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Impact of Local Climate Variability on Cholera Outbreaks in Bida Metropolis of Niger State, Nigeria.

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Abstract

This study assessed local climate variability effects on cholera outbreaks in Bida Metropolis and the environs of Niger State. Bida Metropolis and Environs were purposively sampled. Climatic data (Rainfall and Temperature) of Bida and Environs between the years 2000 to 2020 were collected from the Nigerian Meteorological Agency (NiMET) and the National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR), while cases of reported cholera were collected from Umaru Saad General Hospital and Federal Medical Center Bida. Regression analysis of the collected data reveals that there is positive relationship between rainfall and cholera cases with an F-value of 0.637. This implies that, more cholera cases were reported during the period of high rainfall. However, there is no positive relationship between temperature and cholera cases with a t-value of 0.987. A two-factor regression analysis of the data reveals there is no significant relationship between the climatic elements combined (rainfall and temperature) and cholera cases. Most of the cases of cholera were reported at the beginning of the rainy season between March and April while the cases of cholera were low during the dry season. The study recommended that the government needs to enlighten the people on the need for adequate environmental sanitation with a high level of consciousness at the beginning of the rainy season of the relationship between climatic elements and cholera incidences. There is a need for the people to be enlightened about climate variability, its effects and the means of mitigating or moderating its impact in order to reduce the influence of climate on cholera outbreak.

Keywords: Climate Variability, Cholera Outbreaks, Sanitation, Bida Metropolis

INTRODUCTION

Cholera is an acute diarrheal illness, which is brought on by intestinal infection with the bacteria that causes cholera after ingestion of contaminated water or food. Cholera is a long-standing illness which had disappeared from most developed countries but continues to persist throughout many underdeveloped nations, with severe outbreaks frequently confined to tropical regions (World Health Organization, 2015). Despite improved hygiene in many of these developing countries, along with advances in diagnostic methods by the middle of the 20th century, new medications and vaccinations had been developed yet there appears to have been an upsurge in the appearance of this disease (Smith *et. al.,* 2015). The disease can spread swiftly in areas where sewage and drinking water are not properly managed (World Health Organization, 2015). The cholera bacterium may naturally reside in brackish rivers and coastal waterways though casual contact with an infected individual poses little danger of contracting the disease because it is unlikely to transfer from one person to another (Suk and Sumenza, 2019).

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A relationship between climatic elements (temperature and rainfall) and cholera was observed by Faruque *et. al.*, 2015; Colwell and Huq, 2016. In recent years in developing countries, cholera outbreaks have been linked to periodic climatic variations such as rainfall (Faruque *et. al.,* 2015; Colwell and Huq, 2016). Variations in rainfall in the tropics may lead to predictable variations in Phyto and zooplankton abundance in the aquatic environment, it appears to be associated with the appearance of cholera cases in coastal human communities (Colwell and Huq, 2016). Floods encourages the concentration of cholera virus in the environment, due to high amount of rainfall which mostly exacerbates the tendency of cholera outbreak (Bouma and Pascual, 2013).

Eighty-three per cent of deaths in children under age five are caused by infectious, neonatal and cholera. Such young children make up approximately 10% of the world's population and comprise more than 40% % of the populace suffering from health problems related to the environment (WHO, 2016). Due to their size, physiology, and behaviour, children are more vulnerable to environmental risk factors than adults. Children experience greater levels of toxins from the environment in proportion to their body weight and have greater longevity ahead of them, which they may suffer long-term effects from early exposure.

It is imperative to evaluate the potential effects of climate variability on infectious diseases that are known to be climate-sensitive (Grasso *et al., 2*018), especially in areas where changes in disease distribution and seasonality are thought to pose greater health challenges (World Health Organization (WHO, 2016), particularly in developing countries with low coping capacity (Shuman, 2018). Due to the population's susceptibility, Northern Nigeria is one of the areas designated as climate change hotspots by Diffenbaugh and Giorgi (2016), and it would likely be the most severely impacted (Suk and Sumenza, 2019). Because many elements that impact the outbreaks of these illnesses (both climatic and non-climatic factors) may alter in the future, estimating the risk of infectious diseases is fraught with uncertainty. Additionally, better hygienic conditions, education, and poverty reduction may successfully lower the chance of developing cholera in the future (Suk and Sumenza, 2019).

The increasing prevalence of death and illness rates because of cholera is increasing the burden in emerging nations, by boosting the monetary budget on healthcare, decreasing productivity, and putting pressure on fragile healthcare systems (IPCC, 2017a). The observed changes in climate and the likely rising likelihood of infectious illnesses led to increasing concern, which triggered a plethora of research about the possible magnitude of these changes and their extent and exploring the capacity to foresee climate change’s future impact on significant diseases (Patz and Reisen, 2011; Kovats *et. al.,* 2012). But most of this research has focused on developed countries as reported by Kelly-Hope and Thomson (2018).

Addressing health-related issues is key to achieving the 17 United Nations Sustainable Development Goals (SDGs). This related issues are captured in Goal Number 3 (Good health and well-being), therefore achieving Goal Number 3 is paramount towards achieving several goals of concern such as reducing poverty (Goal Number 1), zero hunger (Goal Number 2) and quality education (Goal Number 4). Climate variability in recent years threatens the drive towards achieving the set Sustainable Development Goals as captured in Goal 11 (Climate Action). In the face of ongoing climate change, poverty, inequality, and environmental degradation, understanding the connections between climate variability and good health and well-being (Goal Number 3) is a matter of concern and urgency.

