

# Cholera Recurrence within Benin Littoral County: Analysis of Epidemics from 2008, 2016 to 2023

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**How to cite this paper:** Virginie, M., Valentin, A., Evariste, A., Ghislain, S., Badirou, A. and Edgard-Marius, O. (2024) Cholera Recurrence within Benin Littoral County: Analysis of Epidemics from 2008, 2016 to 2023. *Open Journal of Epidemiology*, **14**, 353-365.

<https://doi.org/10.4236/ojepi.2024.142025>

**Received:** May 9, 2024

**Accepted:** May 24, 2024

**Published:** May 27, 2024

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## Abstract

**Introduction:** Cholera is an acute diarrheal infection caused by the bacillus *Vibrio cholerae*, which can be fatal in a few hours if left untreated. It rages in endemic-epidemic mode in several countries, including Benin. Despite being the economic capital, the largest city in Benin and the most urbanized municipality in the country, the Littoral County, confounded with the city of Cotonou, is subject to recurrent epidemics. This paper aims to analyze successive cholera epidemics with a view of highlighting the factors contributing to this recurrence. **Methods:** A secondary analysis was done of the cholera-related databases of the County health office from 2016 to 2023, and its Situation Report No. 79 of December 7<sup>th</sup>, 2016, to describe the 2016 epidemic. Database data were analyzed in Excel. **Results:** Similarly to 2008, the 2016 cholera epidemic in Cotonou, which recorded 519 cases and 07 deaths, i.e. a case-fatality rate of 1.35%, spread to the town and six neighboring municipalities. The municipality of So-Ava, home to the index case, had the highest overall attack rate. The two epidemics share the same period of severity. Both epidemic and endemic cases are concentrated in the first seven boroughs of Cotonou, located on the lagoon shore, with low levels of hygiene and sanitation and a poor supply of drinking water. **Conclusion:** Low levels of hygiene, sanitation and drinking water supply all play a part in the recurrence of cholera epidemics. Sanitation work. Undertaken by the Beninese government is a ray of hope for improving this situation. Meanwhile, public awareness of hygiene measures must continue.

## Keywords

Recurrence, Cholera, Cotonou

## 1. Introduction

Cholera is an acute diarrheal infection caused by the bacterium *Vibrio cholerae*, lethal within hours if left untreated. Worldwide, cholera remains a threat to public health and an indicator of poor social development [1].

In spite of the availability of effective, affordable treatment and cholera vaccines, it remains a major public health issue worldwide, particularly in sub-Saharan Africa. A disease with epidemic potential, cholera is endemic-epidemic in several countries.

Every year, there are an estimated 1.3 to 4 million cases of cholera, and 24,000 to 143,000 deaths worldwide [1]. In 2015, 42 countries reported a total of 172,454 cholera cases, including 1,304 deaths, representing a case-fatality rate of 0.8%. Of these cases, 41% came from Africa [2]. In 2017, more than 150,000 cases of cholera, including 3,000 deaths, were reported in 17 countries in the African region, representing a case-fatality rate of 2.3% [3]. In 2022, 472,697 cases and 2,349 deaths were reported in 44 countries [4]. Concern has been expressed by the World Health Organization (WHO) about a possible increase in the burden of cholera, and about the outbreak of large-scale outbreaks in major cities [3].

Among contributing factors to cholera are poor access to drinking water and low levels of hygiene and sanitation.

In Benin, cholera epidemics are now almost an annual occurrence, generally happening during the rainy season. Between 1970 and 2014, Benin recorded 29,502 cases of cholera including 945 deaths, representing a case fatality rate of 0.032%. In 2014, the country recorded 863 cases of cholera including 13 deaths between the 3rd and 48th epidemiological weeks. The departments of Atacora and Atlantique were particularly affected. Analysis of data over the last ten years shows us that the coastal departments: Littoral, Atlantique, Oueme and Mono recorded more than 60% of notified cases. After the 2016 epidemic in the Atlantic and Littoral departments, the year 2021 saw two waves of epidemics, one in the Atlantic Department and the other in the departments of Atlantic, Alibori, Atacora, Collines, Donga, Littoral, Mono and Oueme. This year 2021 recorded 1533 cases including 20 deaths, i.e. a lethality of 1.3% [5] [6].

