Public Health Implications of Cholera- a Water Sanitation and Hygiene (WASH) Related Infectious Disease in the Era of Climate Change: The Nigeria Experience

ABSTRACT

Water, sanitation and hygiene (WASH) play key roles in management of infectious diseases like cholera and other waterborne diseases; given that millions of people globally have no access to safe water. Thiscross-sectional study, conducted in 7 communities of Ogoni region (Khana, Gokana, Tai and Eleme LGAs), Orashi region (Abua/Odual, Ahoada West, Ahoada East and Ogba-Egbema-Ndoni LGAs) and Obolo region (Andoni LGA) all in Rivers State, Nigeria, enrolled274 inhabitants comprising 164 females and 110 males. These includedpersons passing watery stools accompanied with vomiting, abdominal cramps and those with such prehistory. Questionnaires were used to obtain socio-demographic data. A total of 274 faecal samples were collected and transported in Cary-Blair stool culture transport medium to Rivers State University Teaching Hospital laboratory; and inoculated on Thiosulphate sulphate citrate bile salt-sucrose agar. Gram staining and biochemical tests were performed using standard procedures. Among the 274 subjects, 40 were infected giving a prevalence rate of 14.6%, including 26(15.9%) females and 14(12.7%) males though this was statistically insignificant, (U=8738.000, p=0.474). On educational levels, those who attended secondary schools had the highest prevalence rate (26.3%), compared to others and it was statistically significant, (p=0.00). WASH perceived predisposing factor showed the prevalence rate among those without access to safe water was 33(21.6%) against those with access to safe water 7(5.8%) and was statistically significant, (p=0.00). Subjects engaged in routine environmental sanitation and hygiene practices had lower prevalence 7(7.6%) than their counterparts, 33(18.1%), p=0.02. Respondents who think climate change had a positive impact on cholera transmission had prevalence of 34(23.3%) against those who disagreed, 6(4.7%), which was statistically significant. The study deduced that unavailability of safe drinking water, climate change, and unhygienic practices were major predisposing factors to cholera infection. Provision of safe water is advocated as greater percentage of the communities lacked access to safe drinking water. Routine environmental sanitation exercise should be revisited and enforced.

Key words: Cholera, WASH-related infectious diseases, Climate change, Safe drinking water, Unhygienic practices, Environmental sanitation and hygiene, Public Health

INTRODUCTION

Cholera is a waterborne disease with a higher risk of transmission in area where there is poor sanitation and clean water supply. Millions of people globally are at risk of cholera and other infectious diseases like Covid-19, Ebola and typhoid fever due to inadequate water sanitation and hygiene (WASH) services, [1,2,3,4].

Cholera is a WASH related infectious disease that infects the gastrointestinal tract of humans. It is caused by a comma-shaped Gram-negative rod *Vibrio. Cholerae.* cholera was first discovered in the Ganges delta in India from where it spread across the world [3,4,5,6] Cholera is mainly

transmitted by ingestion of food or water contaminated with faecal material containing *Vibrio cholerae*. Cholera has caused significant number of deaths especially amongst children under five and older adults [4,6,7] Cholera is considered a disease linked to poor WASH conditions and is preventable through wide-spread access to safe drinking water and sanitation [4,5,8]. Safe water, sanitation, and hygiene (WASH) are fundamental to human health [4]. Above 884 million people globally have no safe water to drink [4]. Nearly 2.4 billion people lack access to basic sanitation facilities which has resulted in the practice of open defecation that can lead to contamination of water used for drinking and personal use.

WASH is critical in achieving the sustainable development goals particularly goal 3, 6, 9 and 13. Cholera is a major public health threat endemic in low-and middle-income countries (LMIC) with an associated high risk of transmission compared to developed nations [4,9,10]

The global burden of cholera is largely unknown because the majority of cases are not reported, however, previous studies estimate 2.9 million cases, and 95 000 deaths occur annually in endemic countries with (21,000–143,000 deaths per year with sub-Saharan African countries mostly affected [4,8,11,12,13]. Cholera is endemic in most tropical and subtropical developing countries in Asia, Africa, and Latin America with high population density, inadequate supply of safe drinking water, poor sanitary practices and limited access to good public health systems which continue to cause a steady increase in morbidity and mortality rates [3,4,5,13,14]. On the contrary, in developed countries, increased frequency of *Vibrio* spp. infections, may be associated with anthropogenic climate change [3,8]. About 17 African countries reported over 150,000 cholera cases from all the outbreaks in 2017 [4,6,413]. Nigeria experienced the first epidemic of cholera in 1972, this was followed by sporadic reoccurring outbreaks. In Nigeria, the National Centre for Disease Control and Prevention (NCDC), reported a successive increase in cholera outbreaks with rising deaths rates annually. In 2018, 44,201 cases were reported in 20 States with a Case Fatality Rate (CFR) of 1.89%. By 2021, over 111,062 suspected cases and 3,604 deaths were recorded, exceeding the values of the previous year. [14,15]. In 2022, there was a decline in number of cases reported with 2,339 suspected cases of cholera infections with over 74 deaths were reported in 30 States across the country sparing Abia, Ebonyi, Edo, Enugu, Ogun, Yobe and FCT. approximately 68% of all suspected cases were recorded in only five states; Taraba (651 cases), Cross River (593 cases), Katsina (134 cases), Kano (124 cases) and Benue (100 cases) [8, 10]. This may be due to prevailing insecurity challenges that has led to humanitarian crisis in the Northeast where displaced populace is sheltered in crowded IDP camps that characterized by crowded conditions, inadequate hygiene and sanitation [8,10,16]. In addition, In the south region where this study was carried out, severe flooding affected majority of the states increased the susceptibility to cholera due to the presence of other factors like soil topography which allows leakage into drinking water sources like well, taps, surface rivers and ponds that harbors this organism, also giving that most of the water in this region lack treatment, [4,9,10,12,17,18]. There was a further decline by approximately 60% to 342 suspected cases later in the same year [8,10]. children aged ≤5 years irrespective of sex were the most affected, [4,5,10,14]. In Rivers State, various cholera outbreaks have occurred particularly in communities located within some riverine local government areas (LGAs) with poor hygiene and handwashing practices and a lack of potable water supply [10,18]. The Rivers State Ministry of Health (RSMoH reported an outbreak in

Andoni LGA that recorded over 77 suspected cases with 10 reported deaths within two days [10,18]. An epidemiological survey carried out by the Rivers State Ministry of Health in 2021 reported 373,071 people were at risk with the highest frequency observed among children aged 0-5 years [10].