In Nigeria, Leckebusch and Abdussalam (2015), observed climate and socio-economic influences on inter-annual variability of cholera. Dan-Nwafor, *et. al.,* (2019) assessed a cholera outbreak in a rural North-Central Nigerian community. Despite the existence of several studies linking climate variability and environmental risk factors to cholera disease and outbreaks. It is obvious that in recent years, studies that emphasize the implication of local climate variability on a cholera outbreak in the Bida metropolis of Niger State are lacking. This study attempts to understand how regional climate variation impacts cholera outbreaks in the city of Bida in the Nigerian state of Niger.

STUDY AREA

The study area is Bida in Niger State, Nigeria. The study area resides in the heart of Northern Nigeria (Figures 1 and 2). It is in the Niger Valley within latitudes 09º 09′ 9′′ North of the equator and longitudes 05º 56′ 64″ East of the Greenwich meridian. Bid has an area coverage of 1,698 km² (Daramola, 2013).

The inter-tropical convergence zone's fluctuating position governs the climate of the studied area, which has a tropical continental climate with distinct wet and dry seasons. Two primary air masses, tropical maritime air masses and tropical continental air masses, have an impact on the climate of the research area (Ogunjumo, 2010). While tropical continental air masses oversee the dry season, tropical maritime air masses oversee the rainy season. Rainfall begins throughout much of the area in April and lasts until October, with the length of the rainy season fluctuating from 160 to 200 days yearly. In July and August each year, the average yearly rainfall varies from 1100 to 1500 millimetres. The northeasterly winds that bring in the harmattan make the dry season, which runs from November to March every year, very dusty and chilly (Ogunjumo, 2010).The daytime temperatures reach 28°C to 30°C and nighttime lows hover around 22°C to 23°C. In the dry season, daytime temperatures can soar as high as 40°C and nighttime temperatures can dip low to 12°C. Even the chilliest nights can be followed by daytime temperatures well above 30°C (Daramola, 2013).

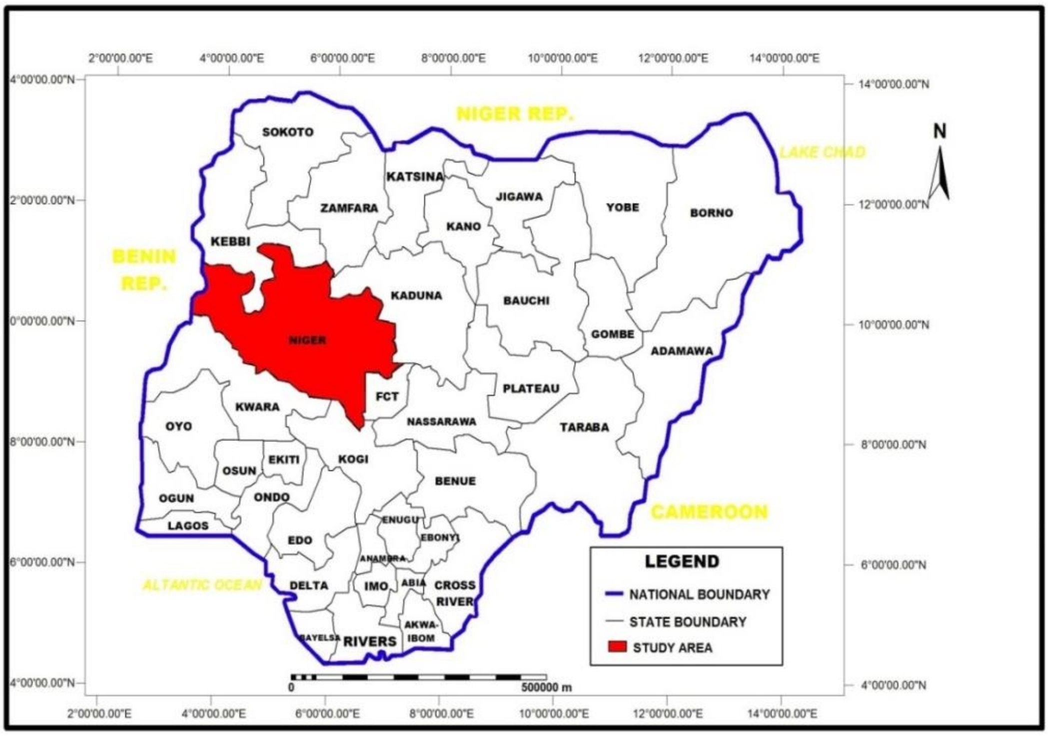

Figure 1: Location of Niger State, Nigeria. (Source: Niger State Geographic Information System, 2022)

