



## REVIEW ARTICLE

## Climate change and emergency care in Africa: A scoping review

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## ABSTRACT

**Introduction:** Climate change is a global public health emergency with implications for access to care and emergency care service disruptions. The African continent is particularly vulnerable to climate-related extreme weather events due to an already overburdened health system, lack of early warning signs, poverty, inadequate infrastructure, and variable adaptive capacity. Emergency care services are not only utilized during these events but also threatened by these hazards. Considering that the effects of climate change are expected to increase in intensity and prevalence, it is increasingly important for emergency care to prepare to respond to the changes in presentation and demand. The aim of this study was to perform a scoping review of the available literature on the relationship between climate change and emergency care on the African continent.

**Methods:** A scoping review was completed using five databases: Pubmed, Web of Science, GreenFILE, Africa Wide Information, and Google Scholar. A 'grey' literature search was done to identify key reports and references from included articles. Two independent reviewers screened articles and a third reviewer decided conflicts. A total of 1,382 individual articles were initially screened with 17 meeting full text review. A total of six articles were included in the final analysis. Data from four countries were represented including Uganda, Ghana, Tanzania, and Nigeria.

**Results:** Analysis of the six articles yielded three key themes that were identified: climate-related health impacts that contribute to surges in demand and resource utilization, opportunities for health sector engagement, and solutions to improve emergency preparedness. Authors used the outcomes of the review to propose 10 recommendations for decision-makers and leaders.

**DXDiscussion:** Incorporating these key recommendations at the local and national level could help improve preparedness and adaptation measures in highly vulnerable, populated areas on the African continent.

## Introduction

Anthropogenic climate change is caused by several processes that release large volumes of heat-trapping gases into the atmosphere, causing the atmosphere to warm at a rate faster than what is expected naturally with resultant devastating effects to human health [1–3]. Extreme weather events—droughts, floods, wildfires, cyclones, and heat waves—contribute to life-threatening health conditions: traumatic injuries, heat-related illnesses, asthma exacerbations, cardiovascular disease, behavioural health disorders, and increasing vector borne diseases such as malaria [2,4]. Emergency medicine, with its focus on acute care, is at the forefront of caring for patients adversely impacted, especially those that are most vulnerable due to physiological, cultural, and socioeconomic factors [5]. Considering that these effects are expected to increase in both prevalence and intensity over time [6], it is increasingly important that emergency care (EC) (out-of-hospital and facility-

based) and health care teams prepare to respond to these changes in presentation and demand. At the same time, the services, treatments and interventions offered by EC also contribute to climate change [7], thus indicating an opportunity for EC to lead in both preparedness and response.

The harmful effects of a warming planet are already felt in multiple regions globally [6]. Africa, despite its relatively low contribution to greenhouse gas emissions, is one of the most vulnerable continents due to existing strain on EC with overall lower adaptive capacity as EC systems are in varying degrees of development [8–11]. Countries in Africa experienced numerous climate-related disasters that affected access to care and health care service delivery, placing an additional burden on a frequently overburdened system [12].

To gain a better understanding of the impact of climate change on EC it is imperative, as a first step, to map and describe the literature that is available on the topic. The review enabled us to identify gaps

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in the literature that can inform future research and guide evidence-based practice. The aim of this study was to describe and summarise the body of literature related to the interaction between climate change and EC in Africa, specifically the impact of climate change on EC provision. Results from this scoping review can inform further research that seeks to improve emergency health care preparedness and response in Africa.

## Methods

This scoping review was designed following the PRISMA-ScR guidelines.

### A Search strategy

The search strategy consisted of three elements: climate change, emergency care, and the African context. Search terms for 1) climate change was combined with search terms for 2) emergency care and 3) the African context (including countries and regions). These were combined to compile a comprehensive search strategy to address the research aim (Appendix B). Literature for review was identified from searches of academic literature databases (Pubmed, Web of Science, GreenFILE, Africa Wide Information, and Google Scholar). Web sites of organisations (World Health Organisation, United Nations Economic Commission for Africa, The Centre for International Governance Innovation) and online search engines, such as Google, were also searched for unpublished ‘grey’ literature. The reference lists of relevant reviews were also checked for relevant literature.

