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Evaluation of Temporal Distribution of Recurrent Cholera Outbreak in Zambia

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Abstract

Background: *Cholera cases in Zambia have been observed over a period without understanding the epidemiological cycles. The aim of the study was to evaluate the temporal distribution of recurrent cholera outbreak in Zambia from 1977 to 2019.* ***Methods:*** *Cholera case records of both sex and all ages were retrospectively analyzed. The primary source documents were reviewed including infectious diseases line list, notifiable diseases reports, Health Impact Assessment, District Health Impact Assessments, surveillance reports, Out-Patient Department & In-Patient Department books, and rapid response meeting minutes at district, provincial and national level. Used Excel to enter data and Stata to analyze data.* ***Results:*** *Zambia experienced 4 major recurrent cholera outbreaks between 1977 and 2020. The cumulative estimated total cases during the period under review accounted for 106,713 cases. While the mortality cumulative total was 4,367 deaths translating into a case fatality rate of 4.1%. The peak frequency of an epidemic curve elucidated an average of 10-year cycle of periodicity for both epidemiological cycle, pattern and interval of occurrence.* ***Conclusion:*** *The key findings from this study have been the elucidation of the 10-year epidemiological cycle. This means that control measures can be developed using the observed cycle of periodicity, as part of an early warning system by policy makers.*

Keywords: Cholera, case fatality rate, epidemiological cycles, epidemic curve, infectious diseases

INTRODUCTION

Cholera is a food borne disease which is a public health concern as it causes morbidity and mortality and has been endemic to Zambia. Outbreaks have occurred approximately since 1990, with a total of 4,731 deaths reported before the 2017–2018 outbreak. Major epidemics occurred in 1991, 1993, 1999, 2004, 2010, 2016 and 2017. The latest outbreak started in October 2017, through to March 2018 which resulted in 91 deaths countrywide. The infection spreads from person to person through contaminated food or drink. The most common vectors are vegetables and shrimp [1].

Further, cholera is caused by contaminated drinking water or food. In spontaneous infection, sometimes the dose can be very low. The organism spreads in the small intestine and causes severe enterotoxins. As a result, the intestinal mucus cells continuously release isotonic fluid. According to Ali et al. [1], Vibrio cholera occurs naturally only in humans.

Cholera is a common and persistent infectious disease in densely populated neighborhoods. According to Ali et al. [1], cholera outbreaks can be either long-term wave spread or explosive outbreaks in endemic areas. This usually occurs in areas where the disease is not endemic.

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Providing drinking water, proper waste disposal, food preparation and hygienic food management is an example of a control measure. Observing personal hygiene and the three-to-six-months protection period after receiving heat-killed phenol vaccination can control the disease. Cholera is severe intestinal diarrhea. It can be fatal if there is no treatment. Cholera outbreaks usually occur during the rainy season. This lasts from October to May or June of the following year. It reaches its peak between January and March. The Lusaka rains and the cholera epidemic are closely linked [2].

Most cholera cases are found in the suburban areas of Lusaka which have little access to sanitation facilities and clean water. Between 2001 and 2010, 73% of cholera cases were reported in Lusaka. The outbreak is mainly caused by inadequate drainage, sanitation and water supply in the western suburbs.

Due to high morbidity and mortality associated with cholera outbreaks, Zambia should have had robust preventive measures in place to control these outbreaks. Therefore, the study aimed at conducting research to evaluate the temporal distribution of recurrent cholera outbreak. This shall help formulate policy change in understanding transmission factors that cause cholera outbreaks and develop robust control measures in place to curb these outbreaks using the observed cycle of periodicity, as part of an early warning system by policy makers.

MATERIALS AND METHODS

Study Area

Study areas included Lusaka (Kanyama, Chawama, Kalingalinga and George), Copperbelt (Kitwe and Ndola), Northern Province (Mpulungu and Kaputa) and Nchelenge in Luapula province.

Study Design

It was a retrospective study analyzing cholera case records of both sexes and all ages.

Study Period

The study was carried out from May 2021 to December 2021.

Data Collection

Data of cholera cases (patients) for both sexes and all ages was collected during 1977–2019 from epidemiological units at Zambia National Public Health Institute (ZNPHI) and Ministry of Health (MoH). Data was collected using abstraction instruments which were standard and amenable to excel format. The primary source documents that were used include infectious diseases line list, notifiable diseases reports, Health Impact Assessment (HIA1) & District Health Information Systems (DHIS reports), surveillance reports, Out-Patient Department (OPD) & In-Patient Department (IPD) books, and rapid response meeting minutes at district, provincial and national level.

