INT'L RESEARCH JOURNAL OF TRANSDISCIPLINARY PERSPECTIVE (IRJTP)
E-ISSN: 3121-9071 - **Vol**. 2 **Issue** 3, 2026
https://journals.chroniva.org/index.php/IRJTP

EFFECT OF FLOODING ON CHOLERA TRANSMISSION AND OUTBREAK PATTERNS IN KOGI STATE, NIGERIA

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Abstract

Flooding remains an important environmental factor influencing the emergence and spread of cholera outbreaks in vulnerable communities. This study assessed the effect of flooding on cholera transmission and outbreak patterns in Kogi State, Nigeria. A retrospective ecological study design was adopted using reported cholera surveillance records, flood occurrence data, and environmental health reports from selected local government areas of the state between 2018 and 2024. Data were analysed using descriptive statistics, trend analysis, and correlation analysis to examine relationships between flood events and cholera occurrence. The study recorded increased cholera cases during periods of extensive flooding, particularly in riverine and low-lying

communities along the Niger and Benue River corridors. Flood years were associated with increased contamination of water sources, disruption of sanitation facilities, and higher frequency of suspected cholera outbreaks. The findings showed a significant association between flood exposure and increased cholera transmission patterns. The study concluded that flooding contributes substantially to cholera vulnerability in Kogi State by increasing exposure to contaminated water and weakening existing sanitation systems. Strengthening flood preparedness, safe water provision, disease surveillance, and community-based sanitation interventions is recommended to reduce future outbreaks.

Keywords: Cholera, Climate change, Flooding, Nigeria, Waterborne disease

Introduction

Cholera remains one of the most persistent waterborne diseases affecting populations where access to safe drinking water, sanitation facilities, and effective disease surveillance remains inadequate. The disease is caused by *Vibrio cholerae*, a bacterium transmitted mainly through ingestion of contaminated food or water. Although cholera outbreaks are preventable through improved water, sanitation, and hygiene practices, outbreaks continue to occur in many low- and middle-income countries, including Nigeria (World Health Organization [WHO], 2023).

Nigeria has experienced repeated cholera outbreaks over the past decades, with transmission often intensified by environmental conditions such as flooding, inadequate sanitation infrastructure, population displacement, and poor access to potable water. The country's vulnerability is linked to rapid urban expansion, pressure on public health systems, and increasing climate variability. Recent outbreaks have demonstrated that heavy rainfall and flood events can create conditions favourable for the survival and movement of *V. cholerae* through contaminated water systems (Ali et al., 2015; Jutla et al., 2013).

Flooding creates multiple pathways through which cholera transmission can increase. During flood events, latrines and sewage systems may overflow, allowing human waste to contaminate surface water sources used for drinking, cooking, and household activities. Communities dependent on rivers, streams, and shallow wells are particularly vulnerable because these sources are easily affected by floodwater contamination. Ugbede et al. (2024) highlighted that inadequate access to clean water and sanitation remains a major public health challenge in rural Nigerian communities, creating conditions favourable for waterborne diseases such as cholera.

Kogi State presents a unique environmental setting for studying the relationship between flooding and cholera transmission. The state is located at the confluence of the Niger and Benue Rivers,

making several communities vulnerable to seasonal flooding. Areas located along river channels frequently experience displacement, damaged sanitation facilities, and disruption of health services during major flood events. These conditions may influence the timing, magnitude, and geographical distribution of cholera outbreaks.

Previous studies have examined cholera transmission in Nigeria, but fewer studies have specifically explored how flood events influence outbreak patterns at the sub-national level, particularly in Kogi State. Understanding this relationship is important because flood-related cholera outbreaks require different preparedness approaches compared with outbreaks driven mainly by routine sanitation challenges.

This study therefore assessed the effect of flooding on cholera transmission and outbreak patterns in Kogi State, Nigeria. Specifically, the study examined the relationship between flood occurrence and cholera cases, identified temporal patterns of outbreaks during flood periods, and evaluated environmental factors contributing to increased transmission.

Literature Review

1 Conceptual Review

Flooding and Public Health

Flooding is the temporary overflow of water onto land that is normally dry. While floods are natural environmental events, their health consequences are influenced by human settlement patterns, infrastructure quality, and preparedness capacity. Flood events can increase exposure to infectious diseases by altering water quality, damaging sanitation systems, and forcing communities to rely on unsafe water sources.

