Nigerian Medical Journal
NIGERIA MEDICAL ASSOCIATION
Print ISSN 0300-1652, E-ISSN 2229-774X

Review Article

Cholera in Nigeria: A review of outbreaks, trends, contributing factors, and public health responses

***Moore Ikechi Mike-Ogburia[1, 4], Chinemerem Cynthia Eze[2], Maureen Onyinyechi Okoli[3], Inimuvie Ekada[5], Candid Uzoma Uhegbu[4], Chioma Ugwu[6], Priscilla Adonike Ogbakiri[7], Favour Chigemezu Alozie[1], Nancy Obutor Ideozu[1], Ayebaemi Wilfred Amesi [8], Margaret Afor Ifeanyi[9].**

[1]Department of Medical Microbiology, Rivers State University, Port Harcourt, Nigeria.
[2] Department of Haematology and Blood Transfusion Science, Rivers State University, Port Harcourt, Nigeria.
[3] Department of Histopathology and Cytology, Rivers State University, Port Harcourt, Nigeria.
[4]School of Public Health, University of Port Harcourt, Nigeria. [5] Department of Clinical Pharmacy and Public Health, Afe-Babalola University, Ado-Ekiti, Ekiti State, Nigeria. [6] Department of Medical Laboratory, Cedarcrest Hospitals, Abuja, Nigeria. [7] United Lincolnshire NHS Hospitals Trust, Lincoln, England. [8] Department of Paediatrics, Madonna University Teaching Hospital, Elele, Nigeria. [9] Department of Medical Laboratory Services, Federal Medical Center, Yenagoa, Bayelsa State, Nigeria.

Abstract

Cholera remains a significant public health challenge in Nigeria, with recurrent outbreaks exacerbated by inadequate water, sanitation, and hygiene (WASH) infrastructure, as well as conflict and displacement. This review examines cholera outbreaks in Nigeria from 2010 to 2024, analyzing epidemiological trends, contributing factors, and public health responses. Seasonal peaks during periods of heavy rainfall and flooding have consistently facilitated *Vibrio cholerae* transmission, with Northern regions disproportionately affected due to poor infrastructure and ongoing conflicts. Displacement into overcrowded camps has heightened vulnerability, particularly in conflict-affected areas such as Borno and Adamawa. The outbreaks have exhibited multiple epidemic waves within single periods, reflecting persistent transmission dynamics. Recent outbreaks have seen higher incidence rates among children under the age of five and vulnerable populations, highlighting the need for targeted interventions. Public health responses have focused on improving surveillance, case management, and WASH infrastructure, with coordinated efforts from national and international agencies. Vaccination campaigns, particularly in high-risk areas, have proven effective in controlling outbreaks. However, challenges remain, including inadequate healthcare capacity, vaccine stockouts, and the emergence of antimicrobial-resistant *Vibrio cholerae* strains (serogroup O1) resistant to antibiotics such as tetracycline, doxycycline, ampicillin, and trimethoprim-sulfamethoxazole, complicating treatment efforts. The COVID-19 pandemic further strained Nigeria's healthcare system, underscoring the need for an integrated health system to be strengthened to manage concurrent public health crises. This review emphasizes the importance of a multi-sectoral approach to cholera prevention and control, addressing underlying social determinants and ensuring sustained investments in public health infrastructure to mitigate future outbreaks.

Keywords: *Cholera; Vibrio cholerae; Epidemiology; Public health; Sanitation; Water; Conflict.*

***Correspondence**: Moore Ikechi Mike-Ogburia. Department of Medical Microbiology, Rivers State University, Port Harcourt, Nigeria.
Email: moore.mike-ogburia@ust.edu.ng

How to cite: Mike-Ogburia MI, Eze CC, Okoli MO, Ekada I, Uhegbu CU, Ugwu C, et al. Cholera in Nigeria: A review of outbreaks, trends, contributing factors, and public health responses. Niger Med J 2024;65(6):824-843.https://doi.org/10.60787/nmj.v65i6.584.

Quick Response Code:

Introduction:

Cholera, an acute diarrheal disease caused by the ingestion of water or food contaminated with the bacterium *Vibrio cholerae*,[1] continues to pose a significant public health threat in many developing countries, including Nigeria.[2] [3] The disease is characterized by the rapid onset of severe watery diarrhoea, which can lead to dehydration and death if not promptly treated.[4] Despite being easily preventable and treatable, cholera remains a major cause of morbidity and mortality in regions with inadequate water, sanitation, and hygiene (WASH) infrastructure.[5]

Nigeria has experienced recurrent cholera outbreaks over the past decades, with significant variations in the scale, impact, and geographic distribution of each outbreak. The period from 2010 to 2024 has been particularly notable, with several major outbreaks affecting various regions of the country. These outbreaks have highlighted the persistent challenges in managing cholera in Nigeria, including the strain on the healthcare system, the interplay between conflict and disease transmission, and the underlying vulnerabilities within affected communities. [6 - 17]

The 2010 cholera outbreak was one of the most severe in the country's history, affecting 18 states and resulting in 41,787 reported cases and 1,716 deaths, with a case-fatality rate (CFR) of 4.1%, marking the beginning of a decade-long struggle against the disease, emphasizing the need for rapid response and coordination among public health authorities.[6] Subsequent outbreaks in 2014 and 2017 further underscored the critical role of vaccination campaigns, robust surveillance systems, and community engagement in controlling the spread of the disease.[10] [13] [18] [19] The 2018 outbreak, one of the largest in recent history with a total of 43,996 suspected cases and 836 deaths reported across 20 states, resulting in an attack rate of 127.43 per 100,000 population and a case fatality rate (CFR) of 1.9%, revealed significant insights into the epidemiology of cholera in Nigeria and the importance of addressing the social determinants of health to prevent future outbreaks.[14] [20]

In the years that followed, the 2020-2021 outbreak was significantly higher with 93,598 cholera cases and 3,298 deaths, resulting in a case fatality rate (CFR) of 3.5%and highlighting the compounded challenges posed by concurrent health crises, such as the COVID-19 pandemic, and the importance of leveraging existing disease preparedness and response capacities.[17] [21] [22] The 2022 outbreak, driven by factors such as flooding and conflict, once again brought to the forefront the need for targeted interventions and a comprehensive approach to cholera prevention and control.[23] [24]

The cholera outbreaks in 2023 and 2024 have continued to underscore these challenges, with significant case numbers and fatalities reported.[16] [17] These recent outbreaks have been exacerbated by similar factors, including poor WASH infrastructure, ongoing conflicts, and environmental conditions such as flooding as well as cholera vaccine stockouts. The continued high incidence of cholera cases in these years highlights the critical need for sustained public health interventions and infrastructure improvements to mitigate the disease's impact.

This paper aims to review cholera outbreaks, trends, contributing factors, and public health responses in Nigeria from 2010 to 2024. By examining the epidemiological trends, response strategies, and underlying factors contributing to these outbreaks, this review seeks to inform future public health interventions and strengthen Nigeria's capacity to manage and mitigate the impact of cholera.

Overview of Cholera

Etiology and Pathogenesis

Cholera is an acute diarrheal illness caused by infection with the bacterium *Vibrio cholerae*.[1] The disease is characterized by the sudden onset of profuse, watery diarrhoea, often accompanied by

vomiting, leg cramps, and rapid dehydration.[25] [26] [27] The loss of fluids and electrolytes can lead to severe dehydration and shock, which, if untreated, can result in death within hours.[4]

The causative agent, *Vibrio cholerae*, is a gram-negative, comma-shaped bacterium.[28] There are more than 200 serogroups of *Vibrio cholerae*, but only two serogroups, O1 and O139, are known to cause outbreaks.[29] The O1 serogroup is further divided into two biotypes: Classical and El Tor, with El Tor being responsible for most of the cholera outbreaks since the 1960s.[30] [31]

Transmission of *Vibrio cholerae* occurs primarily through the ingestion of water or food contaminated with the faeces of an infected person.[32] The bacteria can survive in both fresh and brackish water,[33] [34] making regions with poor sanitation and inadequate water treatment facilities particularly vulnerable to outbreaks.[35] [36] Once ingested, *Vibrio cholerae* colonizes the small intestine and produces cholera toxin (CTX), a potent enterotoxin.[37] Cholera toxin disrupts the normal ion transport mechanisms in the intestinal epithelial cells, leading to the secretion of large volumes of water and electrolytes into the intestinal lumen, resulting in severe diarrhoea.[38] [39] Toxigenic *Vibrio cholerae* produces multiple virulence factors that contribute to its ability to cause disease. The exact pathogenic mechanism is not yet comprehensively understood, but it is commonly acknowledged that it entails the combined action of various virulence factors and the capacity to inhabit and thrive in the small intestine. After being ingested, *Vibrio cholerae* can withstand the acidic conditions of the stomach by activating an acid tolerance response. *Vibrio cholerae* utilises its flagellum to navigate through the mucus layer in the small intestine and successfully reach the epithelial surface. This enables the bacterium to overcome the host's immune system and the natural defense mechanisms of the gut microbiota that prevent colonisation. To establish a presence in the small intestine, the bacterium expresses specific virulence factors, including toxin-coregulated pilus (TCP) and cholera toxin. During the process of infection, other virulence factors like HapA, GbpA, and NanH are also produced to aid the pathogenic process.[40]