STATISTICAL ANALYSIS

Excel spreadsheets are used to enter data from laboratory analyses which were then imported into STATA version 14 (STATA Corp., College Station, Texas) for statistical and descriptive analysis.

Ethical Clearance and Consent to Participate

"Excellence in Research Ethics and Science" received ethical approval for conducting this study. National Health Research Agency (NHRA), Ministry of Public Health, ZNPHI administrators are authorized to conduct studies at ZNPHI and the Ministry of Public Health. Study participants were not endangered, and confidentiality was maintained [3].

RESULTS

Descriptive Results

The results being presented cover a review period of cholera cases from 1977 to 2019. The results span a period of 42 years. Within the 42-year period, Zambia experienced four major waves of cholera

outbreaks with a total of 106,713 cases and 4,367 deaths which translates to case fatality rate of 3.1% (Table 1 and Figure 1).

Table 1. Cases, deaths, and cases fatality rate from 1997 to 2019.

Year	Cases	Deaths	CFR%
1977	144	13	9.0
1978	263	14	5.3
1979	12	1	8.3
1980	57	5	8.8
1981	14	1	7.1
1982	1,403	17	1.2
1983	233	13	5.6
1984	0	0	0.0
1985	0	0	0.0
1986	0	0	0.0
1987	0	0	0.0
1988	0	0	0.0
1989	44	4	9.1
1990	3,717	214	5.8
1991	13,154	1,006	7.6
1992	11,659	928	8.0
1993	6,766	225	3.3
1994	0	0	0.0
1995	0	0	0.0
1996	2,172	31	1.4
1997	36	0	0.0
1998	171	0	0.0
1999	13,511	393	2.9
2000	4,504	302	6.7
2001	3,109	165	5.3
2002	339	12	3.5
2003	1,049	29	2.8
2004	12,149	377	3.1
2005	1,503	8	0.5
2006	5,360	182	3.4
2007	2,286	34	1.5
2008	2061	39	1.9
2009	4,712	80	1.7
2010	6,794	115	1.7
2011	330	5	1.5
2012	198	3	1.5
2013	0	0	0.0
2014	0	0	0.0
2015	0	0	0.0
2016	1,434	28	2.0
2017	2,576	48	1.9
2018	4,477	66	1.5
2019	476	9	1.9
Total	*10,6713*	*4,367*	*4.1*

Description of Cholera Cases

The results show that the first wave was from 1977 to 1983, which lasted for 7 years with a total of 2,126 cases with 144 initial cases, 13 deaths and an initial case fatality rate of 9.0%. The peak was in 1982 with 1,403 cases and 1979 experienced the least number of cases (14). There was a quiescent inter-epidemic period of 5 years from 1984 to 1988 (Figure 1 and Table 2).

Table 2. Total cholera cases, deaths, CFR for the 4 waves.

Wave	Cases	Deaths	CFR %
1st wave (1977–1983)	2,126	64	3.0
2nd wave (1989–1993)	35,340	2,377	6.7
3rd wave (1996–2012)	60,284	1,775	2.9
4th wave (2016–2019)	8,963	151	1.7