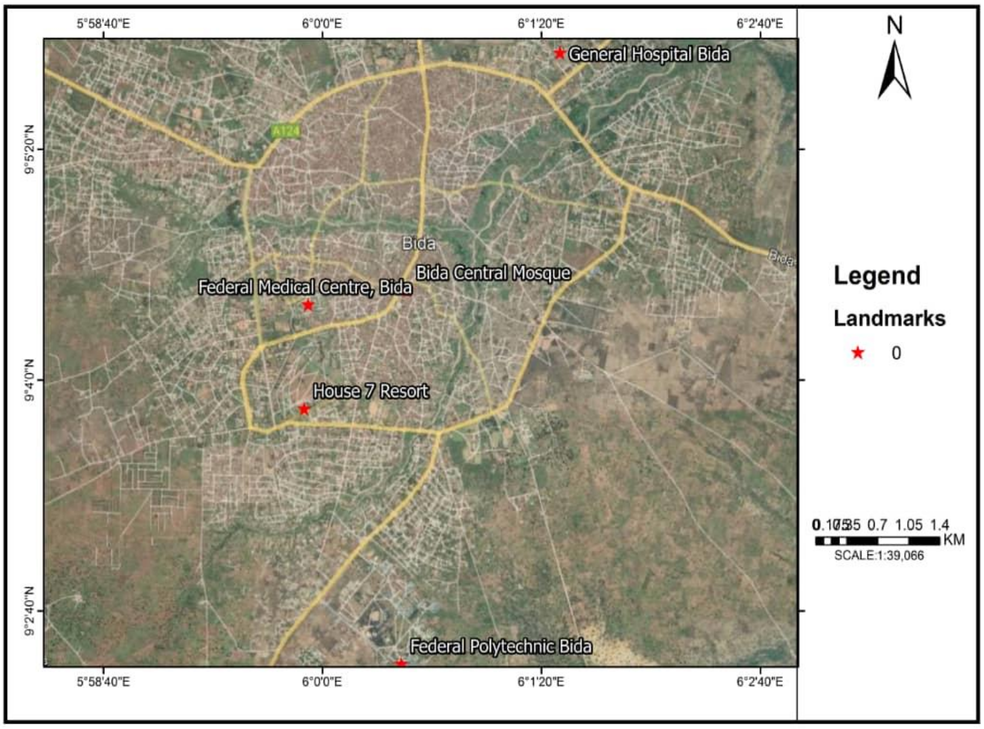

Figure 2: Satellite Image of Bida Metropolis of Niger State, Nigeria. (Source: ***Niger State Geographic Information System, 2022)***

The foundation complex rocks and the sedimentary rocks are the two primary rock types in the geology of the Bida. The study area is situated on a plain since the topography is rather flat. The soil is light in colour and has typical loamy sand topsoil and sand clay B horizon in terms of its textural qualities. The soil are very vulnerable to erosion due to the economic activities it is subjected to (Daudu *et. al.,* 2017). The soil support crops like yam, maize, rice, beans, potatoes, and vegetables like pepper, onions, okra etc (Niger State Agricultural Development Project, 2019). It can however be observed that most of the soil in Bida Metropolis has been occupied by urbanization and there are fewer agricultural activities in the town.

Bida represents a typical guinea savannah due to the composition of plants encountered. The floristic composition of the project area is highly diverse in species even over a seemingly homogenous area. In the wet season, the trees are lush and green, with new leaves and long grasses, but during the dry season, the study area is exposed, with burned-out trees and grassy remnants visible. Locust beans, Shea butter, African mahogany, African teak, Ironwood, and isoberlinia trees are among the cluster-growing, up to six-meter-tall trees that are surrounded by grasses that reach a height of about three metres. Due to urbanization most out of these plant types have disappeared (Daudu *et. al.,* 2017).

Bida is well drained throughout the year by several streams. These include the Gbako River, Chicken River, Musa River, Landzun River etc. The Landzun River is about 8.86 km long, and about 5km lies within the city of Bida, with an overall west-to-east flow (Daudu *et. al.,* 2017). The discharge of household and automobile wash effluents into the Landzun stream is a common practice, alongside a host of untamed domestic and agricultural use (Ogunjumo, 2010). Rivers, wells, and boreholes are the main sources of water for domestic uses in Bida town.

In Niger State, Bida Town is the second-largest town. With an estimated population of 185,553 according to the 2006 census. In 2016, 260,700 people were anticipated to live in the study area, which had a population density of 618.3/km² (NPC, 2016). The indigenes of Bida Metropolis possessed the skills of making glass beads and bangles as well as operating standard black smith, brass smith and gold smith local furnaces or workshops, copper goblets, raffia hats and mats, and locally dyed silk and cotton clothes (Daramola, 2013). The craftsmen work by hand in their premises in distinctive wards and are organized into close-knit guilds. The town is the main collection point for the swamp rice cultivated in the floodplains of the Niger and Kaduna Rivers.

METHODOLOGY

This study adopts a quantitative research design. Secondary data served as the study's main source of information. Climate data (rainfall and temperature) and records of cholera cases in renowned hospitals in Bida metropolis of Niger State, from the years 2000 to 2020 were used by the study's goal. The Nigeria Meteorological Agency provided daily and monthly metrological data, including mean temperature (T), and rainfall in Bida Metropolis (NIMET). The National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis was used to supplement the meteorological data from NIMET. The CFSR website enables users to obtain daily data for a specific place and period for climatic variables (rainfall and temperature).

Hospital records of cholera cases in Bida Metropolis between the period 2000-2020 were collected from Umaru Saad General Hospital and Federal Medical Centre Bida. The records utilized were confirmed cholera cases after clinical symptoms and histopathological and bacteriological investigations. Twenty years of data were utilized due to availability from the sample hospitals.

To check for normalcy in the meteorological element (rainfall and temperature) and cholera cases series from 2000 to 2020, Brazel and Balling (1986) employed the standardised coefficient of Skewness (Z1) and Kurtosis (Z2) statistics.

The standardized coefficient of Skewness (Z_1) was calculated thus:

The standardized coefficient of Kurtosis (Z_2) was determined as

$$Z_1 = \left[\left(\sum_{i=1}^{N}(x_i - \bar{x})^3/N\right) \Big/ \left(\sum_{i=1}^{N}(x_i - \bar{x})^2/N\right)^{3/2}\right] \Big/ (6/N)^{1/2} \quad \text{eq. 1}$$

$$Z_2 = \left[\left(\sum_{i=1}^{N}(x_i - \bar{x})^4/N\right) \Big/ \left(\sum_{i=1}^{N}(x_i - \bar{x})^2/N\right)^{2}\right] - 3 \Big/ (24/N)^{1/2} \quad \text{eq. 2}$$

Where, $\bar{x}$ is the long-term mean of $\mathbf{X}_1$ values, N is the number of years in the sample.

