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Scoping review on assessing climate-sensitive health risks

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Abstract

Background Climate change is making the existing health problems worse and also introducing new health problem and therefore calls for a wider evaluation of climate sensitive global diseases. The review sought to assess and collate quantitative and qualitative evidence on the effects of climate change on global health, more specifically, infectious and respiratory diseases, the impacts of extreme weather events as well as the implications for mental health with the view of establishing appropriate sustainable and resilience public health measures and policies.

Methodology A scoping review of observational studies carried out between the years 2000 and 2024, synthesized information on climate-sensitive health outcomes: infectious diseases, severe weather events, and mental illnesses. This analysis was based on data from PubMed, Scopus, Web of Science and Cochrane Library, where appropriate, utilizing meta-extraction and Meta-analysis techniques.

Results A total of 3077 studies were screened, and 96 articles were included for quantitative and qualitative analysis, highlighting the significant health risks posed by climate change. Key areas of concern identified include climate-sensitive infectious diseases, respiratory and cardiovascular conditions, food- and water-borne illnesses, and mental health effects. Rising temperatures and variable rainfall patterns increase the incidence of diseases like malaria (up to 50%) and dengue (8–10% per 1 °C rise). Extreme weather events, such as heatwaves and floods, contribute to a 30% rise in respiratory diseases and a 25% increase in cardiovascular conditions. Food- and water-borne illnesses are more prevalent in regions like Africa (30–40%) due to climate change. Additionally, climate change exacerbates mental health issues, leading to conditions like post-traumatic stress disorder (PTSD), anxiety, and depression.

Conclusion and recommendations Climate change amplifies global public health risks, worsening diseases and creating new challenges. To address this, enhance machine learning climate sensitive disease surveillance, strengthen climate resilience health infrastructure, and integrate health into climate adaptation and mitigation strategies, promote sustainable agriculture, improve WASH infrastructure, and foster global collaboration.

Keywords Climate change, Extreme weather events, Infectious diseases, Mental health, Respiratory and cardiovascular conditions

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Introduction

Climate change is a well-known global challenge that presents significant threats to public health [1]. Climate change is an urgent global challenge that poses significant risks to public health, particularly through its influence on infectious diseases, respiratory and cardiovascular conditions, injuries, and mental health [2]. Its effects are multifaceted, influencing human health in various ways, such as the increasing frequency and intensity of extreme weather events, shifts in the distribution and prevalence of infectious diseases, and difficulties related to food and water security [3]. It also affects the spread and location of vector-borne diseases, including malaria and dengue, as well as water-borne diseases such as cholera [4, 5]. These changes worsen existing health problems and create new risks, highlighting the need to understand these connections in order to create effective public health strategies and policies [6, 7].

The relationship between climate change and infectious diseases is increasingly evident as rising temperatures and changing precipitation patterns create favorable conditions for the spread of pathogens and their vectors [8]. For instance, warmer climates can expand the geographical range of mosquitoes, leading to increased transmission of diseases such as malaria and dengue fever [4, 5]. Additionally, extreme weather events can disrupt public health infrastructure, making populations more vulnerable to outbreaks [9]. As climate change continues to progress, the burden of infectious diseases is likely to increase, particularly in low- and middle-income countries where healthcare systems are already strained [10].

Climate change also has profound implications for respiratory and cardiovascular health [11, 12]. Air pollution, exacerbated by climate change, is a significant risk factor for both respiratory and cardiovascular diseases [13]. Increased temperatures can lead to higher concentrations of ground-level ozone, a harmful air pollutant that aggravates asthma and other respiratory conditions [14] Moreover, heatwaves and extreme weather events can contribute to cardiovascular events, such as heart attacks and strokes, particularly among vulnerable populations such as the elderly [15, 16]. weather events not only affect people's health directly but also put a significant strain on healthcare systems and emergency response resources [10]. Warmer temperatures and altered rainfall patterns facilitate survival and distribution of pathogens, which in turn lead to increased frequency and wider geographical distribution of the diseases [17, 18]. This kind of change is one of the biggest challenges for public health systems, which have to be flexible to adopt appropriate strategies against the new health hazards.