#### Inclusion/exclusion criteria

All study types that collected primary data or that ran an analysis on an existing data set, reports, and unpublished ‘grey’ literature were included. Systematic reviews and literature reviews were excluded, but their reference lists were checked for relevant literature. Only literature published in English was included. There was no date limit for publications. The search was completed between the 1<sup>st</sup> and 4<sup>th</sup> of February 2021. Only literature related to the interaction between climate change and emergency care in Africa was included in the study.

### Data management

Electronic databases were searched using the finalised search strings and references were imported into Mendeley Desktop (Version 1.19.4, Mendeley Ltd., London, United Kingdom) for storage and for removal of duplicates (ET). All titles and abstracts/forewords/summaries produced by the search were reviewed based on the inclusion and exclusion criteria (ET, CR). Full papers were retrieved for literature considered potentially relevant. Two author reviewers independently screened the literature (ET, CR), and a third independent reviewer (CB) resolved any conflicts using Covidence (Veritas Health Innovation Ltd., Melbourne, Australia). Literature deemed irrelevant was excluded. Thereafter, a final list of literature was compiled. Included literature was not graded.

### Data extraction and analysis

Data were extracted from the included literature and an extraction table was produced in Excel (ET, CR) (Microsoft Corporation, Redmond, Washington, U.S). The extraction table provides a summary of the manuscript type (e.g. original research, report), country of origin, purpose, sample, design, and information related to the interplay between climate change and emergency care. After data extraction, data were analysed inductively by CR and verified by ET, CB, and EC. Results were reported descriptively.

## Ethical considerations

The study did not pose any direct risks or benefits to any persons as there was no direct contact with participants. Furthermore, the literature that is included in the review is accessible in the public domain.

Ethical approval was therefore not a requirement for this study. The study protocol was approved by the University of Cape Town prior to initiation.

## Results

### Overview

More than 1,500 articles were identified in the search and 1,382 individual articles after duplicates were removed (Fig. 1). Of those, 1,365 did not meet inclusion criteria and 17 met criteria for full text review. Six articles met full inclusion criteria for the review (Table 1).

Four countries were represented in the review: Uganda [13,14], Ghana [15,16], Tanzania [17], and Nigeria [18]. Two studies were qualitative [14,15], two quantitative [13,17], and two mixed methods [16,18]. The word “climate” was in four of the six (67%) studies while temperature or heat was mentioned in three in the six (50%). All six articles included flooding. Health impacts that contribute to surges in demand and the need for acute care services were mentioned in every study. Injuries (bruise or abrasion, sprain or strain, infected or not infected laceration, fracture, internal injury, internal head injury, external head injury, other) related to floods and landslides were compared in one study [13]. The five other studies focused on communicable diseases [14–18]. Specific diseases were mentioned as contributing to human mobility [14] and mentioned infectious disease outbreaks in the top three disasters in the last five years in a survey of health care facilities [17]. Malaria [15] and cholera [16] were mentioned as well as leptospirosis, typhoid fever, schistosomiasis, hepatitis A, and hepatitis E, among others [18].

