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Climate Change and Its Impact on Waterborne Typhoid Fever Outbreaks in Uganda: Extreme Weather, Water Scarcity, and Transmission Pathways

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ABSTRACT
Typhoid fever remains a major public health challenge in Uganda, driven largely by fecal contamination of drinking water and beverages in settings with constrained water, sanitation, and hygiene (WASH) services. Climate change is amplifying key environmental and social conditions that favor waterborne transmission: heavier rainfall events and flooding, longer and hotter dry spells that intensify water scarcity, and increased reliance on unsafe water sources and informal food/water vending. Uganda's experience with large water-linked outbreaks—such as the major Kampala outbreak in early 2015—illustrates how breakdowns in safe water access and urban WASH infrastructure can rapidly produce widespread exposure. This narrative review synthesizes evidence on (i) climate-sensitive mechanisms linking extreme weather and drought to typhoid transmission, (ii) the Uganda-specific outbreak and climate context, (iii) the role of rapid urbanization and informal settlements in mediating risk, and (iv) priority interventions and research needs, including climate-informed surveillance, resilient water systems, outbreak-ready WASH, and targeted typhoid vaccination strategies.
Keywords: typhoid fever, Salmonella Typhi, climate change, flooding, drought, water scarcity, WASH, Uganda, Kampala, extreme weather, outbreak

INTRODUCTION
Typhoid fever is a systemic febrile illness caused by *Salmonella enterica* serovar Typhi (*S. Typhi*), a strictly human-adapted pathogen transmitted mainly through the fecal–oral route. Infection typically occurs after ingestion of water or food contaminated with human feces, making typhoid a sensitive indicator of failures in water, sanitation, hygiene (WASH), and food safety systems. Once ingested, *S. Typhi* invades the intestinal mucosa, disseminates via the bloodstream, and can cause prolonged fever, abdominal symptoms, and serious complications such as intestinal perforation, hemorrhage, and neuropsychiatric manifestations if not promptly diagnosed and treated [1]. Although typhoid is preventable, it continues to impose major morbidity in many low- and middle-income settings where safe water access is incomplete, sanitation coverage is inadequate, and rapid urbanization outpaces infrastructure and service delivery. The global burden of typhoid is not evenly distributed; it is concentrated in densely populated urban and peri-urban areas where reliance on shared water sources, intermittent piped water supply, inadequate fecal sludge management, and informal food vending increases exposure risk. In such settings, contamination pathways are multiple and reinforcing [2]. Leaking or intermittently pressurized water pipes can permit intrusion of contaminated water; shallow wells and springs can be affected by runoff and latrine leakage; and open drains can convey fecal waste into community spaces and markets. Food-related transmission is amplified where street-vended beverages and ready-to-eat foods are prepared with unsafe water, handled with limited handwashing facilities, or stored under conditions that support microbial survival. Household coping strategies such as water storage in jerrycans, selective boiling, or reliance on cheaper but unsafe water sources may reduce or increase risk depending on practicality, consistency, and affordability [3].
Uganda has repeatedly experienced typhoid outbreaks, with one notable large outbreak centered in Kampala in early 2015 strongly linked to contaminated water sources and street-vended beverages prepared using unsafe water.

Kampala's setting, characterized by high population density, extensive informal settlements, and pressure on water and sanitation infrastructure, creates conditions where typhoid transmission can escalate rapidly once contamination is introduced into commonly used water or food chains. Similar risks extend to other rapidly growing municipalities where piped water coverage is uneven, wastewater management is constrained, and informal food and beverage markets serve large segments of the population daily [4].

At the same time, Uganda and the wider East African region are experiencing climate change and climate variability that are increasingly expressed through more frequent and intense extremes—heavy precipitation events, flooding, and droughts—rather than gradual, easily manageable changes. These climatic extremes matter because typhoid transmission is fundamentally shaped by environmental contamination and human exposure. Heavy rainfall and floods can mobilize fecal matter from latrines, open defecation sites, overflowing drains, and inadequately managed sludge into surface water sources and, in some cases, into damaged or compromised piped distribution networks [5]. Flooding may also disrupt household hygiene, reduce access to safe water points, and force temporary displacement, increasing reliance on unsafe emergency water sources. Conversely, drought can concentrate contaminants in dwindling water sources, reduce water availability for handwashing, prompt households to ration treated water, and increase dependence on unimproved sources. Drought can also encourage longer-term water storage, which may introduce contamination during collection, handling, or storage. Thus, both extremes, such as too much water and too little, can plausibly raise typhoid risk through distinct but overlapping pathways [6].

