related risks and extreme events reported in the included studies were floods ($n = 15$), storms ($n = 9$), drought ($n = 8$), extreme heat ($n = 7$), and bushfires ($n = 3$), while mixed extreme weather events were reported in 7 studies. Findings are presented in 3 categories: effects of climate-related risks and extreme events on health outcomes of rural populations, effects of climate-related risks on primary care utilization, and adaptation strategies adopted by primary care in response to climate-related risks and extreme

Table 1. PECO search strategy.

Patients/setting	Exposures	Outcomes
Subject terms (MESH): Rural population (includes community, rural, rural popula- tions)	Subject terms (MESH): Ecological and environmental phenomena Ecology Environmental pollution Environmental pollutants Natural disasters	Subject terms (MESH): Delivery of health care Primary health care Hospitals General practice Health services (includes rural health services and rural hospitals) Health facilities (includes hospitals)
Specific terms: Rural, provincial, periurban	Specific terms: Ecology, ecological Climate change Global warming Biodiversity Greenhouse gases Surface temperature, air temperature, heatwave Sea level rise, freshwater, groundwater Storms, hurricane, flood, drought, weather event, desertification, rain Bushfire, wildfire Pollution/pollutants Ecotoxicity, industrial waste, heavy metals, nanoparticles, microplastics Fossil fuel Disaster management, disaster response	Specific terms: Health care/health care primary care, general practice, family medicine, fam- ily practice, health service, community health centre, allied health practice

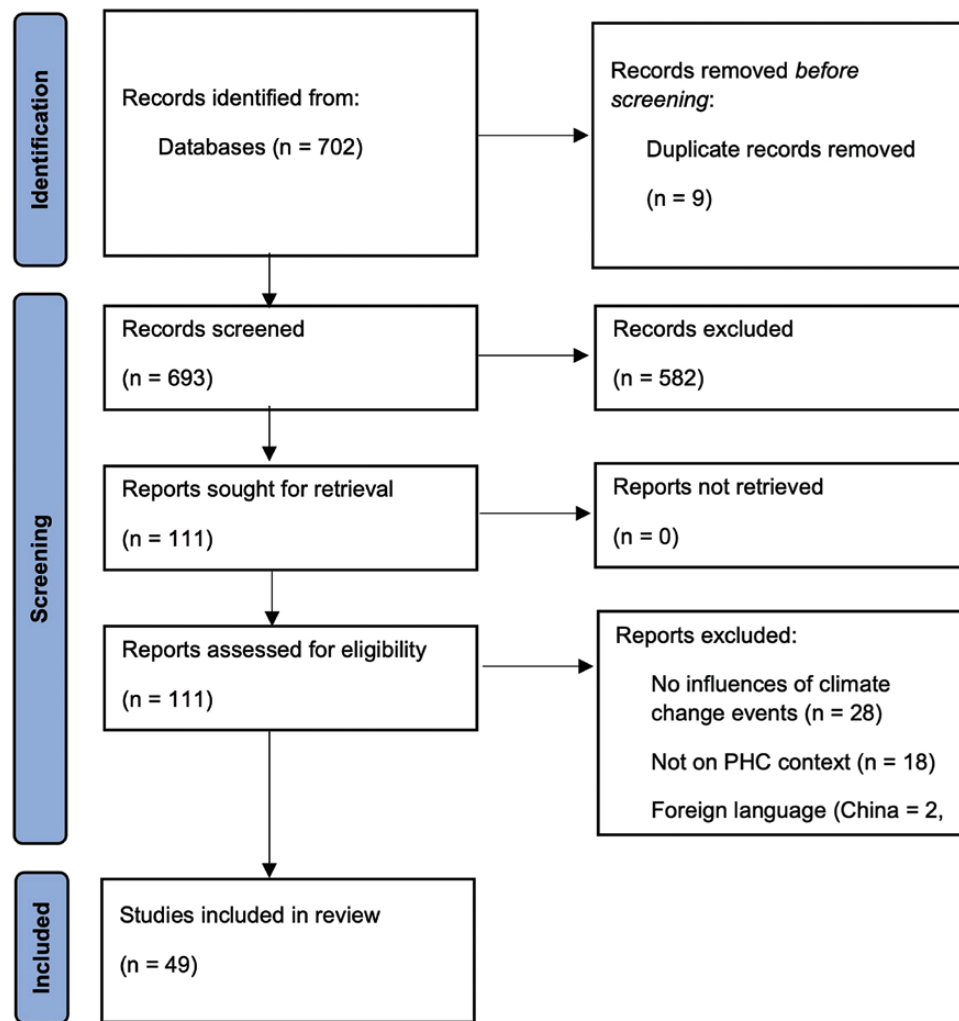


Fig. 1. PRISMA flow diagram. PHC, primary health care.

events. These results are summarized in Table 3 and Fig. 2, with outcomes also considered in terms of effect pathways.

Effects of climate-related risks and extreme events on health outcomes in primary care

Of the 60 included articles, 42 articles examined the effects of climate-related risks and extreme events on the health of rural populations.^{38–78,82,86}

Primary effects were evident in the direct impact of these events on health outcomes in real time, such as asthma and chronic obstructive pulmonary diseases in those with chronic conditions due to dust storms caused by prolonged drought⁸² and bushfires.⁴⁰ Floods and storms caused increased snakebites,^{60,61} accidental injuries and deaths of those living in affected areas.^{58,60} Extreme heat led to heatwaves and initiated heat-related illnesses, such as heat stroke and heat cramps.^{46,72–75}

Climate-related events also triggered environmental changes, producing secondary effects. For example, drought and floods disrupted safe drinking water, sanitation and hygiene, leading to increased water-borne diseases such as diarrhoea.^{60,66,85} In addition, drought and bushfires reduced air quality, leading to respiratory and cardiovascular diseases.^{38,40,47,56} Drought also affected mental health, particularly

in the elderly, adolescents and indigenous peoples.^{51–53,57} Extreme weather events also modified the natural environment of disease pathogens, leading to an increase in vector-borne diseases, such as Malaria, Lyme disease, Dengue fever, Ross River^{40,43,60} and zoonotic diseases, such as Q fever.⁴⁵ Floods and drought also negatively affected agricultural production, as a primary source of food that could create food insecurity.^{44,48,59,63–65,67,70}