When the calculated value of Z_1 or Z_2 is greater than 1.96, it depicts a significant deviation from the normal curve indicated at the 95% level of confidence.

The linear trends of rainfall, temperature, and cholera cases were also determined using linear regression. The following is the linear regression formula:

y = a + b…………………… *eq. 3*

Where ***a*** is the intercept of the regression is a line on the y-axis.

b is the slope of the regression line.

In equation 3, the values of ***a*** and ***b*** were obtained using equations 4 and 5.

$$a = \frac{\sum y - b\left(\sum x\right)}{n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{eq. 4}$$

$$b = \frac{n\left(\sum xy\right) - \left(\sum x\right)\left(\sum y\right)}{n\left(\sum x^2\right) - \left(\sum x\right)^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{eq. 5}$$

In determining the rainfall, temperature, and cholera cases trends and measurement of variability, a standard deviation which provides the deviation from normal for rainfall, temperature, and cholera cases, was determined and plotted using the 2017 Microsoft Excel Statistical Tool. Using the produced graphs, abnormal situations were ascertained. The following formula was used to compute the standard deviation in this study. See equqtion 6:

$$he\delta = \frac{\sqrt{\Sigma(X - X^2}}{n} \qquad rainfall, \text{eq. 6}$$

Where: x = value of rainfall, temperature, and cholera cases.
$\bar{x}$ = mean value of rainfall, temperature, relative humidity, and cholera cases.
n = number of rainfalls, temperature, relative humidity, and cholera cases.
δ = standard deviation.

For detailed trend analysis, rainfall and temperature and cholera case trends were subdivided into decadal non-overlapping sub-periods (2000-2010, 2001-2020). In comparing means of Sub-periods for rainfall, temperature, relative humidity and cholera cases, Cramer's test was used.

To apply Cramer's test, each of the variables (rainfall, temperature, and cholera cases) had to be calculated with its mean and standard deviation, according to Lawson *et. l.,* (1981). The goal of Cramer's test was to compare the mean (xk) for each subsequent n-year period to the mean (x) for the whole time in terms of a moving t-statistic.
The formula for the t-statistic is given as equation 7:

$$t_k = \left(\frac{n(N-2)}{N - n\left(1 + \tau_k^2\right)}\right)^{1/2} \tau_k \quad \ldots\ldots\ldots\ldots\ldots\ldots \textbf{Eq. 7}$$

Where*:* t_k is a standardized measure of the difference between means given as equation 8:

$$t_k = \frac{\bar{x}k - \bar{x}}{\delta}$$ .... Eq. 8

Where, xk is the mean of the sub-period of n-years.
$\bar{x}$ and delta are the mean and standard deviation of the entire series respectively.
t is the value of the student *t*-distribution with *N-2* degrees of freedom.

The calculated ***t*** was tested against the "students" t-distribution table, at a 95% level of confidence level to a two-tailed form of test. When ***tk*** is outside the bounds of the two- tailed probability of the Gaussian distribution (equal to 1.96 at a 95% confidence level), a significant shift from the mean is assumed.
The Product Moment Correlation Coefficient statistics were employed in the correlation study to quantify the strength of the association between two variables—rainfall and temperature and cholera cases. The following is the formula:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$ eq.9

Were.
r =Product Moment Correlation Coefficient /x and y values of the two variables.
n = amount of occurrences/frequency of occurrence
Σx = sum of x
Σy = sum of y
Σy^2 = sum of y^2
Σxy = sum of xy
Σx^2 = sum of x^2

Enter method of Multiple *Regression* was used to determine the relations between the multiple climatic variables (rainfall and temperature) and cholera cases/outbreaks in the study area between the years 2000 to 2020. The Regression Equation is stated as follows.
$D = a + b_1 x_1 + b_2 x_2 + b_3 x_3$........................... eq. 10

Where, X_1 = Rainfall
X2 = Temperature
D = Disease (Cholera)
a_1 = Constant
b_1= Coefficient of rainfall
b_2 = Coefficient Humidity
b_3 = Coefficient Temperature

Ttest was also performed to determine whether there is a statistically significant difference in the incidence of cholera throughout the dry and rainy seasons. For the statistical analysis in this study, SPSS software (Version 23) was employed.

The Hypotheses tasted includes;

I. H_0: There is no significant variation in the climatic variables (rainfall, temperature, and relative humidity) between 2000–2020, in the study area.

II. H_0: There is no significant change in the trend of cholera cases between 2000 – 2020 in the study area.

III. H_0: There is no significant relationship between climatic variables (rainfall, relative humidity, and temperature) and cholera outbreaks in the study area.

IV. H_0: There is no significant difference in the seasonal distribution of cholera occurrences in the study area between 2000 – 2020.

RESULTS AND DISCUSSION

Trend of Climatic Variables (Rainfall and Temperature) between 2000-2020

Mean monthly rainfall in the study area (Figure 3), expressed a variations in the monthly rainfall which is a major characteristics of rainfall within the Guinea Savannah. August had the highest mean monthly rainfall with a value of 282.58mm, and January and February had the lowest with a value of 0.0mm.This demonstrates that the monthly rainfall was particularly high in July, August and September. This was also observed by Ogunjumo, (2010) and Daramola, (2013). This high rainfall surely increases the risk of flooding and associated with an increase in cholera cases in the study region.