Within this context, climate change can influence the "force of infection" for typhoid i.e., the rate at which susceptible individuals acquire infection by reshaping environmental contamination levels, stressing water and sanitation systems, altering household and community behaviors, and shifting exposure through food and beverages. Importantly, these effects are not uniform; they can vary by neighborhood vulnerability, infrastructure quality, seasonality, livelihood patterns, and the capacity of public health systems to detect and respond to outbreaks [7]. Understanding these linkages is increasingly necessary for typhoid control planning, especially in fast-growing urban centers where climate shocks and WASH constraints intersect.

Despite typhoid being preventable through safe water, sanitation, hygiene, food safety measures, and vaccination, Uganda continues to report recurrent outbreaks and sustained transmission in high-risk settings. Traditional typhoid prevention approaches often emphasize "static" risk factors poor sanitation, unsafe water, and limited hygiene facilities without fully integrating how climate variability and climate-driven extremes can destabilize these systems and intensify exposure [8]. As climate extremes become more frequent or severe, the pathways that maintain typhoid transmission may be amplified: floods can overwhelm drainage and sanitation systems, contaminate water sources, and expand exposure through street-vended beverages; drought can worsen unsafe water access and compromise hygiene practices; and both can disrupt routine service delivery and outbreak response [9].

A key problem, therefore, is that typhoid control strategies may remain insufficiently "climate-informed." Without a consolidated understanding of how climate hazards interact with WASH infrastructure, urban informality, household coping practices, and food and beverage pathways, interventions risk being reactive rather than preventive. This gap can delay early warning, weaken preparedness, and allow avoidable increases in cases during high-risk periods. There is a need to synthesize evidence on climate–typhoid linkages in Uganda and comparable settings, identify the most plausible transmission pathways under different climate scenarios, and clarify where integrated WASH–climate–health interventions can yield the greatest impact [10]. This review aims to synthesize and critically evaluate evidence on how climate change and climate variability, particularly heavy rainfall, flooding, and drought, shape typhoid transmission risk in Uganda. It focuses on the ways climate extremes intensify environmental contamination, disrupt water system performance, alter household coping practices, and increase exposure through contaminated food and beverages. The review is significant for public health practice, policy, and research because it can strengthen climate-informed typhoid prevention and preparedness by clarifying when and where transmission pathways are amplified, thereby improving the timing and targeting of interventions such as water quality monitoring, risk communication, and food safety enforcement. It can also guide WASH and urban planning priorities by identifying climate-sensitive contamination routes that justify investments in resilient water distribution, improved drainage, safe fecal sludge management, and protection of water sources, especially in informal settlements and high-density neighborhoods. In addition, the review can support integrated surveillance and early warning by linking epidemiological trends with meteorological signals to enable earlier detection of elevated risk and faster outbreak response. Finally, by highlighting practical household and vendor behaviors that reduce risk during climate shocks, and by emphasizing structural vulnerability, the review supports more equitable, anticipatory, and context-specific typhoid prevention in Uganda's rapidly urbanizing settings.

Approach, scope, and why climate–typhoid linkages matter in Uganda

This section provides a narrative synthesis integrating three evidence streams: (i) Uganda outbreak documentation (e.g., WHO outbreak notices and outbreak investigation reports), (ii) Uganda-relevant climate and hazard summaries (including climate risk profiles and projections), and (iii) broader epidemiologic evidence linking typhoid transmission to climatic drivers (systematic reviews and recent modeling studies). Together, these sources are used to explain how climate variability and extremes can shape typhoid risk by altering water safety, sanitation performance, and exposure pathways in both urban and peri-urban settings [11]. In Uganda, climate–typhoid linkages are especially important because multiple outbreaks have displayed classic waterborne dynamics. During the Kampala outbreak in early 2015, investigations concluded that illness was strongly associated with consumption of contaminated water and locally prepared street beverages made from that water, an archetypal pattern in dense cities where water safety can be inconsistent and reliance on informal vendors is high [12].