There is scientific evidence that cholera is associated with changes in the environment and environmental conditions which range from increased rainfall, high temperatures, floods and drought [8,19,20]. These environmental changes can lead to global warming and greenhouse effect. This will ultimately affect both water quality and quantity and alteration of aquatic life. [8] Climate experts have observed these changes have led to rise in sea levels and rise in global temperatures resulting in heatwaves and flooding which play key role in cholera outbreaks and epidermic [19,20]. Nigeria has experienced a lot of cholera outbreak in recent times and currently reports the second highest number of estimated cholera cases in Africa (6,8). The high burden is likely due to the presence of many underlying socio-economic and environmental risk factors such as favorable climatic conditions [20,21] poor WASH services [8,22,23] and poor living conditions among majority of the populace (62% at <$1.25/day) [8,21,22]. The ongoing insecurity in the country due to intercommunal clashes, destruction of farmlands destruction of communities and WASH facilities have produced extreme environmental climatic changes which may have played key role in cholera outbreak in the country [13, 14,22] Additional predisposing factors that can lead to Outbreaks of disease includes inaccessibility to routine care such as immunization [5,9], insecurity [8,10], destruction of infrastructure [9,24,25], disruption of water, sanitation and hygiene (WASH) services and human displacement [1,4,5,6,22]. On the other hand, other deterrents such as; poorly equipped laboratories [9,10,18], weak epidemiological surveillance systems [3,4,9,10], poor political will and prevailing socio-economic challenges may largely contribute to cholera outbreaks [9,10,26].

Although several studies have examined how WASH factors and climate factors are relevant to cholera transmission and outbreaks in different geographical regions including Nigeria [3,5,9,11,12,22] most of the researcher focused on the prevalence of cholera in different region including the Niger Delta region of Nigeria .However no study has evaluated cholera prevalence in terms of the impact on public health in relation sociodemographic, WASH factors and climatic factors in order to provide additional data that will assist in management of cholera outbreaks .

This study evaluated the prevalence of cholera, its predisposing factors including WASH factors and their health implication. In addition, relationship between perception of the effect of climate change on prevalence of cholera was also evaluated.

The research intends to push to achieve mainly the sustainable development goal (SDG) 3, which is to ensure healthy lives and promote well-being for all at all ages

Remarkably, there are other associated indicators and SDGs linked with this research. The public health implication of cholera as it relates to age, sex, educational status and other socio demographic will culminate into meeting other SDGs, such as goals 1, 2, 4, 6, 8,9 and 10. This target is in line with the 2030 SDGs target

METHODOLOGY

Study Area

This study was carried out in Ogoni region (Khana, Gokana, Tai and Eleme LGAs), Orashi region (Abua/Odual, Ahoada West, Ahoada East and Ogba-Egbema-Ndoni LGAs) and Obolo region (Andoni LGA) of Rivers State, Nigeria. The Ogoni people occupy a territory of approximately 404 square miles, which forms the part of the Eastern Niger Delta, between the Imo River on the East and North. The area lies between latitudes $4^0.05^1$ and $4^0.20^1$ North and longitudes $7^0.10^1$ and $7^0.30^1$ East (Bodo and David, 2018). The Orashi region of Rivers State is in the Niger Delta region of Nigeria, and conservatively covers an approximate landmass of 70,000km2 which represents one of the most extensive wetlands globally. It is an ecological zone located between latitude 4º and 6º North of the equator and longitude 5º and 7º East of Greenwich [27], while the Obolo region is located at the South West fringe of the Andoni Local Government Area, Rivers State, precisely between Long.7^0 20□ 48.639□ E and Lat.4 29' 20.169N [28].

The people found in these areas are predominantly Fishermen, Agriculturists, Traders, partly Civil Servants. The LGAs involved being a riverine bounded communities provides sources of drinking water for her inhabitants. There have been lots of environmental pollutions including poor sanitary condition. Due to poor toilet systems found in the houses of majority of the inhabitants, many resorted to overhung community latrine hence passing excreta in the water bodies which in greater ways serve as their drinking source. Cholera outbreak affected lots of communities.

Study Population

This is made up of 274 residents of these sampled communities (Ogoni region, Orashi region and Obolo region of Rivers State, Nigeria) at the time of investigation.

Sample Size Determination

The sample size was determined by the Cochran 1977 sample size formular: $N = Z^2 \times P(1-P)/e^2$. Where; Z (1.96) is the selected critical value of desired confidence level, e (0.05) is the desired level of precision and P (16.7%) according toastudy by Okwelle and Kpea, (2019) was the estimated proportion of an attribute thatwaspresent in the population. Hence, the calculated sample was 214 plus the 10% (21) of non-response which amounted to 235, however, the higher the sample size the higher the power of the study, therefore, the required 235 was increased to 274 inhabitants of the communities to improve the power of the study.

Nature of Data

The researchers made adequate use of both primary and secondary data.

Study Design

The study adopted a cross sectional descriptive study.

Eligibility Criteria

1. Only residents within the area were included.
2. Residents who gave consent to participate were included into the study. While consent was sort from parents for underage, otherwise excluded.

Data Collection Techniques

Self-structured questionnaires titled "Public Health Implications of Cholera, a WASH Related Infectious Disease in the Era of Climate Change in Nigeria Questionnaire (PHICWRIDECCNQ)" was used for the study. The study instrument (Questionnaire) was divided into two sections namely; Sociodemographic and Perceived WASH factor and Climate Change factors. Probability sampling technique was employed given every participant equal chance of participation.