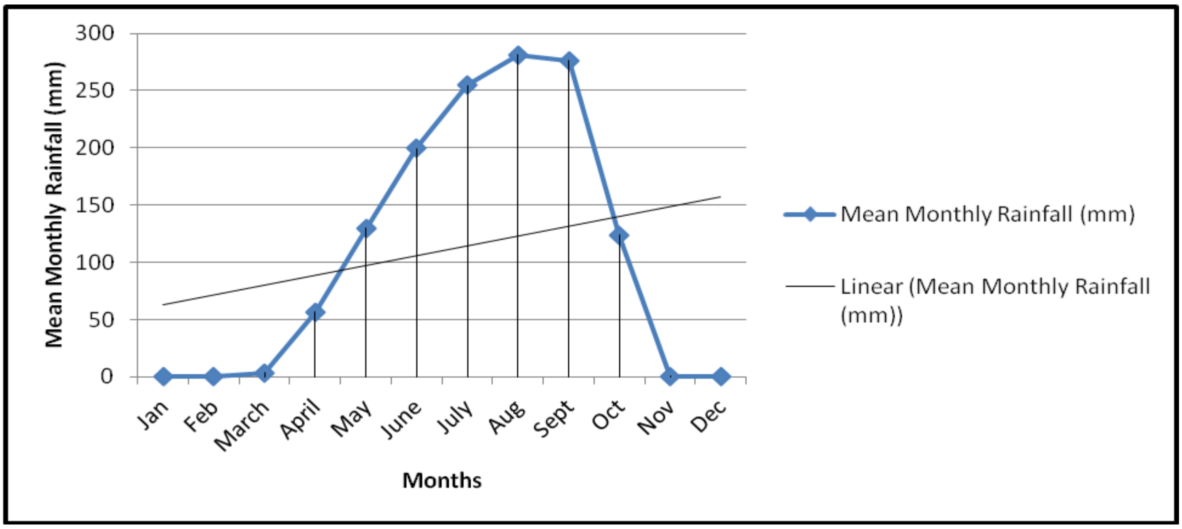

Figure 3: Monthly Rainfall Distribution of the Study Area
Source: Author's Analysis, 2023.

In the study area, the lowest monthly temperature (32.5^{0}C) was recorded in August this is due to the thick cloud cover and extreme rainfall recorded in the month of July and August in the area and April recorded the highest, 34.2^{0}C also due moisture dry cloud, earth surface dryness and the dominance of the tropical continental air-mass over the area. Ogunjumo, (2010) and Daramola, (2013) were also of same view.

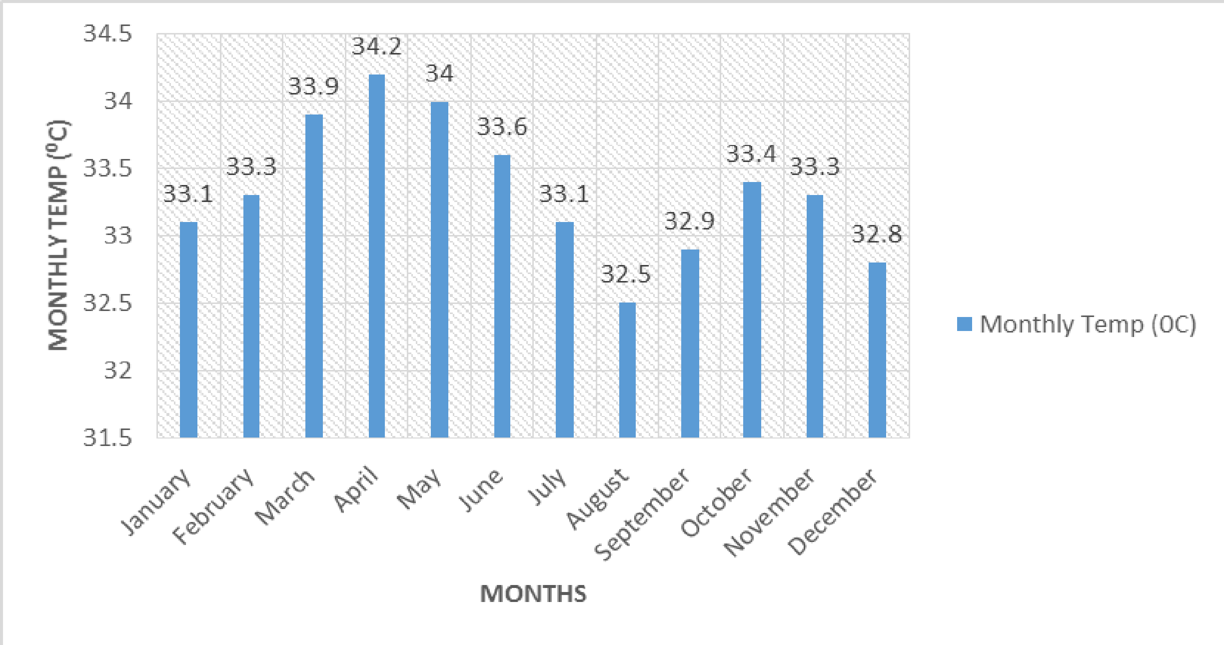

Figure 4: Monthly Temperature of the Research Area (2000 to 2020)
Source: Author's Analysis, 2023.

Temperatures of 20°C to 33°C and relative humidity greater than 60% which can be obtained in the rainy season are optimal for cholera *Vibrio* reproduction long enough to acquire and transmit the cholera parasite into the human body. Figure 4 revealed that temperature varies widely. The range is high between November and February and lower around July/August. The mean temperature is lower in December/January. These fluctuations will jeopardize the predictions of cholera vulnerable periods as observed by Lipp *et. al.,* (2012).

Trend of Cholera Cases Between 2000 – 2020 in Bida Metropolis

Figure 5 revealed that the year 2007 ranked the highest with 231 cases of cholera followed by the year 2014 with 198 cases and the least year was 2013 with 26 cases of cholera this situation is linked to climatic incidences in Bida Metropolies and Environs. This implies that cholera incidence is on the increase despite some fluctuation in some years.The principal mode of transmission of cholera remains the ingestion of contaminated water or food. Contamination's are climatic related as flood, stagnant water and temperature anomalies influences the the occurrences of cholera diseases as observed by Lawoyin *et. al.,* (1999).