The global cholera situation is so alarming that WHO has created a Roadmap to 2030, a new global strategy to interrupt disease transmission and reduce cholera deaths. The strategy, launched in 2017, aims to reduce cholera deaths by 90%. It is based on the Identification of Priority Multisectoral Intervention Areas (PAMI) to optimize the impact of the implementation of a National Cholera Control Plan (PNC). To this end, the analysis of epidemic data over five to 15 years will make it possible to classify all the operational geographical units of the PNC of a country (Togo and Nigeria for Benin) according to a numerical priority index and to validate the definitive list of PAMI. The selected areas will benefit from a situational analysis with a view

to developing operational plans focused on the pillars of prevention and control of cholera including epidemiological surveillance, vaccination, Water, Hygiene and Sanitation, commitment community and strengthening the health system.

The strategy focuses on controlling the epidemic, through early detection and rapid response, through a targeted multi-sectoral approach to prevent the recurrence of cholera [3]. This last approach seems to us to be the most important in the fight against cholera. With this in mind, we undertook an analysis of the cholera epidemics of 2008 and 2016 in the Littoral department, an endemic-epidemic for cholera, in order to identify the factors favoring the recurrence of epidemics and, in order to propose solutions. that can contribute to achieving the objectives of the roadmap.

## 2. Study Framework

Littoral is one of the twelve and the smallest departments of Benin. It merges with the city of Cotonou, the economic capital and largest city of Benin. It is bounded to the north by Lake Nokoué, to the south by the Atlantic Ocean, to the east by the municipality of Sèmè-kpodji (Ouémé County) and to the west by the municipality of Abomey-Calavi (Atlantic County). Covering an area of 79 Km<sup>2</sup> on either side of the lagoon that links Lake Nokoué to the Atlantic Ocean, the Littoral County had an estimated population of 761.969 in 2016, 100% urban and 79% educated, spread over 13 boroughs subdivided into 140 city districts, with a density of 9645 inhabitants/km<sup>2</sup> [7].

In terms of the healthcare system, these 13 boroughs are grouped into four health zones (districts), as shown in **Table 1** below:

The Littoral County, like the rest of southern Benin, has two rainy and two dry seasons: a long rainy season from mid-March to mid-July and a short one from mid-September to mid-November; a long dry season from mid-November to mid-March and a short one from mid-July to mid-September. Rainfall occurs mainly between March and July, with a peak in June (300 mm to 500 mm), leading to flooding in several neighborhoods.

The Littoral County has no rivers, but Lake Nokoué (85 km<sup>2</sup>) and a few low-lying areas are the county's water reservoirs.

Access to drinking water and sanitation is still a major problem in many districts [7].

**Table 1.** Health zones of the Littoral County (city of Cotonou).

Health zones (districts)	Corresponding boroughs
Cotonou I and IV	5 <sup>th</sup> and 6 <sup>th</sup>
Cotonou II and III	1 <sup>st</sup> to 4 <sup>th</sup>
Cotonou V	7 <sup>th</sup> to 10 <sup>th</sup>
Cotonou VI	11 <sup>th</sup> to 13 <sup>th</sup>

### 3. Study Design

This is a retrospective study with a descriptive aim, focusing on the analysis of secondary data. For this purpose, we used data on the 2008 cholera epidemic, through three publications [6] [8] [9], the database on the 2016 cholera epidemic, Situation Report Number 79 of December 7, 2016, describing the 2016 epidemic and the databases on cholera from 2017 to 2023 in the Littoral department.

Databases were analyzed in Excel software. The data were described according to the characteristics of the people, time and place, according to the characteristics recorded in the databases. For this purpose, the parameters of central tendency and dispersion were used. The scale and severity of the epidemic were respectively described by the attack rate (number of cases reported to the population at risk) and lethality (proportion of deaths among recorded cases).

In relation to people, cholera cases were distributed according to sex, age groups and professional categories.

For the distribution over time, we traced the epidemic curve, given by the distribution of cholera cases according to epidemiological weeks.

For geographical distribution, cholera cases were distributed according to administrative divisions, municipalities and districts, as indicated in the databases. The Cotonou case data was mapped according to the attack rate by the district.

