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Recurrent Flooding and Cholera Risk in Mozambique: Structural Vulnerability in a Climate-Stressed Health System

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Abstract

Mozambique experiences recurrent flooding driven by tropical cyclones, extreme rainfall, and riverine overflow, making it one of the most climate-vulnerable countries globally. These hydrometeorological events have repeatedly triggered cholera outbreaks, exposing persistent weaknesses in water, sanitation and hygiene (WASH) infrastructure and health system resilience. This article examines the recurrent flooding-cholera nexus in Mozambique and discusses evidence-based strategies for strengthening climate-resilient health systems. The article highlights how flooding contaminates water sources, disrupts sanitation systems, damages health facilities, and displaces populations, thereby creating conditions favorable for cholera transmission. The recent outbreak, following widespread flooding across several provinces, demonstrates that despite improvements in surveillance, laboratory capacity, oral cholera vaccination, and emergency coordination since the 2019 Cyclones Idai and Kenneth, structural vulnerabilities remain largely unaddressed. Persistent WASH deficits, rapid urbanization in flood-prone areas, constrained health system capacity, and the interaction between climate-related disasters and conflict-driven displacement continue to amplify disease risk. Although emergency interventions have reduced mortality and improved outbreak control, reliance on reactive humanitarian responses is insufficient to prevent recurrent epidemics. The article argues that breaking the cycle of flood-associated cholera requires a transition from emergency response to long-term resilience through sustained investment in climate-resilient health infrastructure, durable WASH systems, integrated disaster risk reduction, multisectoral governance, and predictable climate-health financing. Strengthening these systems will not only reduce cholera transmission but also enhance preparedness for future climate-related public health emergencies and contribute to sustainable progress toward universal health coverage and health security in Mozambique.

Keywords: Climate change; Cholera; Flooding; Health system resilience; Mozambique

Introduction

Mozambique remains one of the most climate-vulnerable countries globally, facing recurrent tropical cyclones, riverine flooding, and extreme rainfall events that increasingly intersect with infectious disease risk. Cholera, a climate-sensitive waterborne disease caused by Vibrio cholerae, has repeatedly followed hydrometeorological shocks in the country, revealing structural weaknesses in water, sanitation and hygiene (WASH) systems and in health system resilience [1].

The relationship between flooding and cholera transmission is well established in epidemiological literature. Studies demonstrate that extreme rainfall increases contamination of surface water sources, disrupts sanitation infrastructure, and facilitates rapid transmission in densely populated or displaced communities. Climate attribution studies further suggest that warming sea surface temperatures in the

southwest Indian Ocean are intensifying precipitation extremes affecting southeastern Africa, including Mozambique [2,3].

Mozambique's recurrent flood-associated outbreaks are not isolated phenomena. Following Cyclones Idai and Kenneth in 2019, major cholera outbreaks occurred in Sofala and Cabo Delgado provinces. Subsequent flood events between 2022 and 2024 were again accompanied by localized cholera surges. Despite repeated emergency interventions, structural vulnerability persists, raising critical questions regarding long-term resilience [4]. This article examines the recurrent flooding and cholera situation in Mozambique and outlines evidence-based directions for climate-resilient health system strengthening.

The Recent Outbreak & Epidemiological Overview

In late 2025, prolonged heavy rainfall and riverine overflow affected central and northern Mozambique, including Sofala, Zambezia, Nampula, Tete, Gaza, and Maputo provinces. Hundreds of thousands of individuals have been displaced, with many residing in temporary accommodation centers where WASH infrastructure is limited or disrupted. Damage assessments report destruction of roads, housing, health facilities, and community water systems [5].

Concurrently, Mozambique has experienced a significant cholera outbreak declared by national health authorities. Thousands of suspected and confirmed cases have been reported, with transmission concentrated in Nampula, Zambezia, and Sofala provinces regions historically vulnerable to flooding. Elevated incidence has been temporally associated with contamination of drinking water sources, breakdown of sanitation systems, and overcrowded shelter conditions [6].