Laboratory Investigations

A total of 274 stool samples were collected from the inhabitants of the communities and transported in cold chain to the testing laboratory (Rivers State University Teaching Hospital Laboratory) with Cary-Blair stool culture transport medium for analysis and characterization. Thiosulphate-citrate bile salt-sucrose (TCBS) agar was used to culture *vibrio cholera*e, Gram stain and biochemical tests (oxidase, citrate, catalase, and indole) were carried out according to the standard procedures [29].

Method of Data Analysis

Data analysis involved the use of SPSS version 21 for frequency, percentage and prevalence rate. Also, Mann Whitney U test and Kruskal-wallis were the non-parametric tests used to measure difference in the distribution of cholera. Besides, correlation was performed in addition to regression model which was used to predict risk of cholera and all test of significance was at 5% alpha level.

RESULTS

1. Frequency and Prevalence Distribution of Socio-demographics and Responses of Perceived WASH and Climate related Predisposing Factors

The study evaluated public health implications of cholera; a WASH related infectious disease in the era of climate change with a presentation of the Nigeria experience. The study included 274 residents of some communities, dichotomously sex stratified into males-110 (40.1%) and females -164 (59.9%). Educational attainment had secondary level as the mostly distributed and tertiary level least common as 137(50%) and 25(9.1%) respectively. Age distribution revealed

age 11 - 20years as the highest -150(54.7%) whereas, subjects greater than 60years appeared least-4(1.5%). See table 1.

Distribution of self-reported perceived predisposing risk factors as pertain WASH and climate change showed the following results; tap water ranked the highest drinking water source having 96(35.0%), followed by well water -75(27.4%) while river source emerged least having 23(8.4%). See table 1.

Furthermore, perceived predisposing factors relative to WASH and Climate Change as obtained in this study demonstrated that 139 (50.7%) of the respondent revealed that climate change exists in the area with the weather reportedly seemly unpredictable although 135(49.3%) had opposite view. Results of prevalence distribution rate of cholera differed significantly between the two groups of respondents (Mann Whitney U=8463.500, p=0.022). See table 1 and table 4.

Also, perception of the respondents measured reveal that 146(53.3%) of the respondent reported that, climate change has afflicted people with different disease including WASH related diseases like cholera, malaria, typhoid, diarrheaetc. Whereas, 128(46.7%) said “No” to that regard. The rate of cholera for the two sets of respondents proved the null hypothesis wrong as significant difference was observed in the prevalence of cholera between the groups (Mann Whitney U=7606.000, p=0.00). See table 1 and table 4.

Being rural communities, greater percentage 153(55.8%) of the populace lacked access to safe drinking water. Similarly, this can be buttressed with high number of well as drinking water source, sachet water, and river as drinking water sources for residents at varying degrees. Test of significance for prevalence of cholera based on the opinions of respondents who had access and those who lacked access to safe drinking water established empirical variation (Mann Whitney U=7795.500, p=0.00). This means that the prevalence rate of cholera infection was not the same for both categories of respondents. See table 1 and 4.

Besides, findings from this study have illustrated a decline in the practice of routine environmental sanitation and hygiene as 182(66.4%) reported compare to 92(33.6%) people who responded that, it is a routine practice. This disparity in the perceptions of respondents corroborates with the study outcome, as indicated in the absence of statistical significance dissimilarity in the rates of cholera infection between the two groups (Mann Whitney U=7491.000, p=0.020). See table 1 and table 4 for details. Also, figures 1 to 5 presents data visualization of the distributions observed in this study.

Table 1: Frequency Distribution of Socio-demographic Characteristics and Predisposing Factors

Variables	Classification	Frequency N=274	Mann-Whitney U / Kruskal Wallis (X^2)	df	p-value
Socio-demographic Characteristics					
Sex	Female	164(59.9%)	8738.000	-	0.473
	Male	110(40.1%)			
Educational Attainment	No Formal Education	41(15.0%)	30.163	3	0.00
	Primary	71(25.9%)			
	Secondary	137(50.0%)			
	Tertiary	25(9.1%)			
Age Group	Less than/equals 10years	33(12.0%)	14.825	6	0.022
	11 - 20years	150(54.7%)			
	21 - 30years	32(11.7%)			
	31 - 40years	35(12.8%)			
	41 - 50years	14(5.1%)			
	51 - 60years	6(2.2%)			
	Greater than 60years	4(1.5%)			
Predisposing Factors (WASH and Climate Change)					
Drinking Water Source	Borehole	47(17.2%)	11.694	4	0.020
	Sachet Water (Commercially Bagged)	33(12.0%)			

	River	23(8.4%)			
	Tap	96(35.0%)			
	Well	75(27.4%)			
Climate Change	Yes	139(50.7%)	8463.500	-	0.022
	No	135(49.3%)			
Climate Change affected health and WASH related disease	Yes	146(53.3%)	7606.000	-	0.00
	No	128(46.7%)			
Access to safe drinking water	No	153(55.8%)	7795.500	-	0.00
	Yes	121(44.2%)			
Environmental sanitation	No	182(66.4%)	7491.000	-	0.020
	Yes	92(33.6%)			