### 4. Results

#### 1) DESCRIBING 2016 OUTBREAK

- **Scope and severity**

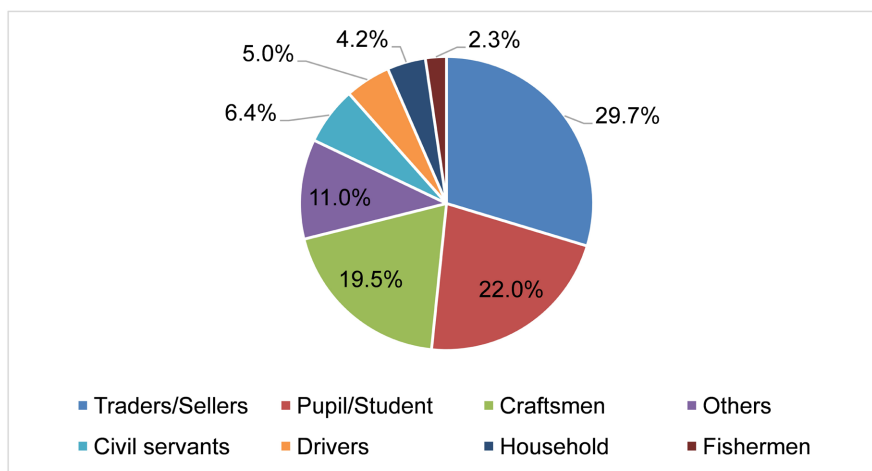
The 2016 cholera epidemic in Cotonou recorded 519 cases, including 07 deaths, for a case-fatality rate of 1.35%. The attack rate varied from 1.6 to 95.0 cases per 100.000 inhabitants from one municipality to another, with great variation between them, especially in Cotonou.

- **Distribution of cases by age group and sex**

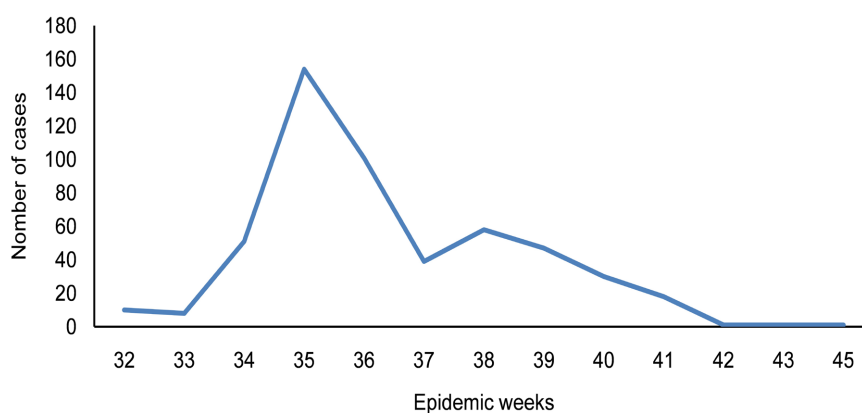
Cases ranged in age from one to 75 years, with a mean of  $28.3 \pm 16.9$  years. **Table 2** below shows the distribution of cases by age and gender.

**Table 2.** Distribution of cholera cases by age and gender; Cotonou 2016 (n = 519).

Age (years)	Sex		Total n (%)
	Male n (%)	Female n (%)	
0 - 4	14 (5.1)	17 (6.9)	31 (6.0)
5 - 14	48 (17.6)	42 (17.1)	90 (17.3)
15 - 24	54 (19.8)	54 (22.0)	108 (20.8)
25 - 34	54 (19.8)	51 (20.7)	105 (20.2)
35 - 44	59 (21.6)	38 (15.4)	97 (18.7)
45 - 54	27 (9.9)	20 (8.1)	47 (9.1)
55 and more	17 (6.2)	24 (9.8)	41 (7.9)
<b>Total</b>	<b>273 (100.0)</b>	<b>246 (100.0)</b>	<b>519 (100.0)</b>



**Figure 1.** Distribution of cholera cases by occupation in Cotonou, 2016 (n = 519).



**Figure 2.** Cholera epidemic curve in Cotonou, Benin in 2016 (n = 519).

Most cases (52.6%) were male, and around one in four was a child under the age of 14.

The distribution of cases according to occupation, shown in **Figure 1** below, shows that shopkeepers/vendors, pupils/students and craftsmen were the most affected by the epidemic, accounting for around 70% of cases.

- **Distribution of cases by time**

In Cotonou, the 2016 cholera epidemic ran from August 09<sup>th</sup> to September 16<sup>th</sup>, 2016. lasted 24 epidemiological weeks, 32 to 45, as shown by the epidemic curve in **Figure 2**. The index case was admitted to the Dékanmey Health Center in So-Ava municipality on August 09<sup>th</sup>, 2016.