The Ministry of Health, supported by the World Health Organization, strengthened surveillance and deployed rapid response teams. Laboratory confirmation capacity has improved compared to earlier disasters, reflecting investments made following previous outbreaks. Nevertheless, geographic spread and recurrent exposure highlight the persistent coupling between environmental shock and outbreak risk [7].

Recurrent Pattern Analysis

Mozambique's recurrent flooding and cholera outbreaks are not isolated incidents but part of a predictable cycle of structural vulnerability. Historical analyses show that large-scale climate shocks particularly cyclones and riverine flooding repeatedly compromise sanitation infrastructure, displace populations, and trigger waterborne disease outbreak (Table 1). The cases of Cyclone Idai (2019) and Cyclone Kenneth (2019) illustrate that despite rapid emergency response, structural reforms have often been insufficient, leaving communities vulnerable to subsequent events [8].

Factors Contributing to Recurrent Flood-Associated Cholera

Climate Intensification

Empirical evidence links anthropogenic climate change to increased frequency and intensity of extreme precipitation in southeastern Africa. Warmer atmospheric conditions increase moisture retention, amplifying rainfall volume during storm systems. Mozambique's extensive river basins and low-lying coastal urban centers make it particularly susceptible to flood accumulation and infrastructure overwhelm [9].

Persistent WASH Deficits

Cholera transmission remains strongly associated with inadequate sanitation and unsafe water sources. National data indicate that significant segments of peri-urban and rural populations rely on unimproved water sources vulnerable to flood contamination. Sewerage infrastructure coverage remains limited, particularly in informal settlements in Beira and Nampula [10].

Emergency chlorination campaigns and hygiene promotion effectively reduce short-term transmission; however, they do not replace the need for durable sanitation systems, protected boreholes, and flood-resilient drainage. Recurrent outbreaks indicate that temporary measures, while lifesaving, are insufficient for sustained prevention.

Urban Expansion in Flood-Prone Zones

Rapid, unplanned urban growth has expanded informal settlements into low-elevation floodplains. High population density combined with inadequate waste management intensifies environmental contamination during heavy rainfall. These structural patterns increase baseline cholera vulnerability irrespective of seasonal variation.

Health System Capacity Constraints

Flood events damage primary healthcare infrastructure, disrupt supply chains, and strain clinical staff. Research in Health Policy and Planning demonstrates that climate shocks reduce routine service delivery capacity in under-resourced district health systems. Mozambique's dependence on international surge support during major outbreaks reflects limited domestic surge autonomy, particularly in rural provinces [11].

Displacement and Conflict Interaction

Conflict-related displacement in Cabo Delgado intersects with

Table 1: Comparative Analysis of Major Climate-Related Health Emergencies in Mozambique from 2019 to 2026.

Event	Provinces Most Affected	Immediate Health & Humanitarian Response	Key Improvements Promised	Gaps That Persisted	Relevance to Current Crisis
Cyclone Idai (2019)	Sofala (Beira), Manica, Tete, Zambezia	Cholera vaccination campaign; emergency WASH; field hospitals; international surge support	Strengthening early warning systems; rebuilding resilient infrastructure; improved drainage in Beira	Urban informal settlements remain high-risk; sanitation upgrades incomplete; health system surge capacity limited	Current floods again triggered cholera risk in same regions
Cyclone Kenneth (2019)	Cabo Delgado	Emergency shelter; outbreak containment; NGO surge response	Decentralised disaster preparedness; improved coastal protection	Ongoing insurgency disrupted follow-through; health access in north weakened	Displacement continues to increase vulnerability
Recurring Cholera Outbreaks (2020–2024)	Nampula, Zambezia, Sofala	Reactive vaccination; WASH campaigns	Expanded cholera vaccination stockpiles; surveillance strengthening	Chronic WASH underfunding; reliance on reactive rather than preventive vaccination	Current outbreak risk follows same pattern
Flood Events 2022–2024	Gaza, Maputo, Sofala	Emergency food aid; WHO technical support	Integration of climate adaptation into planning	Limited infrastructure transformation; drainage and sanitation gaps persist	2025–2026 floods show limited structural change

climatic vulnerability. Studies show that overcrowding, poor sanitation, and population mobility significantly elevate cholera incidence following environmental shocks [12]. This layered vulnerability magnifies outbreak risk during flood events.