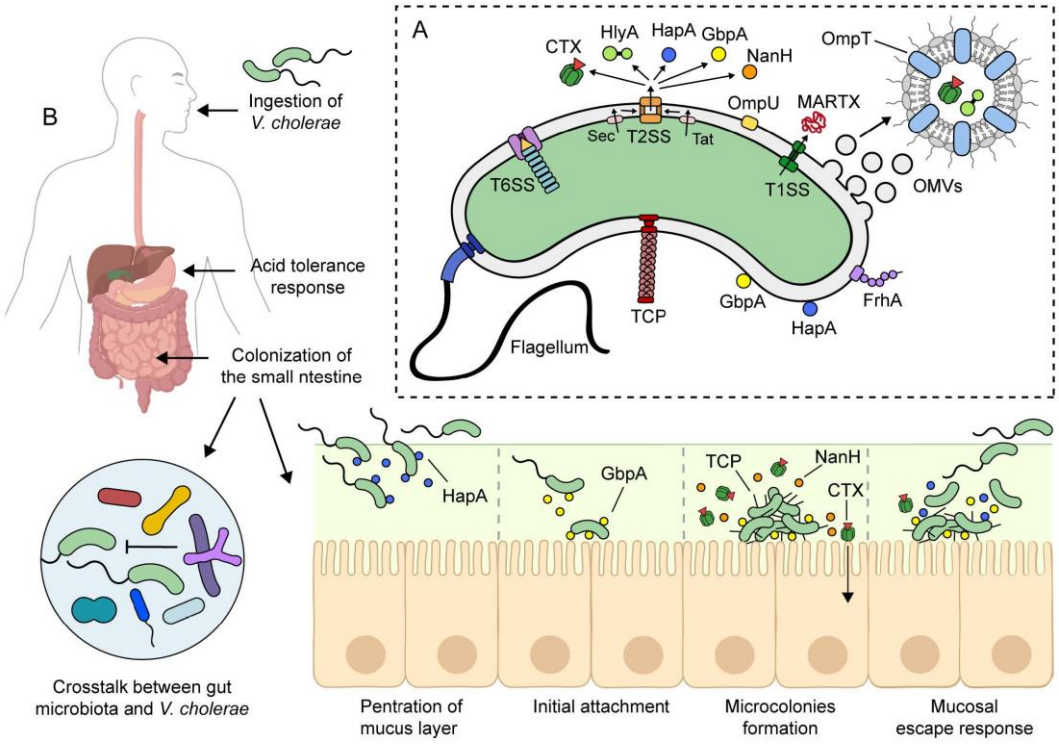

Figure 1: Pathogenesis of toxigenic *Vibrio cholerae* [40]

Clinical Manifestation, Diagnosis and Treatment

Cholera symptoms can range from mild to severe.[25] Mild cases may present with moderate diarrhoea that can be easily mistaken for other gastrointestinal illnesses. Severe cases of cholera are characterized by profuse watery diarrhoea, often described as "rice-water stools" due to its pale, milky appearance, along with vomiting that can occur in the early stages of the illness.[41] Patients may experience leg cramps due to rapid loss of electrolytes.[42] Dehydration signs include thirst, decreased skin turgor, dry mucous membranes, sunken eyes, and decreased urine output. In extreme cases, severe dehydration can lead to hypovolemic shock, which is marked by a rapid, weak pulse, low blood pressure, and cold, clammy skin.[43] [44]

The World Health Organization (WHO) has established a case definition for cholera, recognizing that laboratory tests are not essential for diagnosis due to the distinctive clinical presentation of acute, non-bloody, profuse, watery diarrhoea leading to dehydration.[45] However, WHO recommends collecting samples from the first ten to twenty cases to confirm an outbreak, and periodically thereafter for antibiotic sensitivity testing and epidemiological studies. The Centers for Disease Control (CDC) and WHO regard the isolation and identification of *Vibrio cholerae* serogroups O1 or O139 via stool culture as the gold standard for diagnosis.[46] [47] *V. cholerae* requires selective thiosulfate-citrate-bile salts agar (TCBS) for growth, and Carey-Blair medium or peptone water should be used for sample transport.

Serogroup and serotype identification can be performed using specific antisera, while dark field microscopy can rapidly identify *V. cholerae* in stool samples by observing their characteristic darting movements, which are inhibited by specific antisera.[48] Rapid diagnostic tests, such as the Crystal VC dipstick, exist but have suboptimal sensitivity and specificity; thus, positive results should be confirmed by stool culture.[47] [49] Polymerase chain reaction (PCR) methods have been developed, demonstrating high sensitivity and specificity, and can differentiate virulent *V. cholerae* from other *Vibrio species* and bacteria through the identification of toxigenic genes.[49]

Prompt treatment is crucial for survival. [51] The mainstay of cholera treatment is rapid rehydration, with oral rehydration salts (ORS) solution being the preferred method for most patients,[52] as it can be administered quickly and easily. For patients with severe manifestations of cholera, intravenous (IV) fluids are necessary.[42] Antibiotics, such as doxycycline, azithromycin, or ciprofloxacin, can reduce the duration of diarrhoea and bacterial shedding, but they are considered adjunctive therapy to rehydration and should be based on local antibiotic resistance patterns.[42] [53]

Preventive measures are essential to control cholera outbreaks. These include ensuring access to safe drinking water, improving sanitation and hygiene practices, and promoting the use of oral cholera vaccines (OCVs).[42] [54] In endemic areas, vaccination campaigns can significantly reduce the incidence of cholera, providing both direct protection to vaccinated individuals and indirect protection through herd immunity.[55]

Historical Perspective

Cholera has been a global health challenge for centuries, with seven major pandemics recorded since the early 19th century.[1] The disease, caused by the bacterium *Vibrio cholerae*, originated in the Ganges Delta in India and spread along trade routes to Asia, Europe, Africa, and the Americas.[56] [57] Each pandemic highlighted vulnerabilities in public health infrastructure and the need for effective water, sanitation, and hygiene (WASH) practices.

The first cholera pandemic (1817–1824) originated near Calcutta, India, in 1817 and spread rapidly due to the Kumbh Mela pilgrimage along the Ganges River, affecting Asia and Africa's coastlines.[58] [59] The lack of prior knowledge about cholera led to various unscientific treatments and responses, with some

Western countries mistakenly believing it was not contagious.[60] The second pandemic (1829–1837) saw cholera spread via steamships to North America, the Caribbean, and Britain, prompting substantial public health reforms.[61] Reports of a more virulent strain of *V. cholerae* during this pandemic led to significant changes in public health policy and infrastructure worldwide.[62] The third pandemic (1852–1860) was the deadliest of the 19th century, causing over a million deaths in the Russian Empire and 23,000 in Great Britain. British physician John Snow's work during the 1854 London outbreak identified contaminated water as the infection source, highlighting the importance of clean drinking water in controlling disease.[63] [64] The fourth pandemic (1863–1875) began in the Ganges delta and spread with Muslim pilgrims to Mecca, causing significant mortality. Epidemiologist William Farr linked the East London Water Company to cholera contamination, building on Snow's work.[65][66] The fifth pandemic (1881–1896) was notable for scientific advances, with Robert Koch identifying *V. cholerae* as the causative agent, confirming the germ theory of disease and revolutionizing public health practices.[63] [67] The sixth pandemic (1899–1923) began in India and spread globally, marked by significant outbreaks during events like the Haridwar Kumbh Mela and the Second Balkan War, leading to increased international cooperation in disease control.[65] [68] [69] The seventh pandemic (1961–1975, with sporadic re-emergences) introduced the El Tor biotype, which spread from Indonesia to Asia, Africa, and the Americas, highlighting the importance of vaccines and coordinated international responses.[1] [70-72]

Nigeria has a long history of cholera outbreaks, reflecting challenges with water and sanitation infrastructure, population density, and public health issues. The first significant outbreak in Nigeria was recorded in 1970,[2] resulting in a significant number of cases and deaths, and exposing critical gaps in public health response. Notable outbreaks in the 1990s and early 2000s, including a major outbreak in 1991 with 59,478 cases and a case fatality ratio (CFR) of 13%,[3] [45] underscored the devastating impact of cholera.

Epidemiology of Cholera in Nigeria

Current Cholera Outbreaks in Nigeria: 2023 and 2024

The cholera outbreaks in Nigeria during 2023 and 2024 have highlighted ongoing public health challenges in the country. By the end of epidemiological week 52 (31 December 2023), Nigeria reported a total of 3,683 suspected cholera cases, resulting in 128 deaths, equating to a case fatality rate (CFR) of 3.5%. This marked a significant reduction compared to the previous year, with an 85% decrease in cases and a 79% reduction in deaths.[16] The 2023 outbreak predominantly affected children under the age of five, followed by those in the 5-14 age group. Gender distribution among the cases was relatively balanced, with 51% of the cases being male and 49% female.[16]

Cholera cases were reported in 31 states, with Zamfara State reporting the highest number of suspected cases, accounting for 25% (914 cases) of the total. In Cross River State, Obubra LGA reported 515 cases, making up 14% of the national total. Other significantly affected states included Cross River with 718 cases, Katsina with 343 cases, Bayelsa with 319 cases, Ogun with 295 cases, Ebonyi with 236 cases, and Niger with 195 cases. These states collectively accounted for 57% of the suspected cases (**Figure 2**).[16] The monthly distribution of suspected cases and deaths varied throughout the year. The highest number of cases was reported in February (1,097 suspected cases and 31 deaths), and the lowest was in December (52 suspected cases and 4 deaths). [16]The national response to the cholera outbreak was coordinated by the multi-sectoral Technical Working Group (TWG), involving various federal ministries and development partners. Key activities included ongoing surveillance through Integrated Disease Surveillance and Response (IDSR) and Event-Based Surveillance (EBS), coordination of response efforts, and continuous data collation and harmonization. [16]