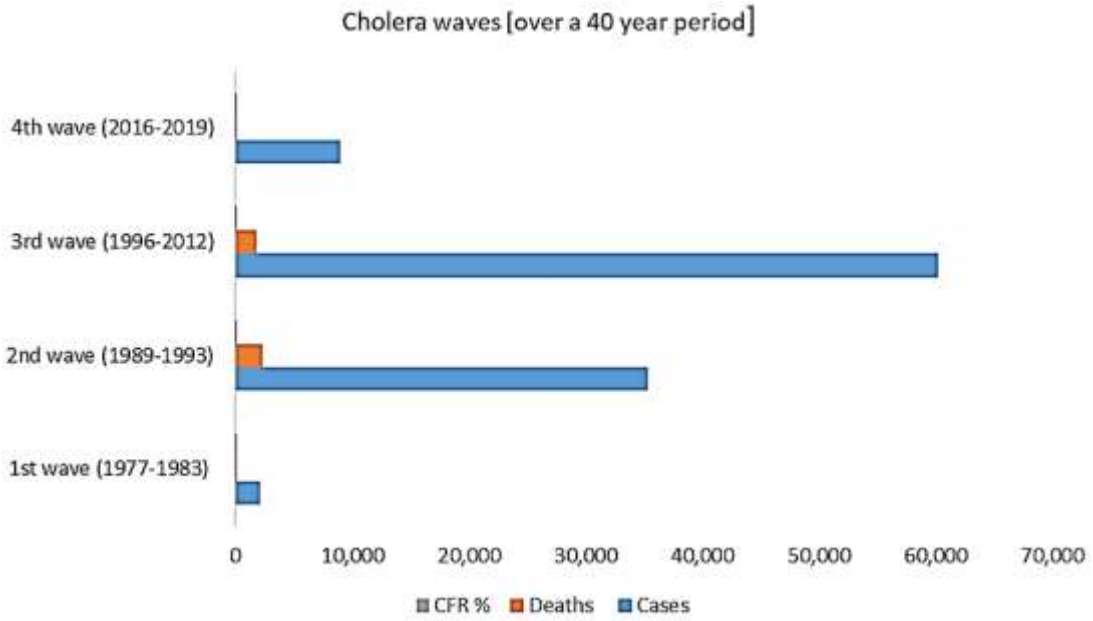

Figure 1. CFR, deaths and cases of cholera waves.

The results highlighted that the second wave occurred from 1989 to 1993 which lasted for five years with a total of 35,240 cases, 44 initial cases, and 4 death and cases fatality rate at 9.1% (Tables 1 and 2). There was inter-epidemic period of two years from 1994 to 1995 (Figure 1).

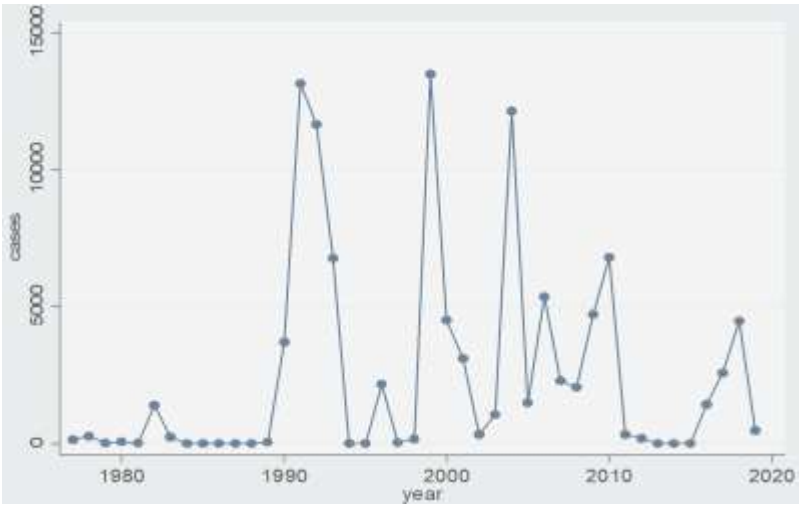

Figure 2. Cholera cases 1980 to 2020 intimating a 10-year cycle of periodicity.

One of the key findings is that the peaks intimated an average of 10-year cycle of periodicity. The third wave occurred from 1996 to 2012 which lasted for 17 years with a total of 60,284 cases, 2,172 initial cases, 31 deaths and a case fatality rate of 1.4% (Tables 1 and 2). The results show that the peak was in 1999 with 13,511 cases followed by 2004 with 12,149 cases (Figure 2). The results show that 1997 had the least number of cases (36) (Table 1). Another inter-epidemic period, indicating the fourth quiescent phase was for 3 years running from 2013 to 2015 (Table 1 and Figure 1).

The fourth and most current wave occurred from 2016 to 2019 which lasted for 4 years with total cases 8,963 cases, 1,434 initial cases, 28 deaths and case fatality was at 4.1% (Tables 1 and 2). The peak was in 2018 with 4,477 cases and 2019 had the least number of cases (476) (Table 1 and Figure 1).