Impact on Public Health and Socioeconomic Stability

Morbidity and Mortality Burden

Cholera disproportionately affects children under five and populations lacking rapid access to oral rehydration therapy. Flood-related road destruction delays care-seeking and referral. Although case fatality rates have improved due to better clinical management protocols, localized mortality spikes remain possible where access is delayed.

Health System Disruption

During previous flood-associated outbreaks, diversion of staff and resources to cholera treatment centers reduced maternal, child health, and malaria services. Post-Cyclone Idai analysis documented significant service interruptions. Similar patterns risk recurring under current conditions. Healthcare workers face increased workload and infection risk, and repeated emergencies contribute to occupational burnout.

Economic Consequences

Flooding damages agriculture, markets, and transport infrastructure. Productivity losses and direct healthcare costs impose significant economic burden, as documented in economic analyses in Journal of Medical Economics. Recurrent disasters undermine development gains and exacerbate poverty cycles [13].

Response Strategies

Surveillance and Coordination

Mozambique has demonstrated commendable improvement in outbreak detection and coordination capacity since 2019. Emergency Operation Centers have facilitated multisectoral coordination between health, water, and disaster management authorities. WHO technical support has strengthened surveillance and laboratory networks.

Oral Cholera Vaccination

Reactive oral cholera vaccination (OCV) campaigns deployed after Cyclone Idai significantly reduced transmission. Evidence supports early deployment of OCV combined with WASH interventions. Current campaigns reflect growing national logistical competence in mass vaccination under emergency conditions.

WASH Interventions

Humanitarian partners including UNICEF and Médecins Sans Frontières have supported chlorination, safe water provision, and case management. These interventions have reduced mortality and deserve recognition for preventing larger epidemics. However, the predominance of reactive emergency WASH underscores insufficient structural transformation.

Lessons Learned and Future Directions

Repeated flood-cholera cycles illustrate that Mozambique's technical emergency response capacity has strengthened, yet preventive infrastructure remains inadequate.

Climate-resilient primary healthcare facilities must be prioritized, incorporating flood-proofing, reinforced supply chains, and decentralized laboratory capacity. WHO's Health Emergency and Disaster Risk Management framework emphasizes integrating preparedness into routine planning [14].

Sustained WASH investment is essential. Evidence in Water Research confirms that durable sanitation infrastructure significantly reduces outbreak risk even during extreme rainfall events [15].

Financing reform is necessary to shift from episodic humanitarian funding toward predictable climate-health adaptation investment. Integrated disaster risk reduction and health planning would reduce recurrent emergency costs.

Multisector governance linking health, water, urban planning, and climate authorities should be institutionalized. Evidence from studies indicates that coordinated cross-sector planning reduces cumulative vulnerability.

Conclusion

Mozambique's recurrent flooding and cholera outbreaks represent the predictable intersection of climate intensification and structural vulnerability. While emergency response capacity has demonstrably improved particularly in surveillance, vaccination, and coordination persistent WASH deficits, fragile infrastructure, displacement pressures, and fragmented financing perpetuate outbreak risk. Breaking the flood-cholera cycle requires transformation from reactive emergency management to integrated climate-resilient health system strengthening. Long-term investment in sanitation infrastructure, primary healthcare resilience, and multisector climate governance is indispensable for safeguarding population health and protecting development gains in an era of escalating climate risk.

Transparency Statement

The lead author Baraka affirms that manuscripts is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted

Data Availability Statement

The authors confirm that data supporting the findings of this study are available within the article.

Authors Contributions

Baraka Kalinga conceived the study design, drafted the manuscripts, carried out the analysis and authored the original draft, Hosea A. Mbwagha carried out the analysis, authored the original draft and revised the manuscript. All authors read and approved the final manuscript.

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