Tertiary effects regenerated as climate-related events institute changes in social, behavioural, and political dimensions that affect the health of rural populations. In this review, disruption of health facilities in flood-affected areas caused medicinal shortages, including antiretroviral therapies for HIV/AIDS, leading to disruption of HIV/AIDS treatment and increased risk of transmission.⁶³ Three maternal deaths were reported during flooding in Bangladesh due to disruption of access that delayed medical help during difficult deliveries.⁷¹ Two studies reported increased domestic violence against women during flooding in Zimbabwe⁷⁰ and Namibia.⁶³ Those who experienced climate-related events such as floods and prolonged drought often decided to displace to a safer location or migrate to a major city.^{53,60} These migrants consequently had a lacked social support, which contributed to poor mental health.

Table 2. Summary of characteristics of included studies.

Study type	Publication (<i>n</i> = 60)
Qualitative methods	23
Quantitative methods	24
Mixed methods	13
Primary care setting	
Community health centre	48
General practice clinic	9
Allied health practice	1
Family medicine practice	2
Location	
Remote	1
Remote and rural	6
Rural	43
Mixed: rural, regional and urban	10
Study setting/country	
Australia	17
Bangladesh	11
Canada	5
China	3
Guatemala	1
India	2
Iran	3
Namibia	1
Pakistan	2
Peru	1
Sri Lanka	3
Tanzania	1
United States	7
Vietnam	2
Zimbabwe	1

Floods, storms, and droughts affected agricultural crops, exacerbating the vulnerability of rural populations to poverty.^{40,42,47,49,50,58,70} In some circumstances, this poverty led to the inability to meet energy requirements, causing protein-energy malnutrition, especially in children⁴⁷ or reducing health care expenditure and resultant worsening of chronic conditions.⁴⁹

Effects of climate-related risks and extreme events on primary care utilization

Thirty-five articles reported changes in the utilization of primary care in rural and remote areas.^{38,40–42,48,49,51,53,58–60,62–65,67,69–72,75–80,82,83,85,86,91,93–95} Increased health care visits were reported during the emergency or acute event (commonly the first 2 weeks), especially for those subjected to primary effects, such as unintentional injuries.^{42,76,89} Once the emergency period was over, there was increased health service utilization (commonly the first 6 months), especially for those experiencing chronic conditions,^{58,72,80,82,94} including mental health.^{41,79,95}

Extreme weather events such as floods and storms caused the destruction of health facilities, power outages, and disruption access to primary care.^{40,53,60–65,67,76,85} While demand for health services increased, PCPs experienced medicinal and health workforce shortages.^{48,61,63,70,77} In this situation, some

communities visited unqualified local health providers for their health issues.^{42,60,71,85} Some survivors found their communities and families were more helpful in assisting their health problems,^{62,76,91,93–95} and the use of self-knowledge of medications and previous healing experiences was also noted.^{42,53} Other studies suggested that decreased utilization for non-urgent services during extreme heat was related to patient adaptation to limit their outdoor activities to prevent heat-related illness.^{40,41,43,75} Once the ambient temperature decreased, the number of services returned to normal. Some studies also suggested that displacement during extreme weather events might contribute to decreased health care utilization in displaced areas.^{43,80,86,97}

Studies reported that maternal care had been seriously disrupted during extreme weather events. There was a decreased number of deliveries attended by trained health workers.^{71,78,86} One study reported that mothers from displaced households had lower prenatal care compared with non-displaced mothers,⁸⁶ while another found that pregnant mothers received inadequate prenatal care that might induce risk of preterm birth and small gestational age.⁷⁸ Similar disruptions also existed in family planning care⁷⁰ and treatment for HIV infection.⁶³ These findings showed that women were more susceptible than men to the impacts of climate-related events.

The exacerbation of poverty in rural populations in response to climate-related events resulted in decreased health expenditure.⁴⁹ In addition, those living in rural or remote areas in LMICs, had out-of-pocket payments generated by unattainable universal health coverage.^{49,59,84} This further reduced health expenditure of personal or family resources on preventive health care or to manage existing chronic conditions.^{64,65}

Adaptation of primary care to climate-related risks and extreme events

Twenty-eight articles discussed strategies used by primary care to adapt health care provision.^{10,38–40,44,52–55,61,63,68–71,75–77,81,85,87–92,94,96} As the first contact for health care, rural populations are relying on PCPs for assistance in managing their health issues.

Emergency task forces were formed within a brief period after events and provided initial responses focussed on managing health concerns.^{38,61,76} PCPs commonly adjusted their operating hours during floods^{61,85} or extreme heat.^{40,75} Additionally, some relocated their health services to other facilities such as schools⁸⁵ or established mobile clinics.⁷⁶ Occasionally, non-clinical staffs were tasked to undertake minor procedures and dispense medications.^{71,85,87,88} Patients were sometimes referred to other health facilities.^{71,85} However, these conditions often did not last long due to limited medical and financial resources as well as access to referrals that could provide more extensive care.^{71,85} Special programmes or health teams were sometimes set up to cover health services that were not readily available. For example, Zika virus screening health brigades were formed after Hurricanes Irma and Maria to provide care for mothers and children in the US Virgin Islands.⁹⁶

Eight articles evaluated the preparedness of primary care for climate-related risks,^{61,76,85,87–90,92} concluding that PCPs in rural areas were unprepared for climate-related impacts, in various ways. Service delivery was focussed mainly on treatment,

Table 3. Effects of climate-related risks and extreme events on health outcomes and health utilization of primary care in rural and remote areas.