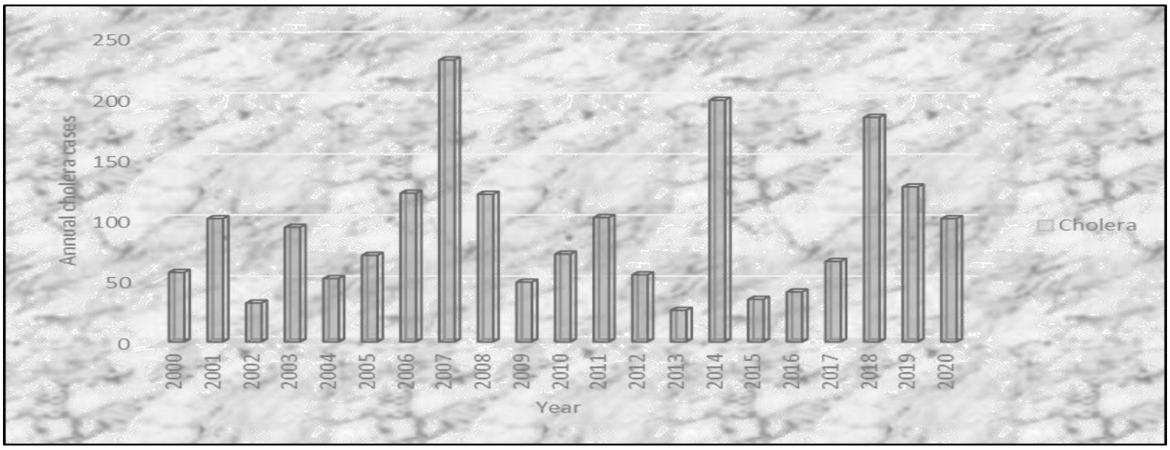

Figure 5: Annual Incidence of Cholera Cases in Bida Metropolis
Source: Author's Analysis, 2023.

Result depicted in Figure 6, ranked March the month with the highest (82) cases of cholera followed by November with 66 cases and the least was August with five cases of cholera. It is obvious that early rains and high temperature stimulates cholera incidences while much rains and and mild temperature does not favour incidences of cholera. This implies that cholera incidence is on the increase during the dry season despite fluctuation in some months. This further indicated that throughout the dry season, there is a shortage of good drinking water which allows people to take untreated water, and this could be attributed to higher cholera cases from November to May.

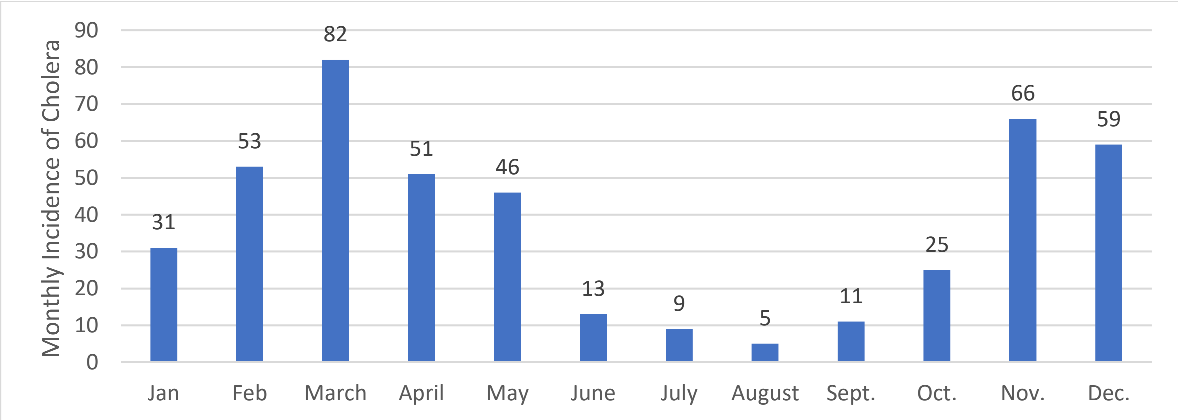

Figure 6: Monthly Incidence of Cholera in Bida Metropolis
Source: Author's Analysis, 2023.

Relationship between Climate Variables and Cholera Outbreaks in Bida Metropolis

Relationship between Cholera and Temperature
The correlation between climatic factors and the cholera occurrences in Bida Metropolis is shown in Table 1. Result shows that there is no connection between temperature and cholera in Bida Metropolis with correlation significance of 0.410* larger than the 0.05 level of confidence. This suggests that there is no statistically significant correlation between the temperature and the cholera occurrences in Bida Metropolis. The alternative hypothesis was rejected and accept the null hypothesis since the P-value is larger than 0.05, which indicates that temperature does not influence cholera.

Table 1: Cholera and Temperature descriptive and regression results

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.190[a]	.036	-.015	1.1471
a. Predictors: (Constant), Annual temperature				

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.934	1	.934	.710	**.410[b]**
	Residual	24.999	19	1.316		
	Total	25.932	20			
a. Dependent Variable: Cholera Outbreak						
b. Predictors: (Constant), Annual temperature						

Coefficients

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	8.297	8.762		.947	.356
	Annual temperature	-.214	.255	-.190	-.842	**.410**
a. Dependent Variable: Cholera Outbreak						

Source: Author's Analysis, 2023.