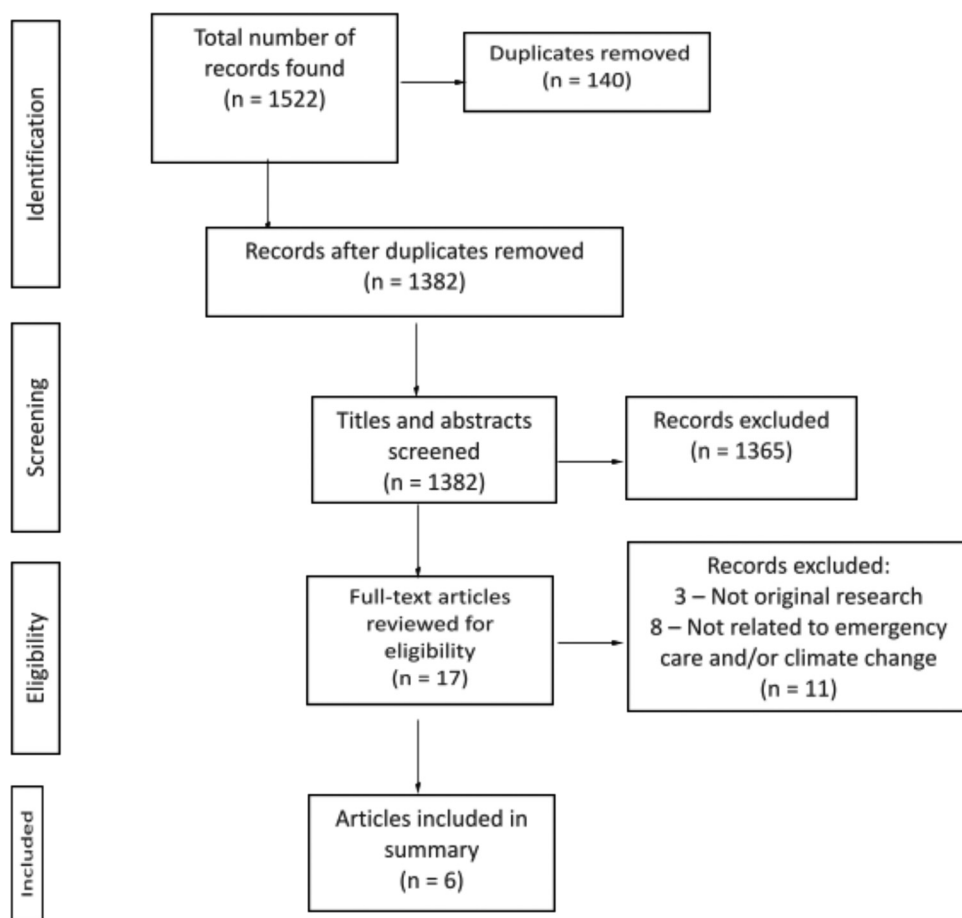
Several vulnerable groups were specifically mentioned as being at-risk in the setting of climate-related exposures. Location (at home, low-lying area, heat island) influenced vulnerability to disasters and ultimately adverse health outcomes. There was emphasis on urban populations [13,15,18] more than rural populations [17]. Low-income neighborhoods were highlighted as vulnerable due to low-lying locations, as that in Ajegunle (Lagos, Nigeria) where there are shortages in water supply and inadequate sewage that contributed to poor hygiene and water contamination during floods [18]. Older individuals were more likely to be injured in floods [13]. Patients and health care workers [15–17] were frequently identified as vulnerable to the impacts of extreme weather events due to their location in public and private health care centers caring for patients during and after events. Young adults [13], children below the age of five and the elderly [18], the illiterate [18], those who are not proficient in major local languages [14], and women [15] were also mentioned as at risk populations.

A summary of the six reviewed articles is shown in Table 1. Several local vulnerabilities were identified in the review and proposed action steps or solutions to improve health and reduce health harms are shown in Table 2. Three key themes were identified as follows: 1) local climate-related health impacts that contribute to surges in demand and resource utilization, 2) opportunities for health sector engagement, and 3) solutions to improve emergency preparedness.

## Discussion

This paper provides an overview of available literature that examines the intersection of climate change and emergency care (EC) (out-of-hospital and facility based) in Africa. Based on our review, there is a dearth of research on EC and climate change. Furthermore, there is a gap in the types of climate-related disasters (droughts, fires, dust) as well as the countries represented in the included literature. Results align with other studies [19–24], which necessitate urgent attention to preparing health systems and health care professionals in low- and middle-income countries (LMICs) to address the health effects of climate change.