The impact of climate change also has its own impact on multifaceted situations, particularly concerning injury rates, prematurity, foodborne and waterborne diseases, and mental health. Climate-related disasters such as hurricanes, floods, and wildfires pose immediate physical risks, leading to injuries and fatalities [19, 20]. These environmental stressors also increase the risk of preterm births, highlighting the need for disaster preparedness, especially for pregnant individuals and young children [21].

Moreover, rising temperatures and altered precipitation patterns facilitate the growth of pathogens in food and water supplies, increasing incidences of foodborne illnesses like Salmonella [22, 23]. and waterborne diseases such as cholera [22, 24]. Additionally, climate change significantly impacts mental health, with individuals exposed to climate-related disasters facing higher risks of anxiety, depression, and post-traumatic stress disorder (PTSD) [25, 26]. Addressing these interconnected health risks is crucial for promoting community resilience.

This scoping review addresses gaps in previous studies on climate-sensitive health risks, which often focus on region-specific and disease-specific analyses, limiting their applicability across high-, middle-, and low-income countries as climate-induced health challenges emerge as a global concern. The review aims to synthesize global evidence on climate-related health risks, highlighting vulnerabilities, disease burden, and resilience strategies. The objectives or aim was to: [1] examine the global impact of climate change on infectious diseases, respiratory and cardiovascular conditions, injuries, and mental health disorders; and [2] inform evidence-based policy and intervention strategies that enhance climate resilience. By integrating global climate data with health outcomes, this review goes beyond previous systematic reviews to provide a comprehensive framework for global climate action and adaptation efforts.

Methods

Search strategy and data extraction

This scoping review was conducted according to the recommendations from the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) [27]. A systematic search was conducted using NLM database, *JBI* database, Scopus, Wiley Online Library, Cochrane library, Hinari and African Journal Online library. Besides, an internet search was also conducted using other data sources such as Google scholar and University repositories (Jimma University, Debre Markos University, University of Gondar & Addis Ababa University). The following Subject Headings (MeSH) terms and Boolean phrases were used to get essential papers **"**climate" **OR** "climate change" **OR** climate sensitive **"OR** " Extreme Weather Events " **OR** "Flooding" **OR** "Poor air quality" OR "High temperature " OR "high cold weather condition" **AND** "heat" **AND** "heatwave" OR "rainfall

variation" OR "Seasonal Changes" **AND** "Infectious disease" **OR** "Respiratory" **OR** "Cardiovascular disease" OR "Respiratory and Cardiovascular disease" **OR** "Injury" **OR** " prematurity Death " **OR** " Injury and prematurity " **OR** " Food Borne disease " **OR** " " water borne Disease " **OR** " " Food Borne and water borne disease " **OR** " Mental health " **OR** " Direct effect on Mental health " **OR** " indirect effect on Mental health " **OR** " Direct and indirect effect on Mental health ". The search strategy for each database can be found as a supplementary material. Three steps of searching were used. In the first step, initial database searches and analyzed the text words contained in the title and abstract, and the index terms used to describe articles. Secondly, all included databases with all identified keywords and index terms were searched. Thirdly, the references of all identified articles were searched to get additional studies.

Study selection

Two or three independent reviewers conducted a systematic screening process based on titles and abstracts to evaluate the literature obtained from the searches. Full-text versions of articles that met the inclusion criteria were retained for further assessment. The authors established an agreement on the inclusion and exclusion criteria. Endnote version 8 was used by the authors to handle and manage the search strategy results. Duplication of research, were also independently examined by the above authors based on their titles and abstracts. Any disagreements between the reviewers during the selection process have been resolved through discussion or consultation with a third independent reviewer if necessary.

Eligibility criteria (Inclusion and exclusion criteria)

All studies addressing climate sensitive health risk and studies that were only published in the English language were included to avoid problems during the translation process. In addition, studies that were fully available and provided relevant data for microbial removal efficacy of wastewater treatment and challenges were included. Study that was inaccessible in full text with repeated Email inquiries, lacked of comparison data were excluded from the study. However, no other significant restrictions were applied regarding time period and geographic locations.

