Quest Journals
Journal of Medical and Dental Science Research
Volume 8~ Issue 6 (2021) pp: 01-10
ISSN(Online) : 2394-076X ISSN (Print):2394-0751
www.questjournals.org

Research Paper

Cholera Epidemic in Nigeria: A 10-year review from 2009 to 2019.

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ABSTRACT
Cholera is an acute secretory diarrheal disease caused by the consumption of food and water contaminated with the bacterium, Vibrio Cholerae. Cholera is most common in regions of the world with poor sanitation. With all the efforts made in controlling cholera, the infection continues to occur as a significant public health issue in many developing countries.
Nigeria is one of the majorly affected countries mostly in the northern regions – northeast, northwest) with resurgent of conflict since 2009; displaced people are forced to share wash facilities with host communities. Unavailability of pure drinking water and poor sanitation conditions means that the region is prone to repeated cholera outbreaks.
Nigeria reported several outbreaks notably were 2010 outbreak with 41,787 cases with 1,716 death and CFR of 4%. Nigeria recorded a total number of 22,454 cholera cases including 715 death plus CFR of 3.2% in 2011 and 43,996 cases with 836 deaths with CFR of 1.9% in 2018.
This study shows an overview of the cholera epidemic for the last ten years in Nigeria. The government should invest in drinking water systems, sanitation systems, and sewage treatment plans through laws that will improve and provide clean water for all. These would create a legal basis for combatting cholera.

Received 02 June, 2021; Revised: 04 June, 2021; Accepted 16 June, 2021

I. INTRODUCTION

Cholera is an acute secretory diarrheal disease caused by *Vibrio cholerae*; Cholera is a potentially fatal bacterial infection caused by consumption of contaminated food or water. Combination of diarrhoea and vomiting without medication can induce dehydration leading to shock and ultimately death[1]. Cholera is most prevalent in regions of the world with poor sanitation such as; parts of Sub-Sahara Africa, South, and Southeast Asia, the Middle East, Central America, and the Caribbean[2]England and Wales have no cholera cases for over 100 years. However, travellers do occasionally import the infection. In 2018, there were seventeen confirmed cases of cholera in travellers[3].

It is rampant in Africa, parts of Asia, the Middle East, South, and Central America. Presently the infection is now confined mainly to developing countries in the tropics and sub-tropics[4].

Nigeria is one of the significantly affected countries. A lack of access to clean drinking water and poor sanitation conditions means that the region is prone to repeated cholera outbreaks**.** Nigeria has experienced sporadic cholera outbreaks in most parts of the country, especially the northern region. Commonly affected areas are; North-East (Borno, Adamawa, Yobe, Bauchi, Gombe Taraba), North-West (Kano, Kaduna, Katsina, Zamfara, Kebbi, Sokoto), North-Central (Niger, Kwara, Abuja, Kogi, Benue, Nassarawa, Plateau), South-East (Ebonyi, Anambra), South-West (Oyo, Lagos). Some of these hotspot areas have been consistent over the years.

Figure 1 shows the hotspot areas of Cholera in Nigeria.

This article gives an update on cholera and if there are any new hotspots to develop strategies for prevention and control. Findings would also be useful to public health researchers in assessing the impact of the intervention.

AIM

To review and give an update on the cholera epidemic in Nigeria in the last ten years, from 2009 to 2019.

II. BACKGROUND

The history of cholera pandemics began in the 19th century when cholera spread across the world from its origin in the Ganges Delta in India[5]Millions of people were killed across all continents following the six subsequent pandemics. The ongoing (seventh) pandemic started in South Asia in 1961 and reached Africa in 1971 and the Americas in 1991[6]. Cholera is now endemic in many countries.

There are eight cholera pandemics worldwide, of which the seventh and eighth continue **(Table 1)**. Cholera appeared in Guinea Conakry in 1970 and gradually spread along the coast and into the interiors of Nigeria.

In 1971; the Lake Chad Basin recorded their first cholera epidemic. In 1971, the disease then repeated in 1991. The lake Chad Basin area shared by Nigeria, Chad, Niger, and Cameroon remains one of the most impacted by the disease in the region. The four countries, according to the regional cholera platform, are often affected at the same time with an epidemic in one country and subsequent spread to neighbouring countries.

Three significant epidemics have occurred during the last two decades[: 1992[5], 1995-1996[7] And 1997[8].

The Northern part of Nigeria is known to be endemic for cholera infection. In 1982, Katsina state, Nigeria was affected by an outbreak of gastroenteritis, associated with *Vibrio-cholerae* serotype Ogawa; the overall case-fatality rate was 7.7%[9]

The Kano State Ministry of Health reported that the epidemic in the state from 1995 to 2001 was 2,630 cases in 1995/1996,847 cases in 1997, 2,347 in 1999,[10]

In 2009, more than 260 people died of cholera in four northern states with over 96 people from about five local government areas in Bauchi State.[11]

In 2010, the outbreak of cholera affected the following states in Nigeria; the North East (Bauchi, Gombe, Yobe, Borno, Adamawa, Taraba), North West (Jigawa, Kaduna, Katsina), North Central Abuja, South-South (Cross-river and Rivers), South West (Osun)[4]. The cholera outbreak was attributed to heavy rains which washed sewage into open wells and ponds, where people get water for drinking and household needs. **(Table 2)**

In June 2017, WHO reported a total of 1,558 suspected cases of cholera including 11 deaths (case fatality rate of 0.7%) in Kwara State, North Central region of Nigeria, Between 1 May and 30 June 2017, suspected cholera cases in Kwara State were reported from five Local Government Areas; Asa (18), Ilorin East (450), Ilorin South (215), Ilorin West (780), and Moro (50) information for local government areas was missing for 45 of the suspected cases.[12]

Poor sanitation observed in the affected communities was one of the predisposing factors for this cholera outbreak. A significant risk factor was the lack of access to clean drinking water and poor hygienic condition.