Concurrently, Uganda is experiencing increasingly disruptive climate impacts, including more frequent/intense droughts, floods, and landslides, alongside a rising proportion of rainfall occurring as heavy precipitation events. Climate projection resources further indicate shifts in temperature and precipitation that can raise both drought stress and flood risk—particularly when heavy rains follow dry spells that reduce soil infiltration. These shifts are epidemiologically meaningful because they strain WASH systems in two opposing but synergistic ways: flooding and heavy rains can amplify environmental contamination and pathogen dispersal, while drought and heat increase water scarcity and encourage high-risk coping behaviors (unsafe sources, household storage, and greater dependence on vendors) [13].

Mechanisms: how climate change drives waterborne typhoid risk

Typhoid transmission under climate change reflects a dynamic interaction between *Salmonella Typhi* contamination, water-system integrity, and human exposure behaviors all highly climate-sensitive. Extreme rainfall and flooding mobilize fecal waste from pit latrines, open drains, and overflowing sewers into surface and shallow groundwater, contaminating drinking-water sources. Floods also increase pressure fluctuations and pipe breakages, enabling contaminated water intrusion into distribution networks [14]. In Kampala's 2015 outbreak, street-vended beverages prepared with unsafe water were central to transmission, illustrating how flood conditions disrupt reliable safe-water access and shift consumption toward higher-risk ready-to-drink options. Flood-related displacement and crowding further intensify fecal–oral spread through shared sanitation and compromised hygiene. Conversely, drought, heat, and water scarcity drive households toward shallow wells, surface water, or unregulated vendors, while reducing handwashing and increasing prolonged household water storage conditions that elevate contamination risk. Scarcity also concentrates reliance on limited water points, amplifying shared exposure if contamination occurs [15]. A particularly high-risk sequence is intense rainfall following prolonged dry periods: stagnation, waste accumulation, and increased open defecation during drought are rapidly flushed into water systems when heavy rains arrive, generating outbreak-like spikes. In Uganda, rapid urbanization, drainage constraints, and dense informal settlements in Greater Kampala magnify these climate-sensitive pathways, transforming extreme weather events into widespread typhoid exposure episodes [16].

Mediators and modifiers in Uganda

In Uganda, climate hazards may be regional, but typhoid outbreak amplification is usually local, especially where drainage, sanitation, and water distribution fail. Rapid urbanization and peri-urban expansion around Kampala, Wakiso, and Mukono have produced dense informal settlements with shared sanitation, crowded exposure networks, and heavy dependence on street foods and drinks; during floods, households and vendors often cannot "avoid" contaminated environments. This helps explain why outbreak communications (e.g., 2015) explicitly referenced Kampala and neighboring districts [17]. Climate shocks can also intensify antimicrobial resistance (AMR) consequences: surges in transmission increase healthcare demand and antibiotic consumption, raising selective pressure and worsening outcomes where resistant strains circulate—so climate change may not *cause* AMR, but it creates conditions that accelerate inappropriate use. A practical climate-smart package for Uganda should combine climate-informed surveillance (rainfall anomalies, flood alerts, water interruptions, hotspot mapping) with threshold triggers that activate rapid WASH and risk communication before cases explode [18]. During extreme events, surge WASH (emergency chlorination, safe water distribution, rapid testing at markets/schools/taxi parks, targeted sanitation of beverage points, and low-water hygiene options) can cut exposure quickly. Longer term, resilient water systems like source protection, drainage and fecal sludge upgrades, and reduced intermittency are core adaptation, with targeted TCVs as an added risk-reduction layer in recurrent hotspots [19].