Data extraction

Two expert researchers (CY & AG) collected the relevant data from the selected articles. The following extracted details were recorded: name of primary authors, publication year, study period, study design, study setting, sample size, effect of climate factor contribution on infectious disease, and identify relevant climate factor were all included. The author (CY & AG) created a simple data extraction format in Microsoft Excel 2016 sheet. Using this structured data extraction form, two authors (CY & AG) independently extracted the data. If disagreements between data extractors persisted a third researcher (GM) varied the extracted data to ensure its accuracy and eliminate any incorrect information.

Methodological quality appraisal

Since this is a scoping review aiming to map on a broad topic to identify key concepts, gaps, and types of evidence available. It, was not conducted any risk of bias assessment or quality appraisal of included studies.

Result and discussion

Study selection and characteristics

A total of 3077 studies were found from various electronic online database sources, of which 2833 were excluded due to duplication and 34 were excluded for deviating from the study's purpose. After reading the title and abstract, 96 articles were excluded because there were not relevant to this systematic review. Again, 37 articles were removed due to poor quality and a lack of clearly stated outcomes. Finally, this scoping review focuses on specific thematic areas, including 13 articles on Climate Sensitive Infectious diseases, 17 on Respiratory and Cardiovascular diseases, 16 concerning Food Borne and Water Borne incidents, and 3 addressing the effects of climate change on mental health. This rigorous selection process ensured that only relevant and high-quality studies were included for analysis, contributing to a comprehensive understanding of the impact of climate change on various health issues, (Fig. 1).

Climate-sensitive infectious diseases

Climate-sensitive infectious diseases are those whose transmission dynamics are significantly influenced by climate factors, including temperature, precipitation, and humidity [28, 29]. Climate change, with rising temperatures and erratic weather patterns, is expected to alter the epidemiology of climate-sensitive infectious diseases, potentially causing outbreaks in previously unaffected regions [30]. This study identifies typical infectious diseases sensitive to climate variations, their transmission mechanisms, and the public health implications [31] Table 1.

Policy implications for climate-sensitive infectious diseases include enhancing surveillance systems to monitor disease patterns in relation to climate data for early detection and response [43]. Strengthening public health infrastructure is essential to handle the dual challenges of climate change and infectious diseases [44]. Integrating health considerations into climate adaptation strategies, such as improving drainage to reduce mosquito breeding sites, is crucial. Public awareness campaigns can educate

