African Journal of Inter/Multidisciplinary Studies (AJIMS)
Volume 7, Issue 2, pp. 1-21
e-ISSN: 2663-4589

Impact of Climate Change on Health: Bridging Science, Adaptation, and Communication

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Abstract: Globally, millions are impacted by climate change, which results in extreme weather events, increasing temperatures, and changing disease patterns, posing substantial risks to public health. This study focuses on the multifaceted effects of climate change on health, emphasizing the urgent necessity of integrating science, adaptation strategies, and effective communication to promote resilience. From the exacerbation of pre-existing conditions to mental health challenges, health risks include respiratory diseases, waterborne infections, and heat-related illnesses. The impact is more severe on vulnerable populations, including the elderly, children, and communities in low-resource backgrounds. Evidence-based policymaking, climate-resilient healthcare systems, and early-warning mechanisms to mitigate health risks are necessary for bridging science and adaptation. In this study, the most effective adaptive responses involve understanding the causes, consequences, interventions, and strategies to mitigate climate-related health risks. The role of strategic communication in promoting behavioural change toward climate-resilient practices, community engagement, and raising public awareness is vital. Informed decisions and protective actions are facilitated by disseminating scientific insights to policymakers and communities through effective communication channels. The study emphasizes the significance of a multidisciplinary approach to protect public health in the context of climate change and promote a more sustainable and healthy future by integrating scientific research and adaptive solutions with communication strategies.

Keywords: *Healthcare*; climate resilience; climate education; effective communication

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EDITORIAL DATES

Received: 08 March 2025
Revised: 22 July 2025
Accepted: 25 July 2025
Published: 12 September 2025

DOI: https://doi.org/10.51415/ajims.v7i2.2480

Introduction

Climate change is a critical concern of the 21st century, significantly affecting human health through many direct and indirect mechanisms. According to the United Nations (UN) report, climate change is a change in temperature and weather patterns. Such alterations may occur naturally, resulting from variations in solar activity or significant volcanic eruptions (United Nations, n.d.). The UN further explained that human activities have predominantly driven climate change, mainly due to the combustion of fossil fuels such as coal,

oil, and gas since the 1800s. The combustion of fossil fuels produces greenhouse gas emissions that envelop the Earth, thus trapping the sun's heat energy and increasing temperatures. The broad effects of climate change are highlighted in Figure 1. The World Health Organization (WHO) recognizes climate change as a primary risk to human health, which affects the physical environment and all dimensions of natural and human systems (World Health Organization, 2023). Furthermore, climate change significantly impacts health in various ways, including sickness and death from increasingly recurrent extreme weather events, like storms, floods, and heatwaves, leading to food chain disruption and mental health issues. A similar observation was made by the National Institute of Environmental Health Sciences, stating that climate change affects human health directly and indirectly (National Institute of Environmental Health Sciences, 2022). The same sentiment was shared by Masson-Delmotte et al. (2021), who reported that severe heat waves, elevated sea levels, alterations in precipitation (leading to flooding and droughts), and intense hurricanes can result in injury, disease, and mortality.

Speaking of the direct and indirect impacts of climate change on health, the direct impact has to do with the immediate reaction to the effects of climate change, while the indirect impact can be damage to social and healthcare infrastructure, thereby limiting access to essential services (Lansbury Hall and Crosby, 2022). Climate change can indirectly impact health by modifying the environment. For instance, deteriorating air quality can adversely affect respiratory and cardiovascular health, leading to death in some instances (Alahmad et al., 2023; Kumar et al., 2023; Tran et al., 2023). Variations in temperature and precipitation, which is an aftermath of climate change, can affect the survival, behavior, and distribution of insects and other animals, potentially resulting in alterations in infectious diseases (Harvey et al., 2023; Skendžić et al., 2021). Excessive precipitation, storm surges, and sea temperatures may increase the incidence of waterborne diseases. Climate change impacts food safety, food security and food spoilage, increasing the risk of exposure to contaminated foods that can lead to foodborne illnesses (Duchenne et al., 2021; Misiou & Koutsoumanis, 2022). Based on all these, the study succinctly discusses the impact of climate change on health, focusing on the science of climate change, adaptation strategies, and effective communication of climate change as it relates to health.

Understanding the health consequences of climate change

In the last decades, there has been a great spotlight on various impacts of climate change and its devastating effects on health and wellbeing (Campbell-Lendrum et al., 2023; Liu et al., 2023; Moyo et al., 2023). Climate change is a complex phenomenon that could result from human activities, nature, or a combination of both. The consequences of climate change have been severe in so many ways, ranging from dehydration to heat-related illnesses, respiratory and cardiovascular disease, and waterborne diseases (including cholera, diarrheal and typhoid) (Abdul-Nabi et al., 2025). Extreme weather conditions, increasing global temperatures, and shifts in ecosystems drastically impact human health by aggravating respiratory diseases, escalating the incidence of infectious diseases, and promoting mental health issues. The early understanding of these health risks is crucial for formulating effective mitigation and adaptation strategies to safeguard global populations (Ofremu et al., 2025). As shown in Figure 2, there are several consequences due to climate change, which have serious health risks for humans now and in the future if they are not urgently attended to with all sense of urgency and seriousness.

A significant health consequence of climate change is the decline in air quality resulting from increased concentrations of pollutants and allergens (Kim et al., 2014). Increasing temperatures facilitate the development of ground-level ozone and fine particulate matter that aggravate respiratory ailments such as chronic obstructive pulmonary disease (COPD) and asthma (Hertig, 2020; Sicard, 2021). Furthermore, intensified wildfires, which are fueled by severe droughts and high temperatures, emit large amounts of smoke and toxins, hence aggravating respiratory and cardiovascular diseases (Heaney et al., 2022; Lei et al., 2024). Continuous exposure to these contaminants has been associated with myocardial infarctions (heart attack), cerebrovascular accidents (stroke), and other cardiovascular disorders. According to Baker et al. (2022), climate change promotes the spread of infectious diseases, which is a huge health consequence of this phenomenon. The distribution of disease vectors, including mosquitoes and ticks, is altered by climate change, resulting in the proliferation of infectious diseases. Higher temperatures and precipitation often create a conducive environment for vector-borne diseases such as malaria, Lyme disease and dengue fever (Caminade et al., 2019; de Souza & Weaver, 2024). In areas once unexposed to these illnesses, shifting climate patterns facilitate the establishment of vectors, heightening the danger of outbreaks. Moreover, severe weather phenomena like hurricanes and floods promote waterborne diseases by polluting the source of drinking water and straining sanitary infrastructures, resulting in epidemics of diarrhea, cholera, and other infections.