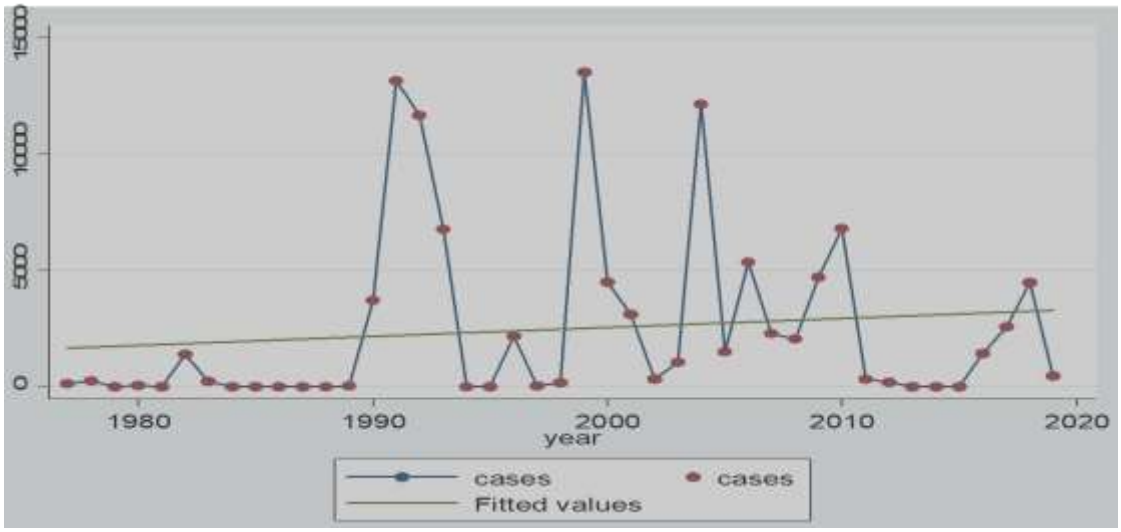

Figure 3.

The results show an increase of CFR in the initial stage and a reduction as cholera outbreaks continued over the period under review as shown by the regression line in Figure 3.

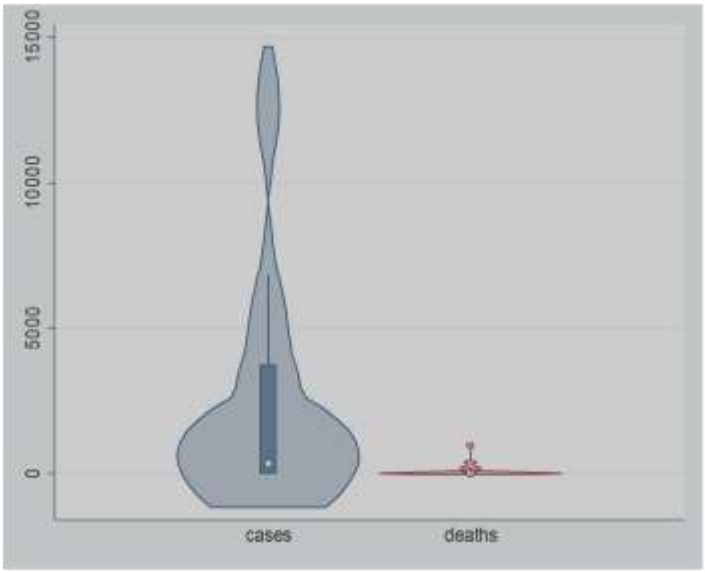

Figure 4. Comparative proportion of case density vs. mortalities, indicating a low mortality rate.

Table 4. Mid coefficient analysis in relation to cases.

Lag	LL	LR	Df	p	AIC	HQIC	SBIC
0	–377.554				19.4	19.4	19.4
1	–375.402	4.3034	1	0.038	19.3	19.3	19.4
2	–75.295	.1478	1	0.643	19.4	19.4	19.5
3	–374.96	.67018	1	0.413	19.4	19.4	19.6
4	–374.891	.13782	1	0.710	19.5	19.5	19.6

In the Table 3 and Figure 4, it is shown that the initial cases were high and mid coefficient analysis there were no significant differences across different time periods (Table 4). The *p*-value was not significant, implying a high degree of homogeneity which shows that cholera is not a disease of ecological inter determinant but a disease of demographic determinant.

DISCUSSION

This study has been able to elucidate the periodicity of cholera outbreaks in Zambia with recurrent epidemiological cycles running a 10-year period. Additionally, mid coefficient analysis revealed no significant differences across different time periods indicating high homogeneity within outbreaks. Our present results are consistent with other earlier studies by Phelps and co-workers. The first cholera outbreak recorded in Zambia occurred in 1977 which registered a total of 178 cases; ever since, there have been outbreaks nearly every other year since then, with peak outbreaks occurring within a ten-year cycle. The peak epidemic cycles in Zambia were in 1991, 1992, 1999, and 2004, with more than 10,000 cases reported each year. Since 1977, cholera has occurred frequently in Zambia. Mainly in Lusaka, the capital of the country [4].