No.	Climate-related risks and extreme events	Effects on health outcomes		
		Primary	Secondary	Tertiary
1	Bushfires	Increased unintentional injury ³⁸	Mental health ^{38,39} Eye irritation ⁴⁰ Increased respiratory diseases ⁴⁰	
2	Droughts	Increased respiratory diseases ⁴¹ Increased heat-related illness ^{42,43}	Increased vector-borne diseases ⁴⁴ Increased infectious diseases ⁴⁵ Increased water-borne diseases ^{44,46,47} Increased respiratory diseases ⁴⁷⁻⁴⁹ Food and water insecurity ^{44,50} Increased cardiovascular diseases ⁴⁹ Mental health ^{44,50-57} Skin disease ⁴⁷	Malnutrition ⁴⁷
3	Floods	Increased unintentional injury ⁵⁸ Death ^{59,60} Increased snakebites ⁵⁹⁻⁶¹	Increased infectious diseases ^{44,48,49,59,61-63} Increased water-borne diseases ^{49,61,63-67} Increased vector-borne diseases ⁶¹ Mental health issues ^{54,55,62,63,68} Food insecurity ^{44,60,63,65,67,69,70} Increased hypertension ⁶⁰ Skin diseases ^{54,61}	Increased risk of HIV and other sexually transmitted diseases ⁶³ Maternal mortality ⁷¹ Malnutrition ^{59,63,64} Increase poverty ^{49,64} Increase domestic violence ^{63,70}
4	Extreme heat	Increased heat-related illnesses ^{40,44,46,54,55,72-75}	Mental health issues ^{41,55,75} Increased vector-borne disease ⁴⁰	
5	Storms	Unintentional injury ^{40,76}	Mental health issues ^{76,77} Increased infectious diseases ⁷⁶ Increased water-borne diseases ⁷⁶	Higher risks of low birth weight, SGA, and spontaneous preterm birth ⁷⁸
No.	Climate-related risks and extreme events	Effects on health services utilization of primary care in rural and remote areas	Adaptation strategies of PCPs	
1	Bushfires	Damage of health care access and facilities ⁴⁰ Decrease visits to PCPs in emergency period ⁷⁹ Increase visits to PCPs ^{38,80} Inconsistency service delivery ³⁸	Training for PCPs to identify mental health risks ³⁸ Community training and preparation ^{39,81}	
2	Droughts	Decreased visits to PCPs ^{53,82,83} Shortages in the medical and health resources ^{48,51,53,83} Patient self-knowledge of medication ⁵³ Increased visits to PCPs ⁸² Increased out-of-pocket payment ^{49,82} Reduced health expenditure ⁸⁴	Training for PCPs to identify mental health risks ⁵³ Community training and preparation ^{52,81} Partnership and collaboration with different agencies ^{52,81} Improve health promotion ^{54,55,81}	

meaning health promotion and prevention programmes, such as disease surveillance, were not well implemented.^{61,76,89} The absence of local disaster management guidelines and lack of primary care involvement in decision-making leadership were also reported.^{61,76,89} Health resources, including financial, workforces, clinical, and information systems, were inadequate for responding to extreme weather events and rarely involved disaster prevention and mitigation strategies at the community level.^{61,76,89} These conditions were predominant for primary care in LMICs.^{54,55,58,61,76,87-89,93}

Conversely, a series of studies described strategies to develop community resilience. One Australian study reported that 5 PCPs in Australia adapted their health promotion practices to address climate-related risks.⁸¹ The key strategies for their health promotion practices were oriented toward

active and sustainable transport; healthy and sustainable food supply; mental health and community resilience; engaging vulnerable population groups such as women; and organizational development.

Four articles from a single study explained the development of mental health programmes for those impacted by drought in Australia.^{10,51,52,83} The difficulties of rural populations in accessing mental health support initiated a state programme collaborating between primary care, community, and government. They conducted programmes to train local health workforces, share information on climate-related risks, identify mental health issues, and allocate resources. The programmes collaborated with communities and local PCPs, to identify risk factors. Local providers, then continued running programmes and modified them to local needs. Similar studies in

Table 3. Continued

No.	Climate-related risks and extreme events	Effects on health outcomes		
		Primary	Secondary	Tertiary
3	Floods	Damage of health care access and facilities ^{38,63,67,85}	Referred patient to other health facilities ⁷¹	
		Shortages in the medical and health resources ^{42,48,58,60,63,64,67,71}	Implement water ambulance ⁷¹	
		Decreased visit to primary care ^{63,65}	Relocate to a safer place ⁷¹	
		Increased visit to unqualified health workers ^{42,60,71}	Training for PCPs to identify mental health risks ⁶⁸	
		Patient self-knowledge of medication ⁴²	Non-clinical staff performed minor procedures and dispense medication ^{87,88}	
		Increased visits to PCPs after flood decreased ^{49,58,63}	Strengthening health promotion ^{54,55,81}	
		Disruption of maternal and child-care ^{70,71,85,86}	Modify health service delivery programmes ^{61,85,89}	
		Disruption of HIV treatment ⁶³	Contingency plan to provide the need of HIV patient, reduce procedure to collect medicine ⁶³	
		Rely on community ⁶²	Community training and preparation ^{10,40,69,90,91}	
		Increased out-of-pocket payment ^{49,60,72}	Develop tools to evaluate community vulnerabilities ⁴⁴	
4	Extreme heat	No disaster preparedness ⁶⁹		
		Decreased visits to primary care ^{41,75}	Community training and preparation ⁴⁰	
		Increased visits to PCPs after heat-wave ^{41,72,75}	Partnership and collaboration with different agencies ⁹²	
5	Storms	Damage of health care access and facilities ^{40,76}	Modify health service delivery programmes ⁷⁵	
		Rely on community ⁹³	Referred patient to other health facilities ^{78,95}	
		Shortages in the medical and health resources ^{67,78}	Community training for emergency and mental health issues ^{77,94}	
		Rely on community, clergy ^{76,91,93,94}	Special team was developed for health service delivery ⁹⁶	
		Disruption of maternal and childcare ⁷⁸	Setting up mobile clinic ⁷⁶	
		Increased visits to PCPs after emergency period ^{91,94}	Modify local clinic as resources centre ⁷⁶	

other countries also supported collaboration and networking with the community to help with mental health issues.^{53,68} These findings highlighted the importance of working with the community to ensure sustainability. These programmes can strengthen community resilience, as reported in the included studies.