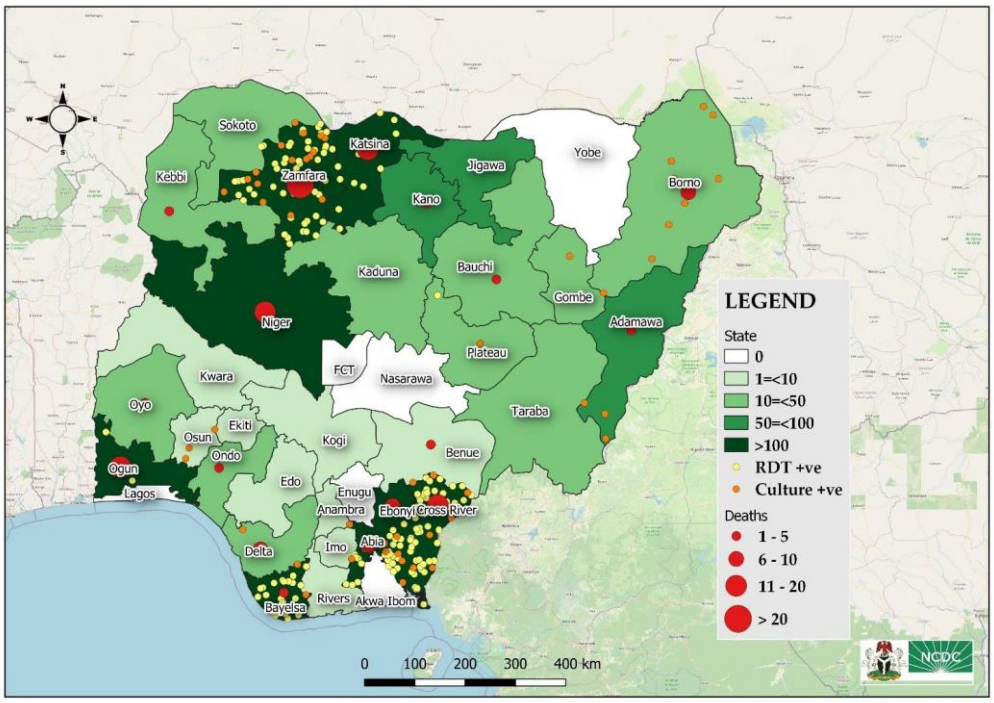

Figure 2: Map of Nigeria showing states with suspected cases and deaths in 2023[16]

In 2024, Nigeria continues to face challenges related to cholera outbreaks, with ongoing efforts to monitor and respond to the situation. As of the latest reports (Epidemiological week 25: (17 June 2024 - 23 June 2024), the outbreak has persisted in several regions, exacerbated by factors such as flooding, inadequate water supply, and poor sanitation infrastructure. Up to mid-2024, the number of cholera cases and related deaths has shown a concerning trend, with an increase in reported cases compared to the same period in 2023. The exact figures are subject to ongoing verification as the situation evolves. As of June 23, 2024, Nigeria has reported a total of 1,579 suspected cholera cases, including 54 deaths, resulting in a case fatality rate (CFR) of 3.4%. The outbreak has affected 32 states, with the most vulnerable age groups being children under five years, followed by those aged 5-14 years, evenly distributed among males and females. Notably, Lagos State has reported the highest number of suspected cases, accounting for 34% (537 cases) of the total. Southern Ijaw LGA in Bayelsa State follows with 151 cases, making up 10% of the national total. Bayelsa State itself has reported 466 cases, while other affected states include Abia (109 cases), Zamfara (64 cases), Bauchi (46 cases), Katsina (45 cases), Cross River (43 cases), Ebonyi (38 cases), Rivers (37 cases), Delta (34 cases), Imo (28 cases), Ogun (21 cases), Nasarawa (19 cases), Ondo (17 cases), Kano (13 cases), Niger (11 cases), and Osun (11 cases), collectively accounting for 97.5% of the suspected cases (**Figure 3**).[17]

Encouragingly, there has been a 37% decrease in suspected cholera cases and a 21% reduction in cumulative deaths compared to the same period in 2023. This decline may reflect improved public health measures and responses to the ongoing cholera threat. The response to the 2024 cholera outbreak includes enhanced surveillance, rapid diagnostic testing, and targeted public health interventions. Efforts are being made to improve water, sanitation, and hygiene (WASH) infrastructure, particularly in high-risk areas. The National Centre for Disease Control (NCDC) and other health agencies are working closely with international partners to provide vaccines, medical supplies, and technical support to affected regions.[17]

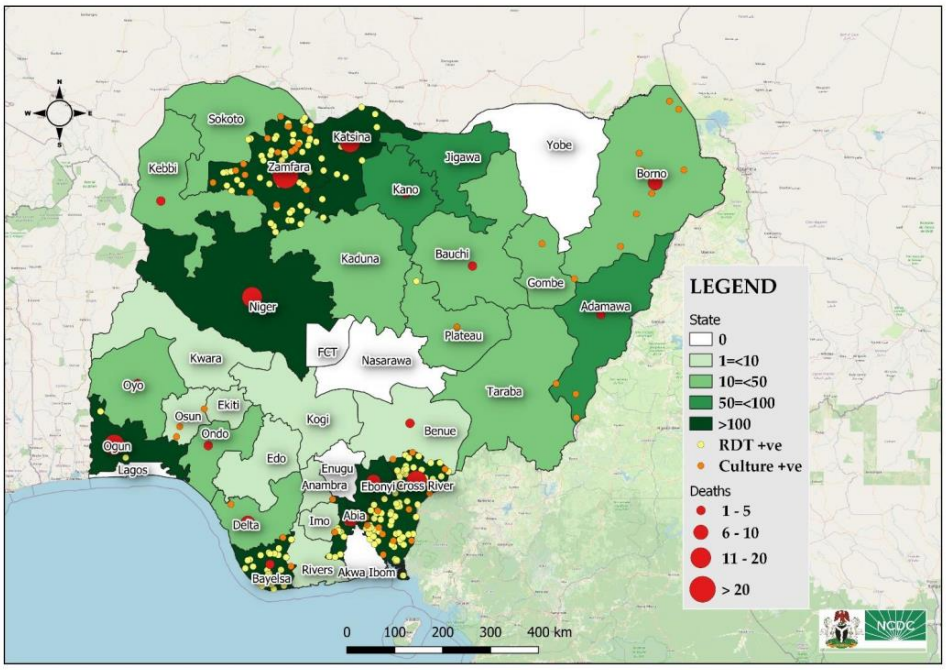

Figure 3: Map of Nigeria showing states with suspected cases and deaths up to mid-2024[17]

Recent Cholera Outbreaks in Nigeria

The 2010 Outbreak

The 2010 cholera outbreak in Nigeria was one of the most severe in the country's history, affecting 18 states and resulting in 41,787 reported cases and 1,716 deaths, with a case-fatality rate (CFR) of 4.1%, significantly higher than the World Health Organization's (WHO) acceptable rate of 1%.[6] This high mortality rate underscored the urgent need for improved cholera surveillance and response mechanisms. A retrospective analysis of data from 10 of the affected states revealed an overall attack rate of 47.8 cases per 100,000 population and a CFR ranging from 3.8% to 8.9%, with the highest age-specific CFR observed among individuals aged 65 years and above, reaching 14.6%. The outbreak exhibited three distinct peaks, with the third coinciding with significant flooding in five states, which contributed to the spread of the disease to previously unaffected Local Government Areas (LGAs).[6]

Further investigation in a cholera-naïve rural community in northern Nigeria identified poor hand hygiene practices as a significant risk factor for the outbreak. The study found that cases were less likely to wash their hands with soap before eating or after using the toilet compared to controls, with adjusted odds ratios of 0.27 and 0.34, respectively. Despite the high incidence of cholera, *Vibrio cholerae* O1 was only isolated from stool samples and not from any open-well water samples, highlighting the role of personal hygiene in preventing the spread of the disease.[71]

The 2010 outbreak highlighted critical challenges in managing public health crises in Nigeria, including suboptimal surveillance, inadequate healthcare infrastructure, and insufficient public education on hygiene practices. The outbreak emphasized the endemic nature of cholera in northern Nigeria and the need for a harmonized and coordinated approach to cholera prevention and control. Key measures identified for future mitigation included the enhancement of surveillance and response systems, improved training and motivation of frontline health workers, and comprehensive community education on hygiene practices.[6] [73]

The 2011 Outbreak

The 2011 cholera outbreak in Nigeria presented another significant public health challenge, with varying impacts across different regions. In Plateau State, the outbreak between May 7 and August 25, 2011, resulted in 651 cases and 13 deaths, with a CFR of 2.12%. A notable 40.3% of these cases occurred at the Federal College of Education (FCE) Pankshin, where a cross-sectional study among 238 students revealed that only 20.2% knew the cause and transmission mode of cholera, while 14.13% believed it was a spiritual issue. Despite a high rate of water treatment and coverage, hand-washing practices were found to be inadequate, with only 51.8% washing hands with soap and water. The study recommended regular health sensitization seminars to improve knowledge and preventive measures among students and staff.[74]

In Osun State, the outbreak began on August 19, 2011, with 11 initial cases confirmed using cholera rapid diagnostic tests. A field investigation recorded 148 cases and 8 deaths, resulting in a case fatality rate (CFR) of 5%. The outbreak affected 12 out of 30 districts, with a higher incidence among females (51%) and individuals aged 15 years and above (61%). The findings from this outbreak highlighted the critical need for ongoing public education on household hygiene and rigorous monitoring of cholera cases to prevent future outbreaks.[8] Additionally, a study in Bauchi, reviewing cholera admissions from November 1, 2010, to October 31, 2011, found that late presentation to hospitals was linked to higher mortality rates, emphasizing the need for better hygiene and sanitation campaigns.[9]

The cholera outbreak in Oyo State in 2011 provided an opportunity to compare water hygiene and sanitation practices in cholera-affected communities (CAC) and non-cholera-affected communities (NCAC) in Ibadan, Nigeria. Among 400 household heads surveyed from each community, 27% of households in CAC were affected by cholera, while none in NCAC reported cases. The study found that poor knowledge of cholera and inadequate water hygiene and sanitation practices were significantly more prevalent in CAC than in NCAC. The research concluded that these factors contributed to the higher vulnerability of CAC to cholera, highlighting the importance of community-based health education programs to address these gaps.[75]