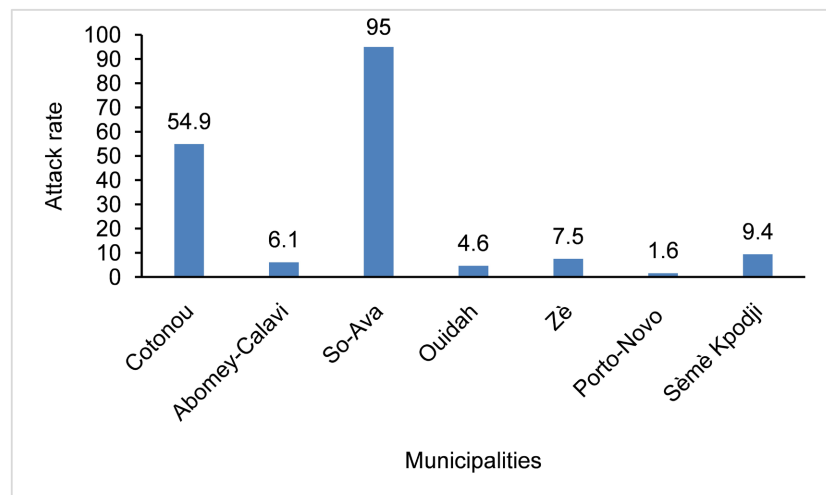
The curve is bimodal, uninterrupted. The first at 160 cases at week 35, with rapid growth and decline. The second peak at 60 cases, at the 38<sup>th</sup> week, has a slower decline, in five weeks (38<sup>th</sup> to 42<sup>nd</sup>)

- **Geographical distribution of cases**

Cases recorded during the epidemic were spread over three counties: Littoral, Atlantic and Ouémé, as shown in **Table 3** below, from which it can be seen that around eight out of ten cases originated in Cotonou.

**Table 3.** Distribution of cholera cases and deaths by department of origin; Cotonou. 2016 (n = 519).

Municipalities	Cas n (%)	Deaths n (%)
<b>County of Littoral (Cotonou)</b>		
Cotonou IV	130 (25.05)	0
Cotonou II	127 (24.47)	2 (28.57)
Cotonou III	70 (13.49)	3 (42.86)
Cotonou V	33 (6.36)	0
Cotonou VI	30 (5.79)	0
Cotonou I	28 (5.39)	0
<b>Sub-total</b>	<b>419 (80.73)</b>	<b>5 (71.43)</b>
<b>County of Atlantic</b>		
Abomey-Calavi	35 (6.74)	0
Sô-Ava	29 (5.59)	1 (14.28)
Ouidah	4 (0.77)	0
Ze	2 (0.39)	0
<b>Sub-total</b>	<b>70 (13.49)</b>	<b>1 (14.28)</b>
<b>County of Ouémé</b>		
Sèmè-Kpodji	29 (5.59)	1
Porto-Novo	1 (0.19)	0
<b>Sub-total</b>	<b>31 (5.97)</b>	<b>1 (14.28)</b>
<b>Total</b>	<b>519 (100)</b>	<b>7 (100)</b>

**Figure 3.** Cholera attack rate (per 100.000 inhabitants) by municipality, during the 2016 epidemic (n = 519).

In terms of mean attack rate, the municipality of So-Ava is the most affected, as shown in **Figure 3**.

In **Figures 4 and 5**, respectively, the affected municipalities and Cotonou's boroughs are shown according to their attack rate.

A comparison of attack rates (per 100.000 inhabitants) in Cotonou's 13 boroughs during the 2008 and 2016 epidemics is shown in **Figure 6** below.

We see in this figure that both for the 2008 epidemic and for 2016 figures in Cotonou, cholera cases are concentrated in the first seven districts.