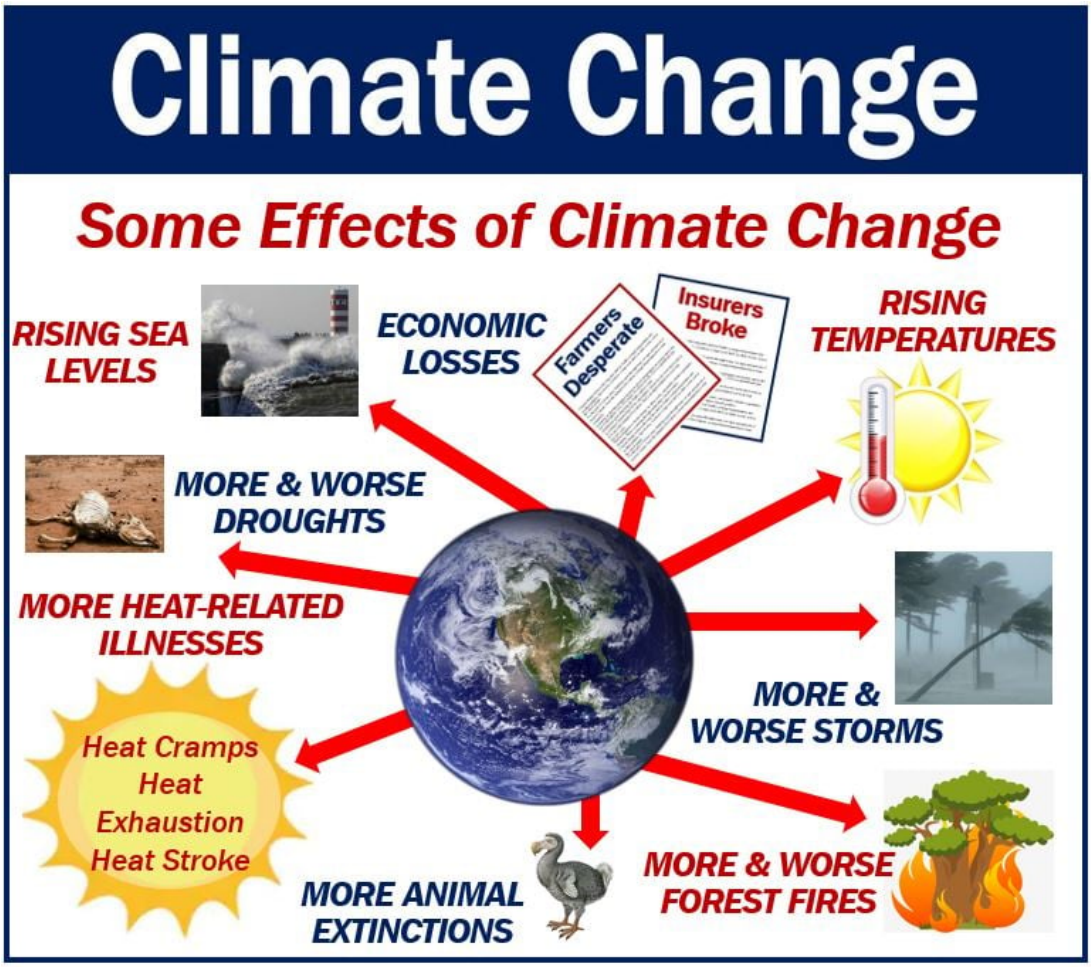

Figure 1. Broad impact of climate change on the well-being of humans and animals.
Source (Market Business News, 2025)

Another noticeable health consequence of climate change is mental health-related issues. The psychological effects of climate change are frequently neglected yet constitute a significant health concern. The heightened occurrence of displacement due to natural disasters (wildfire, flooding, earthquake, landslides, etc.) and loss of livelihoods contribute to a high rate of depression, anxiety, and post-traumatic stress disorder (PTSD) (Chen et al., 2020). Communities that have been impacted by prolonged droughts, hurricanes, flooding, or wildfires endure immediate stress or trauma and mental health issues (Bakic & Ajdukovic, 2021; Lamond et al., 2015). Climate anxiety, an escalating issue, impacts those who dread the unpredictable future due to climate change, resulting in stress and psychological distress. To address mental health issues associated with climate change, there is a need for a multidisciplinary/interdisciplinary approach, which includes psychological support, community resilience engagement, and the development and adoption of policies on climate change.

Certain groups of people are more vulnerable to the health consequences of climate change than others. These have been widely reported in the literature. Among these are children (Hickman et al., 2021), the elderly (Madani Hosseini et al., 2024), low-income individuals (Benevolenza & DeRigne, 2019), and those with underlying health risks (Smith et al., 2022). Children are especially vulnerable to respiratory illnesses due to their immature lungs, whilst elderly persons encounter heightened risks of heat-related disorders and cardiovascular problems. Low-income areas frequently lack access to healthcare, potable water, and robust infrastructure, rendering them more susceptible to climate-related health risks (Ziegler et al., 2019). Mitigating these discrepancies necessitates focused policies that guarantee equitable access to healthcare, early warning systems, and sustainable urban development.

	Climate Driver	Exposure	Health Outcome	Impact
Extreme Heat	More frequent, severe, prolonged heat events	Elevated temperatures	Heat-related death and illness	Rising temperatures will lead to an increase in heat-related deaths and illnesses.
Outdoor Air Quality	Increasing temperatures and changing precipitation patterns	Worsened air quality (ozone, particulate matter, and higher pollen counts)	Premature death, acute and chronic cardiovascular and respiratory illnesses	Rising temperatures and wildfires and decreasing precipitation will lead to increases in ozone and particulate matter, elevating the risks of cardiovascular and respiratory illnesses and death.
Flooding	Rising sea level and more frequent or intense extreme precipitation, hurricanes, and storm surge events	Contaminated water, debris, and disruptions to essential infrastructure	Drowning, injuries, mental health consequences, gastrointestinal and other illness	Increased coastal and inland flooding exposes populations to a range of negative health impacts before, during, and after events.
Vector-Borne Infection (Lyme Disease)	Changes in temperature extremes and seasonal weather patterns	Earlier and geographically expanded tick activity	Lyme disease	Ticks will show earlier seasonal activity and a generally northward range expansion, increasing risk of human exposure to Lyme disease-causing bacteria.
Water-Related Infection (*Vibrio vulnificus*)	Rising sea surface temperature, changes in precipitation and runoff affecting coastal salinity	Recreational water or shellfish contaminated with *Vibrio vulnificus*	*Vibrio vulnificus* induced diarrhea & intestinal illness, wound and bloodstream infections, death	Increases in water temperatures will alter timing and location of *Vibrio vulnificus* growth, increasing exposure and risk of waterborne illness.
Food-Related Infection (*Salmonella*)	Increases in temperature, humidity, and season length	Increased growth of pathogens, seasonal shifts in incidence of *Salmonella* exposure	*Salmonella* infection, gastrointestinal outbreaks	Rising temperatures increase *Salmonella* prevalence in food; longer seasons and warming winters increase risk of exposure and infection.
Mental Health and Well-Being	Climate change impacts, especially extreme weather	Level of exposure to traumatic events, like disasters	Distress, grief, behavioral health disorders, social impacts, resilience	Changes in exposure to climate- or weather-related disasters cause or exacerbate stress and mental health consequences, with greater risk for certain populations.