A suspected cholera case was reported in Muna Garage, Borno State, Nigeria, a camp hosting about 20,000 internally dislodged persons on the outskirts of the state capital Maiduguri. A total of 152 suspected cholera cases, including 11 deaths were reported on 31 August 2017[13].

Between 2010 and 2017, Nigeria recorded 122,239 cases including 3,713 deaths (case fatality 3%), majority of the cases occur in two zones; in the North Eastern and Western Regions (Adamawa, Yobe, Bauchi),(Kano, Kaduna, and Katsina)[14].**Table 3** In Borno State, between 2010 and 2017, there were seven (7) cholera outbreaks that lasted for an average of 18 weeks. The country reported 11.9% of the total cases in this state[15].

Nigeria Centre for Disease Control (NCDC) reported a cholera outbreak in 2018, with around 44,000 suspected cases and 836 deaths, 90% came from the Northern part of Nigeria.

In October 2019, about seven states reported cholera outbreaks, in which total cases reported were 1,583, and 22 death case fatality rate was 1.38%[16]. **Table 4**

AETIOLOGICAL AGENTS

The species of *V. Cholerae* consists of pathogenic and non-pathogenic strains. Only toxigenic or pathogenic strains of sero-groups 01 and 0139 have caused widespread epidemics[17]. *V. cholerae* 01 has two biotypes classical and El-tor and serotype Inaba, Ogawa, and Hikojima[18]. *V. Cholera* 0139 has similar characteristics with El-tor biotype but differs from 01 in its polysaccharide antigen[19] *V. Cholerae* 01 El-tor is the most everyday strain in Nigeria[20] .

PATHOGENESIS

Vibrio cholerae is a facultative anaerobic gram-negative bacillus, which possesses the characteristic features of darting motility under wet mount preparations. 20% of cholera cases are severe and life-threatening,

the onset of clinical manifestations may be sudden and abdominal discomfort is seen in some cases, the initial stool is dark-brown with solid consistency, gradually it turns to harmless whitish, watery stool giving a rice water appearance[21]. This symptom helps to diagnose cholera from other gastroenteritis. Classical strains are more virulent than Eltor.

As soon as the bacterium settles itself in the bowel, the mechanism of invasion begins. Toxin Coregulated Pili (TCP) are mainly to mediate colonization[22], TCP is examined to promote *V. cholerae* intestinal colonization in three approaches:

1. Microcolony formation within the small intestine
 is enabled by the bacterium-bacterium interactions mediated by the pili.
2. The toxic factors produced in the intestine is protected by the pili, and;
3. The intestinal epithelium attachment is promoted by the pili.

Following colonization, mucolytic enzymes facilitate the penetration of the mucous by destroying mucous integrity, allowing the long tail of the invading organism to penetrate the thick mucosal layer.

The attachment of Vibrio onto the microvilli of the small intestine is guided by the pili in the bacterium[23].

The production of endotoxin by the bacteria called *Cholera Toxin* (CT), is the major key virulence mechanism[24]. The CT comprises of six protein subunits; one A subunit and five copies of B subunits denoted as AB_5. B sub-unit also refers to as the binding factor, which joins to the GM_1, ganglioside receiver of the epithelial cells of the small intestine, once bound with target cells, the appearance change into a toxin complex which is then endocytosed by the cell. Following endocytosis, the enzymatic activation of A subunit occurs, leading to increasing adenylate cyclase activity, hence increasing the concentration of cAMP to more than 120 folds. This, sequentially, leads to increased permeability of the chloride channels subsequently mediating the efflux of more ATP mediated chloride ions and secretion of more water, sodium, potassium, and bicarbonate into the lumen of the intestine[25]. The increased absorption of water, as well as the electrolyte, is responsible for the massive dehydration leading to the clinical symptoms of cholera.

CLINICAL PRESENTATION

The incubation timing is between 12 hours and five days after ingestion of unclean food or water. Cholera affects both adults and children and adults and can kill within hours if not treated. Majority of the people infected with *V. cholera*e are asymptomatic. Still, bacteria are present in their faeces for 1 – 10 days after infection. They are shed back into the environment, potentially infecting other people. The majority have mild to moderate symptoms while a minority develops acute watery diarrhoea with severe dehydration which can ultimately lead to death if untreated[26].

As diarrhoea progresses, dots of white mucous (rice-water stool) are found in the stool with a fishy odour. In severe cholera, the volume of watery diarrhoea can exceed 1 L/hr. Vomiting is common. Abdominal cramps and discomfort may occur due to extensive fluid secretion into the intestinal lumen. Ileus, muscle pain, spasm, and tetany can be present if there is severe dehydration with deranged levels of calcium and potassium. Other clinical presentation includes hypothermia, lethargy, sunken eyes, marked skin turgor, dry mucous membranes, cold and clammy skin, anuria, and coma. The complications of cholera reflect severe hypo-perfusion and can consist of partial paralysis, acute tubular necrosis with renal dysfunction, and aspiration pneumonia from extensive vomiting.

Peculiar presentations seen in cholera cases in Nigeria is the rice water stool with signs and symptoms of dehydration.

RISK FACTORS FOR TRANSMISSION

Cholera is associated with inadequate access to clean water and sanitation facilities. Typical at-risk areas include; overpopulated communities, peri-urban slums, camps for internally displaced persons or refugees, where the minimum requirement of water and sanitation does not me[27].

The consequences of a humanitarian crisis such as disruption of water and sanitation systems or the displacement of populations to short and congested camps can increase the risk of cholera transmission, should the bacteria be present or introduced. Infected dead bodies have not to happen mentioned to be a source of the epidemic.