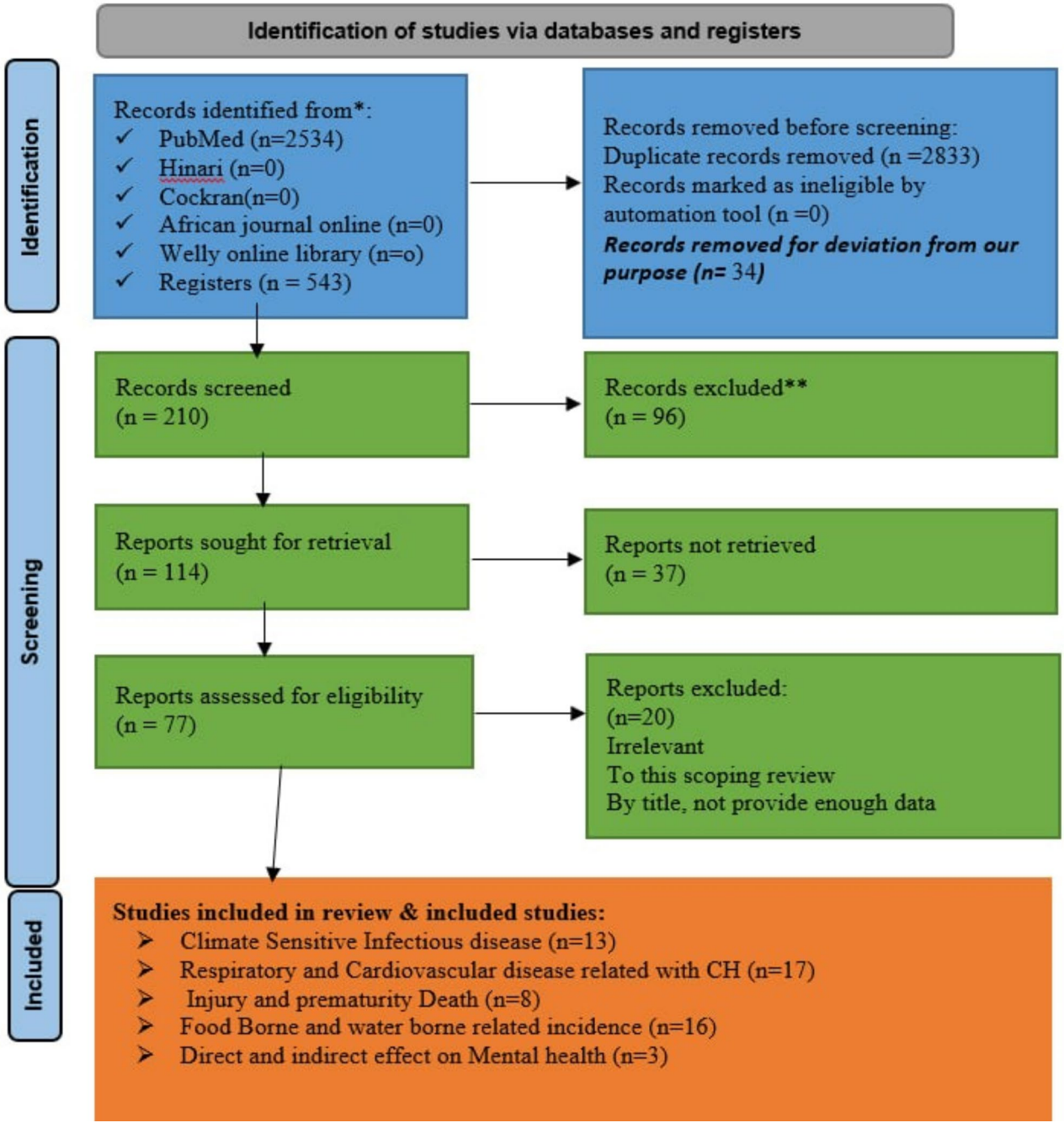

Fig. 1 PRISMA flow diagram of article climate sensitive health risk

communities about risks and prevention strategies. International collaboration and global partnerships are vital for data sharing and resource allocation [45]. Developing evidence-based policies that address climate change and public health is essential for reducing the incidence of climate-sensitive infectious diseases [46].

Respiratory and cardiovascular diseases related to extreme weather events

Extreme weather events, including heatwaves, floods, and storms, have profound effects on public health, particularly concerning respiratory and cardiovascular diseases [47–49]. Heatwaves can lead to increased temperatures, which exacerbate existing health conditions, resulting in a 30% rise in respiratory diseases [50], and a 25% increase in cardiovascular disease incidence [51]. Flooding contributes to these health challenges as well, with a

Table 1 Climate sensitive infectious disease

Infectious disease	Study	Climate factor	Region	Effect of climate factor contribution on infectious disease
Malaria	[32]	Temperature increase	Sub-Saharan Africa	10–20% increase in malaria cases per 1 °C rise.
	[33]	Rainfall Variation	East Africa	30–50% increase in malaria risk with increased rainfall
	[34]	Humidity Level	Southeast Asia	5–25% increase in malaria transmission with higher humidity
	[35]	Seasonal Changes	South America	20–30% increase in malaria cases during rainy seasons
	[36]	Vector Habitat Expansion	Global (various)	25–40% increase in malaria risk due to habitat changes
Dengue Fever	[37]	Temperature Increase	Southeast Asia	8–10% increase in dengue cases per 1 °C rise
	[38]	Rainfall Variation	Latin America	20–30% increase in dengue transmission with increased rainfall
Lyme Disease	[35]	Temperature Increase	North America	20% increase in Lyme disease risk per 1 °C rise
	[39]	Humidity Levels	Europe	15–25% increase in Lyme disease transmission with higher humidity
Cholera	[34]	Temperature Increase	South Asia	10–20% increase in cholera cases per 1 °C rise
	[40]	Rainfall Variation	Sub-Saharan Africa	30–50% increase in cholera risk with increased rainfall
Zika Virus	[41]	Temperature Increase	South America	10–15% increase in Zika cases per 1 °C rise
	[42]	Rainfall Variation	Caribbean	20–30% increase in Zika transmission with increased rainfall