Figure 2. Impact of climate change on human health, now and in the future.
Source (National Institute of Environmental Health Sciences, 2022)

The science behind climate change and health outcomes

Climate change is a scientifically validated phenomenon caused by human activity, which includes deforestation, burning of fossil fuels, and industrial pollutants (Leon et al., 2022). These activities increase greenhouse gas (GHG) emissions, raising global temperatures, changing weather patterns, and environmental disturbances. These alterations significantly impact human health, influencing respiratory illnesses, infectious diseases, heat-related

disorders, and mental wellness. As presented in Figure 3a, the natural GHG effect is the ideal situation that typically retains a portion of the heat from the sun, which is required to keep our planet from freezing, while most of the heat bounces off the earth back into space, but the "enhanced" influence of GHG due human activities create a shield by releasing more GHGs into the atmosphere (Figure 3b), therefore preventing more heat from escaping into space. This trapped heat gets re-emitted back to the earth's surface, thus creating more than naturally needed; this then warms the earth in a phenomenon known as global warming that leads to climate change.

The buildup of GHGs, including carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4), retains heat in the earth's atmosphere, resulting in increased global temperatures. Rising temperatures increase air pollution by increasing the production of ground-level ozone, a significant catalyst for respiratory illnesses such as asthma and COPD. Furthermore, heatwaves lead to dehydration, heat-related illnesses, and cardiovascular strain, which impact vulnerable groups like the elderly, children, and people with prior health issues (Arsad et al., 2022; Margolis, 2021). The correlation between climate change and adverse health effects is well-documented. Increasing temperatures, air contamination, severe weather phenomena, and changing disease trends threaten global well-being. Mitigating these impacts calls for reduced GHG emissions, strengthened healthcare systems, and the formulation of adaptive solutions that protect those most vulnerable. An empirical, evidence-driven approach is crucial for tackling the health issues linked to climate change.

The health impact of climate change in Sub-Saharan Africa

Climate change is recognized as a global crisis for public health with far-reaching implications. While the effects can be felt globally, Sub-Saharan Africa is particularly vulnerable due to circumstances such as limited health-care infrastructure, high levels of poverty, and heavy dependence on climate-sensitive sectors like agriculture and water resources. This region, despite contributing minimally to global greenhouse gas (GHG) emissions, is highly susceptible to the adverse effects of a changing climate due to limited adaptive capacity. As presented in Figure 4, the region has experienced rising temperatures, unpredictable rainfall patterns, prolonged droughts, and extreme weather events, all of which directly and indirectly pose a severe threat to human health. Climate change has varying health impacts in Sub-Saharan Africa, as observed by different countries in the region, which have been reported in several studies.

Vector-borne diseases

Climate change has drastically increased the rapid spread of vector-borne diseases, including malaria and dengue fever, across Sub-Saharan Africa. Increasing temperatures and rainfall have created a conducive environment for mosquitoes, the principal carriers of many diseases. In the highland regions of Kenya and Ethiopia, previously unsuitable for mosquitoes due to the cold have become breeding grounds as a result of rising temperatures, leading to a spike in malaria cases. Research in the Kenyan highlands has indicated that malaria epidemics, once uncommon in those areas, have increased in frequency as a result of higher night-time temperatures (Amadi, 2018). In Uganda, the outbreak of dengue fever is increasing in urban regions due to rising temperatures and stagnant water from substantial rainfall, which provide the ideal environment for mosquitoes to breed (Nsereko et al., 2020). Consequently, climate change broadens the geographical distribution and severity of vector-borne diseases.

Food insecurity and malnutrition

Agricultural systems in Sub-Saharan Africa are mostly reliant on rainfall and are therefore extremely impacted by climatic variability. Droughts, irregular rainfall, and severe temperatures adversely impact crop yields, livestock production, and fishery resources, leading to food shortages and heightened malnutrition. In nations such as Niger and Burkina Faso, persistent droughts have diminished grain output, resulting in enduring food insecurity and undernutrition, particularly affecting children and pregnant women (Mank, 2022; Walton et al., 2024). Research has shown that children under the age of five in Sub-Saharan Africa have stunted growth owing to hunger, a situation caused by climate-induced crop failures (Aheto et al., 2019; Akombi et al., 2017). In 2020, Madagascar experienced a catastrophic drought in the southern region, resulting in acute food shortages and compelling households to consume wild plants and cactus fruits (Barimalala et al., 2024). This humanitarian crisis resulted from a confluence of climate change and socio-economic vulnerability.

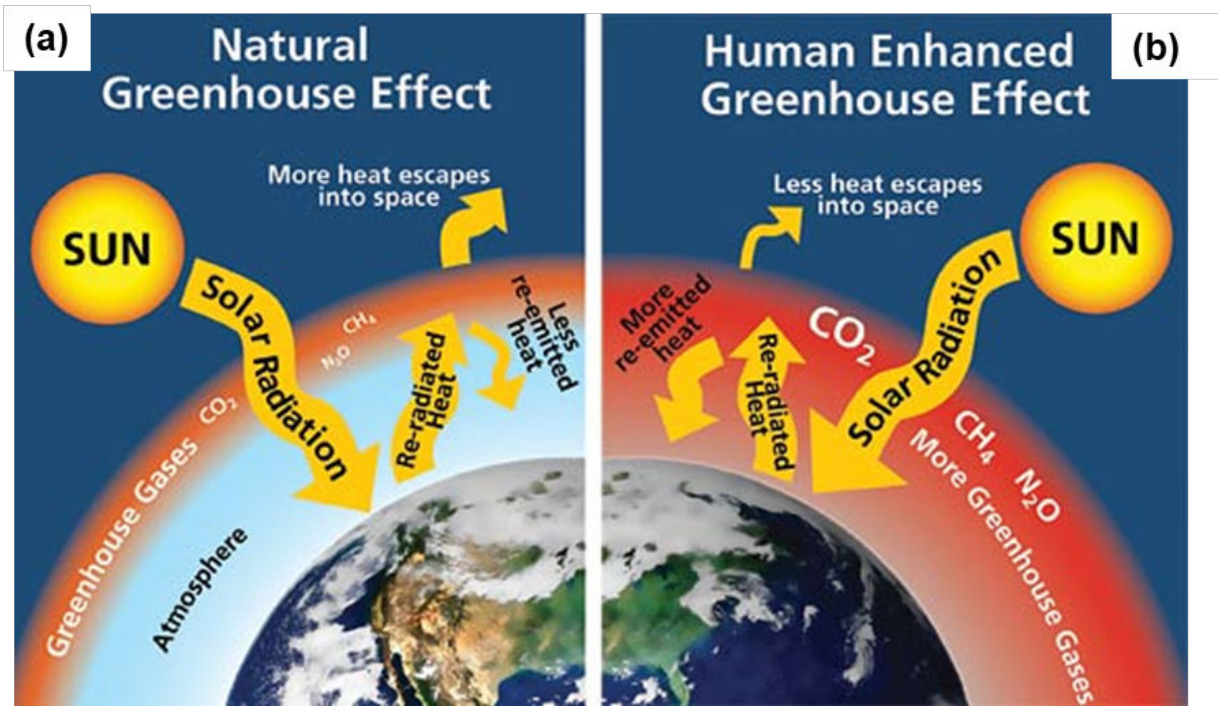

Figure 3. The science and impact of climate change.
Source (Arora, 2020)

Water scarcity and waterborne diseases

Alterations in rainfall patterns and extended droughts are diminishing access to potable water in Sub-Saharan Africa. This scarcity intensifies the proliferation of waterborne infections, including cholera, typhoid, and diarrhea. Furthermore, floods caused by heavy rainfall can pollute water sources with human and animal feces, resulting in the emergence of contagious diseases. Mozambique, for instance, faced significant floods in 2019 due to Cyclone Idai (Tevera et al., 2021). The catastrophic destruction of water and sanitation infrastructure resulted in a cholera outbreak that affected more than 6,700 individuals. In South Sudan, yearly floods displace populations and contaminate water supplies, leading to higher incidences of diarrhea and waterborne illnesses, particularly among children in refugee camps (Biwott et al., 2019).