The role of rural communities in providing aid to their population was crucial. In this review, community members helped each other by sharing knowledge of protection and conservation measures during extreme weather events, and sharing medicine and resources, as well as offering comfort.^{77,91,94} One study reported the development of tools to support community-level assessment of health risks and adaptation response to climate change.⁴⁴ One study also reported that social workers were involved in addressing challenges after a disaster.⁷⁰ These findings highlighted the crucial

role of PCPs in developing community resilience before natural disasters as well as adaptation strategies post-extreme weather events appropriate to community cultural beliefs and needs.

Discussion

Our findings indicate that people living in rural and remote areas are at risk for a range of climate-related health effects, including on mental health, consistent with previous research.^{20,98} While these studies in this review vary widely in their outcomes, they identified primary, secondary, and tertiary effects of climate-related risks and extreme events on a range of health outcomes and health utilization. Various clinical conditions, including unintentional injuries, respiratory diseases, gastrointestinal diseases, cardiovascular diseases,

Climate-related risks and extreme events				
Bushfires	Droughts	Floods	Extreme heat	Storms
Primary effects Death Increased unintentional injury Increased snakebites Increased respiratory diseases (for those with chronic condition) Increased heat-related illness		Secondary effects Mental health issues Eye irritation Increased respiratory diseases Increased vector-borne diseases Increased water-borne diseases Increased cardiovascular diseases Increased skin disease Food & water insecurity		Tertiary effects Malnutrition Increased risk of HIV & other sexually transmitted diseases Increased domestic violence Higher risks pregnancy Maternal mortality Increased poverty
Health utilisation of primary care in rural and remote settings <ul style="list-style-type: none"> • Damage of healthcare access & facilities • Shortages in the medical and health resources • Decrease visits to primary care providers in emergency period (the first 2 weeks) • Increase visits to primary care providers after emergency period over (the first 6 months) • Patients rely on self-knowledge of medication • Increased visit to unqualified health workers Disruption of maternal and childcare • Disruption of HIV treatment • Rely on community • Inconsistency service delivery • Increased out-of-pocket payment • Reduced health expenditure 			Adaptation strategies of primary care providers <ul style="list-style-type: none"> • Relocate to a safer place • Setting up mobile clinic, such as water ambulance • Modify local clinic as resources centre • Referred patient to other health facilities • Non-clinical staff performed minor procedures and dispense medication • Modify health service delivery programs • Special team for health service delivery • Training for PCPs to identify mental health risks • Community training and preparation, especially for emergency and mental health issues • Partnership and collaboration with different agencies • Strengthening health promotion • Contingency plan to provide the need of HIV patient, reduce procedure to collect medicine • Develop tools to evaluate community vulnerabilities 	

Fig. 2. Effects of climate-related events on health outcomes and health utilization of primary care in rural and remote areas. HIV, human immunodeficiency virus.

mental health, heat-related illness, skin diseases, and infectious diseases among people living in rural and remote areas were reported. In addition, food insecurity and increased vulnerability to poverty were identified as indirect impacts. Our findings also show that women were more vulnerable than men to the indirect impacts of climate-related events, similar to other review.⁹⁹ In addition, women also experienced domestic violence related to their role as caring for the family.⁷⁰

Utilization of primary care utilization was affected by reduced availability and disruption to service supply, by changes in behavioural responses among patients, and by tertiary effects of social determinants of health. PCPs adaptation strategies are crucial in maintaining health service delivery and ensuring disaster preparedness and management in rural and remote areas.¹⁰⁰ In this review, people living in

rural and remote areas in LMICs were more affected by their socioeconomic determinants than those in high-income countries. The vulnerabilities to climate-related risks and extreme events of rural populations in LMICs are possibly worsening, particularly with the existing social, environmental, and economic conditions.¹⁸ Our results suggest that LMICs still face challenges in implementing their health programmes, thus often focussing on responding to emergency procedures rather than mitigating community risk and building resilience.^{17,18}

Our findings show that PCPs in rural and remote areas have a crucial role in immediate clinical response by adapting their health programmes to meet the needs of rural populations, as discussed in previous literature.^{101,102} While climate-related risks and extreme events have substantial impacts on both the health outcomes of rural populations and their

health utilization of primary health care services, adaptation strategies are often limited to immediate responses under emergency conditions rather than ongoing adaptation or mitigation strategies.

A range of primary health care adaptation strategies in response to climate-related risks have been identified, including (i) community education and awareness about the risks; (ii) developing and strengthening implementation of early alert systems such as impending weather extremes or disease outbreaks; (iii) disaster preparedness including designing better surge capacity to respond to emergencies; (iv) enhancing infectious disease control programme and surveillance of risks and health outcomes; and (v) appropriate health workforce training on climatic influences on health and public health strategies.¹⁰⁰ These approaches focus on disaster preparedness, as well as disease prevention and surveillance, and support for identifying and responding to secondary or tertiary effects, such as psychosocial and nutritional interventions¹⁰⁰; they are specifically relevant to rural and remote populations, and have international applicability. Furthermore, the lack of disaster management plans as reported in the included studies, emphasize the needs for PCPs be engaged in coordination across different agencies and communities for strengthening health system resilience.¹⁰³ At the country level, health policy should support the development of flexible, resilient health care system that can adapt to climate-related risks and extreme weather events and be suitable to local needs. Our findings also highlight essential factors to identify of health risks and vulnerabilities of rural populations and environment. The information can be used to develop public education and awareness to climate-related risks and weather events that suited to community cultural beliefs.¹⁰¹ As community resilience is crucial for mitigation process, PCPs have a crucial role in supporting this development.

Strengths and limitations

As far as we are aware, this scoping review is the first to describe how primary care utilization in rural and remote areas is impacted by and responds to climate-related risks and extreme events. However, many of the included studies are from Australia, similar to findings from previous umbrella reviews of climate change effects on health.³¹ This may reflect an unidentified bias in our search structure or language, or an underlying predominance in the relevant literature.