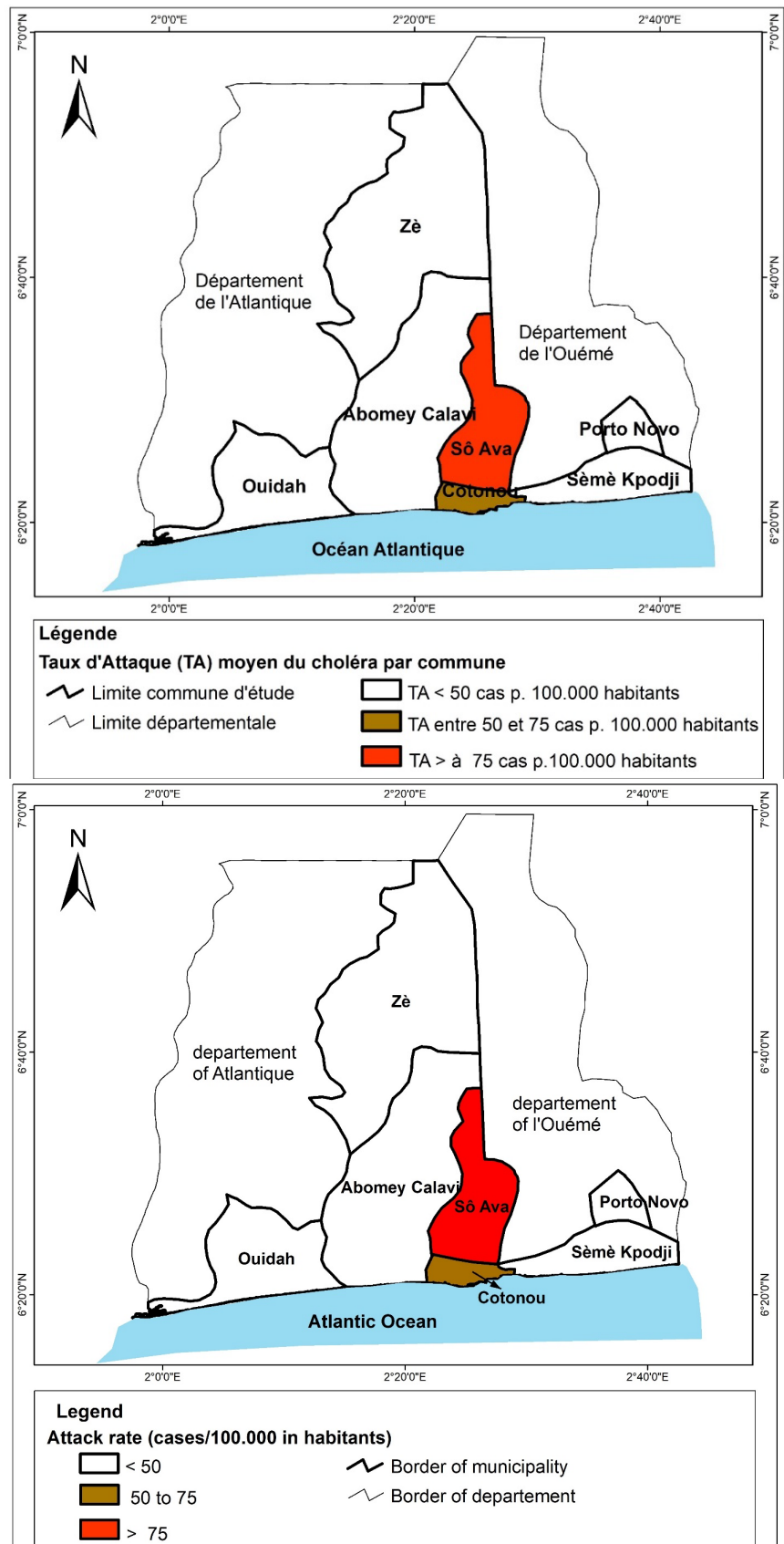


Figure 4. Map of municipalities affected by cholera in 2016 by attack rate (n = 519).