Heat-related illnesses

Extreme heat events are increasingly prevalent in regions of Sub-Saharan Africa, resulting in a rise in instances of dehydration, heatstroke, and cardiovascular strain, especially among children, the elderly, and outdoor vendors. Urban areas such as Accra (Ghana), Lagos (Nigeria), and Dakar (Senegal) are experiencing rising temperatures worsened by the urban heat island phenomenon (Ofoezie et al., 2022). In 2022, urban areas in northern Nigeria experienced temperatures above 45°C (Nasara et al., 2025). Thus, healthcare professionals in Kano have observed an increase in heat-related sicknesses, such as fainting, exhaustion, and dehydration. Marginalized populations, like street vendors, construction site workers, and the homeless, are more prone to the dangers of extended exposure to extreme temperatures while lacking sufficient shelter or hydration.

Mental health effects

Climate change is negatively impacting mental health, a consequence frequently disregarded. Droughts, floods, displacement, and food insecurity may result in psychological stress, anxiety, depression, and post-traumatic stress disorder. In the Sahel region, characterized by increasing desertification and resource-related conflicts, numerous pastoralist communities across Mali, Chad, and Niger are facing resource depletion, loss of livelihood, involuntary migration, and mental health issues (Naz and Saleem, 2024). Displacement resulting from climatic disasters increases the risk of trauma, particularly among women and children. In Somalia, recurrent droughts have displaced thousands of families, resulting in congested refugee camps with little psychosocial support

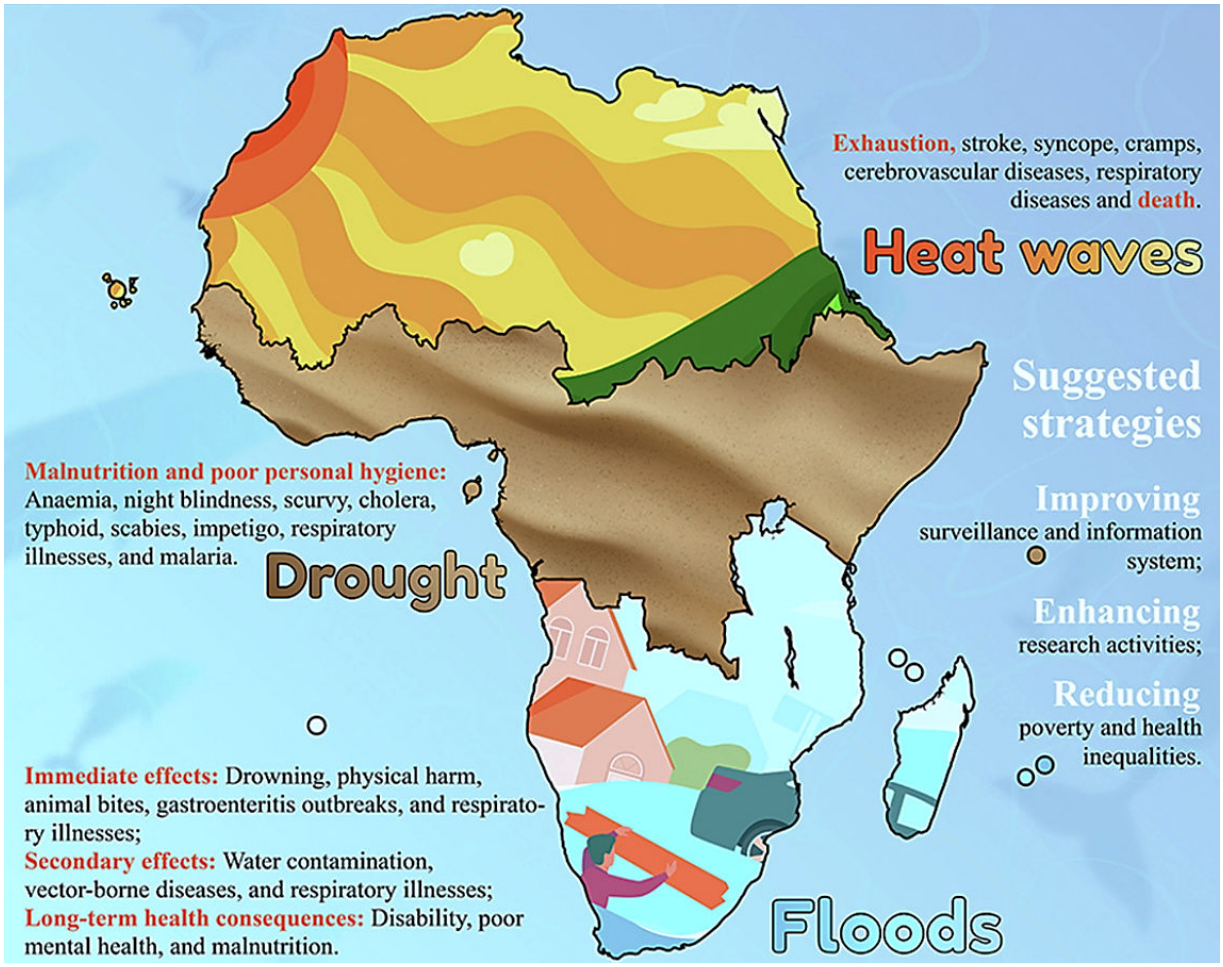

Figure 4. Health effects of climate change on the health of the people in Africa (Moyo et al., 2023).

(Rikter-Ydse, 2024). Humanitarian organizations report an increase in sadness and anxiety among displaced people.

Health system strain

Climate-induced disasters exert pressure on already vulnerable health systems in Sub-Saharan Africa. Severe weather disasters impair healthcare infrastructure, disrupt supply networks, and diminish access to vital medical services. In rural areas, where healthcare services are already scarce, the additional strain of climate-related health issues overwhelms infrastructure and staff. In the 2019 floods in Malawi, numerous clinics became submerged and unreachable, depriving pregnant women and children of medical assistance (Mwalwimba, 2023). The consequences of Cyclone Idai in Zimbabwe exposed comparable vulnerabilities, as essential supplies in hospitals were depleted and struggled to effectively manage illness outbreaks (Tevera et al., 2021).

Air pollution and respiratory diseases

Climate change is responsible for poor air quality by increasing dust storms, wildfires, and the utilization of biomass fuels. Such factors increase the prevalence of respiratory disorders, including bronchitis, asthma, and chronic obstructive pulmonary disease. In the Sahel region of West Africa, desertification and soil degradation are resulting in an increased occurrence of dust storms, referred to locally as Harmattan. These storms diminish air quality and visibility, correlating with increased incidences of respiratory diseases in nations such as Burkina Faso, Senegal, and Nigeria (Glenn et al., 2022). In urban areas, the utilization of wood and charcoal for cooking contributes to indoor air pollution, disproportionately impacting women and children. The adverse health consequences of climate change in Sub-Saharan Africa are significant, complex, and intensified by pre-existing socio-economic and environmental vulnerabilities. Climate change poses an increasing hazard to public health in

Table 1. Possible climate resilience strategies in healthcare. Adapted from (Myhre et al., 2024).