In Nigeria, flooding has become increasingly associated with displacement, food insecurity, and increased risks of infectious diseases. Flood-prone communities often experience difficulty maintaining hygiene practices because water sources become contaminated while access to healthcare services becomes limited.

Cholera Transmission Pathways

Cholera transmission follows a complex interaction between environmental conditions, human behaviour, and water systems. The organism survives naturally in aquatic environments and can multiply under suitable ecological conditions. Flooding may enhance transmission by transporting contaminated materials into domestic water sources.

Research has shown that cholera outbreaks are influenced by rainfall patterns, temperature variations, water availability, and sanitation conditions (Jutla et al., 2013). Communities without

reliable access to treated water remain at higher risk because household water treatment practices are often inconsistent.

2 Theoretical Review

This study was guided by the Environmental Health Theory, which explains disease occurrence as an interaction between humans and their surrounding physical environment. The theory suggests that environmental disruptions, including flooding and contamination of water sources, can modify disease risks.

The theory is applicable to cholera because transmission depends strongly on environmental conditions. Flooding changes the physical environment by increasing contact between contaminated materials and human water sources, thereby increasing opportunities for disease spread.

3 Empirical Review

Studies conducted in different parts of the world have established relationships between extreme weather events and cholera outbreaks. Jutla et al. (2013) demonstrated that climate-related variations influence cholera transmission by affecting environmental suitability for *V. cholerae* survival.

In Nigeria, cholera outbreaks have frequently been reported during rainy seasons and periods of flooding. Poor sanitation coverage, inadequate waste disposal systems, and limited access to safe water have been identified as major contributors to transmission.

Ugbede and colleagues have also emphasized the importance of environmental conditions, sanitation systems, and disease surveillance in controlling public health threats in Nigeria. Their studies on water access, sanitation challenges, and environmental disease risks support the need for integrated approaches to managing waterborne diseases.

However, limited evidence exists regarding how flood events specifically influence cholera outbreak patterns in Kogi State. This study contributes to addressing that gap.

Methods

1 Research Design

The study adopted a retrospective ecological research design to assess the relationship between flooding events and cholera transmission patterns in Kogi State, Nigeria. The design was considered appropriate because the study examined previously recorded cholera cases alongside historical flood occurrence patterns to determine whether changes in flooding intensity corresponded with variations in cholera outbreaks. Retrospective designs have been widely used in infectious disease epidemiology where surveillance records are available and where

understanding temporal relationships between environmental exposures and disease occurrence is required (WHO, 2023).

2 Study Area

The study was conducted in Kogi State, located in the North-Central geopolitical zone of Nigeria. The state lies between approximately latitude 6°30′N and 8°42′N and longitude 5°22′E and 7°49′E. It shares boundaries with several states and is characterised by diverse ecological zones, including riverine environments created by the meeting point of the Niger and Benue Rivers.

Kogi State experiences a tropical climate with distinct rainy and dry seasons. Annual rainfall occurs mainly between April and October, with peak rainfall generally recorded between July and September. The combination of heavy seasonal rainfall, river overflow, and settlement patterns around flood-prone areas makes several communities vulnerable to flooding.

The state has 21 local government areas, with several communities located close to major waterways. Areas such as Lokoja, Ibaji, Kogi/Koton Karfe, Bassa, Omala, and Idah have historically experienced varying degrees of flood exposure. Flooding in these locations often affects water supply systems, sanitation facilities, transportation networks, and healthcare access.

3 Target Population

The target population consisted of individuals affected by cholera outbreaks reported in Kogi State between 2018 and 2024. The study population included all confirmed and suspected cholera cases recorded through state disease surveillance systems during the study period. Flood occurrence records from the same period were also included to examine environmental associations.

4 Sample Size and Sampling Technique

The study utilised secondary surveillance data rather than direct recruitment of human participants. All available cholera outbreak records and flood-related reports within the study period were included through a total enumeration approach.

The inclusion of all available records reduced sampling bias and provided a broader assessment of outbreak patterns across flood and non-flood periods. Records with incomplete information on location, date of occurrence, or disease classification were excluded from the final analysis.

5 Data Collection Instruments

Data were collected using a structured extraction checklist developed by the researchers. Information extracted included:

1. Number of reported cholera cases.
2. Date and location of outbreaks.

3. Flood occurrence and severity during corresponding periods.
4. Demographic characteristics where available.
5. Environmental conditions associated with outbreaks.

ources of information included cholera surveillance reports from the Kogi State Ministry of Health, Nigeria Centre for Disease Control and Prevention (NCDC) reports, flood situation reports, and relevant environmental health records.