No studies evaluated long-term effects, focussing instead on the immediate periods following a disaster. The heterogeneity of study designs and objectives meant that direct comparisons and clustering of results was also challenging. Although this review is limited by its English-language focus, the included studies provided an international overview of various countries. Further studies using longitudinal methods are needed to explain the association of climate-related risks more fully with the health outcomes and health utilization in rural and remote areas to inform the adaptation strategies of PCPs post-extreme weather events as well as health policy for mitigation strategies of rural populations.

Conclusions

This scoping review synthesizes published studies assessing the impact on climate-related risks and extreme events on health outcomes and health utilization of primary care in

rural and remote areas. Changes in the clinical presentation of certain diseases, and associated health outcomes, are reported. These conditions worsen health status of rural populations in general with disrupted access to primary care services and shortages in medical and health resources. PCPs and services in rural areas may be ill-prepared, especially during initial responses, but have an essential role in supporting the development of community resilience and influencing health policy for disaster preparedness in response to such events. PCPs in rural areas may require support, particularly in LMICs, to mitigate risk and help develop community resilience.

Supplementary material

Supplementary material is available at *Family Practice* online.

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Ethical approval

This type of review does not require ethical clearance.

Conflict of interest

None declared.

Data availability

The data underlying this article are available in the article and in its online supplementary material.

References

1. World Health Organization. Climate change and health 2021 [updated 2021 Oct 30; accessed 2022 August 1]. <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>
2. McMichael AJ. Climate change and global health. In: Butler CD, editor. *Climate change and global health*. 1. Australia: CAB International; 2014. p. 11–20.
3. Landrigan PJ, Fuller R, Acosta NJR, Adeyi O, Arnold R, Basu NN, Baldé AB, Bertollini R, Bose-O'Reilly S, Boufford JI, et al. The Lancet Commission on pollution and health. *Lancet*. 2018;391(10119):462–512.
4. United Nations. *Physical and socio-economic trends in climate-related risks and extreme events, and their implications for sustainable development*. New York: United Nations; 2008. 20 November 2008. Contract No. FCCC/TP/2008/3.
5. Vinogradova M. Flood and extreme weather fatalities in the UK [dissertation on the internet]. London (UK): King's College of London; 2019 [cited 1 April 2022]. https://kclpure.kcl.ac.uk/portal/files/117224672/2019_Vinograda_Maria_1412315_thesis.pdf
6. Pathak N, McKinney A. Planetary health, climate change, and lifestyle medicine: threats and opportunities. *Am J Lifestyle Med*. 2021;15(5):541–552.
7. Patz JA, Frumkin H, Holloway T, Vimont DJ, Haines A. Climate change: challenges and opportunities for global health. *JAMA*. 2014;312(15):1565–1580.
8. Adams J, Brumby S, Kloot K, Baker T, Mohebbi M. High-heat days and presentations to emergency departments in Regional Victoria, Australia. *Int J Environ Res Public Health*. 2022;19(4):2131–2148.
9. Sauerzapf V, Jones AP, Cross J. Environmental factors and hospitalisation for chronic obstructive pulmonary disease in a rural county of England. *J Epidemiol Community Health*. 2009;63(4):324–328.