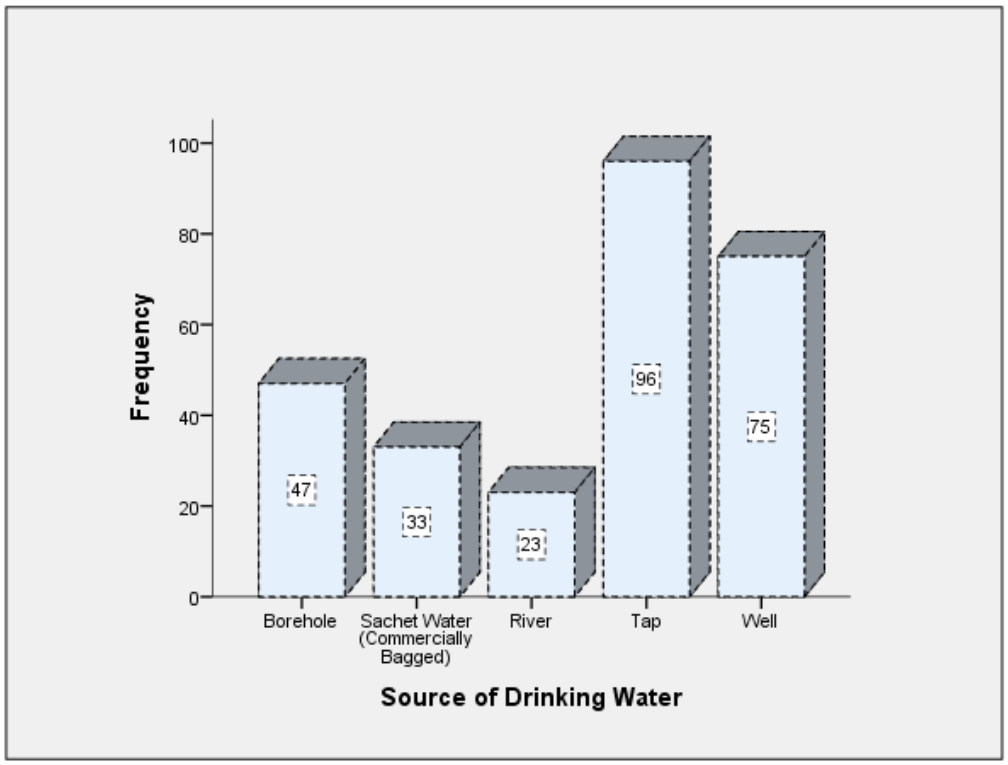

Figure 1: Bar Chart showing Frequency Distribution of different Sources of Drinking Water