Climate Resilience	Key Strategies	Description of Strategies
	Service Delivery	
Infrastructure and facility preparedness	Enhance infrastructure resilience and adaptation	Strengthening healthcare facilities to withstand environmental impacts, such as floods or earthquakes, by enhancing structural resilience, i.e., retrofitting existing facilities and constructing new ones with climate resilience in mind.
	Develop facility preparedness plans.	Tailor preparedness plans to specific types of disasters, define standard operating procedures, and identify clear lines of command and responsibilities during emergencies.
	Ensure baseline standards for healthcare delivery.	Public health care standards identified by the government being met under no-crisis situations will improve the response during crisis.
Community-based health services	Empower primary healthcare.	Community health systems and use of community health extension workers, decentralized decision-making
	Expand local health services.	Expanding health services directly into communities, especially in remote areas, ensures that healthcare is accessible during disasters.
	Address mental health needs.	Develop comprehensive emergency preparedness plans that include mental health and psychosocial support services, recognizing the psychological impact of disasters on affected populations.
Emergency response and disaster preparedness	Enable rapid response and scalability.	Establish protocols that facilitate rapid scalability and flexibility of health services in response to an emergency, including action plans for epidemic outbreaks and natural disasters.
	Support community engagement and training.	Mobilize community resources and train local volunteers to support health service delivery during emergencies and recognize the value of the informal sector (i.e., volunteers).
	Ensure adequate human resources.	Maintain health personnel directories and databases.
Service integration and coordination	Strengthen cross-sectoral collaboration.	Facilitating coordination between the health sector and other sectors ensures optimal resource use and a unified response to public health emergencies.
	Integrate emergency preparedness in processes.	Embed emergency preparedness into daily processes and structures of health facilities to create a culture of resilience.
Technology and information utilization	Leverage digital tools and technology.	Implement digital tools and technology to maintain care when traditional health services are disrupted.
	Facilitate information sharing and data access.	Enhance access to health and climate data to better inform care delivery during emergencies.

(*Continued*)

Table 1. (Continued)

Climate Resilience	Key Strategies	Description of Strategies
Information dissemination and communication	Establish effective communication platforms.	Utilize communication platforms to disseminate health information using social media, mobile apps, and other digital communication platforms and tools to enhance reach.
	Health Workforce	
Human resource management	Build an agile and adaptable workforce accompanied by task-shifting and teamwork.	Utilize community health workers to provide health care services to rural and vulnerable communities and offer training as first responders and health educators, particularly in remote areas where access to care is limited.
	Ensure surge capacity and emergency task force teams.	Prepare for increased patient inflow during disasters by pre-arranging additional staffing and mobilizing volunteers. This strategy involves increasing the number of health workers and improving their distribution based on vulnerability assessments of different regions.
Develop trained and competent workforce	Provide training on climate change and health issues as well as disaster preparedness training.	Implement ongoing and comprehensive training programs focusing on disaster preparedness, climate change awareness, and health threats associated with climate change, including training on handling increased disease prevalence due to climate variability. Health professionals need disaster-specific training, including practical drills, theory sessions, and policy analysis activities tailored to local climate hazards.
	Promote interdisciplinary and intersectoral training to address climate change issues.	Encourage cross-disciplinary training and cooperation among healthcare workers, environmental experts, and emergency management professionals, as this approach fosters a versatile workforce capable of managing complex health emergencies.
Community health (extension) workers	Leverage community health workers' local knowledge and experience.	Community health workers' longstanding work in communities builds trust and enhances resilience.
	Support specialized health professionals to work in rural areas.	Deploy specialized health workers (i.e., midwives) to regions prone to climate impacts to ensure essential services, such as maternal and child healthcare, continue during and after disasters. A sustainable and efficient strategy is to include midwives in formal health structures.
Coordination of workforce	Use health provider databases to enhance communication networks.	Maintain up-to-date registries of health providers in hospital facilities.
	Create databases of health workers.	Coordinate and register overseas health personnel.

(*Continued*)

Table 1. (Continued)

Climate Resilience	Key Strategies	Description of Strategies
Health workers' mental health, psychosocial needs, and safety	Address health workers' mental health needs and provide psychological support for staff.	Provide mental health support and ensure the overall welfare of health workers, especially those involved in high-stress roles such as disaster response. This includes measures to prevent burnout and ensure the emotional resilience of the workforce.
	Ensure health workers' safety.	Climate change imposes many dangers on society and the health sector, so it is necessary to protect the workforce.
	Health Information Systems	
Linkages between climate, health and environmental data	Integrate data on climate, health, meteorology, environment, and other relevant data sources.	Establish links between environmental, meteorological, and health sectors to ensure health planning incorporates relevant data for preparing health systems for climate-sensitive health outcomes.
	Strengthen routine health information systems to support disaster responses.	Integrate routine health data with emergency health data systems to ensure a seamless flow of information during disasters that supports rapid activation of emergency responses and facilitates real-time monitoring and assessment of health needs.
	Encourage information sharing for research and decision-making.	Utilizing data in research endeavours underscores the importance of using evidence to drive decisions.
Early warning systems, surveillance, and monitoring	Develop comprehensive surveillance systems with early warning capabilities.	Implement robust health surveillance systems, including early warning capabilities for epidemic-prone diseases. This involves the detection of disease outbreaks and monitoring health trends that climate factors could influence.
	Utilize real-time data monitoring to enhance climate health insights and response effectiveness.	Utilize digital technologies to enable real-time monitoring of population health and health effects of climate exposures facilitated by mobile health applications and online dashboards that provide access to health data to policymakers and the general public.
	Encourage data use culture, solicit feedback, and support two-way communication among field units and higher levels.	Engaging feedback in the data collection process enhances the accuracy of health data collected.
Data analysis, management capacity building	Provide training for health workers on how to use health information systems for decision-making.	Training for health workers and data managers can focus on how to use health information systems for decision-making, interpret data related to climate impacts on health, and use data for planning and response.
	Strengthen data analysis capabilities.	Enhance analytic capabilities of health systems to use collected data for prediction and risk assessment to help in forecasting health impacts due

(*Continued*)

Table 1. (Continued)