Key vulnerabilities across the continent and opportunities to improve systems were highlighted in the review. Three key themes focused on



**Fig. 1.** PRISMA flow chart for selected studies. Six articles met full inclusion criteria for the review.

**Table 1**  
Summary of included articles.

Title	Author (s)	Design	Year	Country	Climate exposure	Purpose
Risk factors for injuries in landslide and flood-affected populations in Uganda	Agrawal et al. [13]	Quantitative – Stratified cluster design	2013	Uganda	Floods and landslides	Assess the impact of floods and landslides on local populations and ascertain risk factors for outcomes such as injuries
The logic model for Uganda’s health sector preparedness for public health threats and emergencies	Ario et al. [14]	Qualitative – preparedness logic model	2019	Uganda	Infectious diseases	Harmonize public health processes and strengthen emergency preparedness and response
Impact of extreme weather conditions on healthcare provision in urban Ghana	Codjoe et al. [15]	Qualitative – temperature measurements, interviews, field observations	2020	Ghana	Flooding and extreme heat	Investigate health system vulnerabilities due to extreme heat and flooding
Are we ready for it? Health systems preparedness and capacity towards climate change-induced health risks: perspectives of health professionals in Ghana	Hussey et al. [16]	Mixed methods – interviews and surveys	2020	Ghana	Climate-related risks	Examine capacities and preparedness of health professionals (medical practitioners/assistants, senior nurses, public health nurses and disease control officers) and health institutions
Disaster preparedness and response capacity of regional hospitals in Tanzania: a descriptive cross-sectional study	Koka et al. [17]	Quantitative – descriptive cross-sectional survey	2018	Tanzania	Climate-related risks	Assess current state of disaster preparedness and response capacity among regional hospitals for various disasters including floods and infectious disease outbreaks
Impacts of flood disasters in Nigeria: a critical evaluation of health implications and management	Olanrewaju et al. [18]	Mixed methods – field-level questionnaires, interviews	2019	Nigeria	Floods	Evaluate the disaster management framework and other current disaster management policies

**Table 2**  
Vulnerabilities identified and proposed solutions from the included review articles.

Identified Vulnerabilities	Proposed Solutions
Agrawal et al, 2013(13)	
Home versus outdoor location Younger age (< 42 years) Mortality was higher for landslides but an increased number and more severe injuries were observed with flooding compared with landslides	Global Rural Urban Mapping Project (GRUMP) Early warning systems, timely evacuations, immediate and effective medical attention
Ario et al, 2019(14)	
Local burden of communicable and non-communicable diseases Location nearby conflict-prone areas with increase in human mobility, including policies on refugee entry Climate-related environmental and ecosystem changes Resource scarcity e.g. famines Lack of health services	National multi-hazard emergency preparedness plan Preparedness logic model  Office of Prime Minister, Minister of Health, and other diverse stakeholders involved Create a living document that is routinely updated World Health Organization Strategic Tool for Analysis of Risks (STAR) Subject matter experts and having a National Task Force for public health emergencies Four key capabilities: Coordination; epidemiology and surveillance; laboratory; risk communication and social mobilization
Codjoe et al, 2020(15)	
Poor drainage in community Poor sanitation and hygiene Location of health facility in low-lying area and urban heat island	Mobilization of local community members to help clear gutters and debris/trash
CLIMATE CHANGE	
Poor building conditions and design <ul style="list-style-type: none"> <li>o Lack of ventilation</li> <li>o Minimal space and lose ability to place mattresses on the floor as additional patient care areas with flooding</li> <li>o Clay ground gets muddy and makes patient transport with wheelchairs and gurneys challenging</li> </ul>	Building a new area to put essential items higher up during floods and building new walls to reduce flooding inside health care facility  Improving ventilation of building during extreme heat  Real-time temperature monitoring inside of facilities Governance plays a fundamental role in disaster planning
Unstable power supply or 'dumsor' <sup>1</sup> <ul style="list-style-type: none"> <li>o Unable to move generator once floods as it's fixed in place, disruptions in fuel for deployed generators, and/or power companies disconnect system to avoid electrocutions</li> </ul>	
Surges in demand and "no bed syndrome" <ul style="list-style-type: none"> <li>o No beds are available at higher tier hospitals or transportation routes are blocked by flooding</li> </ul>	
Public versus private designation for health service provisions Challenges of extreme events on the built environment such as transportation routes and reducing access to health care facility for residents from poor areas Loss of access to regular appointments and routine medication pick-ups	
Hussey et al, 2019(16)	
Knowledge and skill building of health professionals <ul style="list-style-type: none"> <li>o Training programs and workshops are needed for health professionals</li> </ul>	Health professional engagement Comprehensive policy on climate change and health to build capacities of health institutions and programs, improve research, and increase funding of programs and local communities
Provision of logistics/resources and strengthening of infrastructure 95% of survey respondents explained health risks associated with climate change and 85% said climate change could impact the health sector	
CLIMATE CHANGE	
o Focus on infectious diseases (cholera, malaria, other neglected tropical diseases)	Need to focus on health sector with climate change rather than just agriculture sector
Koka et al, 2018(17)	
Hospitals are in an early stage of disaster development planning Inadequate number of trained health care providers 60% of surveyed hospitals had a disaster committee but only 20% had a disaster plan Lack of back-up communication 40% of surveyed hospitals had a triage area Intensive care unit beds were available in less than 50% of hospitals Imaging shortages e.g. maximum six patients per hour with an x-ray machine and no CT scanners at any facility Majority of hospitals had no fire alarm No facilities had decontamination rooms	Need highly skilled workers and re-distribution of workforce away from just administration positions Frequently updated and actionable disaster plan and associated committee Surge response plan that includes: <ul style="list-style-type: none"> <li>o Triage system</li> <li>o Resources to provide treatments to large number of patients such as portable x-ray capabilities</li> <li>o Sharing of human and other resources with local health care facilities</li> <li>o Plan to cancel elective surgeries, expand care areas, discharge stable patients, and back-up staff to call in</li> <li>o Maintenance of safe and secure facilities</li> <li>o Back-up energy and communication systems</li> </ul>
Lack of temporary morgue storage No hospital had all components of surge capacity	