Access to water and sanitation is life-threatening in the whole country. In 2015, 69% of the total population had access to improved water sources, and 29% had access to improved sanitation. Between 15 and 25% of the total population still practice open defecation, especially in the rural areas where this represents the social norms[28].

In the North East region of Nigeria (Borno, Adamawa, and Yobe), 7.1 million individuals are affected by the crisis precipitated by the resurgent of conflict since 2009. About 80% of these individuals are currently displaced and forced to share resources with host communities. About 3.6 million people are estimated to require wash facilities across North East states mentioned above[29]. UNICEF in February 2019 out of the 168

sites referenced in Borno State, 57% do not meet its fair emergency standards for (15L/person/day), and 58% do not meet sanitation standards (50 people per latrine). The situation is also problematic, over 150 persons per latrine which encourage the practice of open defecation. Majority people do not have detergent for handwashing.[30]

Flooding, strong winds, and sandstorms have resulted in substantial damages of Wash facilities, and congested population in displacement site have led to an environment highly favourable to water-borne diseases such as Cholera.[30] the outbreak of the disease in Katsina was due to open defecation and faecal contamination of well water.[30]

HOST SUSCEPTIBILITY

A variety of host factors influence the human susceptibility to cholera. Gastric hypoacidity is associated with the risk of cholera, people who produce less gastric acid such as the elderly, young children. Those on drugs to reduce gastric acid such as omeprazole, ranitidine is likely to contract the infection[31].

There has also been a relationship between ABO blood group and the risk of cholera infection; the mechanism is not well understood.[32] Studies have shown that individuals with blood group O are at the highest risk of cholera infection, those with Blood group AB are at Intermediate risk and those with A or B are at the lowest risk.[32] Recently, in vitro studies have demonstrated a more potent effect of cholera toxin in inducing cAMP in enteric cells of humans with blood group O than those of humans with blood group A. Interestingly, these relationships apply to the risk of the Eltor biotype but not the classic biotype [32]. Based on these observations and the additional observation that the population prevalence of blood group O in the Ganges Delta is among the lowest in the world, it has been proposed that cholera has acted to influence natural selection in human evolution in this region. People with achlorhydria have an increased risk of cholera infection[31].

Host diet and nutritional status also appear to influence susceptibility. Both innate and adaptive host immunity influences susceptibility to cholera infection.[33] Adaptive immunity plays an important role in protection against cholera as was suggested by research in North American volunteers, in whom an initial experimental challenge with cholera vibrios conferred protection against a subsequent challenge[33]. Variants in the innate immunity protein BPIFB1 (BPI Fold Containing Family B Member 1) are associated with susceptibility to Cholera[34]. Age, gender, nutritional status, social status, economic status, travel history are demographic and socioeconomic factors that play a crucial role in susceptibility to *Vibrio cholerae*[35].

Sanitation and nutrition are also important factors. *Vibrio cholerae* infection is known to be more severe in individuals suffering from malnutrition[36].

SEASONAL DISTRIBUTION AND INFECTIVITY

In high areas of endemicity, the incidence of *Vibrio cholerae* infection follows a seasonal distribution with peaks before and after rainy seasons[37].

Cholera exists as a seasonal disease, occurs most commonly during the rainy season, but there is an exception to this case. In Calabar Nigeria, Cholera mostly occurs during the dry season followed by subsidence at the onset of the rainy season[38].Though, seasonality is not an issue in Nigeria as infections have been reported both in the dry and rainy seasons. Cholera infections can affect any age and sex.

MANAGEMENT OF CHOLERA

Cholera is a treatable disease. Hydration is the gold standard of treatment for cholera. Depending on how severe the diarrhoea is, treatment consists of oral rehydration solution, which is cheap and easy to use or intravenous solution to replace lost fluids.[39] Majority of people can be treated successfully through the timely administration of Oral Rehydration Solution (ORS). The WHO /UNICEF ORS standard sachet is emptied in 1litre of clean water. Adult patients may require up to 6L of ORS to treat moderate dehydration on the first day. Subsequently, the type and quantity of fluids to administer are determined by the level of volume depletion and an assessment of ongoing fluid losses. The entire estimated fluid deficit should be replaced within three to four hours of presentation[39].

Severely dehydrated patients are at risk of shock and require rapid administration of intravenous fluids. These patients should receive appropriate antibiotics to lessen the time of diarrhoea, reduce the level of rehydration fluids needed, and decrease the volume and duration of *V. cholerae* excretion.

Mass usage of antibiotics is not recommended as it has no proven effect on the spread of cholera and may contribute to antimicrobial resistance.

Rapid access to treatment is essential during a cholera outbreak. Oral rehydration should be available in communities, in addition to larger treatment centres that can provide intravenous fluids and 24 hours care. With early and proper treatment, the case fatality rate should remain below 1%[40].

The micronutrient zinc and vitamin A play a vital function in mucosal immunity, and it may reduce the incidence and morbidity of diarrheal disease[41].

Necessary adjunctive therapy for children under 5 is zinc, which reduces the duration of diarrhoea and may prevent future episodes of other causes of acute watery diarrh[42]. Breastfeeding is also one of the significant steps in cholera control.