10. Hart CR, Berry HL, Tonna AM. Improving the mental health of rural New South Wales communities facing drought and other adversities. *Aust J Rural Health*. 2011;19(5):231–238.
11. Kemp L, Xu C, Depledge J, Ebi KL, Gibbins G, Kohler TA, Rockström J, Scheffer M, Schellnhuber HJ, Steffen W, Lenton TM. et al Climate Endgame: exploring catastrophic climate change scenarios. *Proc Natl Acad Sci USA*. 2022;119(34):e2108146119.
12. Stott PA, Christidis N, Otto FEL, Sun Y, Vanderlinden J-P, van Oldenborgh GJ, Vautard R, von Storch H, Walton P, Yiou P, et al. Attribution of extreme weather and climate-related events. *Wiley Interdiscip Rev Clim Change*. 2016;7(1):23–41.
13. Haines A, Ebi K. The imperative for climate action to protect health. *N Engl J Med*. 2019;380(3):263–273.
14. Samano D, Saha S, Kot TC, Potter JE, Duthely LM. Impact of extreme weather on healthcare utilization by people with HIV in metropolitan Miami. *Int J Environ Res Public Health*. 2021;18(5):2442–2451.
15. Wondmagegn BY, Xiang J, Dear K, Williams S, Hansen A, Pisaniello D, Nitschke M, Nairn J, Scalley B, Xiao A, et al. Increasing impacts of temperature on hospital admissions, length of stay, and related healthcare costs in the context of climate change in Adelaide, South Australia. *Sci Total Environ*. 2021;773(6):145656–145665.
16. Curtis S, Fair A, Wistow J, Val DV, Oven K. Impact of extreme weather events and climate change for health and social care systems. *Environ Health*. 2017;16(1):128–137.
17. Perez-Diaz M, Varela Corona C, Borrás C. *Characteristics of a Rural Health Center*. Singapore: Springer Singapore; 2016. p. 3–6.
18. Hughes L, Rickards L, Steffen W, Stock P, Rice W. *On the frontline: climate change and rural communities*. Australia: Climate council of Australia; 2016.
19. Hancock T, Spady D, Soskolne C, Allison S, Chircop A, McKibbin G, Harper S, Parkes M, Poland B. et al *Global change and public health: addressing the ecological determinants of health. The report in brief*. Canadian Public Health Association, Working Group on Ecological Determinants of Health; 2015.
20. Kipp A, Cunsolo A, Vodden K, King N, Manners S, Harper SL. At-a-glance—climate change impacts on health and wellbeing in rural and remote regions across Canada: a synthesis of the literature. *Health Promot Chronic Dis Prev Can*. 2019;39(4):122–126.
21. Australian Institute of Health and Welfare. *Australia's health 2022: data insights*. Canberra: Australian Institute of Health and Welfare; 2022. Cat. no: AUS 240.
22. Gong G, Phillips SG, Hudson C, Curti D, Philips BU. Higher US rural mortality rates linked to socioeconomic status, physician shortages, and lack of health insurance. *Health Aff (Millwood)*. 2019;38(12):2003–2010.
23. Li Y, Zhang Y, Fang S, Liu S, Liu X, Li M, Liang H, Fu H. Analysis of inequality in maternal and child health outcomes and mortality from 2000 to 2013 in China. *Int J Equity Health*. 2017;16(1):66–76.
24. Liu L. Rural-urban disparities in cardiovascular disease mortality among middle-age men in China. *Asia Pac J Public Health*. 2020;32(8):436–439.
25. Ray JG, Guttmann A, Silveira J, Park AL. Mortality in a cohort of 3.1 million children, adolescents and young adults. *J Epidemiol Community Health*. 2020;74(3):260–268.
26. Yaya S, Uthman OA, Okonofua F, Bishwajit G. Decomposing the rural-urban gap in the factors of under-five mortality in sub-Saharan Africa? Evidence from 35 countries. *BMC Public Health*. 2019;19(1):616–625.
27. Public Health Agency of Canada. *The Rural Think Tank 2005—understanding issues families face living in rural and remote communities*. Ottawa: Public Health Agency of Canada; 2007.
28. Russell D, Mathew S, Fitts M, Liddle Z, Murakami-Gold L, Campbell N, Ramjan M, Zhao Y, Hines S, Humphreys JS, et al. Interventions for health workforce retention in rural and remote areas: a systematic review. *Hum Resour Health*. 2021;19(1):1–103.
29. Burns PL, Douglas KA, Hu W. Primary care in disasters: opportunity to address a hidden burden of health care. *Med J Aust*. 2019;210(7):297–299.e1.
30. Blashki G, Butler CD, Brown S. Climate change and human health—what can GPs do? *Aust Fam Physician*. 2006;35(11):909–911.
31. Rocque RJ, Beaudoin C, Ndjaboue R, Cameron L, Poirier-Bergeron L, Poulin-Rheault R-A, Fallon C, Tricco AC, Witteman HO. Health effects of climate change: an overview of systematic reviews. *BMJ Open*. 2021;11(6):e046333.
32. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med*. 2018;169(7):467–473.
33. Peters MD, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. *Int J Evid Based Healthc*. 2015;13(3):141–146.
34. World Health Organization. *Report of the Global Conference on Primary Health Care: from Alma-Ata towards universal health coverage and the Sustainable Development Goals*. Geneva: World Health Organization, 2019. Report No.: WHO/UHC/SDS/2019.62.
35. The EndNote Team. *EndNote*. 20th ed. Philadelphia (PA): Clarivate; 2013.
36. Lisy K, Porritt K. Narrative synthesis: considerations and challenges. *JBI Evid Implement*. 2016;14(4):201–228.
37. The World by Income and Region [Internet]. The World bank 2022 [cited 2022 Aug 1; accessed 2022 August 1]. <https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html>
38. Fitzpatrick KM, Wild TC, Pritchard C, Azimi T, McGee T, Sperber J, Albert L, Montesanti S. Health systems responsiveness in addressing Indigenous residents' health and mental health needs following the 2016 Horse River Wildfire in Northern Alberta, Canada: perspectives from health service providers. *Front Public Health*. 2021;9(12):723613–723626.
39. Forbes RJ, Jones R, Reupert A. In the wake of the 2009 Gippsland fires: young adults' perceptions of post-disaster social supports. *Aust J Rural Health*. 2012;20(3):119–125.
40. Clarke K-L. *Climate-related stresses on human health in a remote and rural region of Ontario, Canada [M.A.]*. Ann Arbor: University of Ottawa (Canada); 2012.
41. Middleton J, Cunsolo A, Pollock N, Jones-Bitton A, Wood M, Shiwak I, Flowers C, Harper SL. Temperature and place associations with Inuit mental health in the context of climate change. *Environ Res*. 2021;198(4):111166–111176.
42. Haque MA, Budi A, Azam Malik A, Suzanne Yamamoto S, Louis VR, Sauerborn R. Health coping strategies of the people vulnerable to climate change in a resource-poor rural setting in Bangladesh. *BMC Public Health*. 2013;13(1):565–575.
43. Haque MA, Yamamoto SS, Malik AA, Sauerborn R. Households' perception of climate change and human health risks: a community perspective. *Environ Health*. 2012;11(1):1–11.
44. Bell EJ, Turner P, Meinke H, Holbrook NJ. Developing rural community health risk assessments for climate change: a Tasmanian pilot study. *Rural Remote Health*. 2015;15(3):3174–3188.
45. Cameron B, Bierl C, Davenport T, Vollmer-Conna U, Hickie I, Wakefield D, Lloyd AR et al. Drought and Q fever: the association between trends in the incidence of infection and rainfall in rural Australia. In: Simeos JCC, et al. *The principles and practice of Q fever: the One Health paradigm*. New York, US: Nova Science Publisher Inc; 2017. p. 301–315.
46. Bakhsh K, Rauf S, Zulfiqar F. Adaptation strategies for minimizing heat wave induced morbidity and its determinants. *Sustain Cities Soc*. 2018;41(5):95–103.
47. Senanayake MP, Jayamma MDCJP. Children affected by severe drought in a rural community in the central highlands of Sri Lanka. *Sri Lanka J Child Health*. 2014;43(1):23–26.
48. Bayer AM, Danysh HE, Garvich M, González G, Checkley W, Alvarez M, Gilman RH. An unforgettable event: a qualitative study of the 1997–98 El Niño in northern Peru. *Disasters*. 2014;38(2):351–374.