Table 2 Respiratory and cardiovascular diseases related to extreme weather events

Extreme weather even	Increase in respiratory disease incidence (%)	Increase in cardiovascular disease incidence (%)	Reference
Heatwaves	30%	25%	[50, 51]
Flooding	25%	15%	[52, 53]
Wildfires	40%	35%	[56, 57]
Cold Snaps	15%	20%	[58, 59]
Hurricanes	20%	18%	[60–62]
High Temperatures	35%	30%	[63, 64]
Air pollution	50%	45%	[54, 55]
High Humidity	20%	15%	[65, 66]

25% increase in respiratory diseases [52], and a 15% rise in cardiovascular diseases [53]. Furthermore, poor air quality, often worsened by extreme weather, significantly impacts health. Air pollution is linked to a staggering 50% increase in respiratory diseases [54], and a 45% rise in cardiovascular diseases [55]. These figurative result highlights the urgent need for public health interventions and climate resilience strategies to mitigate the health impacts of climate change. Understanding the interplay between extreme weather and health can inform policies aimed at reducing vulnerability and improving community health outcomes. Below are tables summarizing the associations between specific extreme weather events and the prevalence of these diseases, expressed in percentages (Table 2).

Injuries and premature deaths related to extreme weather events

Extreme weather events, including hurricanes, floods, heatwaves, and wildfires, pose significant risks to human health, leading to increased injuries and premature deaths [10, 67]. For instance, heatwaves can increase injuries [68], and premature mortality incidence [69] up to 20% and 30%, respectively, while hurricanes can increase

Table 3 Injuries and premature deaths related to extreme weather events

Extreme weather even	Injuries incidence (%)	Premature deaths incidence (%)	Reference
Heatwaves	20%	30%	[68, 69]
Flooding	15%	25%	[75, 76]
Hurricanes	30%	40%	[70, 71]
Tornadoes	25%	35%	[77, 78]

these rates by 30%, and 40% [70, 71]. These impacts are often due to the exacerbation of existing health conditions and the disruption of healthcare services, making it challenging for affected populations to access timely medical care. Vulnerable groups, such as the elderly, children, and individuals with pre-existing health conditions, are particularly at risk during these events [72] (Table 3).

To mitigate the health impacts of extreme weather, policymakers must enhance surveillance systems to effectively monitor health threats. Strengthening public health infrastructure is vital to ensure that healthcare systems can cope with the dual challenges posed by climate change and extreme weather [73]. Integrating health considerations into climate adaptation strategies, like improving drainage systems to prevent mosquito breeding, is essential. Public awareness campaigns can educate communities on risks and prevention strategies, fostering resilience among vulnerable populations [10]. Additionally, international collaboration for data sharing and resource allocation is crucial in developing evidence-based policies that address the intersection of climate change and public health, ultimately reducing climate-sensitive health issues [74].

Geographical distribution of food- and water-borne illnesses related with climate changes

The geographical distribution of food and water-borne illnesses is increasingly influenced by climate change, which alters temperature, precipitation patterns, and the

Table 4 Geographical distribution of food- and water-borne illnesses related with climate changes

Region	Climate change factor	Food-borne illnesses (%)	Water-borne illnesses (%)	Reference
North America	Rising temperatures	15%	10%	[83, 85]
Europe	Increased rainfall	20%	15%	[87, 88]
Asia	Flooding and extreme heat	25%	30%	[89–91]
Africa	Drought and water scarcity	30%	40%	[80–82]
Latin America	Changing precipitation patterns	20%	25%	[92–94]
Australia & Oceania	Heatwaves	10%	5%	[84, 86, 95]