Some researchers have linked the cycles observed in cholera outbreaks to ecological determinants, although they have been unable to pinpoint the exact period of occurrence. One of the effects that has been supposedly influencing these outbreaks is alluded to be the *El Niño* oscillation phenomena, that coincidentally occurs after every 10 years. An article on mortality rates during Cholera Epidemic, in Haiti by Moore and co-workers in 2017 revealed that the shifting of cholera outbreaks was linked to *El Niño*. The report further notes that there were several cholera outbreaks in East Africa during the 2015–2016 El Niño, including the largest outbreak in Tanzania since the 1997 El Niño. –1998, which indicates a link between El Niño and cholera in Africa. Throughout Africa, cholera incidence rates increased three-fold during the *El Niño*-sensitive periods, and 177 million people were affected [5].

Based on the analyzed data, Zambia experienced 4 major recurrent cholera outbreaks between 1977 and 2020. The cumulative estimated total cases during the period under review accounted for 106,713 cases. From this data, the cumulative mortality total was 4,367 deaths translating into a case fatality rate of 4.1%. The first recorded cholera outbreak was in 1977 with 144 cases. The cases increased the following year. This led to the first wave from 1977 to 1983 with the total number of 2,126 cases, 64 deaths and 3% CFR. Unlike Zambia which experienced first cholera cases in 1977, Senegal in West Africa experienced first cholera outbreak in 2004 in the low-income neighborhood in the capital Dakar, as it is an acute intestinal infection caused by contaminated food and water. Returning to West Africa in 1970, it is now endemic in many parts of the region, especially Sierra Leone, Burkina Faso and Côte d'Ivoire. This is because of poor hygiene standards in the affected areas and population increase [6].

Additionally, number of newly constructed sanitary facilities has not matched with rapid population growth (Misch, 1991). The number of people using sanitary facilities has increased while the number of sanitary facilities has not changed. Inadequate water supply is another challenge which is why developed countries have had cholera outbreaks. Other studies show that cholera outbreaks occurred despite adequate municipal water infrastructure. A good example is the 1853 Danish cholera outbreak in large city of Copenhagen. Although outbreaks in some areas have similar duration and severity, same as the outbreaks in Coursur and Aalborg, but the pandemic appears to be taking longer. The outbreak lasted about a month at all three locations, whether there is water infrastructure in the city or not.

Consequently, inadequate sanitary facilitates and water supply has compromised hygiene standards especially in low income neighborhoods. This has been the case worldwide (Misch, 1991) [7].

The peak of the first wave was in 1982 with 1,403 cases but had a lower fatality rate of 1.2 unlike in 1977 that was estimated at 9.0%. The first wave lasted for 7 years, and 5 years inter epidemic followed due to case management, contact tracing, treatment of drinking of water and improved sanitation and hygiene conditions.

There was a reduction in cholera outbreaks due to increased access to safe water, sanitation, and hygiene (WASH) facilities and through behavioral changes resulting from community education and training; oral cholera vaccines are increasingly used as a temporizing measure.

However, our results revealed that there was a second wave which started in 1989 with 44 cases, 4 deaths and the highest case fatality rate at 9.1 from 1977 to 2020. It had total cases of 35,340 cases, 25,340 deaths and 6.7% CFR. According to a CDC publication ("Cholera – Worldwide, 1989", n.d.), 16 African countries reported 35,606 cases in 1989, while 12 countries recorded 23,186 cases in 1988. The peak occurred in 1991 with 13154 cases. The second wave ended in 1993 with 6766 cases, 225 deaths at CFR of 3.3%. It lasted for 5 years and 2 years inter epidemic period followed from 1994 to 1995 with the help of intervention from the Ministry of Health and stakeholders.

The third wave started from 1996 with 2172, 32 deaths at 1.4% CFR because of reduced levels of hygiene and sanitation conditions. It lasted for 17 years with several peaks. The highest peak was in 1999 with 13,511 cases, 393 deaths at 2.9% CFR. The second peak in this long wave was in 2004 with 12,149 cases, 377 deaths at 3.1% CFR. After 17 years, the third wave of cholera outbreak ended in 2012 due to interventions from the government through the Ministry of Health and stakeholders followed 3 years inter epidemic from 2013 and ended in 2015. The World Health Organization issued urgent advice to member countries in 2005, during the third wave of cholera, which killed more than 700 people in West Africa and affected more than 45,000 people, resulting in 1,212 new cases and 24 deaths in the week ending 25 September. Just 709 new cases were reported in the first week of September [8].