Climate Resilience	Key Strategies	Description of Strategies
	to climate variability and planning interventions.	
Data access and use	Leverage digital technology tools for health monitoring.	Introduce electronic health records and other digital tools to maintain continuity of care when traditional health services are disrupted. When possible, incorporate advanced and innovative technologies.
	Enhance data accessibility with data-sharing agreements and protocols.	Enhancing the accessibility of health and climate data to better inform health service delivery during emergencies. this includes establishing communication platforms to quickly disseminate health information to the public and health workers.
Access to Medical Products and Technologies		
Ensure continuity of medical supplies	Stockpile essential medicines and maintain basic medical supply kits at the facility level.	Maintain reserves of essential medicines, vaccines, and medical supplies to ensure availability during and after climate-related disasters. Maintain updated inventories and ensure that stock levels are sufficient to handle increased demand during emergencies.
	Share medical equipment among facilities to ensure continuous service delivery.	Share medical equipment among facilities to maintain continuous service delivery, as evidenced by prioritizing coordination in health system resilience checklists and rotating equipment in response to emergencies.
Enhance procurement and supply chain system	Establish pre-disaster vendor agreements.	Develop agreements with suppliers to ensure the provision of medical products during emergencies.
	Strengthen forecasting, procurement, distribution and donation systems.	Consider the impact of disasters on forecasting, procurement, distribution, and donation systems.
Strengthen supply chain management	Ensure efficient distribution networks for timely delivery.	Enhancing distribution networks for medical products to ensure they can handle logistical challenges from climate impacts. This involves optimizing routes, using technology for tracking supplies, and ensuring distribution centers are located near vulnerable areas.
	Utilize climate-resilient storage facilities and infrastructure.	Develop storage facilities resistant to climate impacts (i.e., temperature control, backup power) to ensure medical products are stored properly (i.e., temperature-sensitive vaccines).
	Enhance coordination and monitoring to prevent over and understocking.	Enhance mechanisms for quality assurance (e.g., regular inspections and monitoring of supply chains).
	Manage donations to comply with protocols and maintain quality standards.	Inspect and manage the supply of medical products, especially during

(*Continued*)

Table 1. (Continued)

Climate Resilience	Key Strategies	Description of Strategies
	emergencies when the risk of substandard or counterfeit products increases.	
Innovation and technology utilization	Utilize climate-resilient medical products.	Encourage the development and use of medical products designed to be effective under varying climatic conditions.
	Adopt electronic registries and reduce reliance on paper records.	Electronic data is much more accessible than paper-based records during emergencies.

the region, including the spread of infectious diseases, food insecurity, heat stress, and mental health disorders (Maurya, 2024). Health implications of climate change in Sub-Saharan Africa can be addressed through the following actionable recommendations: strengthen health systems, promote early warning systems, improve water and sanitation, enhance food security, address air pollution, integrate mental health support, and strengthen regional collaboration. Taking these proactive and inclusive measures, Sub-Saharan Africa can better safeguard the health of the people in the face of a changing climate.

Adaptation strategies for climate-resilient healthcare systems

Climate change presents substantial difficulties to global healthcare systems, requiring proactive adaptation techniques to improve resilience. Escalating temperatures beyond the ordinary, severe weather phenomena, and evolving disease trends jeopardize public health systems, increase the disease burden, and disrupt healthcare services. To maintain the effectiveness of healthcare systems in terms of climate-related issues, it is imperative to adopt comprehensive adaptation measures with improved infrastructure, accessible healthcare, and climate change considerations in public health policy. Figure 5 shows the various changes in climate, their observable effect, health impacts, and possible interventions that require all hands on deck to make it work and be sustainable.

A fundamental adaptation strategy for climate resilience is enhancing healthcare infrastructure to endure extreme weather events. Corvalan et al. (2020) explained that the objective of building climate-resilient and sustainable healthcare facilities is in two folds, namely (i) to enhance their ability to preserve and improve the health of the targeted communities amid an uncertain and changing climate and (ii) to enable the maximization of resources utilization while minimizing waste and pollution due to emissions into the environment. Hospitals and healthcare facilities must be constructed or modified to withstand hurricanes, floods, and heatwaves. This entails the construction of energy-efficient buildings, integrating sustainable cooling systems, and providing backup power sources, including solar energy and battery storage. Furthermore, telemedicine and mobile health units might improve healthcare accessibility in disaster-prone and rural regions, mitigating interruptions in healthcare during climate-related circumstances. Table 1 highlights climate resilience possibilities in healthcare and strategies for improved systems.

Enhanced disease surveillance and early warning systems are good strategies that should be adopted and implemented to promote better climate-resilient healthcare globally. Climate change affects the dissemination of infectious diseases, necessitating enhanced surveillance and early warning systems for the timely detection and response to outbreaks. Investing in data-driven disease surveillance, geographic information systems (GIS), and climate health modeling can enhance the prediction of illness trends and optimize resource allocation (Ogwu & Izah, 2025; Wongpituk et al., 2024). The integration of climate data with health information systems enhances preparedness and accelerates responses to emerging health concerns, especially in vulnerable areas that are impacted by waterborne and vector-borne diseases. Building a healthy healthcare workforce is another essential adaptation strategy that has been proposed and practiced to a reasonable extent in most Nations of the world to ensure the impact of climate change on healthcare systems is minimal or prevented (Robinson et al., 2025). A climate-resilient healthcare system needs a proficient and skilled workforce that can respond to any climate-related health issues (Corvalan et al., 2020). Healthcare practitioners ought to be educated and retrained on climate-sensitive illnesses, disaster management, and mental health support for communities that are impacted by climate-induced displacement and trauma. Improving community health worker programs is a way

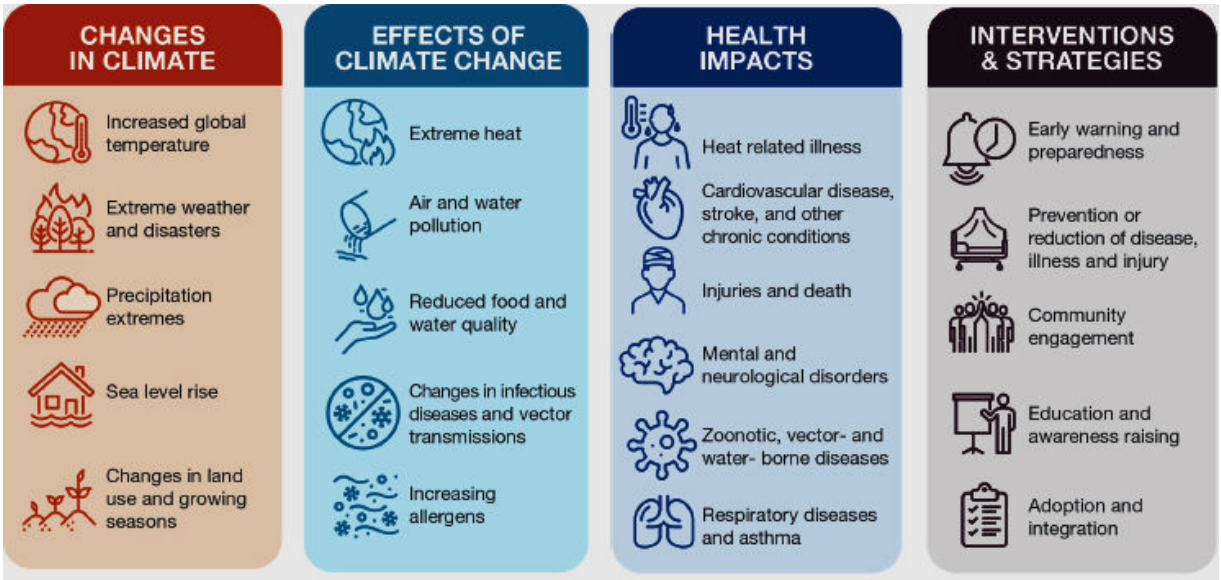

Figure 5. Effects of climate change on health and possible interventions and strategies.
Source (National Institute of Environmental Health Sciences, 2022)

to strengthen healthcare delivery in marginalized regions, thus securing equal access to medical services amid climate crises (Ahmed et al., 2022; Rosenthal et al., 2010).