Table 5 Direct and indirect effect of climate change on mental health

Effect	Description	Examples
Direct Effects		
Extreme Weather Events	Trauma and loss due to natural disasters	Hurricanes, floods, wildfires leading to PTSD, anxiety, and depression
Heat Stress	Increased mental health issues due to high temperatures	Exacerbation of anxiety and mood disorders from prolonged heat exposure
Indirect Effects		
Food and Water Insecurity	Stress and anxiety from disrupted access to food and clean water	Increased rates of anxiety and depression in food-scarce regions
Economic Impact	Financial stress from climate-related job losses	Mental health issues arising from unemployment in agriculture or tourism
Social Disruption	Weakened community ties due to displacement	Increased feelings of isolation and mental health challenges in displaced populations
Environmental Grief	Grief over loss of ecosystems and biodiversity	Emotional distress and anxiety related to environmental degradation

frequency of extreme weather events [22, 24]. Warmer temperatures can enhance the growth of pathogens in food and water supplies, leading to higher rates of illnesses like salmonellosis and cholera. Regions that are already vulnerable, such as low-lying coastal areas and arid regions, may experience exacerbated health risks as climate change progresses [79]. The higher occurrence of food- and water-borne diseases in Africa, at 30–40%, it is due to factors such as frequent droughts, inadequate sanitation, and limited access to clean water [80–82]. In contrast, high-income countries like North America and Australia benefit from robust healthcare systems, stringent food safety regulations, and better public health education, resulting in disease occurrences below 15% [83–86] (Table 4).

The rising incidence of climate-sensitive illnesses strains healthcare systems and impacts economic productivity. Future policies should improve surveillance systems for outbreak monitoring, invest in climate-resilient infrastructure, and promote public health education on safe food and water practices. Supporting sustainable agricultural practices and water management is crucial to mitigate climate-induced risks. Collaborative efforts between governments and communities are essential for effective response strategies.

Direct and indirect effect of climate change on mental health

Climate change has both direct and indirect effects on mental health. Direct effects include trauma and stress from extreme weather events like hurricanes, floods, and wildfires, which can lead to anxiety, depression, and PTSD [96]. Indirect effects arise from long-term changes in climate, such as rising temperatures and prolonged droughts, which can exacerbate existing mental health conditions and increase the risk of suicide [97]. Additionally, the awareness of climate change and its potential impacts can cause eco-anxiety, a chronic fear of environmental doom and addressing these mental health challenges requires integrated climate and health policies [98] (Table 5).

Future impact of climate change on human health

This prediction model for forecasting heatwave-attributed mortality from 2020 to 2090 (Fig. 2), building on findings from the study conducted in China, can provide crucial insights into the future impact of climate change on human health. The model would integrate historical and projected temperature data under various emissions scenarios (e.g., RCP4.5, RCP8.5), mortality data from heatwaves, and demographic factors such as population age, vulnerability, and pre-existing health conditions [99]. Additionally, it would account for the role of public health infrastructure—such as early warning systems and urban cooling strategies—in mitigating the impacts of heatwaves. By using time-series forecasting methods like ARIMA or Prophet for temperature projections, and machine learning algorithms like Random Forest or XGBoost for mortality prediction, the model can provide detailed projections of heatwave-related deaths. These projections would highlight regional variations and incorporate the effectiveness of adaptation measures,