The 2014 Outbreak

The 2014 cholera outbreak in Nigeria posed a significant public health challenge, with studies highlighting the epidemiology, risk factors, and the influence of climate and socioeconomic conditions on its spread. In November 2014, an increase in suspected cholera cases was reported in Gomani, Kwali Local Government Area (LGA). The Nigeria Field Epidemiology and Laboratory Training Programme (NFELTP) conducted an unmatched case-control study to verify the diagnosis, identify risk factors, and implement control measures. The study involved 43 cases and 68 controls, with stool samples and community water sources testing positive for *Vibrio cholerae*. Key findings revealed significant associations between cholera cases and factors such as drinking from the Zamani River, living in households with more than five persons, and poor hand hygiene. The outbreak had a high attack rate of 4.3% and a case fatality rate (CFR) of 13%, underscoring the importance of hand hygiene and water treatment in controlling the spread.[76]

In Kaduna State, the 2014 cholera outbreak was analyzed for its magnitude, pattern, and trends. The outbreak affected seven out of 23 LGAs, resulting in 1,468 cases and 54 deaths, with a CFR of 3.68%. The median age of the case patients was 15 years, with a notable 55.08% being female. The highest attack rate was recorded in Igabi LGA, while Chikun LGA had the highest CFR. The outbreak spread across contiguous LGAs over 33 weeks, beginning from the first epidemic week of 2014. The study recommended strengthening the state's disease surveillance system for timely detection and response to future outbreaks, emphasizing the need for better outbreak management strategies.[10]

A separate study explored the impact of meteorological and socioeconomic factors on the spatiotemporal variability of cholera morbidity and mortality in Nigeria. Using stepwise multiple regression and generalized additive models, the study analyzed data across various states, highlighting that both climate variables, such as temperature and rainfall, and socioeconomic factors, including poverty, literacy, and access to piped water, significantly influenced cholera's spatial and temporal variability. The study underscored the regional importance of different factors and proposed that predictive models could aid authorities in implementing effective control measures focused on prevention and efficient response to cholera outbreaks.[77]

The 2015 Outbreak

The 2015 cholera outbreak in Nigeria was marked by significant morbidity and mortality across various states, with environmental, behavioural, and socio-cultural factors playing critical roles in the spread of the disease. In January 2015, an outbreak in Ebonyi State affected 38 communities, leading to 551 cases and a high case fatality rate (CFR) of 8.6%. *Vibrio cholerae* was identified as the causative agent, with key risk factors including inadequate safe water supplies, poor sanitation, and unhygienic practices. Socio-cultural behaviours, such as attendance at burials and communal eating, further exacerbated the outbreak. Recommendations focused on promoting behaviour change communication and engaging in community dialogue to control the spread of cholera.[11]

Later in the year, a cholera outbreak in Maiduguri, Borno State, particularly affected internally displaced persons (IDP) camps, resulting in 385 cases and 13 deaths, with a CFR of 3.4%. The outbreak was linked to poor hygienic practices among IDPs, with significant risks associated with contact with infected individuals. The outbreak's spread was further facilitated by the movement of people from outside the camp to within it. Control measures emphasized improving sanitation and personal hygiene through targeted awareness campaigns.[12] Additionally, Andoni LGA in Rivers State reported 62 cases of cholera in January 2015, where the primary risk factors were unhygienic hand-washing practices and drinking contaminated water from wells and ponds. Community health education on personal hygiene and the superchlorination of wells were recommended as key interventions to curb the outbreak.[78]

Throughout the year, various regions reported localized cholera outbreaks linked to environmental factors. For example, a study using GIS and microbial analyses in a rapidly urbanizing environment revealed that proximity to waste dump sites, markets, and rivers significantly correlated with higher cholera incidences. The study emphasized the need for strategic planning and environmental supervision to mitigate cholera risks.[79] In Kaduna State, the Dutsen-Abba Ward experienced 50 cholera cases in August 2015, with a high CFR of 14%. Poor hygienic practices, particularly drinking un-boiled water and inadequate hand washing, were identified as major risk factors. The study recommended improving sanitation and encouraging regular hand washing to prevent future outbreaks.[80] Similarly, the Gajala community in Jigawa State reported 50 cases in September 2015, where poor hand hygiene and a lack of cholera knowledge were significant contributors to the outbreak. Public health education on cholera prevention and proper hand hygiene practices were underscored as critical control measures.[18]

The 2017 Outbreak

The 2017 cholera outbreak in Nigeria was a significant public health crisis, especially in Borno State, which was already under severe strain due to ongoing conflict and the displacement of large populations. The outbreak predominantly affected areas with internally displaced persons (IDP) camps, highlighting the immense challenges in managing public health emergencies in conflict zones. Borno State reported 5,889 cases across five local government areas (LGAs) hosting IDPs, with an overall attack rate of 395.3 per 100,000 population. Despite the challenging conditions, the case fatality rate (CFR) was relatively

low at 0.87%, although it varied across different LGAs, with the highest CFR observed among individuals aged 60 years and above.[13]

The outbreak was exacerbated by the destruction of critical infrastructure due to the Boko Haram insurgency, which severely impacted health facilities, sanitation systems, and water supplies. The Muna Garage camp for IDPs was identified as the initial focal point of the outbreak, which then spread to neighbouring LGAs. The response to the crisis involved coordinated efforts from various organizations, including the Nigeria Center for Disease Control (NCDC), the World Health Organization (WHO), and Médecins Sans Frontières (MSF). A key component of the response was the establishment of an Emergency Operations Center (EOC) by the State Ministry of Health, which significantly improved coordination and intervention efforts.[81]

A reactive oral cholera vaccine (OCV) campaign was launched, targeting nearly one million people in IDP camps and surrounding communities across six LGAs. The campaign achieved a high coverage rate, with 90% of the target population receiving at least one dose of OCV. The success of these vaccination efforts, along with other multisectoral interventions such as improved surveillance, water, sanitation, and hygiene (WASH) initiatives, played a crucial role in containing the outbreak. However, the outbreak underscored the ongoing need for robust emergency response mechanisms and the importance of addressing underlying determinants of health to prevent future cholera outbreaks in conflict-affected areas.[81] [82]

The 2018 Outbreak

The 2018 cholera outbreak in Nigeria highlighted the ongoing public health threat that cholera poses in the country. Spanning from January to November, the outbreak resulted in 43,996 reported cases and 836 deaths across 20 states, with an attack rate of 127.43 per 100,000 population and a case fatality rate (CFR) of 1.90%.[14] The most affected demographic was individuals aged 15 years or older, with an almost equal gender distribution among the cases. The outbreak occurred in four distinct waves, with the third and fourth waves seeing the highest fatalities, particularly in the northwest and northeast regions, which reported the highest attack rates.[14] In Sokoto State, 14 local government areas were affected, recording 1,602 suspected cases and a CFR of 5.2%.[83]

Several factors were identified as contributing to cholera-related deaths during this period, including older age, male gender, residency in peri-urban or flood-prone areas, and delays in seeking healthcare. Conversely, living in urban areas, hospitalization, and treatment at secondary hospitals were found to be protective factors.[84] The recurring transmission of cholera in Nigeria is heavily influenced by a complex interplay of social, environmental, and health system factors. Notably, regions with poor water and sanitation infrastructure, particularly those affected by conflict, were more vulnerable to outbreaks. In Maiduguri, northeastern Nigeria, the outbreak was predominantly driven by the Ogawa serogroup, with strains of this serotype showing resistance to several antibiotics like trimethoprim/sulfamethoxazole and tetracycline, underscoring the importance of continuous surveillance of antimicrobial resistance patterns.[85]

The 2018 outbreak underscores the critical need for a comprehensive, multi-sectoral approach to cholera prevention and control in Nigeria. Addressing the underlying social determinants of health, such as improving water and sanitation infrastructure, is essential. Additionally, ensuring timely access to healthcare services and maintaining regular surveillance of antimicrobial resistance are key components of effective outbreak management. These measures are vital to reducing the incidence and severity of future cholera outbreaks in Nigeria.[14] [85]

The 2019 Outbreak

In 2019, Nigeria faced significant cholera outbreaks, particularly in the Northeast and Adamawa State, underscoring the ongoing challenges in managing the disease in regions with inadequate water, sanitation, and hygiene (WASH) infrastructure. A notable outbreak in Bauchi State resulted in 9,725 cases with a low case fatality rate (CFR) of 0.3%. Dass Local Government Area (LGA) reported the highest CFR at 14.3%, while Bauchi LGA had the highest attack rate (AR) of 1,830 cases per 100,000 persons. Key risk factors identified included attending social gatherings and drinking unsafe water. Public health interventions, such as chlorination of wells and public education on cholera prevention, were critical in mitigating the outbreak, highlighting the need for sustained improvements in WASH practices.[86]

In Adamawa State, another cholera outbreak occurred between May and August 2019, affecting several Local Government Areas (LGAs). The World Health Organization (WHO) reported 687 cholera patients during this period, with only four deaths, resulting in a CFR of 0.6%. The most affected area was Yola North, with a majority of cases involving females and children aged 1-14 years. Despite demographic differences, there was no significant association between mortality and various factors such as culture status or hospitalization. The study emphasized the importance of effective treatment, with a high survival rate of 99.4%, and the need for continuous monitoring and public health interventions to control cholera's spread.[87]

Globally, cholera continued to be a significant public health issue, particularly in resource-limited countries. In 2019, Nigeria had the highest age-standardized rate (ARS) of cholera mortality at 39.19 per 100,000 population, followed by the Central African Republic. The rising cholera-related mortality in Africa, particularly for both males and females, highlights the need for intensified cholera management efforts and comprehensive public health strategies to address the persistent challenges of cholera outbreaks.[88]