(continued on next page)

Table 2 (continued)

Identified Vulnerabilities	Proposed Solutions
Olanrewaju et al, 2019(18)	
Impact of urbanization and deforestation Living quarters built on flood plain	Early warning systems to alert community of extreme weather events Contingency plan for the most vulnerable areas that addresses prevention, preparedness, response, and recovery
Inadequate storm drainage Lack of maintenance of facilities or infrastructure o Potholes in roads for flood water and mosquito outbreaks Lack of response to emergency calls during flood events Poverty	Resource allocation to the populations who need it the most Temporary care units in areas affected by extreme weather events
CLIMATE CHANGE	
Increased run-off on impermeable surfaces from land use changes Weak institutional capacity and health care delivery Poor waste disposal and sanitation Lack of health care facilities	Institutional frameworks Update public health care centers to match private sector

<sup>1</sup> Local term created to describe the unstable electricity system in Accra, Ghana

local climate-related health impacts that contribute to surges in demand and resource utilization, opportunities for health sector engagement, and solutions to improve emergency preparedness, thus building community climate resilience. We review these themes and offer recommendations for those in leadership positions to address the aforementioned gaps with attention toward development of climate resilient Emergency Care Systems (ECS) in LMICs.

### Key Themes

#### *Climate-related health impacts that contribute to surges in demand and resource utilization*

Flooding was the single hazard identified across all included studies with significant focus on infectious diseases as a result of flooding. Emphasis on infectious diseases after hydrologic disasters is well known [22,25,26]. One key component missing was a discussion of the cascading and often compounding effects related to flood exposures. As one example, leptospirosis was identified as an infectious disease linked with flooding in our review [18]. Researchers in Taiwan found an association with newly diagnosed leptospirosis and subsequent increase in hemorrhagic stroke in young patients [27]. The risk of intracranial hemorrhage or other consequences related to infections are not always attributed to climate exposures.

Another example is heat exposure after power outages secondary to flooding or other disasters. Unstable power supply and lack of beds to provide care caused significant strain on health care facilities in our review [15]. Researchers in other countries have shown that electrical grid failures increased heat wave exposure risks in large cities [28]. In South Africa, load shedding or temporarily shutting down power was associated with an increase in admissions for children to the hospital [29]. Metrics to include these compounding, yet frequently unrecognized, health impacts associated with climate exposures will be increasingly important for clinicians and researchers.