6 Validity and Reliability

The data extraction instrument was reviewed by experts in epidemiology, environmental health, and public health research to ensure that variables selected were relevant to the study objectives. Reliability was enhanced through cross-checking extracted information against multiple official records where available.

7 Data Collection Procedure

The researchers obtained available surveillance reports and environmental records covering the period 2018 to 2024. Cholera cases were organised according to year, location, and outbreak period. Flood data were matched with cholera occurrence periods to identify possible relationships between flood exposure and disease transmission.

The data collection process involved reviewing outbreak reports, extracting relevant variables, cleaning datasets, and preparing information for statistical analysis.

8 Ethical Considerations

Ethical approval for the study was obtained from the appropriate institutional research ethics committee before commencement of data analysis. Since the study used secondary surveillance records, no direct interaction with human participants occurred. Confidentiality of disease records was maintained throughout the research process.

9 Data Analysis

Data were analysed using Statistical Package for Social Sciences (SPSS) version 27. Descriptive statistics including frequencies, percentages, means, and trend distributions were used to describe cholera occurrence patterns.

The relationship between flooding and cholera transmission was assessed using correlation analysis. Cholera cases were compared between flood and non-flood periods to identify differences in outbreak occurrence. Results were presented using tables, charts, and figures.

Results

1 Distribution of Cholera Cases According to Year and Flood Occurrence

The study analysed cholera surveillance records between 2018 and 2024. A total of 2,846 suspected cholera cases were recorded during the study period, with 186 confirmed cases reported from different local government areas of Kogi State.

The highest number of suspected cases occurred during years associated with extensive flooding, particularly 2022 and 2024. The lowest occurrence was observed during years with limited flood activity.

Table 1: Annual Distribution of Cholera Cases and Flood Events in Kogi State (2018–2024)

Year	Flood occurrence	Suspected cholera cases	Confirmed cases
2018	Moderate	214	12
2019	Low	167	8
2020	Moderate	286	17
2021	High	421	29
2022	Severe	638	48
2023	Moderate	391	26
2024	Severe	729	46

Source: Researchers' compilation from surveillance and environmental records (2025).

The distribution showed that cholera occurrence increased during years classified as severe flood periods. The two years with the highest flood intensity, 2022 and 2024, accounted for the highest number of reported cholera cases.

2 Cholera Cases by Flood-Prone Local Government Areas

The analysis showed that local government areas located close to major rivers recorded higher cholera occurrence compared with areas less affected by flooding.

2: Cholera Cases by Selected Flood-Prone Local Government Areas

Local Government Area	Flood exposure level	Confirmed cholera cases
Lokoja	High	38
Ibaji	High	31
Kogi/Koton Karfe	High	27
Omala	High	24
Idah	Moderate	19
Bassa	Moderate	16
Other LGAs	Low	31

Source: Researchers' compilation from Kogi State cholera surveillance records (2025).

Lokoja recorded the highest number of confirmed cases, followed by Ibaji and Kogi/Koton Karfe. These locations are characterised by communities situated near river systems and areas frequently affected by seasonal flooding.

3 Relationship Between Flood Occurrence and Cholera Transmission

Correlation analysis demonstrated a positive relationship between flood intensity and cholera occurrence.

Table 3: Correlation Between Flood Severity and Cholera Cases

Variable	Correlation coefficient (r)	p-value
Flood severity and suspected cholera cases	0.78	<0.001
Flood severity and confirmed cholera cases	0.71	0.002

Source: Researchers' statistical analysis (2025).

The results indicated that increases in flood severity corresponded with increases in cholera cases during the study period.

Discussion of Findings

This study assessed the effect of flooding on cholera transmission and outbreak patterns in Kogi State, Nigeria. The findings demonstrated that cholera occurrence increased during periods associated with major flooding events. The observed pattern suggests that flood conditions may contribute to increased exposure to contaminated water sources and reduced effectiveness of sanitation systems, thereby creating favourable conditions for cholera transmission.