The 2020-2021 Outbreak

The 2020-2021 cholera outbreak in Nigeria represented a major public health crisis, exposing significant weaknesses in the healthcare system. Over this period, a retrospective analysis of national surveillance data revealed 93,598 cholera cases and 3,298 deaths, resulting in a case fatality rate (CFR) of 3.5%. The outbreak's severity was most pronounced in the North-West region, which recorded the highest attack rate (AR) of 102 per 100,000 persons. Key factors contributing to the increased mortality included older age, male gender, residency in the North-Central region, and severe dehydration.[15] The outbreak was exacerbated by ongoing conflicts, water scarcity, and poor sanitation infrastructure, particularly in Northern Nigeria, where flooding and displacement further amplified the risk of cholera transmission.[89]

The concurrent COVID-19 pandemic added strain to Nigeria's already challenged healthcare system, necessitating a multifaceted public health response. This included leveraging the disease preparedness and response capacities developed for COVID-19 to manage the cholera outbreak more effectively.[21] In Katsina State, the outbreak affected 33 Local Government Areas (LGAs), with older adults experiencing the highest case fatality rates. Continuous monitoring and rapid response were essential to control the outbreak's persistence beyond initial peaks.[21] In conflict-affected regions like North-East Nigeria, varied capacities within healthcare facilities, particularly in water, sanitation, and hygiene (WASH) and surveillance, highlighted the need for strengthened coordination and targeted interventions.[90]

An important aspect of the response was the implementation of case-area targeted interventions (CATIs) in Northeast Nigeria. These targeted strategies, which involved providing a package of interventions to affected households and their neighbours, significantly reduced cholera clustering despite operational challenges. The success of CATIs emphasized the importance of rapid implementation and scaling up of

targeted interventions, particularly in conflict settings with limited WASH access.[91] The 2020-2021 cholera outbreak in Nigeria emphasized the need for resource availability, enhanced healthcare worker knowledge, and the implementation of targeted strategies to effectively manage and mitigate the impact of cholera outbreaks, especially in regions affected by conflict and water scarcity.

The 2022 Outbreak

In 2022, Northern Nigeria faced significant cholera outbreaks, primarily driven by flooding and conflict. The situation escalated notably from June 2022, with over 10,000 probable cholera cases reported by September, particularly concentrated in the Northeastern states of Borno, Adamawa, and Yobe. Borno State was the hardest hit, accounting for 70.13% of the 7,700 cases and 324 deaths reported in these states by December 24, 2022.[89] Flooding, limited access to hygiene services, and water contamination were major contributors to the cholera spread. Furthermore, ongoing insurgency and armed banditry in the Northeast and Northwest exacerbated the situation by displacing millions, thereby limiting their access to clean water and food, leading to recurring outbreaks with high morbidity, increased hospitalizations, and significant mortality. The complex security challenges in these regions have made it difficult to accurately assess the cholera burden due to reporting and access issues, underscoring the need for improved awareness and robust prevention strategies.[89] In response to these challenges, various public health interventions were implemented, though they often encountered significant operational difficulties due to prevailing hostilities.

A separate outbreak in Degema Local Government Area (LGA) of Rivers State, occurring between December 2021 and February 2022, was managed through an interventional epidemiological study that followed WHO's case definition of acute watery diarrhoea. The outbreak in this rural community saw two distinct waves, with the highest frequency among children aged 0-5 years. Although standard outbreak investigation procedures, including active case search, case management, and WASH interventions, were implemented, the attack rate and case fatality rate stood at 0.01% and 8%, respectively. The study emphasized the need for vaccine deployment and improved access to potable water to enhance future cholera outbreak responses.[24]

Trends and Patterns of Cholera Outbreaks in Nigeria

Cholera outbreaks in Nigeria from 2010 to 2024 have shown distinct trends and patterns shaped by various epidemiological and contextual factors. A key trend is the seasonal variability in cases, often peaking during periods of heavy rainfall and flooding, which leads to increased water source contamination and facilitates the spread of *Vibrio cholerae*.[14] [89] The distribution of outbreaks across Nigeria has been uneven, with Northern states, particularly those affected by conflict and inadequate water and sanitation infrastructure, experiencing more frequent and severe outbreaks. This regional disparity underscores the importance of targeted interventions in these vulnerable areas.[14] [89]

Conflict and displacement have also significantly influenced cholera outbreaks, particularly in the northeastern states of Borno and Adamawa. Displacement into overcrowded camps with poor sanitation has heightened vulnerability, contributing to recurrent outbreaks in these regions.[81] [87] The persistence of multiple epidemic waves within a single outbreak period reflects ongoing transmission challenges and underscores the need for sustained surveillance and response strategies.[84] [22] Demographically, recent outbreaks have shown higher incidence rates among older adults and vulnerable populations in conflict-affected or underserved areas, highlighting the need for targeted interventions to address these shifts.[87] [90]

The management of cholera outbreaks in Nigeria has faced numerous challenges, including inadequate healthcare facilities, limited resources, and healthcare worker capacity. Coordinated efforts from national

and international health agencies have focused on enhancing surveillance, case management, and public health interventions amidst these systemic challenges. The emergence of antimicrobial-resistant strains of *Vibrio cholerae* has added further complexity to outbreak management, emphasizing the need for regular monitoring to guide treatment protocols and control the disease's spread.[82] [85] The intersection of global health trends, such as the COVID-19 pandemic, with cholera outbreaks has strained healthcare systems and necessitated adaptive strategies for prevention and control, underscoring the importance of integrating cholera response efforts with broader health system strengthening initiatives to build resilience against future epidemics.[21]

Contributing Factors

Cholera outbreaks in Nigeria from 2010 to date have been driven by several contributing factors that have exacerbated the disease's spread and severity. A key factor has been the inadequate Water, Sanitation, and Hygiene (WASH) infrastructure, particularly in northern regions, where access to clean water and proper sanitation is limited. The destruction of essential infrastructure due to the Boko Haram insurgency during the 2017 outbreak in Borno State is a prime example, where contaminated water sources played a significant role in the outbreak's spread.[81] Additionally, conflict and displacement have further heightened the vulnerability of populations to cholera, especially in overcrowded and poorly managed camps for internally displaced persons (IDPs), as seen during the same 2017 outbreak.[13]

Environmental factors such as seasonal flooding have also critically influenced cholera outbreaks by contaminating water sources and disrupting sanitation systems. The 2022 outbreak in Northern Nigeria, driven by flooding, underscores this environmental dimension.[23] High population density and rapid urbanization without adequate infrastructure have intensified cholera transmission, particularly in urban slums and peri-urban areas, as illustrated by the 2018 outbreak.[14] Socioeconomic factors like poverty and limited access to healthcare have further perpetuated the persistence of cholera, with delays in seeking healthcare being a significant risk factor for cholera-related deaths, as noted in an analysis of the 2018 outbreak.[20]

Moreover, the inadequate health system response, compounded by concurrent health crises such as the COVID-19 pandemic, has hindered effective cholera outbreak management, as evidenced during the 2020-2021 outbreak.[21] Cultural and behavioural factors, including attending social gatherings and using unsafe water sources, have also contributed to cholera transmission, with the 2019 Bauchi State outbreak highlighting the role of these behaviours in the spread of the disease.[86] Addressing these multifaceted factors through targeted public health interventions is crucial for mitigating future outbreaks.

The 2024 cholera outbreak in Nigeria has highlighted critical vaccine shortages, emphasizing the urgent need for local vaccine production capacity. The oral cholera vaccine (OCV), effective for both outbreak response and prevention, is currently limited in supply due to high global demand. Past campaigns using OCV in states like Borno, Yobe, and Adamawa have proven successful; however, ongoing shortages underline the necessity for Nigeria to invest in local vaccine manufacturing infrastructure to mitigate future stockouts and enhance preparedness for epidemic-prone diseases like cholera.[92] [93] Establishing local production facilities would enable Nigeria to ensure a reliable supply of vaccines, strengthen public health defences, and align with broader health security goals.

Antimicrobial resistance (AMR) in *Vibrio cholerae* poses a significant challenge to cholera management in Nigeria. The predominant serogroups responsible for cholera outbreaks are O1 and O139, with serogroup O1 being more prevalent. Studies have reported resistance in these serogroups to antibiotics such as tetracycline, doxycycline, ampicillin, and trimethoprim-sulfamethoxazole. For instance, a meta-analysis indicated that the average resistance rate for serogroup O1 to tetracycline was 50% and for doxycycline was 28%.[94] Additionally, research from sub-Saharan Africa, including Nigeria, has

documented resistance to ampicillin, chloramphenicol, and streptomycin in *V. cholerae* isolates.[95] These findings underscore the necessity for establishing regional laboratory AMR surveillance systems to monitor resistance patterns and inform treatment protocols effectively.

Public Health Response

The public health response to cholera outbreaks in Nigeria from 2010 to 2024 has been multifaceted, evolving to meet the challenges posed by conflict, displacement, and infrastructural deficiencies. Key elements of this response include enhanced surveillance systems for early detection, such as the establishment of Emergency Operations Centers (EOCs), which have facilitated timely reporting and intervention. A notable example is the improved surveillance during the 2017 outbreak in Borno State, which was crucial for effective outbreak management.[13] Vaccination campaigns, particularly the use of oral cholera vaccines (OCV), have also played a pivotal role in controlling outbreaks. The reactive OCV campaign during the 2017 Borno State outbreak, which targeted approximately one million people, was instrumental in containing the spread of the disease.[19]

Water, sanitation, and hygiene (WASH) interventions have been central to cholera prevention efforts, with initiatives such as chlorination of water sources, distribution of water purification tablets, and public education on hygiene practices proving effective. For instance, during the 2019 Bauchi State outbreak, these WASH interventions were critical in mitigating cholera spread.[85] Additionally, effective case management and treatment, leveraging capacities developed during other health crises like COVID-19, have been essential in reducing cholera-related mortality.[21] These efforts have been supported by multi-sectoral coordination among government bodies, NGOs, and international partners, which has ensured comprehensive and unified responses, particularly during complex outbreaks like that of 2018.[14]

Innovative strategies have further enhanced the response to cholera outbreaks, with Case-Area Targeted Interventions (CATIs) proving effective in reducing cholera clustering in resource-constrained and conflict-affected settings, such as Northeast Nigeria during the large-scale epidemic.[91] Additionally, the monitoring of antimicrobial resistance among cholera strains has guided treatment protocols, ensuring the use of effective antibiotics and preventing the spread of resistant strains, as highlighted during the 2017 outbreak in Ilorin.[81]The public health response in Nigeria has been comprehensive and adaptive, addressing the multifaceted challenges posed by cholera through surveillance, vaccination, WASH improvements, and innovative interventions, significantly advancing the control and mitigation of cholera outbreaks.