Sustainable practices are ways to ensure a climate-resilient healthcare system. Adopting environmentally sustainable healthcare practices is vital in decreasing the carbon footprint in the sector while improving the resilience that comes with such a global phenomenon. Hospitals and clinics, regardless of location or region, should be encouraged to adopt and implement green energy solutions, develop waste reduction strategies, and conserve water as much as possible. Procurement of medical supplies should be done sustainably by advocating against single-use products and hazardous waste, contributing to environmental sustainability while ensuring the availability of essential resources during supply chain disruptions caused by climate events (Lomboy-Capino et al., 2024). Policy integration and vibrant community engagement are essential and proven strategies to strengthen healthcare in the wake of growing climate change. These approaches will go a long way in addressing the healthcare system's resilience to climate change and the impact of climate on healthcare facilities and services. Effective and efficient adaptation demands incorporating climate resilience into national health policies and disaster preparedness strategies. Governments and healthcare organizations must collaborate to formulate policies that tackle climate-related health hazards, allocate resources for climate-adaptive initiatives, and encourage research that is associated with climate and health (Agache et al., 2022). Furthermore, involving communities in climate resilience measures, such as public education campaigns and participatory planning, improves local readiness and fortifies community-based health programs.

Improving healthcare systems to address the challenges posed by climate change is essential for maintaining public health resilience. Strengthening infrastructure, improving disease surveillance, expanding workforce capacity, implementing sustainable healthcare practices, and incorporating climate policy are vital solutions for reducing or eliminating climate-related health risks. Implementing these adaptation methods enables healthcare systems to effectively withstand climate-related challenges, protect vulnerable groups, and guarantee the enduring sustainability of public health globally.

Effective communication of climate-related health risks

Effective climate-related communication on health risks is vital for promoting awareness, fostering preparedness, and stimulating action to mitigate health consequences resulting from climate change. Climate change significantly impacts public health, resulting in heightened respiratory diseases from air pollution, heat-related issues, vector-borne infections, and mental health stress (Sen & Chatterjee, 2024). Nonetheless, without clear and accessible communication, policymakers, the public, or healthcare workers may not comprehensively understand the gravity and urgency of such related health issues. The primary problem in conveying climate-related health

threats is addressing ignorance, misinformation, language barriers, political resistance, digital divides, cultural perceptions and doubt. Climate change is frequently regarded as a remote or abstract matter rather than a pressing health issue. To address this disparity, communicators must employ evidence-based messaging that directly links climate consequences to individual health and daily existence (Peters et al., 2022). Customizing communications to highlight local climatic impacts, such as increasing temperatures, severe weather occurrences, and alterations in disease trends, might provide information that is pertinent and persuasive (Weathers et al., 2020). An essential element of good communication is customizing messages for diverse audiences. Policymakers, healthcare providers, and the public have varying degrees of depth and presentation to stimulate engagement and prompt action. Policymakers demand explicit, data-driven insights highlighting economic and societal ramifications, whereas healthcare practitioners require specific information regarding the growing climate-related health risks and medical interventions. Conversely, society gains from straightforward, practical communications that enable individuals to adopt preventive strategies, such as keeping themselves hydrated during heatwaves or utilizing mosquito repellent in high-risk zones.

The communication channel is crucial to disseminating climate-related health information effectively. Conventional media, including newspapers, television, and radio, are significant for engaging the audience extensively. Digital platforms, such as social media, websites, and mobile applications, provide novel options for interactive participation. Infographics, brief movies, and instantaneous alerts help elucidate intricate information and enhance the accessibility of climate-health communication. Community-oriented communication, including public forums, seminars, and collaborations with local leaders, builds trust and guarantees that messages are culturally appropriate and contextually relevant. Transparency and trust are essential for good and effective interaction. Relevant authorities and specialists must be transparent and truthful and provide uniform information while recognizing uncertainty. Ambiguous communications or contradictory information might undermine public trust and impede proactive measures. Cooperative initiatives among governmental bodies, healthcare institutions, climate researchers, and non-governmental organizations (NGOs) can facilitate the standardization of communications and enhance trust (Biermann et al., 2016).

Language and framing largely influence public perception and behavior. Communications emphasizing only threats and disastrous consequences may induce anxiety, powerlessness, and disengagement (Reser & Bradley, 2017). A balanced strategy that emphasizes both hazards and solutions might stimulate action. Contextualizing climate-related health issues through resilience, adaptation, and social responsibility motivates communities to engage in climate mitigation initiatives by embracing healthier and more sustainable practices. Educational initiatives are essential to long-term climate-health communication strategies. Incorporating climate and health subjects into academic curricula, medical training initiatives, and public awareness campaigns can establish a basis for informed decision-making (Orme & Dooris, 2010). When individuals comprehend the connections between climate change and health, they are more inclined to endorse policies and habits that mitigate climate risks. Efficient communication of climate-related health concerns requires a planned, audience-centric approach that utilizes many communication channels, builds trust, and encourages interaction (Ebi & Prats, 2015). Presenting climate health information in a relatable, transparent, and solution-driven way will help policymakers, communities, and individuals take proactive measures to protect public health in a changing climate. Improving communication tactics to address these concerns would boost awareness and promote significant action toward a healthier, more climate-resilient future.

Language barriers

Language barriers are associated with diminished health literacy, challenges in comprehending alerts and public health information, and reduced utilization of healthcare services, particularly in places with a lack of access to interpreter services (Pandey et al., 2021). To overcome this obstacle, governments, emergency services, and healthcare professionals must implement inclusive, multilingual risk communication strategies that promote clear comprehension among various linguistic communities. A case study in Australia demonstrated that bilingual, culturally and linguistically diverse (CALD) community members efficiently understood emergency notifications through a citizen translation method known as Collaborative Translation of Emergency Messages (Hansen et al., 2013). This strategy encompassed the simplification of official communications, the provision of translator training for bilingual individuals, the utilization of technologies like as online dictionaries and mobile applications, and the involvement of communities in emergency planning and response initiatives. Community-oriented interventions can strengthen community networks and augment social support within CALD communities, which are essential for mitigating severe mental health effects linked to extreme weather conditions caused by climate

change. Language obstacles increase vulnerability to heat, since older and newly arrived migrants struggle to acquire a new language and often converse solely within their age group, while younger generations find it challenging to speak traditional dialects (Sharma & Anikeeva, 2025).