EMERGENCE OF ANTIMICROBIAL RESISTANCE IN VIBRIO CHOLERAE

A new variant of *Vibrio cholerae* associated with high virulence and drug resistance is known as a hybrid, or atypical biotype evolved during the seventh pandemic[43]. Atypical *Vibrio Cholerae* has the El-Tor biotype with the non-El-Tor ctxB toxigenic allele[44]. Hybrid *Vibrio Cholerae* carries mobile genetic elements known as conjugative/integrative elements (ICEs) capable of integration and self-transfer into host chromosomes facilitating rapid spread and stable acquisition[45]. Currently, the occurrence of a new variant of pathogenic strains of *Vibrio cholera*e has been attributed to new CTX prophage rearrangement[46]. Resistant *Vibrio Cholerae* which have spread globally threaten the effective treatment and control of cholera in developing countries[46]. The emergence of multidrug-resistant (MDR) and extensively drug-resistant (XDR) *V. Cholerae* in recent studies, suggests that it is mainly facilitated by horizontal gene transfer (HGT) through cell transmissible autonomously replicating plasmids or integrating mobile genetic elements (IMGEs) including Integrating Conjugating Element (ICEs), Insertion Sequences (IS) and transposable Genetic Element[47].

The MDR *V. Cholerae* isolates belonging to serotype 01 displaying resistance against tetracycline, streptomycin, and chloramphenicol were first reported in 1970[48]. Tetracycline resistant *V. cholerae* 01 reported from a cholera outbreak in Tanzania between 1877-78 was due to the prophylactic use of the drugs. This resistance was as a result of the presence of a megaplasmid belonging to an unstable incompatible complex C. In 1994, tetracycline-resistant *V. cholerae* 01 was reported in Rwanda[49] Leading to the death of 12,000 refugees.

In Nigeria, very little microbiological surveillance has occurred. Still, virtually all recently isolated *V. cholerae* 01 strains show resistance to trimethoprim-sulphamethoxazole and most to tetracycline, fluoroquinolones, erythromycin, chloramphenicol, ampicillin[50]. The multidrug-resistant atypical El-tor strains in a study done in Nigeria was found to be resistant to ciprofloxacin, chloramphenicol, streptomycin, trimethoprim, and sulfonamides[51].

INFECTION, PREVENTION, AND CONTROL

A multifaceted approach is vital to prevent, control, and to reduce the rate of deaths from cholera. Notably, political will on the part of the government is needed to create a legal basis for combatting cholera. They should invest in drinking water systems, sanitation systems, and sewage treatment plans. These could be achieved through laws that will improve and provide clean water for all.

Surveillance and prompt reporting are vital in the control and prevention of cholera because it allows rapid containment of cholera epidemics[52]. Proper surveillance systems provide an early alert to outbreaks and enable coordinated and fast track responses as well as the development of preparedness plans.

Health promotion activities such as massive sensitization and continuous public enlightenment on cholera are essential in controlling the infection. Proper discard and treatment of all materials that may come into contact with cholera victims' faeces (e.g. clothing, bedding, etc.) are fundamental. These should be cleaned and disinfected by washing in hot water and using chlorine. Hands that touched cholera patients or their clothing, bedding, etc., should be thoroughly washed and disinfected.[53]

Sewage and faecal sludge in Cholera endemic areas need to be treated and managed carefully to stop the spread of the disease. Open defecation, the release of untreated sewage, or dumping of faecal sludge from pit latrines or septic tanks into the environment must be prevented and abolished[53].

Boiling and treatment of water before drinking is very vital. Water can also be treated by chlorination, ozonation, and ultraviolet sterilization[54]. Chlorination and boiling of water are less expensive and are the most effective means of halting cholera transmission.

Proper handwashing with soap and water after using the toilet and before handling food or eating is also essential in cholera prevention[55]

HYGIENE PROMOTION AND SOCIAL MOBILIZATION

Health education campaigns should promote hygiene practices adapted to local culture and beliefs, such as hand sanitation, safe preparation, and storage of food, and safe disposal of faeces of children. Funeral practices for individuals who die from cholera must be cautioned to prevent infection among attendees. Information should be provided to the community about the potential risks, symptoms of cholera, precautions to take to avoid cholera, when and where to report cases, and to seek immediate treatment when symptoms appear[55].

Oral Cholera Vaccines

Currently, there are three WHO pre-qualified oral cholera vaccines (OCV) Dukoral, Shanchol, and Euvichol-plus®. All three vaccines require two doses for full protection.

Dukoral is a killed whole-cell vaccine including *V. cholerae* 01 serogroup and the recombinant B subunit of cholera toxin. It can be given to children older than two years and adults. For children, 2 – 5 years of age, three doses, 1-6 weeks apart, are given orally, and a booster dose is given after six months. For adults and children older than six years, two doses, 1-6 weeks apart, are given orally while a booster dose is given after two years. The earliest onset of protection is seven days after the second dose. The protection at six months is 85-90%[56]

Shanchol is a killed bivalent (01 and 0139 serogroups) whole-cell vaccine suspension. Shanchol and Euvichol-plus® are essentially the same vaccines produced by two different manufacturers. They are given to all individuals over the age of one year, two doses, two weeks apart, given orally. The earliest onset of protection is 7-10 days after the second dose, and there is 65% protection for at least [57].

Shanchol and Euvichol-plus are the vaccines currently available for mass vaccination campaigns through the global OCV stockpile.

Based on the available evidence, the August 2017 WHO position paper on vaccines against cholera states that[58]:

- OCV is used in endemic cholera areas, in humanitarian crises with a high risk of cholera, and during cholera outbreaks; always in conjunction with other cholera prevention and control strategies;
- Vaccination should not disrupt the provision of other high priority health interventions to control or prevent cholera outbreaks.

More than 30 million doses of OCV have been used in mass vaccination campaigns.

III. CONCLUSION

Cholera is an indicator of a lack of social development and a global threat to public health with a rapidly increasing population and insurgency in Nigeria. The population living in unsanitary conditions is increasing. Hence, resources are being diverted to the care of cholera patients. There is limited epidemiological information on studies regarding the extent of infection and the characteristics of circulating strains in Nigeria. In the last ten years, the Northern part of Nigeria has experienced multiple large cholera outbreaks associated with significant mortality.

Community engagement is the key to long term changes in behaviour and the control of cholera.