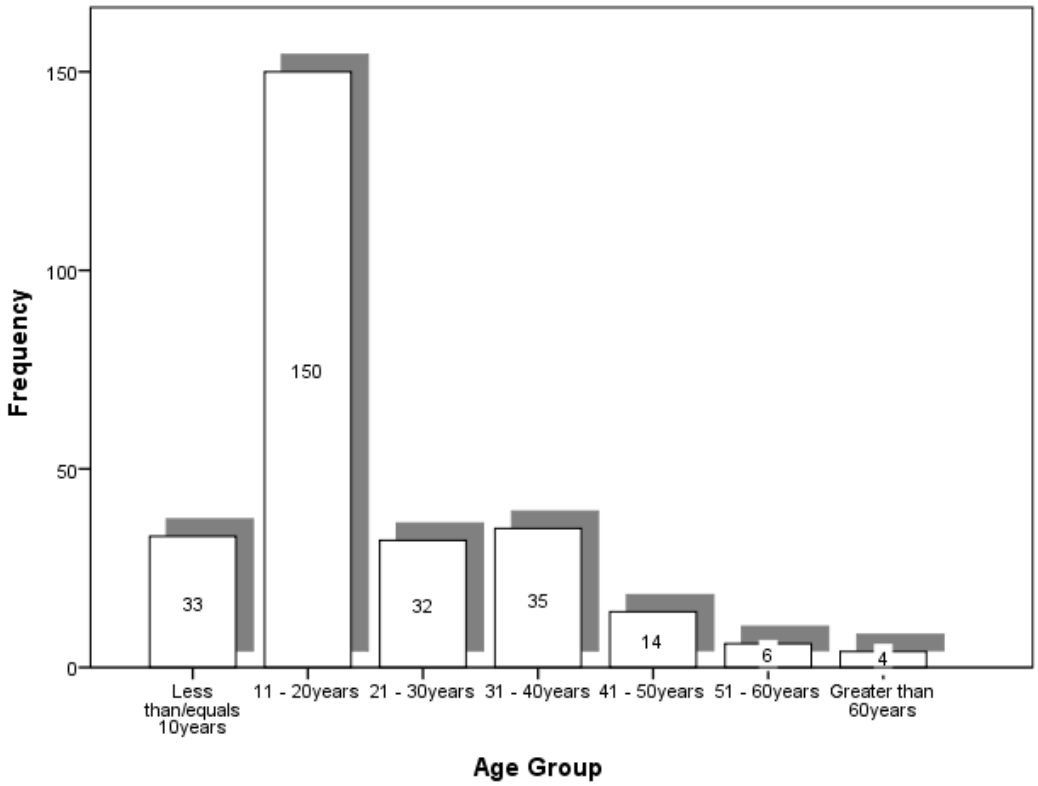

Figure 2: Bar Chart showing Age Distribution of Study Participants

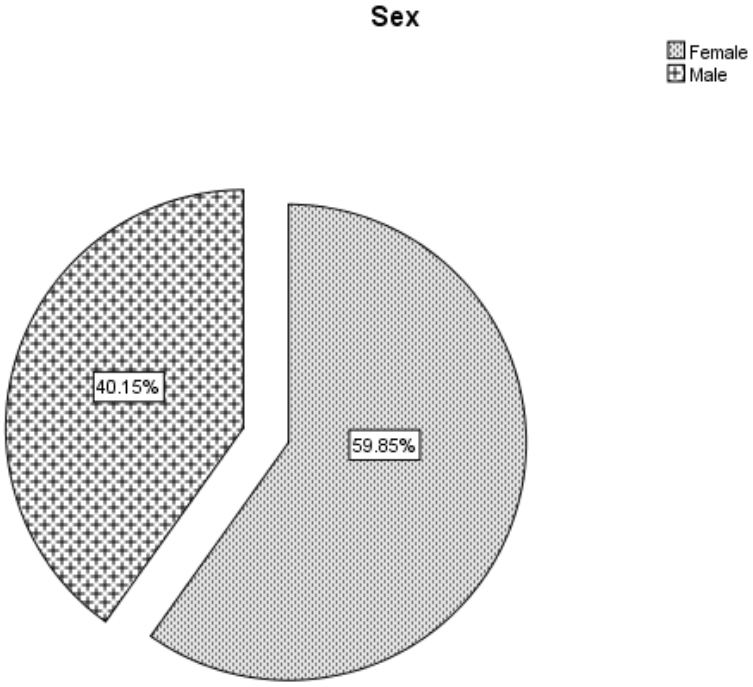

Figure3: Pie Chart of Sex Distribution of Study Population

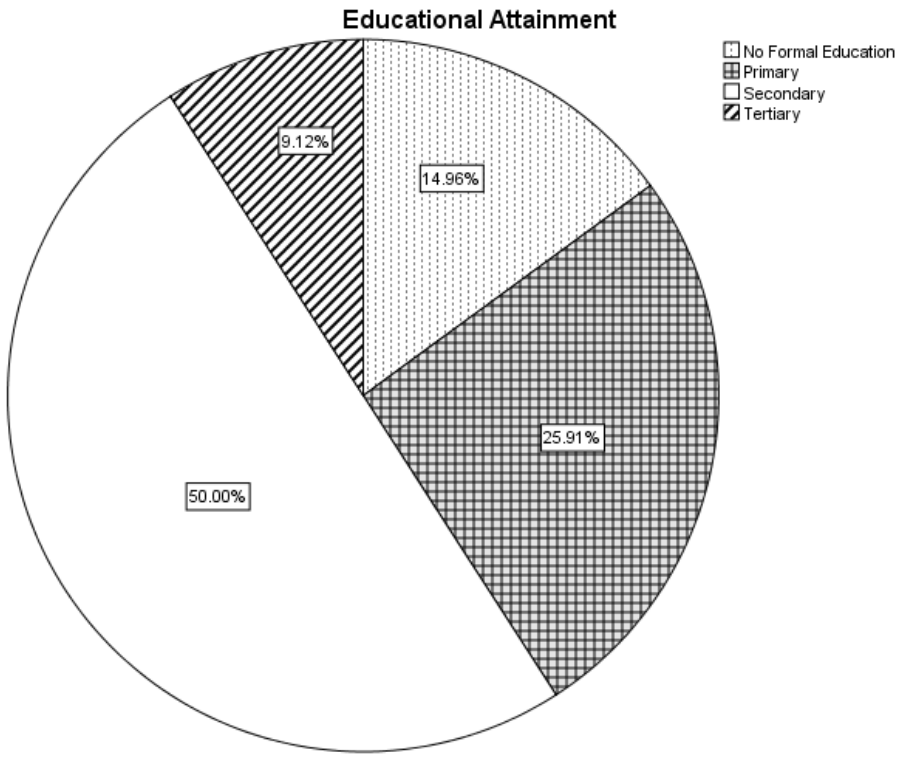

Figure 4: Pie Chart of Educational Attainment of Study Population

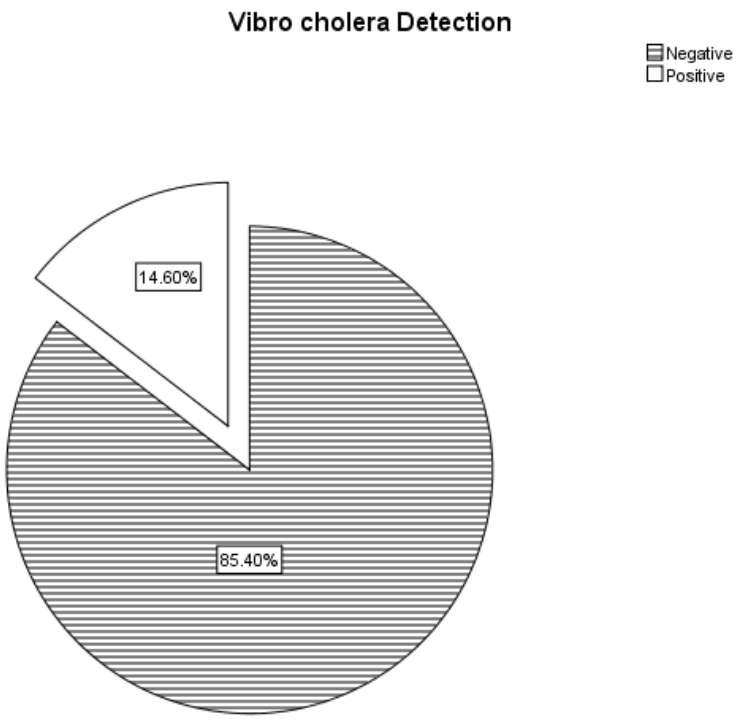

Figure 5: Pie Chart showing Overall Prevalence Distribution of Cholera in the Study Population

Prevalence Distribution of WASH Related Infectious Cholera Disease

The results obtained showed that from total of 274 examined, *Vibro cholera* was detected in 40 samples giving the overall prevalence of cholera in the study population as 14.6%. This is presented on table 2.

Table 2: Overall Prevalence of **Cholera in the Study Population**

Number Examined	***Vibro cholera* Not Detected**	***Vibro cholera* Detected**	**Prevalence of *Vibro cholera***
274	234 (85.4%)	40 (14.6%)	14.6%

Additionally, specific prevalence of cholera performed according to socio-demographic characteristics and perceived predisposing factors illustrates as follows: see table 3 and table 1 (Mann Whitney U and Kruskal-wallis tests for comparison of difference in the prevalence distribution of cholera). Sex specific prevalence rate of cholera had female as most prevalent group with 15.9%* although, there was no significant difference in the prevalence of cholera between male and female (Mann Whitney U=8738.000, P=0.473).

With respect to educational attainment secondary level had the highest prevalence of cholera (26.3%*) and null hypothesis was rejected as the result showed significant difference in the distribution of cholera across the group (Kruskal-wallis-X^2 =30.163, df=3, p=0.00).

Similarly, the prevalence of cholera varied statistically across age groups studied (Kruskal-wallis-X^2=14.825, df=6, p=0.022) and age specific prevalence of cholera demonstrated age 11 – 20years as the age group mostly affected (21.3%*).