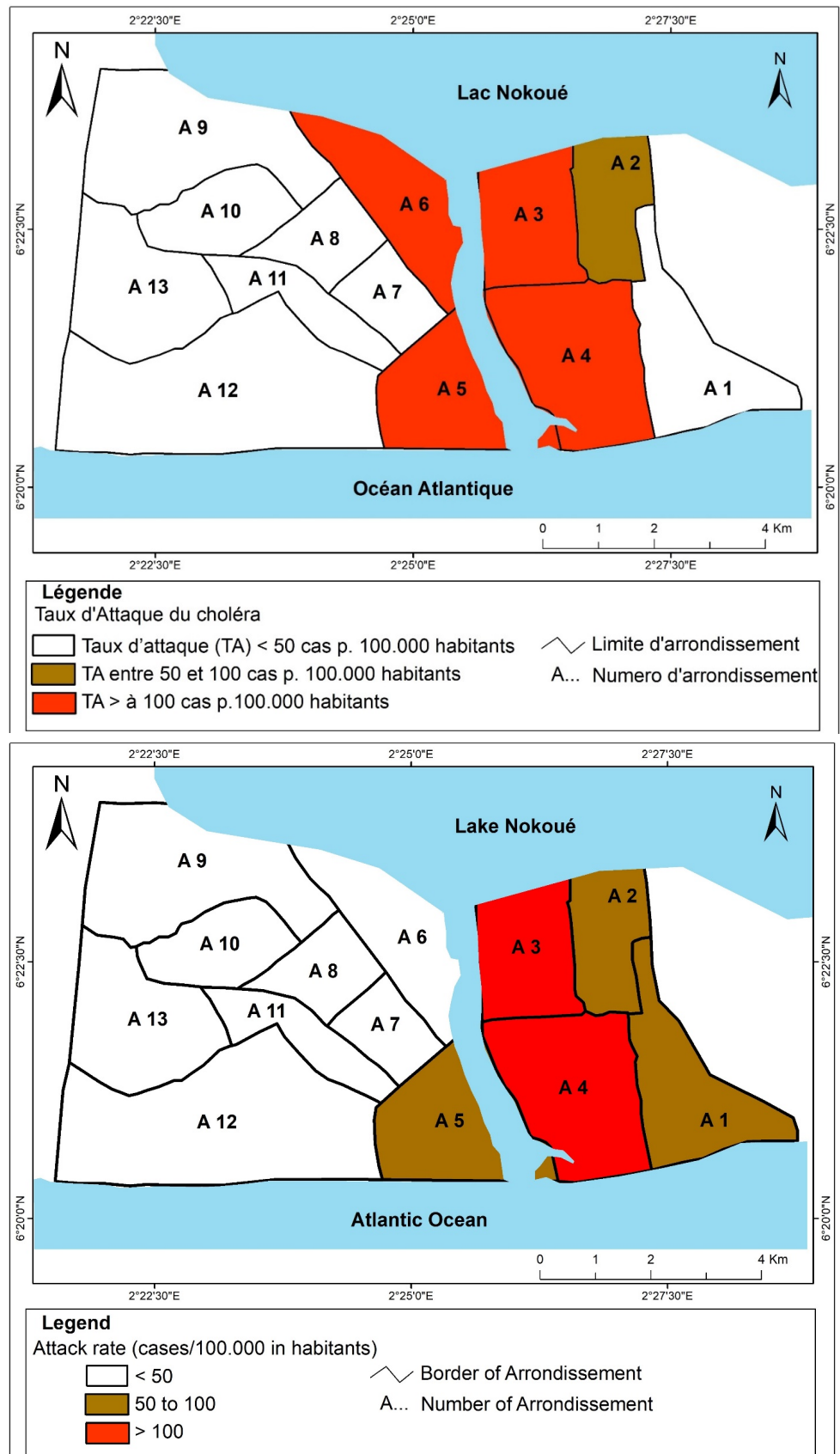
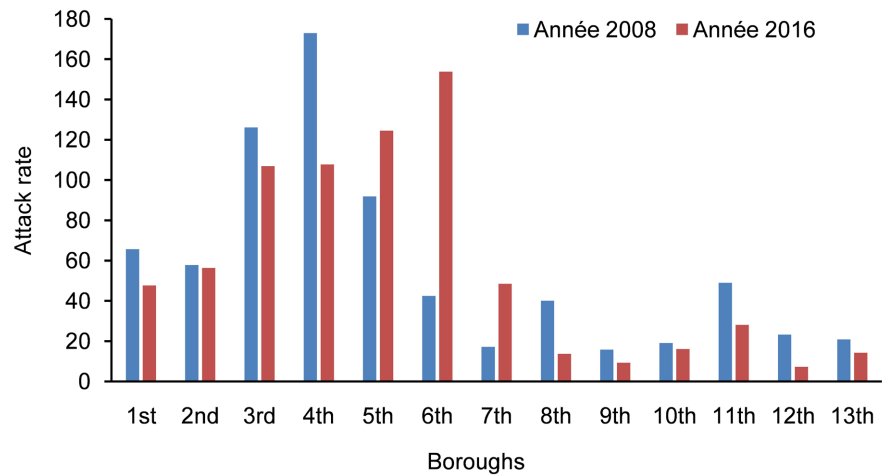
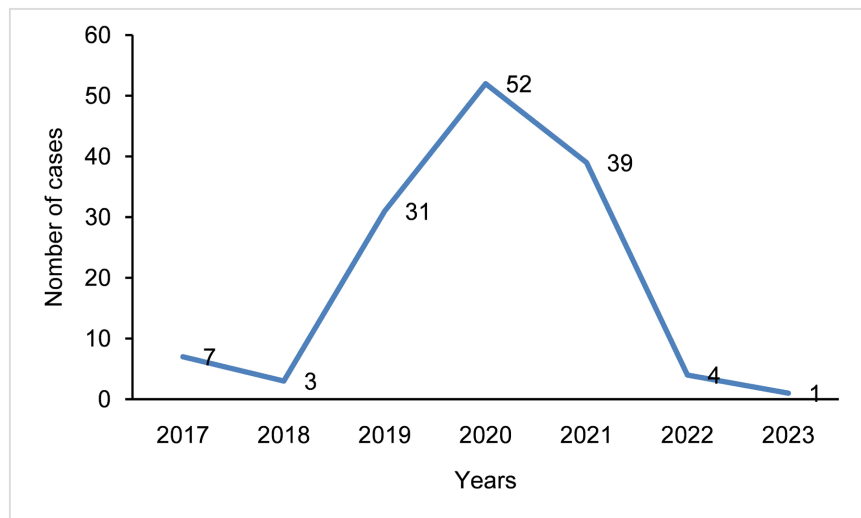