A second component to address is the impact of infections on resources, such as testing and treatment of infectious diseases. Hepatitis E was mentioned [18] with common transmission via fecal-oral route and contaminated drinking water; yet, its role as an emerging infectious disease threat and implications for patients is yet to be fully recognized [30]. Specific outbreaks of hepatitis E have been demonstrated to be associated with heavy rainfall in the Central African Republic [31]. Prioritizing resources and ensuring resource safety during times of extreme weather events with potentially increased strain and demand will be essential for treating climate-related conditions safely.

Injuries were addressed in one study associated with flooding and mudslides [13]; however, there was no follow-up for longer term outcomes or influence on health care usage. After Typhoon Haiyan in the Philippines, 44% of patients with traumatic injuries experienced in-

jured wounds, many of which required definitive management; foreign body contamination and poor wound care were positively associated with infected wounds [32]. In LMICs, there is a need for better systematic monitoring of flood disaster deaths [33] and the development of injury and disease databases. Databases can meaningfully contribute to addressing the African burden of disease and injury as it relates to climate change and identify conditions that are amendable to emergency care in the short and long term.

While flooding was in every article, there was a lack of emphasis on heat stress and heat waves with only half of articles mentioning temperature. Only one article emphasized the impact of extreme heat on health care facilities with quantitative and qualitative data [15]. Cold storage for drugs needed to treat patients with human immunodeficiency virus, long patient wait times and lack of shade in public health care facilities, challenges of treating patients in hot environments as a clinician, high cost of energy for health facilities, and lack of warning about heat were mentioned; other urban social factors were mentioned as influencing exposure particularly in impoverished areas [15].

Reducing heat stress and treating heat-related illnesses were not explicitly mentioned as an opportunity to improve emergency care either [34]. One example is with the maternal ward for laboring mothers and newborn infants. A hospital in Ahmedabad, India had more neonatal intensive care unit admissions during a heat wave, prompting movement of the maternal ward to a lower level of the hospital [35]. Others have proposed an evidence-based algorithm to rapidly recognize and treat patients with heatstroke with focus on prehospital provider involvement and maximizing available human and supply chain resources [36]. Such attention at the facility level, and in the setting of unreliable energy infrastructure, may be crucial to protecting patients and staff. Heat exposure linked with freshwater scarcity on the continent as well as other climate-related influences are seldom mentioned and could prove even more harmful [37,38].

While droughts, fires and dust storms pose a large threat to health on the African continent, these events were not discussed in the included literature.

#### *Opportunities for health sector engagement*

The review demonstrated a clear need for increased engagement of health systems (public and private) and health professionals in addressing climate change as a public health emergency. Improving health system infrastructure to provide basic care for patients and space was a critical challenge for several facilities [15,17,18]. The weaknesses align well with another study that assessed infrastructure gaps for emergency and surgical care [39]. Strengthening infrastructure in a systematic manner beginning at the scene, in emergency units, and in operating theatres and intensive care units to provide definitive care will be necessary to maximize care for emergent conditions. It is also a core aspect of com-

munity resilience during extreme weather events. Likewise, expanding renewable energy, as has been planned on the continent [40], should prioritize health care facilities.

In our review, there was opportunity to improve the knowledge of the workforce that was surveyed on climate and health [16]. Authors saw climate change as a public health issue, rather than traditionally recognized agriculture issue, with interest in workshops and expanding educational material for practicing health professionals [16]. Surveys of climate-health curricula in health professional institutions support the expansion of climate-health curricula [41]. Unfortunately, shortages in the health care workforce are well recognized on the continent [42]. Health care workers are one of the fundamental components of climate resilient health systems [43]. As emergency care systems continue to develop, there will need to be increased focus on building climate resilient and environmentally sustainable health care facilities as proposed by the World Health Organization [43,44]. Several strategies to reduce emissions and build climate resilience with examples have already been supported by the World Bank Group [45]. Health workers will need to be involved and can be the catalysts necessary for obtaining resources and garnering support for ensuring equitable access to high quality EC.