Based on the various drinking water sources identified in this study, well water source had the highest rate of cholera (21.3%). Also, the rate of cholera across the six different water sources was at variance with marked statistically significant difference (Kruskal-wallis-X^2=11.694, df=4, p=0.020). See tables 1 and 3 for details.

Table 3: Demographic Specific Prevalence of Cholera in the Study Population

Variables	Number Examined	*Vibro cholera* Not Detected	*Vibro cholera* Detected	Prevalence of *Vibro cholera*
Sex				
Female	164(100.0%)	138(84.1%)	26(15.9%)	15.9%*
Male	110(100.0%)	96(87.3%)	14(12.7%)	12.7%
Education				
No Formal Education	41(100.0%)	39(95.1%)	2(4.9%)	4.9%
Primary	71(100.0%)	69(97.2%)	2(2.8%)	2.8%
Secondary	137(100.0%)	101(73.7%)	36(26.3%)	26.3%*
Tertiary	25(100.0%)	25(100.0%)	0(0.0%)	0.0%
Age Group				
≤10years	33(100.0%)	33(100.0%)	0(0.0%)	0.0%
11 - 20years	150(100.0%)	118(78.7%)	32(21.3%)	21.3%*
21 - 30years	32(100.0%)	30(93.8%)	2(6.3%)	6.3%
31 - 40years	35(100.0%)	31(88.6%)	4(11.4%)	11.4%
41 - 50years	14(100.0%)	12(85.7%)	2(14.3%)	14.3%
51 - 60years	6(100.0%)	6(100.0%)	0(0.0%)	0.0%
> 60years	4(100.0%)	4(100.0%)	0(0.0%)	0.0%
Drinking Water Sources				
Borehole	47(100.0%)	43(91.5%)	4(8.5%)	8.5%
Sachet Water (Commercially Bagged)	33(100.0%)	33(100.0%)	0(0.0%)	0.0%
River	23(100.0%)	21(91.3%)	2(8.7%)	8.7%

Tap	96(100.0%)	78(81.3%)	18(18.8%)	18.8%
Well	75(100.0%)	59(78.7%)	16(21.3%)	21.3%

N/B: * represents group with the highest prevalence

Comparatively the prevalence of cholera was determined using perception metric termed Perceived Climate Change and WASH associated Predisposing Factors. The “Climate Change Perceived Predisposing Factors” measured respondents’ perception about occurrence or existence of climate change and its impact. Also, WASH Perceived Predisposing Factors assessed respondents’ view about access to safe drinking water and Routine environmental sanitation and hygiene practices. Both metrics were estimated on a binary scale of “Yes/No” and the prevalence of cholera was measured for any single response, double and multiple responses.

For any predisposing factor identified, respondents opined their perceptions for each. Single response tagged superscripts a, b, c & d; it represents specific responses for queries about climate change, climate change impact, safe water access and routine environmental sanitation -hygiene practices respectively. For superscript “a” which is climate change, the prevalence of cholera recorded among respondent who perceived climate change “Yes” showed 27(19.4%) while among those who did not perceive climate change “No” had 13(9.6%) prevalence of cholera. Also, those who believed climate change has impact reported prevalence of cholera as 34(23.3%) when compared to those who said “No” 6(4.7%).

A flip to the “WASH Perceived Predisposing Factors” demonstrated low prevalence rate among those who had access to safe drinking water=7(5.8%) compared to the proportion of populace who lacked access to safe drinking water -33(21.6%). See subscript c on table 5.

Similarly, subscript d which connotes “routine environmental sanitation and hygiene practices” illustrates low prevalence among those who engage in sanitary and hygienic practice -7(7.6%) than those who do not 33(18.1%) 2. See table 5 for double responses. Lastly multiple comparison prove that for individuals who are aware of climate change, its impact, but lack access to safe drinking water and do not practice routine sanitation and hygiene, the prevalence of cholera showed 25(18.2%) for this category of respondents. See table 5 for more.

Table 4 Comparison of Prevalence of Cholera by Perceived WASH and Climate Change associated Predisposing Factors

Climate Change Perceived Predisposing Factors		WASH Perceived Predisposing Factors		
Climate Change	Climate Change impact	Safe water Access	Routine environmental sanitation and hygiene practices	Prevalence
Single Response				
[a]Yes				27(19.4%
No				13(9.6%)
	[b]Yes			34(23.3%)
	No			6(4.7%)
		[c]Yes		7(5.8%)
		No		33(21.6%)
			[d]Yes	7(7.6%)
			No	33(18.1%)2
Double Comparison				
[a]Yes	Yes			25(18.2%)
	No			2 (100%)
[b]No	Yes			9(100%)
	No			4 (3.2%)
		[c]Yes	Yes	7(7.6%)153
			No	--

		[d]No	Yes	--
			No	33(21.6%)
Multiple Comparison				
[a]Yes	Yes	No	No	25(18.2%)
	No	No	No	2 (100.0%)
[b]No	Yes	No	No	4 (100.0%)
		Yes	Yes	5(100.0%)
	[c]No	No	No	2(20%)
		Yes	No	0(0%)
			Yes	2(2.3%)

2. Association with Predisposing Factors of socio-demographics, perceived WASH and Climate Factors

Correlation

Correlation analysis showed indication of statistically significant correlation between cholera and educational attainment being the only socio-demographic characteristics with significant relationship with cholera (r=0.171, P=0.00, N=274).

Furthermore, 67% variables of the "perceived WASH predisposing factor" showed negative correlation with evidence of statistical significant association; r= -0.222, p=0.00, N=274 and r=-0.141, p=0.02 N=274 for 'Access to safe drinking water and Environmental sanitation/hygiene practice" respectively. By implication, increase access to safe drinking water as well as high level of environmental sanitation and hygienic practices will result to likely decrease in cholera epidemic. Nevertheless, a direct link was confirmed to exists between cholera and "Source of Drinking Water "as seen r= 0.176, p=0.00, N=274.