Figure 7 shows that there is a positive correlation between the lowest temperature and the square root of the monthly recorded cholera cases, indicating that the higher the mean temperature, the greater the cholera cases, notwithstanding some seasonal variation over the research period.

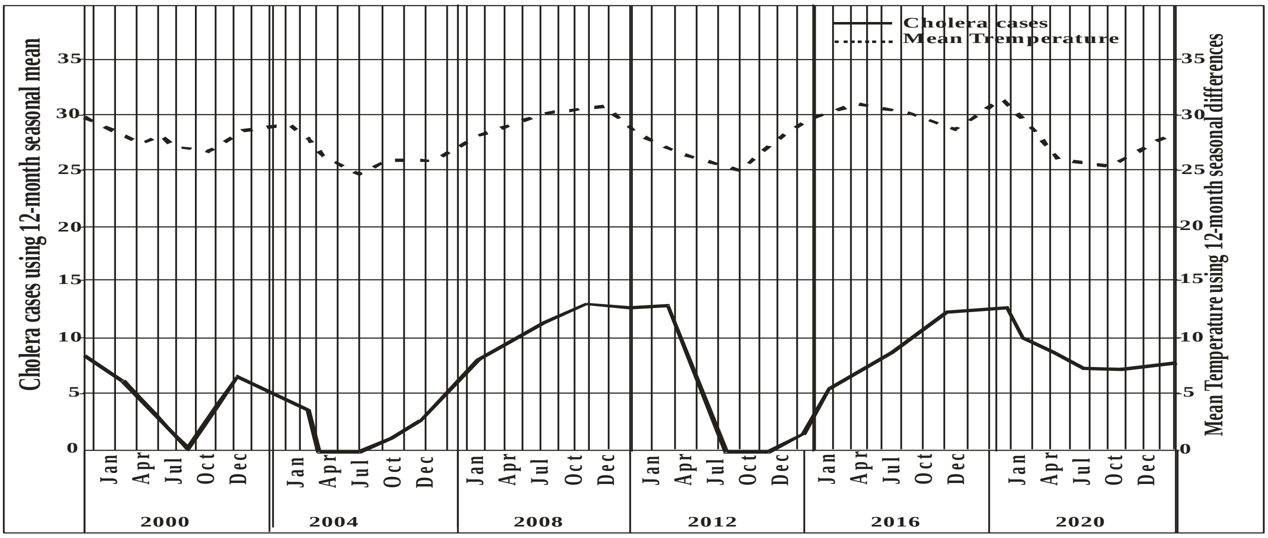

Figure 7: Relationship between the square root of monthly observed cholera cases and temperature using seasonal differencing between 2000–2020.

Relationship between Cholera and Rainfall

There is no discernible connection between cholera and rainfall in the research region, according to the analytical results shown in Table 2. This is because the obtained correlation P-value (0.550)* between cholera and rainfall is higher than the 0.05 level of confidence. The P-value is higher than 0.05 and the alternate hypothesis is rejected, the null hypothesis is accepted.This suggests that there is no statistically significant connection between the cholera occurrences and rainfall. Although there are certain months when cholera outbreaks start mostly at the beginning of the raining season.

Table 2: ***Cholera and rainfall descriptive and regression results***

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.138[a]	.019	-.033	1.1570
a. Predictors: (Constant), Annual rainfall				

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.496	1	.496	.370	**.550[b]**
	Residual	25.436	19	1.339		
	Total	25.932	20			
a. Dependent Variable: Cholera Outbreak						
b. Predictors: (Constant), Annual rainfall						

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.370	.937		.395	.697
	Annual rainfall	.000	.001	.138	.609	**.550**
a. Dependent Variable: Cholera Outbreak						

Source: Author's Analysis, 2023.

Despite minor changes in some months throughout the research period, Figure 8 shows a positive link between the square root of monthly recorded cholera cases and rainfall, indicating that the higher mean monthly rainfall the lower cases of cholera. In the other hand, the lower the rainfall the greater the cholera cases.

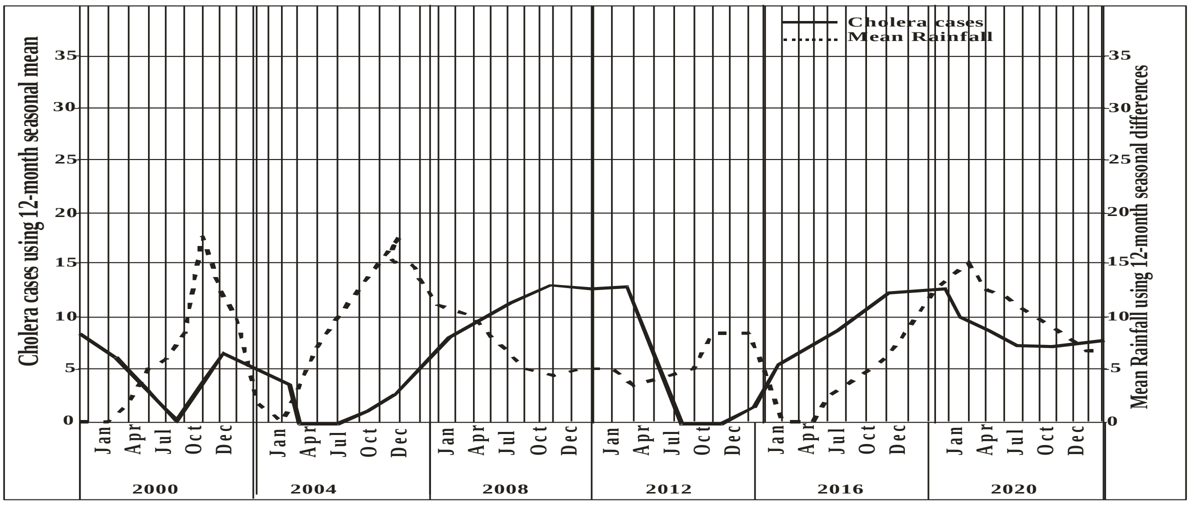

Figure 8: Relationship between the square root of monthly observed cholera cases and rainfall using seasonal differencing in the study area between 2000–2020.