Based on our review, there is a dearth of research on EC and climate change. Included studies articulated risks to community [14] or health care facilities [16] or specific populations [13]. Olanrewaju and colleagues did mention poor government response to calls during flood events [18]. Prehospital providers represent a group to engage as the health effects of climate change unfold and as stakeholders for adapting to the effects. Researchers in Kenya have articulated the need for training and developing an integrated prehospital Ambulance and Fire and Rescue service to respond to major incidents on the continent [46]. Linking climate-related flood, fire, heat, dust, and drought responses beginning at the scene and as a component of EC systems will be increasingly important with life-threatening climate exposures. Changes in health impacts and demand from climate-related conditions such as trauma, non-communicable diseases, communicable diseases, and behavioral health disorders [5] will also be imperative to address for EC.

#### *Proposed solutions to improve emergency preparedness*

The review identified vulnerabilities to target as next steps to address with a comprehensive approach for academic institutions, governments, and other organizations. There was no single strategy or tool across all included studies for preparing for climate-related hazards. Two technology tools identified were the Global Rural Urban Mapping Project (GRUMP) [13] and Strategic Tool for the Analysis of Risk (STAR) [14]. The Emergency Care Assessment Tool [47] and designated heat action plans [48] are others strategies that could help improve capacity through evaluation of emergency care capacity, surge capability, and regional climate risks. Disaster tools to promote health care facility flood preparedness [49] and use of satellite technology to better prepare for disasters [50] are already available. Utilizing these technologies, while mobilizing all members of the community across geographically diverse regions, with a focus on the health sector and public health can guide both preparedness and response.

These concepts should also be incorporated into existing emergency care system research frameworks [51] and already recognized adaptation measures submitted by countries to the United National Framework Convention on Climate Change (UNFCCC) [52]: early warning systems; public education and awareness; surveillance, research, and monitoring; infectious disease control; policy development; public health infrastructure and technology. EC and disaster preparedness should also be brought into public health research [4,53].

Lastly, there is a need to adapt [1,54] and better link disaster management and climate change [55]. Accra was one of two cities included in the Co et al. article to assess health system vulnerabilities to extreme heat and flooding [15]. Accra also created the Accra Climate Action Plan as part of the C40 Cities initiative [56]. Health was included in the Action Plan and represents one example of local leadership and a model

for other metropolitan areas to follow. Others have articulated the vital role of local stakeholders and organizations to advocate for protective flood management policies in sub-Saharan African cities [57] or health and climate change policies, in general [58].

Protecting lives and livelihoods is a key component and priority of the Sendai Framework for Disaster Risk Reduction and public health disaster planning [59,60]. Partnering with the African Federation for Emergency Medicine [61] and other medical organizations may prove useful for scaling changes and managing research databases to measure impacts and interventions. *The Lancet* has already outlined policy changes and actions [58,62] and a global call to action on climate change and health at the Conference of the Parties, which summons an international group of stakeholders [63]. The African continent will need to be involved and can lead LMICs in preparing now at future international convenings.

#### *Recommendations*

Authors used the outcomes of the review to propose the following ten recommendations for decision-makers and leaders (Fig. 2). Recommendations are supported by the various vulnerabilities and proposed solutions discussed in the included literature. While the recommendations are not comprehensive, we believe incorporating these foundational elements at the local and national level would help improve preparedness and adaptation measures in highly vulnerable, urbanized areas on the continent. They should also be adapted to be locally relevant and feasible based on community resources and stakeholder priorities.

This study has several strengths. The initial review screening included more than 1,300 articles and incorporated diverse settings across the continent. Several vulnerable groups were captured that are disproportionately impacted by climate-related exposures. There was discussion of community- and facility-level responses that highlighted the unique partnership of medicine and public health in resource constrained settings. Mobilization of community members to clean debris was one example [15]. Another positive aspect was incorporating key capabilities, such as coordination; epidemiology and surveillance; laboratory; risk communication and social mobilization when addressing preparedness [14]. Through this process, several essential functions of the health sector and solutions were highlighted of which to focus on during times of increased strain.