Research gaps

Uganda's typhoid evidence base still has clear, publishable gaps that align with climate variability and urban WASH realities. First, locally quantified climate–typhoid relationships remain limited: district- and city-level time-series should link laboratory-confirmed typhoid (including severe disease) with rainfall extremes, flooding indices, temperature anomalies, and utility metrics such as water interruptions, building on recent Kampala-focused analyses that demonstrate feasibility. Second, attribution of exposure pathways during extreme events is underdeveloped; combining microbial source tracking with feasible *S. Typhi* detection proxies across water networks (e.g., distribution points, informal supplies, and high-risk nodes) could clarify transmission during floods [20]. Third, behavioral risk during scarcity needs granular study: how households and food vendors respond to rationing or drought, how storage duration/containers and water handling shift, and which coping behaviors most strongly predict typhoid risk. Fourth, Uganda lacks robust economic evaluations of "climate-smart" control bundles like integrating early warning triggers, surge WASH responses, and targeted typhoid conjugate vaccine (TCV) deployment in hotspots under realistic budget constraints. Finally, antimicrobial resistance (AMR) dynamics during climate-linked outbreaks are poorly characterized; tracking antibiotic use, treatment outcomes, and resistance evolution across outbreak versus non-outbreak periods would inform guidelines and stewardship while strengthening outbreak preparedness [21].

CONCLUSION

Uganda's typhoid evidence base now points to a practical, publishable agenda at the intersection of climate variability and urban WASH constraints. Priority gaps include locally quantified climate–typhoid links using district/city time-series that pair laboratory-confirmed typhoid (incl. severe disease) with rainfall extremes, flooding indices, temperature anomalies, and utility performance (e.g., water interruptions), extending the feasibility shown in Kampala analyses. Equally important is stronger attribution of exposure pathways during extreme events: coupling microbial source tracking with feasible S. Typhi detection proxies across formal and informal water networks could identify transmission "hot nodes" during floods. Behavioral risk under scarcity also needs granular evidence such as how households and vendors adapt to rationing or drought, how storage duration/containers and handling change, and which coping behaviors most predict infection. Uganda also needs economic evaluations of climate-smart bundles that integrate early-warning triggers, surge WASH, and targeted TCV deployment under realistic budgets. Finally, AMR dynamics during climate-linked outbreaks remain under-described; linking antibiotic use, outcomes, and resistance trajectories across outbreak vs non-outbreak periods will improve guidelines, stewardship, and preparedness.

REFERENCES

1. Bhandari, J., Thada, P.K., Hashmi, M.F., DeVos, E.: Typhoid Fever. In: StatPearls. StatPearls Publishing, Treasure Island (FL) (2025)
2. Boakye Okyere, P., Twumasi-Ankrah, S., Newton, S., Nkansah Darko, S., Owusu Ansah, M., Darko, E., et al.: Risk Factors for Typhoid Fever: Systematic Review. JMIR Public Health Surveill. 11, e67544 (2025). https://doi.org/10.2196/67544
3. Alum, E. U., Uti, D. E., Agah, V. M., Orji, O. U., Ezeani, N. N., Ugwu, O. P., et al. (2023). Physico-chemical and Bacteriological Analysis of Water used for Drinking and other Domestic Purposes in Amaozara Ozizza, Afikpo North, Ebonyi State, Nigeria. *Nigerian Journal of Biochemistry and Molecular Biology*, 38(1), 1-8. https://doi.org/10.2659/njbmb.2023.151.
4. Kabwama, S.N., Bulage, L., Nsubuga, F., Pande, G., Oguttu, D.W., Mafigiri, R., et al: A large and persistent outbreak of typhoid fever caused by consuming contaminated water and street-vended beverages: Kampala, Uganda, January – June 2015. BMC Public Health. 17, 23 (2017). https://doi.org/10.1186/s12889-016-4002-0
5. Odongo, R.A., Schrieks, T., Streefkerk, I., de Moel, H., Busker, T., Haer, T., et al.: Drought impacts and community adaptation: Perspectives on the 2020–2023 drought in East Africa. Int. J. Disaster Risk Reduct. 119, 105309 (2025). https://doi.org/10.1016/j.ijdrr.2025.105309
6. Agwu E (2011). Distribution of Community acquired typhoid fever among febrile patients attending clinics in Bushenyi, Uganda: case study of the year 2005. *Journal of Medical Microbiology and Diagnosis, 1, (101), 1-4.*
7. Alexander, K.A., Carlson, C.J., Lewis, B.L., Getz, W.M., Marathe, M.V., Eubank, S.G., et al.: The Ecology of Pathogen Spillover and Disease Emergence at the Human-Wildlife-Environment Interface. Connect. Ecol. Infect. Dis. 5, 267–298 (2018). https://doi.org/10.1007/978-3-319-92373-4_8
8. Malebana, L.F., Sepadi, M.M., Mokgobu, M.I.: Communicable Disease Surveillance in South Africa and LMICs: A Systematic Review of Systems, Challenges, and Integration with Environmental Health. Trop. Med. Infect. Dis. 10, (2025). https://doi.org/10.3390/tropicalmed10110314
9. Jia, C., Cao, Q., Wang, Z., van den Dool, A., Yue, M.: Climate change affects the spread of typhoid pathogens. Microb. Biotechnol. 17, e14417 (2024). https://doi.org/10.1111/1751-7915.14417
10. Risk Factors for Typhoid Fever: Systematic Review. JMIR Public Health Surveill. 11, (2025). https://doi.org/10.2196/67544
11. Nakisuyi J, Bernis M, Ndamira A, Kayini V, Mulumba R, Theophilus P, et al, (2023). Prevalence and factors associated with malaria, typhoid, and co-infection among febrile children aged six months to twelve years at kampala international university teaching … Heliyon, 9, (9), e19588.
12. Murphy, J.L., Kahler, A.M., Nansubuga, I., Nanyunja, E.M., Kaplan, B., Jothikumar, N., et al.: Environmental Survey of Drinking Water Sources in Kampala, Uganda, during a Typhoid Fever Outbreak. Appl. Environ. Microbiol. 83, e01706-17 (2017). https://doi.org/10.1128/AEM.01706-17
13. The escalating impact of Climate Change on Child Labour in Uganda – Economic Policy Research Centre, https://eprcug.org/blog/the-escalating-impact-of-climate-change-on-child-labour-in-uganda/