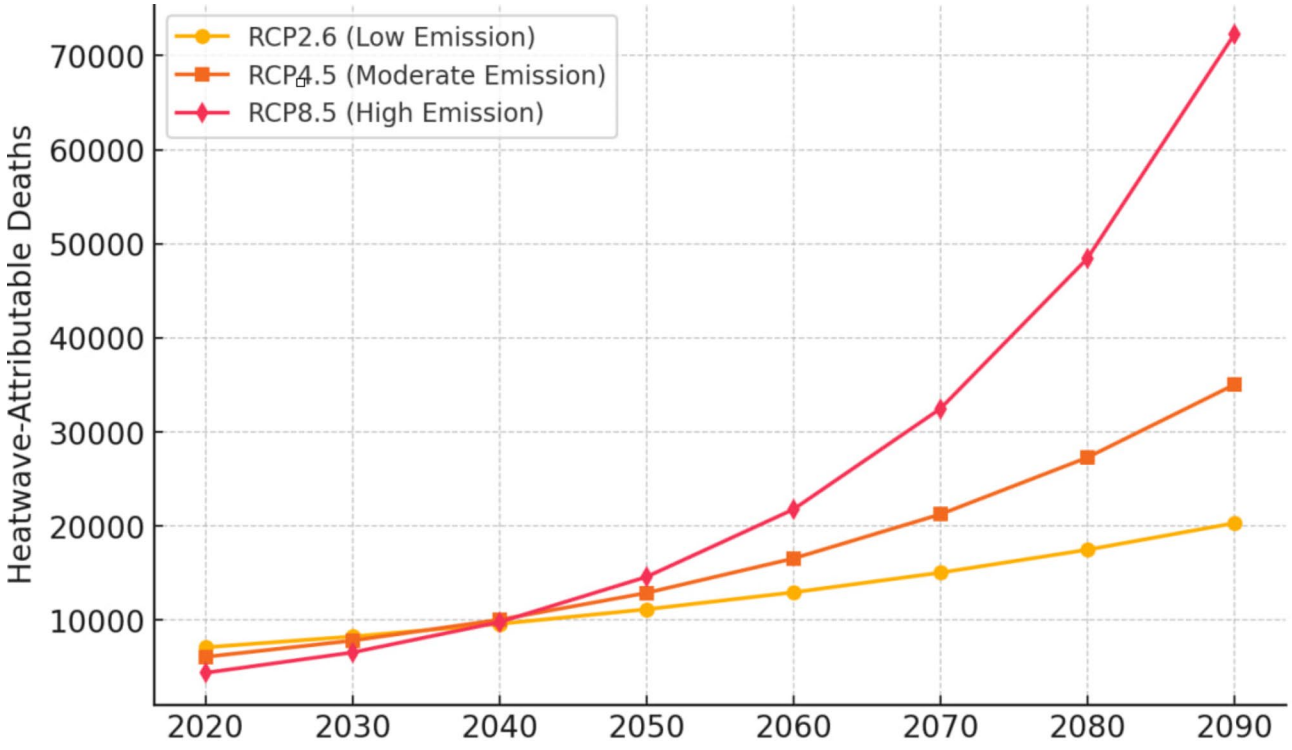

Fig. 2 Projected heatwave-attributed mortality from 2020 to 2090, adapted from data published by China smart

showcasing how public health efforts can reduce mortality. Ultimately, the model's results could guide policy decisions, emphasizing the need for climate adaptation strategies and public health interventions to protect vulnerable populations and mitigate the effects of extreme heat in the coming decades [100].

Conclusions and recommendations

This scoping review underscores the substantial and multifaceted impacts of climate change on public health, particularly through climate-sensitive infectious diseases, respiratory and cardiovascular conditions, injuries, food- and water-borne illnesses, and mental health issues. While the review integrates high-quality studies, it also highlights the limitations of existing research, including gaps in global climate related data including both high and low-income regions, and the need for more comprehensive climate-health data integration. Furthermore, it emphasizes how climate-related disasters exacerbate pre-existing health conditions and increase disease incidence. The projections for heatwave-attributed mortality demonstrate the urgency of addressing these health risks and the need for comprehensive adaptation and mitigation strategies. Effective policy responses must include enhancing surveillance systems, strengthening public health infrastructure, and integrating health considerations into climate adaptation strategies. Public awareness campaigns and international collaboration are also key for tackling the intersection of climate change and health. A multi-faceted approach is necessary to address these challenges, mitigate adverse health effects, and safeguard public health.

Author contributions

C.H.Y., G.M.B., A.A.G., A.S.E., Z.A.A., A.G.E., T.D.T., and A.T. wrote the main manuscript text. R.M.A., Z.A.Y., G.Y., S.S.T., A.F.A., and A.G.Y. prepared Tables 1, 2, 3, 4, 5 and 6. All authors reviewed the manuscript.

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Data availability

Data is provided within the manuscript.

Declarations

Ethics approval and consent to participate

This study is a scoping review; therefore, it did not require an ethical review.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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