A few limitations remain. Due to a lack of existing literature, included literature was not graded and all literature regardless of quality of methods was included in the review. Only four countries were included and there is significant heterogeneity across the continent. This may limit generalizability. The review was also limited by the English language. Other common languages of publication relevant to the African context could be considered to strengthen future reviews, such as French, Spanish, and Portuguese. Emphasis was also on flooding despite a myriad of other climate-related exposures such as dust storms, droughts, wildfires, and extreme heat. For example, the hot, dry, windy periods and seasonality of dust and meningitis [64] with the widespread impact of dust storms on health [65] were not found in the review. Our discussion expanded upon opportunities to increase research and education in this sphere, but interventions may not be the same in each location or for different learners. Finally, the feasibility of implementing solutions was not discussed. Other priorities and financial limitations are a reality for countries. A global pandemic and equitable distribution of vaccinations cause new challenges yet addressing climate change is a step to addressing other public health crises as well [6].

Vulnerabilities outline a path of proposed solutions and action steps to improve systems on the African continent. Emergency care professionals will be crucial in guiding municipalities and aiding out-of-hospital and facility-based health care in preparedness and response to climate-related hazards, turning a deficits approach to one of strength and prosperity. Heat exposure and flooding and the cascading threats associated with these burdens will increasingly threaten human well-

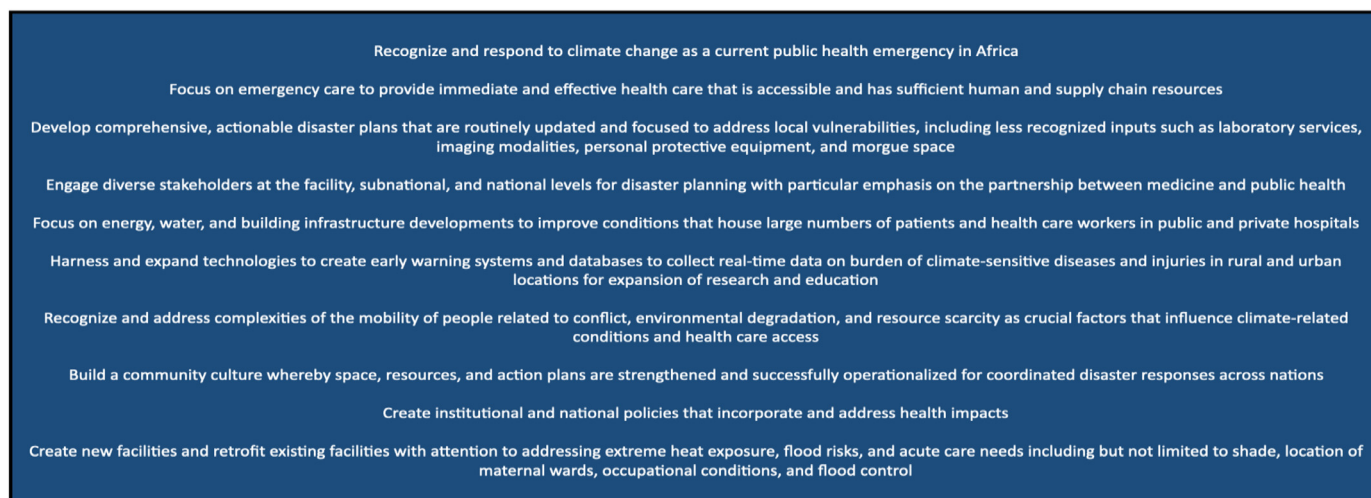


Fig. 2. Ten recommendations for leaders to consider that address climate-related health threats.

being without aggressive action. Proposed solutions were outlined for multidisciplinary stakeholders to create policies and action plans.

#### Dissemination of results

No primary data collection was undertaken and only published literature was included in the review. The findings of this paper have not been disseminated beyond this publication.

#### Authors' Contributions

Authors contributed as follows to the conception or design of the work; the acquisition, analysis or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: ET and CR contributed 35% each, CB contributed 16%, and ECH and WS contributed 7% each. All authors approved the version to be published.

#### Conflict of Interest

The authors declare the following conflict of interest: WS is an associate editor of the African Journal of Emergency Medicine. WS was not involved in the editorial workflow of this manuscript. The African Journal of Emergency Medicine applies a double blinded process for all manuscript peer reviews. The authors declared no further conflict of interest.

#### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.afjem.2022.02.003.

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