The study recorded the highest number of cholera cases during 2022 and 2024, which corresponded with periods of severe flooding in the state. This finding agrees with previous studies that identified flooding and heavy rainfall as important environmental drivers of cholera outbreaks. Floodwater can transport faecal materials from damaged sanitation facilities into rivers, wells, and other community water sources, increasing the likelihood of human exposure to *Vibrio cholerae* (Jutla et al., 2013; WHO, 2023).

The higher burden of cholera observed in riverine local government areas such as Lokoja, Ibaji, Kogi/Koton Karfe, and Omala reflects the vulnerability of communities located around major waterways. These areas often experience direct impacts of flood events, including displacement, contamination of drinking water sources, and interruption of routine public health services. Similar observations have been reported in studies examining climate-related disease risks in flood-prone communities, where environmental disruption and inadequate water infrastructure increased susceptibility to waterborne infections (Ali et al., 2015).

The positive correlation between flood severity and cholera occurrence found in this study indicates that increasing flood intensity was associated with increased disease transmission. Although flooding alone does not cause cholera outbreaks, it creates environmental conditions that facilitate transmission. The interaction between contaminated water, inadequate sanitation, population movement, and limited access to healthcare determines the magnitude of outbreaks.

The findings are also consistent with environmental health studies conducted in Nigeria, which emphasise that poor access to safe water and sanitation remains a major challenge affecting disease prevention. Ugbede et al. (2024) reported that rural and underserved communities continue to face difficulties accessing reliable water and sanitation services, increasing vulnerability to water-related diseases. These challenges become more pronounced during flood events when existing infrastructure may become overwhelmed.

The findings have important implications for disease prevention strategies in Kogi State. Traditional cholera control approaches often focus on treatment and outbreak response after cases occur. However, the relationship between flooding and cholera transmission suggests that prevention activities should begin before flood seasons. Early warning systems that combine flood

forecasting with disease surveillance may improve preparedness and allow health authorities to respond rapidly when environmental conditions become favourable for outbreaks.

Community-level interventions are also important. Many flood-affected communities depend on untreated surface water sources, particularly when normal water supply systems are disrupted. Improving access to safe drinking water, promoting household water treatment, strengthening sanitation infrastructure, and increasing public awareness can reduce transmission risks.

The study contributes evidence on the connection between environmental events and infectious disease patterns in Kogi State. However, the findings should be interpreted with consideration of some limitations. The study relied on secondary surveillance records, and variations in reporting capacity across local government areas may have influenced the number of documented cases. Additionally, other factors such as population movement, healthcare access, and individual hygiene practices were not directly measured.

Despite these limitations, the observed relationship between flooding and cholera occurrence highlights the need for integrated approaches combining environmental management, climate adaptation, and public health surveillance.

Conclusion

This study demonstrated that flooding significantly influenced cholera transmission patterns in Kogi State, Nigeria. Areas exposed to frequent and severe flooding recorded higher cholera occurrence, with major outbreaks observed during years characterised by extensive flood events.

The study showed that flooding contributes to cholera risk through several pathways, including contamination of water sources, disruption of sanitation systems, and increased vulnerability among affected communities. The findings indicate that flood-prone communities require targeted preventive measures to reduce future outbreaks.

The objectives of the study were achieved by identifying the relationship between flood occurrence and cholera transmission, describing outbreak patterns across flood-prone areas, and highlighting environmental factors contributing to disease spread. Effective cholera control in Kogi State will require coordinated efforts involving health authorities, environmental agencies, water management organisations, and local communities.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. Strengthening flood-related disease surveillance

2. The Kogi State Ministry of Health should integrate flood monitoring information with cholera surveillance systems to allow early detection and rapid response during periods of increased flood risk.
3. Improving access to safe water
4. Government agencies and development partners should expand access to treated water in flood-prone communities, particularly during and immediately after flood events.
5. Improving sanitation infrastructure
6. Flood-prone communities should receive support for improved sanitation facilities that can withstand seasonal flooding. Damaged toilets and waste disposal systems should be repaired promptly after flood events.
7. Increasing community health education
8. Regular community education programmes should focus on safe water practices, household water treatment, food hygiene, and early reporting of suspected cholera symptoms.
9. Developing climate-sensitive public health planning
10. Public health programmes should incorporate climate-related risks into disease prevention strategies, especially in communities located around the Niger and Benue River systems.

Conflict of Interest Statement

The authors declare that there is no conflict of interest associated with this study.

Funding Statement

This study received no external funding. The research was conducted using available institutional and publicly accessible surveillance information.

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