49. Begum A, Hamid SA. Impoverishment impact of out-of-pocket payments for healthcare in rural Bangladesh: do the regions facing different climate change risks matter? *PLoS One*. 2021;16(6):e0252706.
50. Barua A, Katyaini S, Mili B, Gooch P. Climate change and poverty: building resilience of rural mountain communities in South Sikkim, Eastern Himalaya, India. *Reg Environ Change*. 2014;14(1):267–280.
51. Carnie TL, Berry HL, Blinkhorn SA, Hart CR. In their own words: young people's mental health in drought-affected rural and remote NSW. *Aust J Rural Health*. 2011;19(5):244–248.
52. Fragar L, Kelly B, Peters M, Henderson A, Tonna A. Partnerships to promote mental health of NSW farmers: the New South Wales Farmers Blueprint for Mental Health. *Aust J Rural Health*. 2008;16(3):170–175.
53. Heaney AK, Winter SJ. Climate-driven migration: an exploratory case study of Maasai health perceptions and help-seeking behaviors. *Int J Public Health*. 2016;61(6):641–649.
54. Purcell R, McGirr J. Preparing rural general practitioners and health services for climate change and extreme weather. *Aust J Rural Health*. 2014;22(1):8–14.
55. Purcell R, McGirr J. Rural health service managers' perspectives on preparing rural health services for climate change. *Aust J Rural Health*. 2018;26(1):20–25.
56. Raphael B, Taylor M, Stevens G, Barr M, Gorringer M, Agho K. Factors associated with population risk perceptions of continuing drought in Australia. *Aust J Rural Health*. 2009;17(6):330–337.
57. Rigby CW, Rosen A, Berry HL, Hart CR. If the land's sick, we're sick: the impact of prolonged drought on the social and emotional well-being of Aboriginal communities in rural New South Wales. *Aust J Rural Health*. 2011;19(5):249–254.
58. Jacquet GA, Kirsch T, Durrani A, Sauer L, Doocy S. Health care access and utilization after the 2010 Pakistan floods. *Prehosp Disaster Med*. 2016;31(5):485–491.
59. Kabir MI, Rahman MB, Smith W, Lusha MA, Azim S, Milton AH. Knowledge and perception about climate change and human health: findings from a baseline survey among vulnerable communities in Bangladesh. *BMC Public Health*. 2016;16(1):266–275.
60. Kabir MI, Rahman MB, Smith W, Lusha MA, Milton AH. Climate change and health in Bangladesh: a baseline cross-sectional survey. *Glob Health Action*. 2016;9(1):29609–29617.
61. Phalkey R, Dash SR, Mukhopadhyay A, Runge-Ranzinger S, Marx M. Prepared to react? Assessing the functional capacity of the primary health care system in rural Orissa, India to respond to the devastating flood of September 2008. *Glob Health Action*. 2012;5(1):10964–10973.
62. Acharya MP, Kalischuk RG, Klein KK, Bjornlund H. Health impacts of the 2005 flood events on feedlot farm families in southern Alberta, Canada. In: Brebbia and Kungolos, Canada, editors. *Water resources management IV*. WIT Press; 2007. p. 253.
63. Anthonj C, Nkongolo OT, Schmitz P, Hango JN, Kistemann T. The impact of flooding on people living with HIV: a case study from the Ohangwena Region, Namibia. *Glob Health Action*. 2015;8(1):26441–26453.
64. Alam GMM, Alam K, Mushtaq S, Clarke ML. Vulnerability to climatic change in riparian char and river-bank households in Bangladesh: implication for policy, livelihoods and social development. *Ecol Indic*. 2017;72(8):23–32.
65. Alam GM. Livelihood cycle and vulnerability of rural households to climate change and hazards in Bangladesh. *Environ Manage*. 2017;59(5):777–791.
66. Phung D, Huang C, Rutherford S, Chu C, Wang X, Nguyen M, Nguyen NH, Manh CD, Nguyen TH. Association between climate factors and diarrhoea in a Mekong Delta area. *Int J Biometeorol*. 2015;59(9):1321–1331.
67. Toufique KA, Islam A. Assessing risks from climate variability and change for disaster-prone zones in Bangladesh. *Int J Disaster Risk Reduct*. 2014;10(9):236–249.
68. Crompton D, Shakespeare-Finch J, FitzGerald G, Kohleis P, Young R. Mental health response to disasters: is there a role for a primary care-based clinician? *Prehosp Disaster Med*. 2022;37(5):706–711.
69. Chan EYY, Guo C, Lee PY, Liu S, Mark CKM. Health Emergency and Disaster Risk Management (Health-EDRM) in remote ethnic minority areas of rural China: the case of a flood-prone village in Sichuan. *Int J Disaster Risk Sci*. 2017;8(2):156–163.
70. Nyahunda L, Chibvura S, Tirivangasi HM. Social work practice: accounting for double injustices experienced by women under the confluence of Covid-19 pandemic and climate change impacts in Nyanga, Zimbabwe. *J Hum Rights Soc Work*. 2021;6(3):213–224.
71. Abdullah ASM, Dalal K, Halim A, Rahman AF, Biswas A. Effects of climate change and maternal morality: perspective from case studies in the rural area of Bangladesh. *Int J Environ Res Public Health*. 2019;16(23):4594–4602.
72. Li H, Guan J, Ye H, Yang H. A survey of rural residents' perception and response to health risks from hot weather in ethnic minority areas in southwest China. *Int J Environ Res Public Health*. 2019;16(12):2190–2199.
73. Liu T, Xu YJ, Zhang YH, Yan QH, Song XL, Xie HY, Luo Y, Rutherford S, Chu C, Lin HL, et al. Associations between risk perception, spontaneous adaptation behavior to heat waves and heatstroke in Guangdong province, China. *BMC Public Health*. 2013;13(10):913–926.
74. Loughnan ME, Carroll M, Tapper N. Learning from our older people: pilot study findings on responding to heat. *Australas J Ageing*. 2014;33(4):271–277.
75. Williams S, Bi P, Newbury J, Robinson G, Pisaniello D, Saniotis A, Hansen A. Extreme heat and health: perspectives from health service providers in rural and remote communities in South Australia. *Int J Environ Res Public Health*. 2013;10(11):5565–5583.
76. Lin JY, King R, Bhalla N, Brander C. Assessment of prehospital care and disaster preparedness in a rural Guatemala clinic. *Prehosp Disaster Med*. 2011;26(1):27–32.
77. West JS, Price M, Gros KS, Ruggiero KJ. Community support as a moderator of postdisaster mental health symptoms in urban and nonurban communities. *Disaster Med Public Health Prep*. 2013;7(5):443–451.
78. Pan K, Beitsch L, Gonsoroski E, Sherchan SP, Uejio CK, Lichtveld MY, Harville EW et al. Effects of Hurricane Michael on access to care for pregnant women and associated pregnancy outcomes. *Int J Environ Res Public Health*. 2021;18(2):390–406.
79. Australian Institute of Health and Welfare. Data update: Short-term health impacts of the 2019–20 Australian bushfires [Internet]. Canberra: Australian Institute of Health and Welfare, 2021 [cited 2022 Sept 30]. <https://www.aihw.gov.au/reports/environment-and-health/data-update-health-impacts-2019-20-bushfires>
80. Australian Institute of Health Welfare. *Australian bushfires 2019–20: exploring the short-term health impacts*. Canberra: AIHW; 2020.
81. Patrick R, Capetola T. It's here! Are we ready? Five case studies of health promotion practices that address climate change from within Victorian health care settings. *Health Promot J Austr*. 2011;22(Spec No):S61–S67.
82. Miri A, Ahmadi H, Panjehkeh N, Ghanbari A, Moghaddamia A, Galavi M. Dust storms impact on air pollution and public health: a case study in Iran. Proceedings of the 2nd WSEAS international conference on management, marketing and finances: recent advances on development and financial engineering. 2008. p. 134.
83. Polain JD, Berry HL, Hoskin JO. Rapid change, climate adversity and the next 'big dry': older farmers' mental health. *Aust J Rural Health*. 2011;19(5):239–243.
84. Khalili N, Arshad M, Farajzadeh Z, Kächele H, Müller K. Does drought affect smallholder health expenditures? Evidence from Fars Province, Iran. *Environ Dev Sustain*. 2021;23(1):765–788.
85. Shah R, Miller NP, Mothabbir G. Approaches to support continued iCCM implementation during a flooding emergency in rural Bangladesh. *J Glob Health*. 2019;9(2):021001.