Given the observation of Figure 7 depicting a positive correlation between the low temperature and the square root of the monthly recorded cholera cases, indicating that the higher the mean temperature, the greater the cholera cases, notwithstanding some seasonal variation over the research period. The observation in Figure 8 indicating negative link between the square root of monthly recorded cholera cases and rainfall, indicating that the higher mean monthly rainfall the lower cases of cholera. This findings coincides with that of Reyburn *et. al.,* (2011) and Hashizume *et. al.,* (2008) that rain generally has a beneficial effect on cholera. According to findings of Richard *et. al.*, (1999), the seasonal tendency seen in the monthly hospital time series coincides with the wet season which is contrary to the findings in this study. Emch *et. al.,* (2008); Hashizume et al., 2010) observed that flooding exposes people to bacteria, which is why there is a connection between rainfall and cholera. This argument may not be applicable in Bida Metropolis as flooding not a prominent incidence in the area. Asadgol *et. al.,* (2019) in their investigation on the impact of climate change on cholera disease from 1998 to 2016, daily information on cholera infection cases in the Iranian city of Qom somewhat similar method was used maximum and lowest temperatures as well as rainfall were observed climatic variables labelled as predictors. Their sensitivity analysis revealed that low rainfall is significantly correlated with cholera infection. Given that cholera might spread more quickly during warmer months of the year due to minimal rainfall and high temperatures, there is significant evidence linking the illness to environmental factors. These circumstances are similar to the findings in this study.

Multiple Regression Result of Cholera Cases with Rainfall and Temperature in Bida Metropolis

Table 3 depicts multiple regression results of the influence of climatic variables (rainfall and temperature) on cholera occurrences in Bida Metropolis. Cholera cases being the dependent variable and the climatic variables (rainfall and temperature) as independent variables. By the analysis's findings, the regression model is not significant since Anova = P-value = 0.541 > 0.05. Accordingly, it follows that the null hypothesis is true, and the alternative hypothesis is rejected. This indicates that there is no substantial correlation between cholera occurrences and climatic variables (rainfall and temperature) in Bida Metropolis.These findings went contrary to the observation of Quinn (2017) where it was observed that cholera epidemics are linked to water quality, temperatures, rainfall, and the bacteria that cause them, as well as a range of flora and fauna.

The "cholera paradigm" holds that the illness is spread by environmental exposure to cholera reservoirs, with climatic conditions directly driving outbreaks. It is obvious that the climatic conditions that favours coholera outbreak exist in Bida but the environmental exposure seems to be more in the beginning of the dry season and the beginning of the rainy season when there is scarcity of water for sanitation and a positive correlation between mean temperature and the square root of the monthly recorded cholera cases, indicating that the higher the mean temperature, the greater the cholera cases, notwithstanding some seasonal variation over the research period while negative link exist between the square root of monthly recorded cholera cases and rainfall, indicating that the higher mean monthly rainfall the lower cases of cholera. In agreement with findings in Haiti, Rebaudet, *et. al*., (2013) observed re-emergence of cholera outbreaks during the dry season is due to the environmental reservoir of cholera and poor sanitation associated with inadequate water supply that is common in urban centres in developing countries.

During the dry season, due to scarcity of water, inhabitants in Bida Metropolis utilizes untreated water from shallow wells, which carries a higher risk of contamination with the cholera which can be spread to high-risk individuals through ingestion and result to sickness, death and economic damage. In underdeveloped nations, cholera manifests in places without access to proper water treatment systems and sewage collection lines and it has been designated as the "sickness of poverty" (Chowdhury *et. al.,* 2017). Gina *et. al.,* (2022) also provides evidence of temperature being influential in cholera outbreaks, with temperature driving epidemics and rainfall acting as a dispersal mechanism. For example, a 1°C rise in temperature was associated with a 2-fold increase in cholera cases in Zanzibar (Reyburn *et. al.,* 2011).

Table 3: Multiple Regression Result of Cholera cases with Rainfall and Temperature in Bida Metropolis

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.257[a]	.066	-.038	1.1600
a. Predictors: (Constant), Annual rainfall, Annual temperature				

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.713	2	.857	.637	**.541**[b]
	Residual	24.219	18	1.346		
	Total	25.932	20			
a. Dependent Variable: Cholera Outbreak						
b. Predictors: (Constant), Annual rainfall, Annual temperature						

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.771	8.882		.987	.336
	Annual temperature	-.249	.261	-.220	-.951	.354
	Annual rainfall	.000	.001	.176	.761	.456
a. Dependent Variable: Cholera Outbreak						

Source: Author's Analysis, 2022.

CONCLUSION

This study concluded that there is no correlation between climate conditions (rainfall and temperature) and cholera outbreaks.All the two climatic factors, rainfall, and temperature were discovered to have a seasonal impact on cholera outbreaks. Cholera outbreaks seem to occur more frequently during the drier months than during the rainier months. This might be explained by the water's scarcity and that promote the growth and spread of the microorganisms that cause cholera. The increase in cholera outbreak cases may have been caused by the consequence of urban growth in the Bida Metropolis without an equal increase in social amenities and infrastructure. Based on the findings of this study, there is need for inhabitants enlightenment on adequate environmental sanitation with high level of consciousness in the beginning of the rainy season to curtail incidences of cholera outbreaks in Bida Metropolis.

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