Figure 5. Map of Cotonou boroughs by cholera attack rate in 2016. (n = 419).





**Figure 6.** Attack rates in Cotonou’s 13 boroughs during the 2008 and 2016 cholera epidemics.



**Figure 7.** Evolution of cholera cases in Cotonou from 2017 to 2023.

**Table 4.** Cholera cases in Cotonou from 2017 to 2023.

	2017	2018	2019	2020	2021	2022	2023	Total
COTONOU I	0	0	3	38	4	0	0	45
COTONOU II	1	0	13	0	3	0	0	17
COTONOU III	2	0	4	2	10	2	1	21
COTONOU IV	1	1	2	10	9	2	0	25
COTONOU V	2	0	8	2	10	0	0	22
COTONOU VI	1	2	1	0	3	0	0	7
<b>TOTAL</b>	<b>7</b>	<b>3</b>	<b>31</b>	<b>52</b>	<b>39</b>	<b>4</b>	<b>1</b>	<b>137</b>

## 2) DESCRIPTION OF CHOLERA CASES FROM 2017 TO 2023 IN COTONOU

Between 2017 and 2023, the Littoral County (Cotonou) regularly recorded cases of cholera, as shown in **Figure 7** below.

The figure shows that cholera cases are recorded every year in Cotonou. that the scope varies from one year to the next. The period 2019 - 2021 recorded the maximum number of cases, with the peak in 2020.

**Table 4** shows the same temporal trend as **Figure 6**. All localities in Cotonou recorded cases of cholera in the period

## 5. Discussion

This secondary data analysis is prone to error, especially in terms of data completeness and consistency. In fact, there could be some differences or errors in the reporting of the number of cases from one locality to another, affecting the description of the epidemic according to the characteristics of the people, time and place.

Furthermore, the databases did not allow for disaggregated analysis by city district.

Despite these possible shortcomings, the results of the analysis lead to a number of observations which, if taken into account, will help to reduce the recurrence of Cholera in Cotonou.

### *Scope and severity of cholera*

At 404 and 419 cases respectively, with corresponding average attack rates of 54 and 54.9 cases per 100.000 inhabitants [6], the epidemics of 2008 and 2016 appear to be similar in scale although the attack rate across the boroughs remained higher in 2008 (15.86 to 172.98 cases p.100.000 inhabitants) than in 2016 (7.3 to 153.8). Furthermore, in 2016 the scale of the epidemic spread to six other neighboring municipalities. just as in 2008 when the epidemic affected 939 people, more than half of whom (53.46%) were from the Littoral County alone [6].

In terms of case-fatality, with a case-fatality rate of 1.3%, the 2016 epidemic was more severe than that of 2008 (0.24%) in the Littoral County. And yet, the 2008 epidemic was the largest recorded in the country after that of 2001, when 3.943 cases were reported [6].

### *Distribution in time*

Cholera rages in endemo-epidemic mode as evidenced by the permanence of cases between 2016 and 2023.

For epidemics, the devastation period is similar for both (July 26 to December and lasted 21 weeks (30 to 50) in 2008; from August 09th to September 16th, 2016. lasting 24 epidemiological weeks, 32 to 45. This period of epidemic severity coincides with the end of the rainy season when many Cotonou neighborhoods are flooded.