Lessons Learned

The recurrent cholera outbreaks in Nigeria from 2010 to 2024 have underscored several critical lessons for better epidemic management and prevention. A primary lesson is the importance of rapid response and coordination, as delays during the 2010 outbreak exacerbated the disease's spread. The establishment of an Emergency Operations Center (EOC) in 2017 improved response efforts significantly, illustrating the value of centralized coordination.[13] [96] Additionally, the success of reactive oral cholera vaccine (OCV) campaigns, particularly during the 2017 outbreak, highlights vaccination as a key strategy in controlling cholera, with high coverage rates playing a crucial role in reducing cases.[19]

Surveillance and data utilization have also proven essential, as effective surveillance systems enabled early detection and informed public health strategies, particularly evident during the 2020-2021 outbreak.[15] Regular monitoring of antimicrobial resistance, as seen in the 2018 outbreak, is critical for guiding effective treatment protocols.[81] The recurring outbreaks further emphasize the need for robust Water, Sanitation, and Hygiene (WASH) infrastructure, with inadequate facilities exacerbating the 2010 and 2018 outbreaks, particularly in conflict-affected areas.[14] Public health actions such as chlorination of

water sources during the 2019 Bauchi State outbreak were effective in reducing cases, demonstrating the importance of WASH interventions.[83]

Finally, the importance of community engagement and integrated health system strengthening has been highlighted. Rapid formative research and community involvement during the 2017 outbreak enhanced emergency response effectiveness, while the dual burden of cholera and COVID-19 in 2020-2021 showcased the benefits of leveraging existing disease preparedness capacities.[3] [20] Addressing the social and environmental determinants of health, such as poverty, conflict, and displacement, remains essential for long-term cholera prevention, as demonstrated by the challenges faced in Northern Nigeria.[22] The application of case-area targeted interventions (CATIs) in Northeast Nigeria further highlighted the effectiveness of targeted strategies in reducing cholera clustering, particularly in conflict settings with limited WASH access.[87] These lessons emphasize the need for a comprehensive and adaptive approach to cholera response in Nigeria

Conclusions

Cholera continues to be a significant public health challenge in Nigeria, with outbreaks from 2010 to 2024 underscoring persistent vulnerabilities in the country's healthcare and WASH infrastructure. Recurrent outbreaks, fuelled by inadequate access to clean water, poor sanitation, environmental conditions, conflict, vaccine stockouts, and the emergence of antimicrobial-resistant *Vibrio cholerae* strains highlight the need for a multifaceted approach to prevention and control. Key lessons from these outbreaks emphasize the importance of rapid, coordinated responses, robust surveillance systems, and effective vaccination campaigns. The compounded impact of concurrent health crises like COVID-19 further underscores the need for integrated disease preparedness and response capacities. The recent outbreaks in 2023 and 2024 reinforce the urgency of sustained investments in healthcare and WASH infrastructure as well as comprehensive public health strategies, including community engagement, vaccination, and healthcare worker training. Learning from past outbreaks and implementing evidence-based interventions is crucial for Nigeria to strengthen its capacity to prevent and control cholera, ultimately reducing the disease's burden and improving public health outcomes.

References

1. Awofeso N, Aldbak K. Cholera, migration, and global health–a critical review. Int J Travel Med Glob Health. 2018;6(3):92-9. https://doi.org/10.15171/ijtmgh.2018.19
2. Ajayi A, Smith SI. Recurrent cholera epidemics in Africa: which way forward? A literature review. Infection. 2019; 47:341-9. https://doi.org/10.1007/s15010-018-1186-5
3. Ngwa MC, Ihekweazu C, Okwor T, Yennan S, Williams N, Elimian K, et al. The cholera risk assessment in Kano State, Nigeria: a historical review, mapping of hotspots and evaluation of contextual factors. PLoS Negl Trop Dis. 2021;15(1). https://doi.org/10.1371/journal.pntd.0009046
4. Dutta P, Sur D, Bhattacharya SK. Management of cholera. Epidemiol Mol Asp Cholera. 2011:341-53. https://doi.org/10.1007/978-1-60327-265-0_19
5. D'Mello-Guyett L, Gallandat K, Van den Bergh R, Taylor D, Bulit G, Legros D, et al. Prevention and control of cholera with household and community water, sanitation and hygiene (WASH) interventions: a scoping review of current international guidelines. PLoS One. 2020;15(1). https://doi.org/10.1371/journal.pone.0226549
6. Dalhat MM, Isa AN, Nguku P, Nasir SG, Urban K, Abdulaziz M, et al. Descriptive characterization of the 2010 cholera outbreak in Nigeria. BMC Public Health. 2014;14:1-7. https://doi.org/10.1186/1471-2458-14-1167
7. Adeneye AK, Musa AZ, Oyedeji KS, Oladele D, Ochoga M, Akinsinde KA, et al. Risk factors associated with cholera outbreak in Bauchi and Gombe States in North East Nigeria. J Public Health Epidemiol. 2016;8(11):286-96. https://doi.org/10.5897/JPHE2016.0865

8. Fatiregun AA, Isere EE, Ayede AI, Olowookere SA. Epidemiology of an outbreak of cholera in a south-west state of Nigeria: brief report. South Afr J Epidemiol Infect. 2012;27(4):201-4. https://doi.org/10.1080/10158782.2012.11441510
9. Kolo P, Jibrin Y, Sanya E, Alkali M, Salami A, Omotoso A, et al. Outcome of cholera admissions in Bauchi, Nigeria. South Afr J Epidemiol Infect. 2013;28(3):143-6. https://doi.org/10.1080/10158782.2013.11441536
10. Sule IB, Yahaya M, Aisha AA, Zainab AD, Ummulkhulthum B, Nguku P. Descriptive epidemiology of a cholera outbreak in Kaduna State, Northwest Nigeria, 2014. Pan Afr Med J. 2017;27. https://doi.org/10.11604/pamj.2017.27.172.11925
11. Onwe FI, Agu AP, Umezuruike D, Ogbonna C. Factors responsible for the 2015 cholera outbreak and spread in Ebonyi State, Nigeria. J Epidemiol Soc Nigeria. 2018;2:53-8. https://jeson.org.ng/index.php/jeson/article/view/23
12. Abubakar AT, Dalhat M, Nguku P. Cholera outbreak-IDP camps in Maiduguri, northern Nigeria, September 2015. Int J Infect Dis. 2016;45:132. https://doi.org/10.1016/j.ijid.2016.02.326
13. Denue BA, Akawu CB, Kwayabura SA, Kida I. Low case fatality during 2017 cholera outbreak in Borno State, North Eastern Nigeria. Ann Afr Med. 2018;17(4):203-9. https://doi.org/10.4103/aam.aam_66_17
14. Elimian KO, Musah A, Mezue S, Oyebanji O, Yennan S, Jinadu A, et al. Descriptive epidemiology of cholera outbreak in Nigeria, January–November 2018: implications for the global roadmap strategy. BMC Public Health. 2019;19:1-1. https://doi.org/10.1186/s12889-019-7559-6
15. Elimian K, Yennan S, Musah A, Cheshi ID, King C, Dunkwu L, et al. Epidemiology, diagnostics, and factors associated with mortality during a cholera epidemic in Nigeria, October 2020–October 2021: a retrospective analysis of national surveillance data. BMJ Open. 2022;12(9). https://doi.org/10.1136/bmjopen-2022-063703
16. Nigeria Centre for Disease Control and Prevention. Cholera situation report - monthly epidemiological report 12 [Internet]. 2023 [cited 2024 Sep 6]. Available from: https://ncdc.gov.ng/themes/common/files/sitreps/bd3442b030951d6ed73d475d1d4d0c18.pdf
17. Nigeria Centre for Disease Control and Prevention. Cholera situation report - monthly epidemiological report 8 [Internet]. 2024 [cited 2024 Sep 6]. Available from: https://ncdc.gov.ng/themes/common/files/sitreps/790b8fab2b6d4f793cb3bcb012358ee1.pdf
18. Nnaji RN, Ajumobi O, Oladimeji A, Sarki M, Buba M, Sale F, et al. Cholera outbreak investigation, Gajala community, Birnin Kudu local government area (LGA), Jigawa state, Nigeria, September 2015. Int J Infect Dis. 2016;45:144-5. https://doi.org/10.1016/j.ijid.2016.02.351
19. Ngwa MC, Alemu W, Okudo I, Owili C, Ugochukwu U, Clement P, et al. The reactive vaccination campaign against cholera emergency in camps for internally displaced persons, Borno, Nigeria, 2017: a two-stage cluster survey. BMJ Glob Health. 2020;5(6). https://doi.org/10.1136/bmjgh-2020-002431
20. Elimian KO, Musah A, Ochu CL, Onwah SS, Oyebanji O, Yennan S, et al. Identifying and quantifying the factors associated with cholera-related death during the 2018 outbreak in Nigeria. Pan Afr Med J. 2020;37(1). https://doi.org/10.11604/pamj.2020.37.368.20981
21. Oladapo RK, Oyetola AB, Obidiro OP, Olajide A, Osuagwu-Nwogu E, Olaitan OM, et al. Rising cholera cases: Harnessing the momentum of COVID-19 to strengthen Nigeria's health systems. Int J Health Plann Manage. 2021;36(6):2030-4. https://doi.org/10.1002/hpm.3289
22. Suleiman SY, Idris AS, Suleiman K, Abubakar A, Ruma MT, Haladu S, et al. A descriptive epidemiology of cholera outbreak in Katsina State, Nigeria, 2021. Int J Infect Dis. 2022;116. https://doi.org/10.1016/j.ijid.2021.12.194
23. GulumbeBH, Yusuf ZM, Faggo AA, Yahaya TO, Manga SS. The interplay among conflict, water scarcity, and cholera in Northern Nigeria. Public Health Chall. 2023;2(3). https://doi.org/10.1002/puh2.118