86. Haque MR, Parr N, Muhidin S. The effects of household's climate-related displacement on delivery and postnatal care service utilization in rural Bangladesh. *Soc Sci Med.* 2020;247(1):112819–112829.
87. Farley JM. Evaluation of flood preparedness in public health facilities in Eastern Province, Sri Lanka [master's thesis on the Internet]. Seattle, WA: University of Washington; 2016 [cited on 1 April 2022]. https://digital.lib.washington.edu/researchworks/bitstream/handle/1773/36427/Farley_washington_02500_15983.pdf?sequence=1&isAllowed=y
88. Farley JM, Suraweera I, Perera W, Hess J, Ebi KL. Evaluation of flood preparedness in government healthcare facilities in Eastern Province, Sri Lanka. *Glob Health Action.* 2017;10(1):1331539.
89. Van Minh H, Tuan Anh T, Rocklöv J, Bao Giang K, Trang le Q, Sahlen KG, Nilsson M, Weinehall L. et al Primary healthcare system capacities for responding to storm and flood-related health problems: a case study from a rural district in central Vietnam. *Glob Health Action.* 2014;7(1):23007–23017.
90. Ardalan A, Holakouie Naieni K, Kabir MJ, Zanganeh AM, Keshtkar AA, Honarvar MR, Khodaie H, Osooli M. Evaluation of Golestan Province's Early Warning System for flash floods, Iran, 2006–7. *Int J Biometeorol.* 2009;53(3):247–254.
91. Aten JD, Gonzalez RA, Boan DM, Topping S, Livingston WV, Hosey JM. Church attendee help seeking priorities after Hurricane Katrina in Mississippi and Louisiana: a brief report. *Int J Emerg Ment Health.* 2012;14(1):15–20.
92. Deegan HE, Green J, El Kurdi S, Allen M, Pollock SL. Development and implementation of a Heat Alert and Response System in rural British Columbia. *Can J Public Health.* 2022;113(3):446–454.
93. Moore S, Daniel M, Linnan L, Campbell M, Benedict S, Meier A. After Hurricane Floyd passed: investigating the social determinants of disaster preparedness and recovery. *Fam Community Health.* 2004;27(3):204–217.
94. Aderibigbe YA, Bloch RM, Pandurangi A. Emotional and somatic distress in eastern North Carolina: help-seeking behaviors. *Int J Soc Psychiatry.* 2003;49(2):126–141.
95. Rosen CS, Matthieu MM, Norris FH. Factors predicting crisis counselor referrals to other crisis counseling, disaster relief, and psychological services: a cross-site analysis of post-Katrina programs. *Adm Policy Ment Health.* 2009;36(3):186–194.
96. Godfred-Cato S, Fehrenbach SN, Reynolds MR, Galang RR, Schoelles D, Brown-Shuler L, Hillman B, DeWilde L, Prosper A, Hudson A, et al. 2018 Zika health brigade: delivering critical health screening in the U.S. Virgin Islands. *Trop Med Infect Dis.* 2020;5(4):168–173.
97. Nayna Schwerdtle P, Baernighausen K, Karim S, Raihan TS, Selim S, Baernighausen T, Danquah I. et al A risk exchange: health and mobility in the context of climate and environmental change in Bangladesh—a qualitative study. *Int J Environ Res Public Health.* 2021;18(5):2629–2645.
98. Hanigan IC, Butler CD, Kocic PN, Hutchinson MF. Suicide and drought in New South Wales, Australia, 1970–2007. *Proc Natl Acad Sci USA.* 2012;109(35):13950–13955.
99. Desai Z, Zhang Y. Climate change and women's health: a scoping review. *Geohealth.* 2021;5(9):e2021GH000386.
100. Blashki G, McMichael T, Karoly DJ. Climate change and primary health care. *Aust Fam Physician.* 2007;36(12):986–989.
101. Willson KA, FitzGerald GJ, Lim D. Disaster management in rural and remote primary health care: a scoping review. *Prehosp Disaster Med.* 2021;36(3):362–369.
102. Lamberti-Castronuovo A, Valente M, Barone-Adesi F, Hubloue I, Ragazzoni L. Primary health care disaster preparedness: a review of the literature and the proposal of a new framework. *Int J Disaster Risk Reduct.* 2022;81(9):103278.
103. Burns PL, FitzGerald GJ, Hu WC, Aitken P, Douglas KA. General practitioners' roles in disaster health management: perspectives of disaster managers. *Prehosp Disaster Med.* 2022;37(1):124–131.