REFERENCES

[1]. Israel OA, George OA, Rowland OA. Contemporary Nigeria public health problem: Prevention and surveillance are key to combating cholera. GMS Hyg. Infect Control 2019;14 Doc16. Available from https://www.ncbi.nih.gov accessed at 14 June 2020

[2] GMS | GMS Hygiene and Infection Control | Contemporary https://www.egms.de/static/en/journals/dgkh/2019-14/dgkh000331.shtml

[3] Available at https://www.travelhealthpro.org.uk/factsheet/56/cholera.

[4] Adagbada OA, Adesida AA, Nwaokorie OF, Niemogha MT, Coker AO. Cholera epidemiology in Nigeria an overview. Pan Afr Med J. 2012;59:1-12

[5] Cholera vaccines: WHO position paper. Wkly Epidemiol Rec. 2010 26 March;85(13):117-128. Available at https://www.who.int/wer/2010/wer8513.pdf.Accessed on 18 June 2020.

[6] World Health Organization. Cholera – key facts, 2018. Available from: https://www.who.int/en/news-room/fact-sheets/detail/cholera.Accessed on 18 June 2020.

[7] GMS | GMS Hygiene and Infection Control | Contemporary https://www.egms.de/static/en/journals/dgkh/2019-14/dgkh000331.shtml

[8] Usman A, Sarkinfada F, Mufunda J, Nyarango P, Mansur K, Daiyabu TM. Recurrent cholera epidemic in Kano-Northern Nigeria. Cent Afr J. Med. 2005 Mar-Apr; 51(3-4):38-4.

[9]. Umoh, JU, Adesiyun AA, Adekeye JO. Epidemiological Features and Outbreaks of Gastroenteritis/Cholera in Katsina Northern Nigeria. J Hyg Camb. 1983; 91:101-111.

[10] Two thousand fifty cases and 80 deaths in 2001. Faruque SM, Albert MJ, Mekalanes JJ, Epidemiology, genetics and ecology of choleragenic Vibrio cholerae. Microbiol. Mol. Biol. Rev. 1998 Dec 62(4) 1901-14.

[11] Igomu T. Cholera epidemic: far from being over, NBF News. www.nigerianbestforum.com/blog/?p=60321 Accessed on 22 June 2020

[12] World Health Organization. Cholera-Nigeria 2017. Available from https://www.who.int/csr/don/12-July-cholera-nigeria/en/.Accessed on 18 June 2020.

[13] Available from http://reliefweb.int/node/2094509, accessed on 13 June 2020.

[14] Available at https://www.plateformecholera.info/index.php/country-monitoring/nigeria. Accessed at 24 June 2020

[15] Unicef, Cholera epidemiology, and Response Factsheet Nigeria 2018. Available at https://www.unicef.org/cholera/files/UNICEF-factsheet-Nigeria-EN-FINAL.pdf.Accessed on 24 June 2020.

[16] National monthly update for Cholera in Nigeria October 2019 (epi week 39-43) situation report. Nigeria Centre for Disease Control. Accessed on 2 July 2020

[17] Available at https://www.wikipedia.org "serotype of Vibrio cholerae" accessed at 16 June 2020.

[18] Available at https://www.medscape.com "serotype of Vibrio cholerae" accessed on 16 June 2020.

[19] Sozhamannan S, Yildiz FH. Diversity and Genetic Basis of Polysaccharide Biosynthesis in Vibrio cholerae In Epidemiological and Molecular Aspects on Cholera. Infect Dis. 2011; 129-160.