24. Owhonda G, Luke A, Ogbondah BO, Nwadiuto I, Abikor V, Owhondah E. Outbreak investigation of cholera in a rural community, Rivers State Nigeria: an interventional epidemiological study. Int J Community Med Public Health. 2023;10(2):860. https://dx.doi.org/10.18203/2394-6040.ijcmph20230248
25. Mandal S, Mandal MD, Pal NK. Cholera: a great global concern. Asian Pac J Trop Med. 2011;4(7):573-80. https://doi.org/10.1016/S1995-7645(11)60149-1
26. MacGarty D. Cholera: An Infectious Waterborne Disease. In: Disaster Medicine: A Case Based Approach. London: Springer London; 2012. p. 263-76. https://doi.org/10.1007/978-1-4471-4423-6_18
27. Sharmila T, Thomas TA. Pathogenesis of cholera: recent perspectives in rapid detection and prevention of cholera. Bacterial Pathogenesis Antibact Control. 2018;129. http://dx.doi.org/10.5772/intechopen.74071
28. Lekshmi N, Joseph I, Ramamurthy T, Thomas S. Changing facades of *Vibrio cholerae*: an enigma in the epidemiology of cholera. Indian J Med Res. 2018;147(2):133-41. https://doi.org/10.4103/ijmr.IJMR_280_17
29. Marin MA, Thompson CC, Freitas FS, Fonseca EL, Aboderin AO, Zailani SB, et al. Cholera outbreaks in Nigeria are associated with multidrug resistant atypical El Tor and non-O1/non-O139 *Vibrio cholerae*. PLoSNegl Trop Dis. 2013;7(2). https://doi.org/10.1371/journal.pntd.0002049
30. Siddique AK, Cash R. Cholera outbreaks in the classical biotype era. Curr Top Microbiol Immunol. 2014;379:1-6. https://doi.org/10.1007/82_2013_361
31. Mukhopadhyay AK, Takeda Y, Balakrish Nair G. Cholera outbreaks in the El Tor biotype era and the impact of the new El Tor variants. Cholera Outbreaks. 2014;17-47. https://doi.org/10.1007/82_2014_363
32. Baker-Austin C, Oliver JD, Alam M, Ali A, Waldor MK, Qadri F, et al. Vibrio spp. infections. Nat Rev Dis Primers. 2018;4(1):1-9. https://doi.org/10.1038/s41572-018-0005-8
33. Momba M, Azab El-Liethy M. *Vibrio cholerae* and Cholera biotypes. Glob Water PathogProj. 2017. https://doi.org/10.14321/waterpathogens.28
34. Abioye OE, Osunla AC, Okoh AI. Molecular detection and distribution of six medically important Vibrio spp. in selected freshwater and brackish water resources in Eastern Cape Province, South Africa. Front Microbiol. 2021;12:617703. https://doi.org/10.3389/fmicb.2021.617703
35. Osunla CA, Okoh AI. Vibrio pathogens: a public health concern in rural water resources in sub-Saharan Africa. Int J Environ Res Public Health. 2017;14(10):1188. https://doi.org/10.3390/ijerph14101188
36. Mengel MA, Delrieu I, Heyerdahl L, Gessner BD. Cholera outbreaks in Africa. Cholera Outbreaks. 2014;117-44. https://doi.org/10.1007/82_2014_369
37. Sousa FB, Nolêto IR, Chaves LS, Pacheco G, Oliveira AP, Fonseca MM, et al. A comprehensive review of therapeutic approaches available for the treatment of cholera. J Pharm Pharmacol. 2020;72(12):1715-31. https://doi.org/10.1111/jphp.13344
38. Field M. Intestinal ion transport and the pathophysiology of diarrhea. J Clin Invest. 2003;111(7):931-43. https://doi.org/10.1172/JCI18326
39. Keely SJ, Barrett KE. Intestinal secretory mechanisms and diarrhea. Am J Physiol Gastrointest Liver Physiol. 2022;322(4). https://doi.org/10.1152/ajpgi.00316.2021
40. Montero DA, Vidal RM, Velasco J, George S, Lucero Y, Gómez LA, et al. *Vibrio cholerae*, classification, pathogenesis, immune response, and trends in vaccine development. Front Med. 2023;10:1155751. https://doi.org/10.3389/fmed.2023.1155751
41. Ebob TJ. Epidemiological distribution of different *Vibrio cholerae* strains causing cholera disease in endemic countries: a review. J Adv Med Res. 2019;31:1-5. https://doi.org/10.9734/JAMMR/2019/v31i530298
42. Davies HG, Bowman C, Luby SP. Cholera–management and prevention. J Infect. 2017;74. https://doi.org/10.1016/S0163-4453(17)30194-9
43. LaRocque R, Harris JB. Cholera: clinical features, diagnosis, treatment, and prevention [Internet]. This Top. 2018 [cited 2022 Sep 20]. Available from: https://www.uptodate.com/contents/cholera-clinical-features-diagnosis-treatment-and-prevention

44. Ahmed AK, Sijercic VC, Akhtar MS, Elbayomy A, Marouf MA, Zeleke MS, Sayad R, Abdelshafi A, Laird NJ, El-Mokhtar MA, Ruthig GR. Cholera rages in Africa and the Middle East: A narrative review on challenges and solutions. Health Science Reports. 2024 May;7(5):e2013.https://doi.org/10.1002/hsr2.2013
45. World Health Organization. Cholera: Number of reported cases: 2016–2017 [Internet]. 2019 [cited 2024 Sep 6]. Available from: http://gamapserver.who.int/gho/interactive_charts/cholera/atlas.html
46. World Health Organization. Cholera outbreak: assessing the outbreak response and improving preparedness [Internet]. 2004 [cited 2024 Sep 6]. Available from: https://www.humanitarianlibrary.org/sites/default/files/2021/11/final%20outbreak%20booklet%20260105-OMS.pdf
47. Centers for Disease Control and Prevention. Cholera Diagnosis and Detection Online: CDC; 2015. Updated February 2015. Available from: http://www.cdc.gov/cholera/diagnosis.html.
48. Dick MH, Guillerm M, Moussy F, Chaignat CL. Review of two decades of cholera diagnostics--how far have we really come? PLoS Negl Trop Dis. 2012;6(10). https://doi.org/10.1371/journal.pntd.0001845
49. Ley B, Khatib AM, Thriemer K, Von Seidlein L, Deen J, Mukhopadyay A, et al. Evaluation of a rapid dipstick (Crystal VC) for the diagnosis of cholera in Zanzibar and a comparison with previous studies. PLoS One. 2012;7(5). https://doi.org/10.1371/journal.pone.0036930
50. Mehrabadi JF, Morsali P, Nejad HR, Fooladi AA. Detection of toxigenic *Vibrio cholerae* with new multiplex PCR. J Infect Public Health. 2012;5(3):263-7. https://doi.org/10.1016/j.jiph.2012.02.004
51. Kuna A, Gajewski M. Cholera—the new strike of an old foe. Int Marit Health. 2017;68(3):163-7. https://doi.org/10.5603/IMH.2017.0029
52. Pietroni MA. Case management of cholera. Vaccine. 2020;38. https://doi.org/10.1016/j.vaccine.2019.09.098
53. Harris JB, LaRocque RC, Qadri F, Ryan ET, Calderwood SB. Cholera. Lancet. 2012;379(9835):2466-76. https://doi.org/10.1016/s0140-6736(12)60436-x
54. Pezzoli L. Global oral cholera vaccine use, 2013–2018. Vaccine. 2020;38. https://doi.org/10.1016/j.vaccine.2019.08.086
55. Saha A, Rosewell A, Hayen A, MacIntyre CR, Qadri F. Improving immunization approaches to cholera. Expert Rev Vaccines. 2017;16(3):235-48. https://doi.org/10.1080/14760584.2017.1249470
56. Sen S. Indian cholera: a myth. Indian J Hist Sci. 2012;47(3):345-74. https://cahc.jainuniversity.ac.in/assets/ijhs/Vol47_3_2_SSen.pdf
57. Høiby N. Pandemics: past, present, future: that is like choosing between cholera and plague. APMIS. 2021;129(7):352-71. https://doi.org/10.1111/apm.13098
58. Tasnia R. Production of polyclonal antisera of *Vibrio cholerae* O1 & O139 to detect pathogenic *Vibrio cholerae* (Doctoral dissertation, Brac University). 2023. https://dspace.bracu.ac.bd/xmlui/handle/10361/18282
59. Arnold D. Pandemic India: From Cholera to Covid-19. Oxford University Press; 2022. https://doi.org/10.1093/oso/9780197659625.001.0001
60. Mosley M. Eight lessons from cholera for COVID-19. Emerg Med News. 2020;42(12A):10-97. https://doi.org/10.1097/01.EEM.0000724472.42949.46
61. Wailoo K. Spectacles of difference: the racial scripting of epidemic disparities. Bull Hist Med. 2020;94(4):602-25. https://doi.org/10.1353/bhm.2020.0085
62. Mackenbach JP. Health problems of industrializing societies. A History of Population Health. 2020:149-216. https://brill.com/downloadpdf/book/9789004429130/BP000007.pdf
63. Tulchinsky TH. John Snow, cholera, the broad street pump; waterborne diseases then and now. Case Stud Public Health. 2018:77. https://doi.org/10.1016/B978-0-12-804571-8.00017-2
64. Itrich-Drabarek J. The Pandemic in Central Europe: A Case Study. Taylor & Francis; 2023. https://doi.org/10.4324/9781003353812
65. Smith-Dobbs AK. A Developmental Origin of Infectious Disease? Applying Bioarchaeological Methods and Theory to Investigate the Influence of Early Childhood Stressors on Infectious Disease