With regard to "Perceived Climate Change Predisposing Factor", all variables investigated assumed significant correlation exist with risk of cholera. The results suggest that, increase in climate change and its impact might probably lead to increase cholera outbreak orchestrated by climate change. See table 5.

Table 5: Correlation Analysis between Cholera and Other Variables

Variables	Description of Variables	Correlation	P-value
Socio-demographics	Sex	-0.043	0.474
	Educational Attainment	0.171	0.004
	Age Group	-0.026	0.667
Perceived WASH relate Predisposing Factor	Source of Drinking Water	0.176	0.003
	Access to safe drinking water	-0.222	0.00
	Environmental sanitation and hygiene practice	-0.141	0.020
Perceived Climate Change Predisposing Factor	Climate Change exists	.0139	0.022
	Climate Change impact	0.263	0.00

p<0,05=significant, p>0.05=not significant, r=1-perfect correlation, r=0.9-0.7=strong correlation, 0.6-0.4=moderate correlation,0.3-0.1=weak correlation, 0=no correlation. Minus(-) =inverse correlation, plus(+)=direct correlation

Binary LogisticRegression Model

Binary logistic regression was performed to measure the effects of demographics, perceived WASH related predisposing factors and climate change predisposing factors on the probability of been at risk of cholera. The binary logistic regression model was statistically significant, (χ^2 = 66.270, df=8, *p*= 0.00).and the model explained 21.5% (Cox & Snell R Square) and 38.1% (Nagelkerke R Square) of the variance in the prevalence of cholera disease. Also, it accurately classified 87.2.0% of the infection rate. See table 6.

Table 6: Classification Table[a]

Observed		Predicted		
		Vibro cholera Detection		Percentage Correct
		Negative	Positive	
Vibro cholera Detection	Negative	229	5	97.9
	Positive	30	10	25.0
Overall Percentage				**87.2**

Omnibus Tests - Chi-square =66.270, df=8, p=0.00. 2 Log likelihood=161.524, Cox & Snell R Square=0.215, Nagelkerke R Square=0.381. a. The cut value is .500

Table 7 further presents the individual contribution of the regressors in the binary logistic regression model which was used to predict the occurrence of Cholera infection using regressors of socio-demographic characteristics (sex, education and age) and perceived predisposing factors such as WASH related (water source, access to safe drinking water, environmental sanitation and hygienic practices) and climate change perceived factors (climate change occurrence, and its impacts).

Firstly, all socio-demographic included here added significantly ($p<0.05$) to the model prediction. In the WASH group of predictors, only drinking water source supported the prediction ($p=0.00$). Comparably, all variables of the perceived climate change factors significantly ($p<0.05$) contributed to the model predicting the occurrence of cholera as WASH related infectious disease affected by climate change.

In addition, the odd of having cholera was higher in males compared to females (0.212, CI:0.076-0.0589). See table 7 for more details.

Table 7: Logistic Regression showing Individual Contribution of Regressors to Predict Risk of Cholera

Socio-demographics Characteristics/ Perceived Predisposing Factors		B	S.E.	Wald	df	p-value	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Socio-demographics	Sex	-1.552	.522	8.859	1	**.003**	.212	.076	.589
	Education	.781	.293	7.088	1	**.008**	2.184	1.229	3.881
	Age	.678	.267	6.454	1	**.011**	1.971	1.168	3.326
WASH	Drinking water Source	.595	.208	8.215	1	**.004**	1.814	1.207	2.725
	Access to safe drinking water	-21.005	7198.679	.000	1	.998	.000	.000	.
	Routine environmental sanitation and hygiene practice	18.116	7198.679	.000	1	.998	73746861	.000	.
Climate change	Climate change	3.612	1.322	7.468	1	**.006**	37.058	2.777	494.450
	Climate Change affected health and WASH related disease)	-3.865	1.071	13.023	1	**.000**	.021	.003	.171
	Constant	-1.615	1.259	1.646	1	.199	.199		

N/B: B=Beta (slope), S.E=Standard Error, Wald=Chi square, df=degree of freedom, Exp=Exponential, Exp(B)=Odd Ratio, C1=Confidence Interval.

Summary of Findings

Conclusively, based on the empirical evidence obtained in this study, WASH related infectious cholera disease was observed in the population studied with an overall prevalence of 14.6% and varying specific prevalence rates for different variables. Study findings revealed indication of statistical significant difference in the prevalence of cholera for almost all variables investigated except sex.

Measure of association showed that, education is linked with the risk of cholera infection. Also, all variables of the perceived WASH and climate predisposing factors were evidently connected with the probability of having cholera disease.

Generally, binary logistic regression model significantly predicted effect of socio-demographic characteristics; perceived WASH related predisposing factors and perceived climate change factors on the risk of cholera. Although, at varying levels of contributions with two having null.

Discussion

This study highlights the public health implications of cholera as a WASH related disease and substantially sought to ascertain the relationships between socio-demographic parameters, access to water, sanitation, hygiene and climate change as determinants of the prevalence of cholera disease. Earlier study shares similarities with the scope of this study [30,31].

It was found that cholera remains a major public health problem as attested by the overall prevalence of 14.6% in the study population. The disease has been described as major signpost of social inequities and inequalities [8,32,33,34]. The acronym WASH, encapsulates and communicates the preeminent roles of water, sanitation and hygiene in the promotion of healthy living and wellbeing of people across the globe; as contained in some of the united nations' 17 sustainable development goals (SDGs) agenda for the year 2030, [8,20,31,35].

The age and sex specific socio-demographic disease burdens which appeared to be heavier on females and children as obtained in this study, though these were found to be statistically insignificant is similar with previous study. In a study across thirty-three states of Nigeria during a prolonged cholera outbreak the prevalence for males and females were almost equitably distributed at 50.1% and 49.9% respectively [26]; while a study in rural Haiti found the disease burden to be more on the male gender [36]. Notwithstanding, greater attention need to be paid to women's health as part of efforts against cholera and related infections, given the physiological peculiarities of women such as pregnancy related conditions, the fact that poverty is a major driver of the infections and women are more at risk of poverty, consisting of over 70% of the people living below poverty line particularly in low- and medium-income countries [37,38].