Political resistance

Climate change and public health are interconnected and influenced by scientific data, community advocacy, and political decisions (Goniewicz et al., 2025). However, political denial of climate change can have significant consequences, such as reduced investment in sustainable technologies and public health initiatives. Countries with denialistic tendencies are more likely to withdraw from or undermine international climate agreements, affecting global cooperative efforts. This denial is often rooted in economic motivations, prioritizing short-term gains over long-term sustainability. This misalignment hinders progress in critical areas of innovation and extends to policymaking, leading to decisions that worsen climate-related health risks (World Health Organization, 2009). Examples include regulatory rollbacks favouring polluting industries and underinvestment in healthcare infrastructures resilient to climate change. The interplay between climate change, public health, and political denial is a challenging reality. Recognizing and counteracting such denial requires a concerted effort from citizens, scientists, and leaders to champion evidence-based approaches, foster international collaboration, and prioritize long-term global welfare over immediate, narrow interests (Phattharapornjaroen et al., 2023). Inconsistent political support affects progress, with some leaders prioritizing climate denial and reducing investment in sustainable technology and renewable energy. This opposition weakens climate-resilient healthcare efforts, highlighting the need for unified action from citizens, scientists, and policymakers to drive evidence-based, sustainable policies for global well-being.

Climate change has become a political battleground, necessitating initiatives to tackle the crisis through negotiations and policy implementation (Ittefaq, 2024). Achieving climate cooperation has become increasingly challenging. In a study that involved participants from diverse US states, each with their unique political landscape (Bernauer, 2013). States governed by Republicans may have different climate-related policies and social media reception of trolling or climate denial. Participants in the Midwest indicated that their communities perceive climate change differently compared to other parts of the US, suggesting that the political climate indirectly influences their work dynamics, potentially shaping attitudes and responses towards climate-related issues in their respective regions. This is further confirmed by Bieniek-Tobasco et al. (2020), who stated that climate change in the United States is a politically polarized issue with partisans divided in their behaviours and attitudes.

Digital divide

The global digital divide refers to the gap in digital resource access among vulnerable communities, particularly those in the global south, who are also affected by climate change. This divide is characterized by the first-level digital divide, which refers to differences in digital access among citizens, and the second-level digital divide, which relates to differences in citizens' use of computers and the internet (Bhawra et al., 2024). Factors contributing to this divide include smartphone penetration varying across the global south, with high smartphone ownership in countries like India, South Africa, Ghana, and Nigeria, and relatively low access in Tanzania and the Central African Republic (Silver & Johnson, 2018). Internet inequity also plays a significant role, as not all populations have easy access to the internet, which may prevent citizens from participating in digital research or climate change initiatives. Additionally, differences in digital literacy levels among vulnerable sociodemographic groups can further deepen existing inequalities, as older individuals and those with cognitive disabilities or communication challenges often face barriers to effectively using digital technologies (Wilson et al., 2021). According to Nakai et al. (2022), digital technology can improve early warning and emergency response systems, promoting citizen engagement for community health issues. Mobile technology can enable continuous citizen involvement and equitable reach to rural and remote communities, including vulnerable populations who may lack access to information or resources to manage climate change impacts.

Cultural perceptions

Cultural influences significantly influence individuals' perceptions and responses to climate change risks. However, most research on climate change adaptation often neglects the many cultural interpretations of risk adopted by local populations to navigate climate shocks (Rühlemann & Jordan, 2021). This leads to lower effective attempts by organizations to assist at-risk populations and can increase the level of loss and harm

due to climate change, particularly with local cultural and non-material values. A recent study indicates that the scientific, practical, or logical methodologies applied by intervening entities to understand climate risk may significantly differ from the lived experiences and interpretations of risk by the people in such locations (Graham et al., 2018). In Bihar, India, individuals believed they were being punished by the goddess Kosi for their misconduct, whereas in Funafuti, and Tuvalu, most residents prefer to remain due to their spatial identification and attachment to the atoll, shaped by cultural, historical, familial, and spiritual connections (Rühlemann & Jordan, 2021). Despite access to climate data, certain companies fail to see climate change as a concern or respond in accordance with their perceived threats. This may be due to their perception of climate change as an 'act of God,' a lack of personal accountability, or the prioritization of other non-climatic risks (Cannon et al., 2014). Consequently, perceptions of responsibility and actions vary significantly across various organizational structures and cultures, comprising various groups of individuals who may likewise be vulnerable to climate change. Perceptions of risk and responses to climate change are intrinsically connected to social and cultural factors, which often have greater significance than scientific information for many individuals facing risk. Consequently, there is no clear distinction between a reasonable scientific perspective and the "strange" beliefs of vulnerable populations in many regions of the world (Cannon et al., 2014).

Conclusion

Climate change poses an immediate and complex threat to public health, reflected in rising temperatures, severe weather occurrences, heightened incidence of infectious diseases, and deteriorating mental health conditions. Vulnerable populations, such as children, the elderly, and individuals in low-resource regions, endure the most significant consequences, highlighting the need for focused interventions. This study highlights the importance of a multidisciplinary approach that combines scientific research, adaptive healthcare actions, and effective communication to minimize climate-related health threats. Strengthening healthcare infrastructure, improving disease surveillance, enlarging workforce capacity, and instituting sustainable healthcare practices are essential for establishing climate-resilient health systems. Climate change is significantly impacting public health in Sub-Saharan Africa through increased disease burden, food and water insecurity, heat-related illnesses, and mental health challenges. These health threats are intensified by socio-economic vulnerabilities, weak infrastructure, and limited healthcare access. Countries in the region face rising cases of malaria, malnutrition, respiratory diseases, and psychological distress, particularly among marginalized populations. Effective interventions must prioritize strengthening healthcare systems, investing in early warning mechanisms, ensuring clean water and food access, and addressing mental health needs. With coordinated efforts and climate-resilient policies, Sub-Saharan Africa can mitigate these health risks and promote a healthier, more resilient future. Effective communication of climate-related health hazards in Sub-Saharan Africa demands culturally sensitive, inclusive, and audience-specific strategies. Overcoming obstacles such as language, politics, and digital access, while cultivating trust and highlighting relevant solutions, can enable communities, governments, and health professionals to engage in important and informed initiatives aimed at climate resilience and safeguarding public health. Furthermore, clear and accessible communication is essential for enhancing awareness, promoting readiness, and empowering communities to implement protective measures. To achieve long-term resilience, policymakers must prioritize evidence-based adaptation techniques, early warning systems, and community involvement. Cooperation between governments, healthcare institutions, and environmental agencies is crucial for formulating comprehensive climate health strategies. Through integrating knowledge, adaptation, and communication, society can protect public health from climate-related change and strive for a more sustainable and healthy future.

Declarations

Interdisciplinary Scope: The article demonstrates an interdisciplinary scope by focusing on the health impacts of climate change in Sub-Saharan Africa, which requires an interdisciplinary approach that bridges environmental science, public health, social policy, and communication. Integrating climate data with health surveillance, strengthening healthcare systems through sustainable practices, and developing culturally sensitive communication strategies are essential. Collaboration among scientists, healthcare professionals, policymakers, and community leaders enable effective early warning systems, resource planning, and targeted interventions.

Author Contributions: All four authors (Ibrahim, Aniki, Nkomo and Mbatha) contributed equally to the article by providing input and review of each section within the article. All authors were

involved in the conceptualisation, drafting and reviewing of the study until the final stage of acceptance. All authors have read and approved the final published version.

Conflict of Interest: The authors declare no conflicts of interest related to this study.

Funding: The study did not receive any funding or financial support from any organisations or partners.

Availability of Data: All relevant data have been included in the article. However, additional information will be made available by the corresponding author upon reasonable request.

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