Standards of hygiene probably dropped, and our study revealed that the fourth wave occurred in 2016 with an initial 1434 cases, 28 deaths at 2.0% CFR. The findings indicated that the peak for the fourth wave happened in 2018 with 4,477 cases, 66 deaths at 1.5% CFR. The fourth wave lasted for 4 years. The low CFR is evident in cholera outbreaks in other African countries. An example is Nigeria, where a retrospective study was conducted to determine the epidemiological and spatio-temporal characteristics for the 2010 cholera outbreak in 10 out of 18 states. From the research results, a total of 21,111 patients were found. The attack rate and CFR were 47.8 cases/100,000 people, or 5.1% and 5.1%, respectively. The CFR ranged between 3.8% and 8.9% [9].

WHO states that if left untreated, cholera can reach a fatality rate of 25% to 50%. In 2016 and 2018, the Ministry of Public Health recommended cholera immunization along with other preventive control measures to prevent spread and manage outbreaks. This is due to limitations in vaccine availability and the logistical support required to administer the vaccine. Therefore, the use of oral cholera vaccine (OCV) is recommended. To combat the 2016 cholera outbreak, Zambia's Ministry of Health implemented cholera vaccinations in addition to normal cholera management strategies, such as providing clean water, improving hygiene and promoting hygiene. The Global Task Force on Cholera Control (GTFCC), the Global Strategy to End Cholera by 2030, and Zambia's National Cholera Eradication Plan (NCEP), all call for the implementation of these control measures [10, 11].

Our present study revealed that although the number of cases increased over the years, the case fatality rate kept on reducing. It is believed that when cholera first occurred in its early years, more people died because the population was still naive about the disease, but case fatality gradually decreased over the years because the population gained its immunity. Other studies confirm the increase

in the number of cases and the low case fatality rate. The annual cholera outbreak in the country has increased steadily since 2003. A retrospective study conducted in 2009 for the period from 2003 to 2006 in Zambia agreed with these findings of an increase in cholera cases. This is due to the change in health seeking behavior. People started reporting the cases to the health facilities instead of not reporting until they got worse. According to Olu and colleagues [12], Lusaka province accounted for 85 percent of the disease's cases, as approximately 6,794 cases in 2010, more than 500 percent in 2003, and deaths, 115 cases (CFR 1.6%). The outbreak begins in epidemiological week 40 to 45 of the year, followed by the 20th of the year, ending in week 25, when the rainy season in Zambia occurs. In the Southern Region, most outbreaks occur in suburban areas of the Copperbelt, Lusaka and Luapula provinces [13].

CONCLUSIONS

There are deterministic and ecological factors that predict cholera outbreaks. The case of the *El Niño* effect, this is known well in advance, accordingly, there is need to develop early warning systems alongside the climatology indicators. With an estimated 2.9 million cases and 1.3 billion people at risk of infection, Cholera is a public health problem worldwide. Further studies are required to establish the impact on the spatial distribution of recurrent cholera outbreak as highlighted in this study.

Peri-urban areas such Kanyama, Kalingalinga, George etc., should be turned into planned settlements so that adequate water and sanitation are provided in addition to cholera prevention and control interventions.

Street vending should not be allowed in the streets of cities to maintain cleanliness and hygiene.

Abbreviations

CFR: Case Fatality Rate
OCV: Oral Cholera Vaccine
CTCs: Cholera Treatment Centers
IPD: In-Patient Department
UNICEF: United Nations International Children's Emergency Fund
WHO: World Health Organization
ZNPHI: Zambia National Public Health Institute

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Ethics Consideration

The protocol was approved by ERES Converge under ref no. 2021-Sep-001 on 15th October 2021.

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Availability of Data and Materials

The data sets and materials used in the analysis of this current study are readily available from the corresponding author and can be accessed upon reasonable request.

Authors' Contributions

NN, conducted the research work and wrote the report, drafted and edited the manuscript, OS, analyzed the data, reviewed and edited the manuscript, MM, conceptualized the study, drafted the manuscript and supervised research work. All authors read and approved the final version of the manuscript.

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