[20] Utsalo SJ, Eko FO, Umoh F, Asindi AA. Faecal excretion of Vibrio cholerae during the recovery of cholera patients in Calabar, Nigeria. Eur. J. Epidemiology 1999 15 April (4):379-81.
Opajobi SO, Kandakai OYT, Mawak JD, Olukemi MA, Bello CSS. Vibrio cholerae 01 infections in Jos, Nigeria. African J. Clin Exp, Biol. 2004; 5(3):260-264
Shittu OB, Akpan TO, Popoola S, Oyedepo JA, Ogunshola EO, Epidemiological features of a GIS-supported investigation of the cholera outbreak in Abeokuta, Nigeria. J Public Health Epidemiol. 2010;2(7):152-162.
[21] T. Sharmila 2018, the pathogenesis of cholera; recent prospective in rapid detection and prevention of cholera. http://www.intechopen.com>books. Accessed on 4 July 2020.
[22] Taylor RK, Miller VL, Furlong DB, Mekalanos JJ. Use of phoA gene fusions to identify a pilus colonization factor coordinately regulated with cholera toxin. *Proc Natl Acad Sci U S A*. 1987;84:2833-2837.
[23] Centre for Disease Control and Prevention (CDC) update outbreak of Cholera – Hait 2010. MMINR, morbidity, and mortality weekly report 2010; 59;1586
Harris JB, Larocque RC, Chowdhury F. et al. Susceptibility to *Vibrio cholerae* infection in a cohort of household contacts of patients with Cholera in Bangladesh. PLOS neglected Tropical Diseases 2008; 2e221 production of an endotoxin called CT is the primary violence mechanism.
[24] Harris JB, Khan AI, LaRocque RC. Blood group, immunity, and risk of infection with *Vibrio cholera* in an area of endemicity. Infection and Immunity. 2005;73(11):3422-7427 DOI: 10.1128/IAL.73.11.7422-7427.2005
[25]Nelson E, Harris JB, Morris JG, et al. Cholera transmission: the host, pathogen, and bacteriophage dynamic, native reviews Microbiology 2009;7.693
Silva Anisia, Benitez A, Vibrio cholera bio-films and cholera pathogenesis, PLOS Neglected Tropical Diseases 2016; DOI: 10-2/e00004330.
Saulat J. Cholera; Epidemiology, Prevention, and Control. Agricultural and biological sciences significance, prevention, and control of food-related disease 2015 978-953-51 2277-7DOI:10-57772/63358.
[26] Azman AS, Rudolph KE, Cummings DA, Lessler JJ. The Incubation period of cholera, a systematic review. Infect 2013;66(5)432-8d0101016/j.jinf 2012.11.013. Pub. Med. PMID:23201968. Pub. Med. Central PMCIO PMC3677557. Available at http://www.ncbl.nim.nih.gov/pubmed/23201968. Accessed on 12 June 2020.
[27]et with the World Health Organization standard. Accessing the outbreak response and improving preparedness (2004) available at https://apps.who.int/iris/bitstream/10665/43017/1/WHO_CDS_CPE_ZFK_2004.4_eng.pdf
[28] Water sanitation and hygiene and cholera epidemiology: evaluated in the country of Lake Chad Basin, Mission reported by; Pierre Yver Oger and Betrand Sudre for Unicef.
[29] http://www.plateformcholera.info/indexphp/country-monitoring/nigeria accessed at 6 June 2020
[30] Qadi F, Enterotoxigenic Escherichia coli and Vibrio cholerae diarrhoea, Bangladesh, 2004. Emerg Infect Dis. 2005 Jul;11(7):1104-7.
[31], F.P. Van Loon, J.D. Clemens, M. Shahrier, et al. Low gastric acid as a risk factor for cholera transmission: application of a new non-invasive gastric acid field test. J. Clin Epidemiol, 43(12) (1990) pp. 1361 – 1367.
Sack DA, Sack RB, Nair GB, Siddique Ak. Cholera. Lancet 2004 17 January;363(9404):223-33.
[32]RI Glass, J. Holmgren, C.E. Haley, et al. Predisposition for Cholera of individuals with O blood group. Possible evolutionary significance. Am J. Epidemiol, 121(6) (1985), pp. 791-796.
J.D. Clemens, DA Sack, J.R. Harris et al. ABO blood groups and Cholera new observation on the specificity of risk and modification of vaccine efficacy. J. Infect Dis, 159(4) (1989), pp. 770 – 773.
[33] G.A. Losonky, J. Yunyongying, V. Lim, et al. factors influencing secondary vibriocidal immune responses: relevance for understanding immunity to cholera. Infect immune, 64(1) (1996),pp 10 – 15.
[34] Laroque RC, Sabeti P, Duggal P, Chowdhury F, Khan AL, Lebrun LM; et al. (2009). " A variants of in long palate, lung and nasal epithelium clone 1 is associated with cholera in Bangladeshi population" Genes Immune. 10(3):267-72. DOI:10.1038/gene.2009.2.
[35] Jason BH, Regina CL, Fahima C, Ashraful IK, Tanya K, Abu SGF, et al. "susceptibility to Vibrio cholerae infection in a cohort of household contacts of patients with cholera in Bangladesh". PLoS Negl Trop Dis. 2008 Apr; 2(4):e221.
[36]Hsiao A., Ahmad A.M., Subramanian S., et al. Members of the human gut microbiota involved in recovery from *Vibrio cholerae* infection. Nature, 515 (7527) (2014), pp 423 – 426.
[37] Harris JB, LaRocque RC, Qadri F, et al. cholera. Lancet 2012;379:2466
[38] Ndon JA, Udo SM, William B. Vibrio-Associated Gastroenteritis in the Lower Cross-River Basin of Nigeria. J Clin Microbiol, 1992;30(10):2730-2732.
[39] WHO. WHO position paper on Oral Rehydration Salts to reduce mortality from cholera.pdf – 1 page. Who Global Task Force on cholera control.
[40] Prevention and control of cholera outbreak: WHO policy and recommendations – WHO available at https://www.who.int>index1. Accessed on 25 July 2020.
[41] when given in community-based supplementation programs. Fisher Walker CL, Black RE. Micronutrient and diarrheal disease. Clin. Infect Dis. 2007;45(Suppl1)S73-7.
[42]oea Imran Qadri M, Arfa Arshad, and Bashir Ahmad. Zinc: Role in the management of diarrhoea and cholera" World J Clin Cases 2013 16 July; 1(4): 140-142.
[43]. Yahaya M, Aaron O. Aboderin. Inuka N Okeke, Adebola TO Antimicrobial resistance of Vibrio Cholerae from Sub-Sahara Africa; A systematic review Afri J. Lab Med. 2018 7(2) 778
[44] Salim A, Lan R, Reeve PR. Pathogenic clones. Emerge Infect Dis. 2005. 11:1758-1760. 10.3201/eid1111.041170 [PMC free article] [PubMed] [CrossRef] [Google Schoolar]
[45] Kitaoka M, Miyata ST, Unterweger D, Pukafzki S. Antibiotic resistance mechanisms of Vibrio Cholerae. Med microbial (serial online) 2011 60:397-407. Available from http://wwww.ncbi-nlm.nih.gov/pubmed/21252269. Accessed on 25 July 2020.
[46] Ceccarelli D. Spagnoletti M. Bacciu D, Cappuceinelli P. Mavro Mic, New Vibrio Cholerae typical El-Tor variant emerged during the 2006 epidemic outbreak in Angola BMC Microbial 2011:11:130 10.118611471-2180-11-130
[47] Sjolund-Karlsson M, Reimer A, Folster JP, Walker M, Dahourou GA, et al.; Drug resistance mechanism in Vibrio Cholerae 01 outbreak strain, Haiti, 2010. Emerg Infect Dis 17:2151 – 2154 Available at http://wwwnc2.cdc.gov/eid/pdfs/11-0720-ahead_of_print.pdf. Accessed on 26 July 2020.
Kim H Bin, Wang M, Ahmad S, Park CH, LaRocque RC, et al. Transferable quinolone resistance in Vibrio Cholerae. Antimicrobial agents and chemotherapy 54:799-803 available at http://www.pubmedcentral,nih.gov/articlerender.fcgi? Accessed on 26 July 2020