Educational attainment was the only socio-demographic characteristic shown to have significant association with cholera infection, with persons educated up to tertiary levels having the least distributions of cholera infection while individuals whose highest educational attainments are

secondary school manifested the highest distribution. While the disparity between persons educated up to tertiary level and those having only secondary education may be explained by reason of the fact that functional health literacy, knowledge of risk factors and preventive health behaviors are in direct proportionality with educational attainment. This however does not explain the disparity observed between persons with secondary education and those with lower academic attainment, [39,40,41]. The explanation may be found in the contention that mere possession of knowledge about food safety and risky behaviors do not always translate to safety practices during food preparation. It may also be ascribed to confounding factors such as economic conditions, age and infrastructural constraints. Thus, persons who have some knowledge of WASH practices but lack access to improved water may be constrained in performance of the WASH practices [42,43].

The quality and sufficiency of water supply in the study area reveals a rather parlous situation as only 35.0%, of the respondents had access to tap water, which happens to be the commonest single source of water while the rest of the others rely on such other sources whose safety are mostly dependent on how the owners (wells, boreholes) or producers (sachet waters) were able to maintain the safety status or rivers whose safety may be difficult to preserve. This puts a drag on the realization of universal and equitable access to safe and affordable drinking water for all people across the world by the year 2030 (goal number 6.1 of the SDGs) (Sustainable Development Goals Knowledge Platform, 2015; [44]. This situation mirrors the case in rural communities elsewhere in Nigeria and sub-Saharan Africa where demand for safe water outstrips its supply by a wide margin. As a basic necessity of life, this demand must be met one way or the other, through alternative sources such as drilling of boreholes, digging of wells, trekking long, sometimes tortuous distances in search of streams, rivers and so on, patronizing vendors of sachet water and such other vended waters, as well as economizing the available water; which come at great pains and sacrifices at the detriment of the health and wellbeing of the rural dwellers [8,22,30,45].

A decline in the practice of routine environmental sanitation and hygiene as reported by a preponderance of respondents was hardly surprising given that Nigerian rural areas have been reported to have one of the poorest accessibilities to clean water; such deficiency invariably impacts negatively on sanitary and hygienic behaviors leading to adverse consequences such as the spread of infectious diseases [8,44]. Inadequate availability of safe water has been linked to default in observing other WASH practices such as hand washing, as people will tend to economize the available water or make use of contaminated water [46,47].

It is the perception of about half of the respondents as regarding the predisposing factors relative to WASH and Climate Change as obtained in this study that climate change exists in the area with the weather reportedly seemly unpredictable. The majority perceived that climate change afflicted people with different diseases including WASH related diseases. The perception on the effects of climate on transmission of diseases has been corroborated in several studies [20,48,49,50]. Fallouts of climate change includes variations in temperature, extreme variations in rainfall, flooding, drought among others. High temperatures are likely to lead to proliferation of pathogens and vectors, while high rain may result in flooding and associated disruption of water infrastructure as well as contamination of water sources with

waste water and sewage. Low rainfall may cause water scarcity resulting in concentration of pathogens, scarcity of water and drought which hinders compliance to WASH practices [20,50,49].

There is apparently higher prevalence of cholera in persons with positive perceptions about the effects of climate change than in those with negative perception. There may be no causative nexus between the perception and the prevalence, as persons who have such awareness are most probably educated enough to embrace safe WASH habits. Conversely lower prevalence observed in persons with better access to improved water sources against a higher prevalence in those with restricted access; as well as those who engage in routine sanitary and hygienic practices as compared to higher prevalence in those who do not, is a validation of the public health benefits of the WASH practices. Expectedly, multiple comparisons shows that persons who are knowledgeable about the consequences of climate change without commensurate access to improved water supply and could not engage in the WASH practices could not enjoy the protection afforded by the practices as shown by the high prevalence of 18.2%.

The levels of educational attainments, access to improved water, routine observation of rules of sanitation and hygiene were shown to be statistically correlated to infection with cholera and related diseases. Also, the investigated variables on the perceptions of the respondents regarding climate change predisposing factors exhibited significant correlation with the risks of cholera infection. The observations in these regards are not unexpected as they are in agreement with the results of many researchers elsewhere [8,49,51,52]. High levels of health literacy lead to observance of the WASH practices which greatly reduces the chances of the pathogens getting to humans to initiate infection. Knowledge of the possible adverse fallouts of climate change helps in taking anticipatory measures to mitigate the impacts.

The statistically predicted infection rate of 87.2.0% is another cause for concern. It is a call for action at all levels of concern– governmental, communities and individuals to put up concerted efforts to address the issues raised in this study. Provision of improved water supplies is of prime concern as a driver of the other components of the WASH practices. Efforts should be intensified to enlighten the residents of the communities on the implications and adverse effects of climate change and the relevant measures to curtail them.

Conclusion and Recommendations

The outcome of this study has reinforced the fact that cholera constitutes a great public health threat. The high prevalence of cholera recorded in this study is a clear indicator that the infection is far from being eradicated, while the statistically predicted rate of infection at 87.2.0% is another cause for substantial concern. It is a call for action at all levels of concern– governmental, communities and individuals to put up concerted efforts to address the issues raised in this study. Provision of improved water supplies is of prime importance as a driver of the other components of the WASH practices. Efforts should be intensified to enlighten the residents of the communities and other communities within the region on the implications and adverse effects of climate change and the relevant measures to curtail them. High levels of health literacy should be promoted as it leads to observance of the WASH practices which greatly reduces the chances of the pathogens getting to humans to initiate infection. Knowledge

of the possible adverse fallouts of climate change helps in taking anticipatory measures to mitigate the impacts.

Study Limitations

The "Climate Change Perceived Predisposing Factors" which measured respondents' perception on climate change and its impact as well as WASH Perceived Predisposing Factors employed to assessed respondents' view about access to safe drinking water and Routine environmental sanitation and hygiene practices are subjective in nature

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