The superposition of epidemics in this period indicates the presence of a determinant, such as floods which are a major factor in the occurrence of diseases of hydro-fecal origin, including cholera.

### **Geographical distribution**

Cholera cases are spread across the 13 boroughs of Cotonou and neighboring

municipalities. The index case was detected in the municipality of So-Ava, and the spread of the epidemic was probably facilitated by public transport and trade.

The scale of cholera epidemics in Cotonou compared with other municipalities could be explained by its location. Benin's economic capital Cotonou is a cosmopolitan city, home to most of the major administrative and financial structures, and therefore a place of work for a large proportion of the population whose homes are in neighboring municipalities. Cotonou is also home to several markets, including the Dantokpa international market, which attracts thousands of people from all counties of Benin and even neighboring countries (Nigeria, Togo, Niger).

However, is this position as an administrative and economic hub enough to expose Cotonou to recurring cholera epidemics? In our opinion, no, since Cotonou is the country's economic capital. Cotonou is the most urbanized city in the country, with the best health coverage [6].

Sanitation in Cotonou could also explain the recurrence and scale of cholera epidemics. In fact, the first six boroughs have the highest attack rates for both epidemics. Between 2017 and 2023, Cotonou I to IV, corresponding to the first six boroughs (see **Table 1**) recorded 79% of cases. The physical environment contributes to the recurrence of diseases, including cholera epidemics. This area lies on the shores of Lake Nokoué. Most of the neighborhoods are less than a kilometer from the Cotonou lagoon, and in several districts, people live in marshy areas [6] [8].

Made up of swamps and reservoirs, these localities face the problem of cyclical flooding, which favors the proliferation of water-borne diseases [10]. These brackish waters are a reservoir for *Vibrio cholerae*.

Moreover, the water table is everywhere superficial, less than a meter above ground level [6]. Well water in these localities is therefore contaminated, and unfit for consumption, given the lack of infrastructure in these localities, including wastewater and household waste management, the non-existence of latrines. The pollution of well water has been confirmed by the assessment made by Hounsounouet al [11].

These populations are therefore among the 663 million people worldwide without access to drinking water. and the more than two billion people who drink water from sources contaminated by fecal matter [3].

In addition, coverage by the National Water Company (Société Nationale des Eaux du Bénin) is inadequate, involving retail water distribution. A 25-liter can be sold at 40 FCFA (€0.06), whereas a cubic meter is billed on average at 500 FCFA (€0.76) by the national water company [6]. In these conditions of high water prices, well water consumption is favored.

This situation of low drinking water coverage was well described in Cotonou's 6th arrondissement by Hounsounouet al. They observed that tap water vendors represent a solution for non-subscribers in low-income neighborhoods, yet this supply system constitutes a multi-phase "water chain", i.e. the purchase, trans-

port and storage of water at home, which does not guarantee the hygienic quality of drinking water [12].

As part of the response to epidemics, community activities to disinfect wells have been carried out [6] [8] [9]. This seems to us to be a palliative solution, since it cannot be applied to all Cotonou wells outside epidemics. However, the source of drinking water and the treatment of water before consumption are associated with the occurrence of cholera [13]. Above all, Cotonou needs major work on the water, hygiene and sanitation pillars.

We suggest that the government of Benin accelerate the installation work of sanitary, water and sanitation infrastructure undertaken in 2018 with a view to better drainage of rainwater, [14] and coverage of drinking water throughout the population in order to reduce infectious pathologies including cholera. To the population, we recommend a change in behavior for a higher level of hygiene, both food and body hygiene, particularly of the hands.

## 6. Conclusion

A number of factors predispose the city of Cotonou to recurrent cholera epidemics. Its location in relation to the lagoon shoreline, the marshy areas, cyclical flooding, low sanitation levels, inadequate wastewater and household waste management infrastructures, non-existent latrines, Low level of drinking water supply and shallow water table. The town's position as a major crossroads for trade should not be overlooked, especially if hygiene is poor. It is important for the government to continue its work on the development, sanitation and drinking water coverage of the city of Cotonou. In addition, raising the population's awareness of hygiene must be an almost permanent process, and not just during epidemics.

## Acknowledgments

Heartfelt thoughts go out to all the patients and their families affected by these epidemics. We extend special thanks to those who lost their lives. Our gratitude to the health authorities.

## Conflicts of Interest

The authors declare that the study was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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