[48] Ang GY, YU CY, Balqis K, Elina HT, Azura H, et al.; Molecular evidence of cholera outbreak caused by toxigenic Vibro cholera 01 El tor variant strain in Kelantan, Malaysia. Journal of clinical microbiology 48:3963 – 3969 available at http://www.pubmedcentral.nih.gov/articlerender.fcgi? Accessed on 24 July.
[49] Mintz Ed, Guerrant RL. A lion in our village-the unconscionable tragedy of cholera in Africa. The new England journal of medicine 360:1060 – 1063. Available at; http://www.ncbi.nlm.nih.gov/pubmed/20668130. Accessed on 26 July 2020.
[50] Kaas RS, Ngandijo A, Nzouankeu A, et al. The Lake Chad Basin, an isolated and persistent reservoir of Vibrio Cholerae 01: A genomic insight into the outbreak in Cameroon, 2010. Plos One. 2016;11(5): e0155691 10.1371/journal.pone.0155691
Kacou-N'douba A, Blessa Anne JC, Okpo LS, Elogne-Kouame C, Koffi S, Koffi V. Antimicrobial resistance of Vibrio Cholerae 01 isolated during a cholera epidemic in 2011 in the dry season in Cote d'Ivoire. J Infect Dev Ctries. 2012;6(7):595-597.10.3855/jidc.2001
[51] Michel A. Marin, Cristiana C. Thompson, Fernandas Freitas, Erica L. Fonseca, A. Dolapo Aboderin, Sambo B. Zailani, et al. "cholera outbreaks in Nigeria are associated with multidrug-resistant atypical El-Tor, and non 01/non 0139 Vibrio Cholerae/ PLoS neglected Tropical Diseases 7(2): ez049.
[52] World Health Organization. Cholera – key facts, 2018 (accessed 2020 14 June) available from http://www.who.int/en/newsroom/fact-sheets/details/cholera.Accessed 22 July 2020.
[53] Purdy AE. Fly Models of Vibrio Cholerae infection and Colonization. Methods Mol Biol. 2018; 1839:77-96 DOI: 10.1007/978-1-4939-8685-9_8.
[54] Zhang Y, Sivakumar M, Yang S, Enever K, Ramezanianpour M. Application of solar every in water treatment processes: A review. Desalination. 2018; 428:116-145: DOI: 10.1016/j.desal. 2017.11.020.
[55] World Health Organization/Emerging and other Communicable Diseases, Surveillance, and Control. WHO guidance on the formulation of national policy on the control of cholera. WHO/CDD/SER/92.16 REV.1. 1992 (assessed 2020 14 June) available from http://www.who.int/topics/cholera/publications/WHO/CDD/SER/92. 16/en/
Gidado S, Awosanya E. Haladu S, Ayanleke HB, Idris S, Mamuda I, Mohammad A, Micheal CA, Waziri NE, Nguku P. Cholera outbreak in a naïve rural community in Northern Nigeria: the importance of handwashing with soap, September 2010. Pan Afr. Med. J. 2018 May 4:30:5. Doi: 10.11604/pamj.2018.30.5.12768.

[56] WHO|Cholera: Oral Cholera Vaccines: use of Oral Cholera Vaccines in Humanitarian Emergencies (internet) available at http://www.who.int/cholera/vaccines/OCV_in_humanua=1 accessed on 14 June 2020.
[57]five years of Cholera vaccines: WHO position Paper – August 2017 http://apps.who.int/iris/bitstream/10665/258764/1/v477-498.pdf. Weekly Epidemiology record 25 August 2017 no 34, 2017,92,477-500.Accessed 25 July 2020.
[58] Cholera annual report 2017 http://www.who.int/wer/2018/wer9338/en/weekly Epidemiological Record 21 September 2018 Vol. 93, 38 (pp 489 – 500). Accessed 20 July 2020.