Mortality (Doctoral dissertation, University of Georgia). 2020. https://search.proquest.com/openview/1792837c796258cf076ff17d83802c10/1?pq-origsite=gscholar&cbl=18750&diss=y

66. Vinten-Johansen P, editor. Investigating Cholera in Broad Street: A History in Documents:(From the Broadview Sources Series). Broadview Press; 2020 Mar 15.https://www.researchgate.net/publication/342338800_Investigating_Cholera_in_Broad_Street_A_History_in_Documents_Peterborough_ON_CA_Broadview_Press_2020-updated_full-_text_includes_entire_preface_and_an_overview_from_the_Introduction_of_documents_liste
67. Mehlhorn H. Cholera (blue skin disease) and its history. Parasite Dis Spread Major Rivers Earth. 2019:143-59. https://doi.org/10.1007/978-3-030-29061-0_3
68. Rodó X, Bouma MJ, Rodríguez-Arias MÀ, Roy M, De Yebra P, Petrova D, et al. Strain variation and anomalous climate synergistically influence cholera pandemics. PLoS Negl Trop Dis. 2024;18(8). https://doi.org/10.1101/2021.04.07.21255051
69. Promitzer C. Combating Cholera During the Balkan Wars: the Case of Bulgaria. War Balkans. 2016. https://unipub.uni-graz.at/obvugroa/content/titleinfo/4363082/full.pdf
70. Islam MT, Alam M, Boucher Y. Emergence, ecology and dispersal of the pandemic generating *Vibrio cholerae* lineage. Int Microbiol. 2017;20(3):106-5. https://doi.org/10.2436/20.1501.01.291
71. Magana-Arachchi DN, Wanigatunge RP. Ubiquitous waterborne pathogens. In: Waterborne Pathogens. Butterworth-Heinemann; 2020. p. 15-42. https://doi.org/10.1016/B978-0-12-818783-8.00002-5
72. Kohnert D. On the socio-economic impact of pandemics in Africa-Lessons learned from COVID-19, Trypanosomiasis, HIV, Yellow Fever and Cholera. Trypanosomiasis, HIV, Yellow Fever and Cholera. 2021. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3839067
73. Gidado S, Awosanya E, Haladu S, Ayanleke HB, Idris S, Mamuda I, et al. Cholera outbreak in a naïve rural community in Northern Nigeria: the importance of hand washing with soap, September 2010. Pan Afr Med J. 2018;30(1):5. https://doi.org/10.11604/pamj.2018.30.5.12768
74. Okeke L, Badung S, Ajani G, Gidado S, Fawole O. Assessment of knowledge, attitude and disease prevention practice following Cholera outbreak investigation among students of the Federal College of Education Pankshin in Plateau State, Nigeria, 2011. Int J Infect Dis. 2012;16. https://doi.org/10.1016/j.ijid.2012.05.446
75. Omoregie P, Oladepo O, Adelekan A. Comparative assessment of water and sanitation practices in cholera affected and non-cholera affected communities in 2011 outbreak in Ibadan, Nigeria. Eur J Biomed. 2017;4(10):69-83. https://bgri.org.ng/assets/publication/19.pdf
76. Dan-Nwafor CC, Ogbonna U, Onyiah P, Gidado S, Adebobola B, Nguku P, et al. A cholera outbreak in a rural north central Nigerian community: an unmatched case-control study. BMC Public Health. 2019;19:1-7. https://doi.org/10.1186/s12889-018-6299-3
77. Leckebusch GC, Abdussalam AF. Climate and socioeconomic influences on interannual variability of cholera in Nigeria. Health Place. 2015;34:107-17. https://doi.org/10.1016/j.health
78. Kanu NE, Osinubi M, Nwadiuto I, Okeke C. Cholera outbreak in Andoni Local Government Area, Rivers State, Nigeria; January 2015: the role of hand washing with soap. Niger J Med. 2018;27(2):140-6. https://doi.org/10.4103/1115-2613.278772
79. Olanrewaju OE, Adepoju KA. Geospatial assessment of cholera in a rapidly urbanizing environment. J Environ Public Health. 2017;2017:6847376. https://doi.org/10.1155/2017/6847376
80. Ibrahim BS, Mohammed Y, Usman R, Okon UA, Katchy UI, Olufemi AA, et al. Outbreak of cholera at Dutsen-Abba Ward Zaria local government area, Kaduna state Nigeria 2015: the importance of hygienic practices. Int J Community Med Public Health. 2017;4(5):1473-8. http://dx.doi.org/10.18203/2394-6040.ijcmph20171757
81. Ngwa MC, Wondimagegnehu A, Okudo I, Owili C, Ugochukwu U, Clement P, et al. The multi-sectorial emergency response to a cholera outbreak in internally displaced persons camps in Borno state, Nigeria, 2017. BMJ Glob Health. 2020;5(1). https://doi.org/10.1136/bmjgh-2019-002000

82. Amadu DO, Abdullahi IN, Seibu E, Fadeyi A, Kamaldeen K, Aliu Ajibola Akanbi II, et al. Retrospective analysis of the serovars and antibiogram of *Vibrio cholerae* isolates of the 2017 Ilorin Cholera Outbreak, Nigeria. Infect Chemother. 2021;53(2):368. https://doi.org/10.3947/ic.2021.0001
83. Asunduwa K, Usman A, Isyaku A, Shehu A, Francis O, Balogun M, et al. Descriptive analysis of a cholera outbreak in 14 LGAs of Sokoto State–Nigeria, 2018. Int J Infect Dis. 2020;101:363. https://doi.org/10.1016/j.ijid.2020.09.951
84. Elimian KO, Mezue S, Musah A, Oyebanji O, Fall IS, Yennan S, et al. What are the drivers of recurrent cholera transmission in Nigeria? Evidence from a scoping review. BMC Public Health. 2020;20:1-3. https://doi.org/10.1186/s12889-020-08521-y
85. Garbati MA, Baba AS, Mursal A, Gadzama GB. Circulating serotypes and antimicrobial susceptibility pattern of *Vibrio cholerae* isolates from insurgency-stricken Maiduguri, northeastern Nigeria. Sub-Sahar Afr J Med. 2019;6(1):21-6. https://doi.org/10.4103/ssajm.ssajm_12_19
86. Fagbamila IO, Abdulkarim MA, Aworh MK, Uba B, Balogun MS, Nguku P, et al. Cholera outbreak in some communities in North-East Nigeria, 2019: an unmatched case–control study. BMC Public Health. 2023;23(1):446. https://doi.org/10.1186/s12889-023-15332-4
87. Musa BT, Olayemi OS. Application of logistic regression models for the evaluation of cholera outbreak in Adamawa state Nigeria. Int J Math Stat Stud. 2020;8(1):32-54. https://www.academia.edu/download/79055575/Application-of-Logistic-Regression-Models-for-the-Evaluation-of-Cholera-Outbreak-in-Adamawa-State-Nigeria.pdf
88. Ilic I, Ilic M. Global patterns of trends in cholera mortality. Trop Med Infect Dis. 2023;8(3):169. https://doi.org/10.3390/tropicalmed8030169
89. Gulumbe BH, Aminu U, Yusuf ZM, Liman UU, Faggo AA, Abubakar J, et al. Cholera outbreaks in conflict-hit regions of Northern Nigeria: an overview. Afro-Egypt J Infect Endem Dis. 2023;13(2):134-42. https://doi.org/10.21608/AEJI.2023.205724.1286
90. Elimian K, Musah A, Dewa O, King C, Crawford K, Pembi E, et al. Resource availability and capacity to implement multi-stranded cholera interventions in the north-east region of Nigeria. BMC Glob Public Health. 2023;1(1):6. https://doi.org/10.1186/s44263-023-00008-3
91. OKeeffe J, Salem-Bango L, Desjardins MR, Lantagne D, Altare C, Kaur G, et al. Case-area targeted interventions during a large-scale cholera epidemic: a prospective cohort study in Northeast Nigeria. PLoS Med. 2024;21(5). https://doi.org/10.1371/journal.pmed.1004404
92. Global Task Force on Cholera Control. Use of cholera vaccine, Nigeria, 2021 [Internet]. 2021 [cited 2024 Nov 4]. https://www.gtfcc.org/wp-content/uploads/2022/01/8th-meeting-of-the-gtfcc-working-group-on-ocv-2021-day-1-james-onah.pdf
93. Abdulrahim A, Ibrahim MN, Gulumbe BH. Cholera emergency in Nigeria: urgent need for better vaccine access and public health action. Bulletin of the National Research Centre. 2024;48(1):86.https://doi.org/10.1186/s42269-024-01242-x
94. Ahmadi MH. Global status of tetracycline resistance among clinical isolates of *Vibrio cholerae*: a systematic review and meta-analysis. Antimicrobial Resistance & Infection Control. 2021;10:1-2.https://doi.org/10.1186/s13756-021-00985-w
95. Mohammed Y, Aboderin AO, Okeke IN, Olayinka AT. Antimicrobial resistance of *Vibrio cholerae* from sub-Saharan Africa: A systematic review. Afr J Lab Med. 2018 Jun 1;7(2):1-7. https://doi.org/10.4102/ajlm.v7i2.778
96. Adagbada AO, Adesida SA, Nwaokorie FO, Niemogha MT, Coker AO. Cholera epidemiology in Nigeria: an overview. Pan Afr Med J. 2012;12(1). https://www.ajol.info/index.php/pamj/article/view/82694/72839