14. Effects of climate change on waterborne diseases | News, https://wellcome.org/insights/articles/how-climate-change-affects-waterborne-diseases
15. Murphy, J.L., Kahler, A.M., Nansubuga, I., Nanyunja, E.M., Kaplan, B., Jothikumar, N., et al.: Environmental Survey of Drinking Water Sources in Kampala, Uganda, during a Typhoid Fever Outbreak. Appl. Environ. Microbiol. 83, e01706-17 (2017). https://doi.org/10.1128/AEM.01706-17
16. Deshpande, A., Chang, H.H., Levy, K.: Heavy Rainfall Events and Diarrheal Diseases: The Role of Urban–Rural Geography. Am. J. Trop. Med. Hyg. 103, 1043–1049 (2020). https://doi.org/10.4269/ajtmh.19-0768
17. Kalule, J.B., Valeria, N.Z., Samuel, M.: Assessing the environmental and climatic influences on the incidence of severe typhoid in Kampala, Uganda. PLOS Glob. Public Health. 5, e0004214 (2025). https://doi.org/10.1371/journal.pgph.0004214
18. Aslam, B., Aljasir, S.F.: Climate Change and AMR: Interconnected Threats and One Health Solutions. Antibiotics. 14, (2025). https://doi.org/10.3390/antibiotics14090946
19. Agwu E, Ihongbe J C, Okogun G R A, Inyang N J (2009). High incidence of co-infection with Malaria and Typhoid in febrile HIV infected and AIDS patients in Ekpoma, Edo State, Nigeria. *Brazilian Journal of Microbiology, 40, 329-332.* https://doi.org/10.1590/S1517-83822009000200022.
20. Kalule, J.B., Valeria, N.Z., Samuel, M.: Assessing the environmental and climatic influences on the incidence of severe typhoid in Kampala, Uganda. PLOS Glob. Public Health. 5, e0004214 (2025). https://doi.org/10.1371/journal.pgph.0004214
21. Baker, N., Kang, Y., Makabila, G., Tadesse, S., Doocy, S.: Prevalence and risk factors for severe food insecurity and poor food consumption during a drought emergency in Ethiopia. PLOS Glob. Public Health. 5, e0004636 (2025). https://doi.org/10.1371/journal.pgph.0004636

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