Fig. 1: Summary of cholera hotspots areas in Nigeria by LGA, 2010- 2014

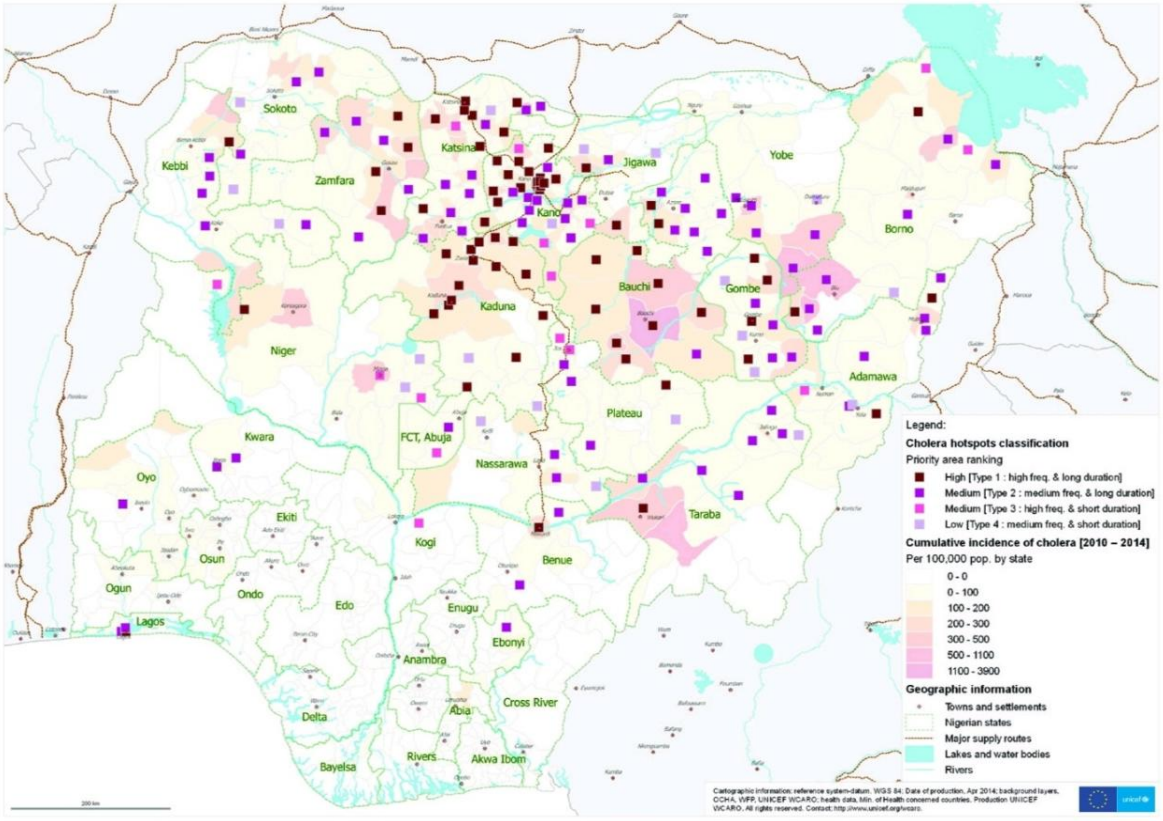

Table 1: Cholera pandemics,1817 till present

Pandemic	Years	Origin	Other region affected	Pathogen
First	1817-1823	India	South-east Asia, Middle East, and East Africa	*Vibro cholera serogroup 01 biotype classical*
Second	1829-1851	India	South-east Asia, Middle East Europe, America, and Africa	*Vibro cholera serogroup 01 biotype classical*
Third	1852-1859	India	South-east Asia, Middle East Europe, America, and Africa	*Vibro cholera serogroup 01 biotype classical*
Fourth	1863-1879	India	South-east Asia, Middle East Europe, America, and Africa	*Vibro cholera serogroup 01 biotype classical*
Fifth	1881-1896	India	South-east Asia, Middle East Europe, America, and Africa	*V. cholerae 01, classic*
Sixth	1899-1923	India	South-east Asia, Middle East Europe, America, and Africa	*V. cholerae 01, classic*
Seventh	1961 to present	Sulawesi (Celebes), Indonesia	South-east Asia, Middle East Europe, South America, and Africa	*V. cholerae 01, El Tor*
Eight	1992 to present	Madras, India	South-east Asia	*V. cholerae 0139*

Adapted from (4)

Table 2: Epidemiology parameters of cholera outbreaks by leading affected states in Nigeria, 2004 -2014

State	Cases / Deaths [1]	% of total cases	CFR (%)	Number of year with notified cases [2]
Katsina*	61 790 / 1 240	31.1	2.0	9
Bauchi*	33 430 / 290	16.8	0.9	8
Kano*	13 430 / 160	6.8	1.2	9
Borno*	12 510 / 510	6.3	4.0	7
Gombe*	10 340 / 180	5.2	1.8	7
Kaduna*	9 520 / 170	4.8	1.8	5
Zamfara*	6 410 / 180	3.2	2.8	4
Adamawa	6 360 / 440	3.2	6.9	4
Sokoto*	6 330 / 360	3.2	5.7	5
Taraba	5 590 / 180	2.8	3.2	6
Niger	4 590 / 110	2.3	2.4	2
Lagos	4 060 / 20	2.0	0.6	6
Yobe*	3 180 / 160	1.6	5.1	2
Kebbi*	2 850 / 70	1.4	2.5	3
Jigawa*	2 690 / 120	1.3	4.3	5
Nassarawa	2 550 / 70	1.3	2.5	6

Note. [1]Total cases ≈ 199,000 and total deaths ≈ 4,600 between 2004 and 2014; [2] Number of years with more than 50 notified cholera cases between 2004 and 2014; *: States of Northern part.

Adapted from Unicef

Table 3: Epidemiology parameters of cholera outbreaks in most affected states in Nigeria, 2010 -2017

State	Cases / Deaths [1]	% of total cases	CFR %	Number of outbreaks	Outbreak duration (average in weeks)
Bauchi	30579 / 334	25	1.1	6	21.83
Borno	14491 / 414	11.9	2.9	7	18
Kano	13049 / 351	10.7	2.7	7	29.14
Kaduna	9964 / 247	8.2	2.5	6	36.33
Katsina	9528 / 420	7.8	4.4	7	8.86
Zamfara	6748 / 229	5.5	3.4	8	12.62
Kebbi	4810 / 281	3.9	5.8	9	9.78
Gombe	4592 / 166	3.8	3.6	5	19.4
Taraba	3575 / 127	2.9	3.6	3	35.67

Note: [1] Total cases = 122,239 and total deaths = 3,713 between 2010 and 2017.

Table 4: Large cholera outbreaks in Nigeria

Nigeria largest number of reported cholera cases and resulting deaths between 1971 and 2019

Year	Reported cases	Recorded deaths	Case fatality rate (%)
1971	22,931	2,945	12.8
1991	59,478	7,654	12.9
2001	2,050	80	4.0
2005	37,289	1,434	3.4
2008	5,140	247	4.8
2009	13,691	431	3.2
2010	41,787	1,716	4.0
2011	22,454	715	3.2
2018	43,996	836	1.9
2019	1,583	22	1.38

Source: Nigeria Centre for Disease Control, Date accessed 24 June 2020.