

Geospatial analysis of cholera outbreak in Kano Metropolis, Kano State, Nigeria

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Abstract

This study investigated the geospatial analysis of cholera in Kano Metropolis, Kano State Nigeria, from 2010-2019. Health Facility Based records of cholera cases were obtained from Kano State Ministry of Health (KSMoH) which includes the years of cholera outbreak, number of people affected, their age and sex, locations and the state of their health after being treated. These were analyzed using both descriptive and inferential statistics. Arc GIS was used to map out areas with cholera cases. Choropleth maps were generated showing yearly rates of occurrence for each ward. The results show that cholera is endemic and it occur yearly in the study area in both the wet and dry season, though with more cases in the wet season. Highest number of cases was recorded in 2013 and 2014 (21% and 43%) and other years of the study period having low and moderate cases respectively. For the study period, cholera cases were recorded in the entire Local Government Area with Dala and Kano Municipal having the highest number of cases (16% and 15% respectively) while Tarauni has the least number of cases (5% of the total cases). The result also revealed that male cases slightly outnumbered that of females, which is 54% against 46 while children between the age group of 0-14 were more affected than any other age group, accounting for about 30% of the total cases recorded. The result of this study is important for public health interventions, especially among the vulnerable age groups such as children.

Keywords: Cholera; Water and Food Borne Disease; GIS; Environmental Quality

1. Introduction

Cholera is an acute intestinal infection caused by the bacterium *Vibrio Cholerae*. Its mode of infection is through the consumption of contaminated food and water related to poor sanitation and hygiene practices. When consumed, *Vibrio Cholerae*, produces a toxin that provokes the release of fluids from the vascular walls of the gastro intestinal tract producing large volume of fluids resulting in watery diarrhea. Without immediate treatment, *Vibrio Cholerae* can cause severe dehydration and even leads to death within hours of onset in a severely purging individual. Case Fatality Rate (CFR) or death can be as high as 50% of severe cases in a vulnerable community. Cholera can be transmitted primarily through ingestion of the bacterium that is present in faeces of an infected person or secondarily through diffusion amongst infected individuals. The World Health Organization (WHO) first reports of cholera dates back to 1949 for Asia and to 1970 for Africa and it recognizes that there are many more cases than those reported due to lack of detection in remote areas and political suitability of nations avoiding the potential economic impacts of releasing such information (2). However, every year there is an estimated 3-5 million cases and 100,000 – 120,000 deaths due to cholera on a global scale (WHO, 2010:306) and climate variability has the tendency of inducing vulnerability to cholera.

Cholera is endemic and has become a yearly occurrence in Nigeria, especially the northern parts of the country (3). It is caused by drinking or eating contaminated food or water. Cholera affects both adults and children and can even lead to

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death within hours if untreated. Cholera outbreaks can disrupt the social and economic structure and can impede development in the affected communities. World Health Organization in collaboration with NCDC has repeatedly reported the increase in cholera cases in Kano State and the case fatality rate. Previous research on cholera infections in Kano has identified poor hygiene practices and over population as the major causes of cholera outbreak (4).

Kano state located in the northwest zone of Nigeria reports cholera outbreaks almost every year, and the disease still occurs in many local government areas even with the efforts from the government in providing water, sanitation and hygiene interventions to stop the outbreaks (5). Cholera has claimed many lives in Kano state and will still continue to, if proper majors are not taken. In 1999, Kano municipal reported a cholera outbreak which was due to the interruption of domestic water supply, of which 815 cases with 28 deaths were recorded (5). Out of the 44 local government areas in Kano, 18 recorded 2050 cholera cases and 80 deaths in 2001. 176 cases and 12 deaths were reported in 2002, most of these outbreaks have been attributed to problems of poor sanitation and unsafe water supplies. The fact that Kano State is considered one of the hotspot states with high burden of cholera in Nigeria is the reason for this study, to actually link the hotspot areas with environmental factors.

2. Methodology

For the purpose of this study, Health Facility Based records of cholera cases and issues like date of occurrence, age and sex of the infected patients, their location, and the state of their health after being treated were obtained from Kano State Ministry of Health for the period of 2010-2019, exception of 2012 data that got missing according to the Disease Surveillance and Notification Officer.

Trend analysis which helps to quantifies and explains trends and pattern of a given data set was used to assess the seasonal trend in cholera infections within the study period. The archived cholera data was first imputed into the Microsoft Excel (2007) applications in order to create a simple database. This was represented on a table and chart, showing the years of cholera outbreak, number of people affected, their age and sex, locations and the state of their health after being treated.

For the spatial trend in cholera occurrence, the Local Government Area map of Kano Metropolis was obtained from the GIS unit of Geography Department. The obtained map was geo-referenced and digitized in the GIS laboratory. The cholera archived cases were input into the GIS and merged, which formed the database for the analysis. From the database using prevalence rate at ward level, choropleth maps were generated showing yearly rates of occurrence for each ward within the Metropolitans. Six major categories were identified (No cholera, wards with 1-5 cases, 6-15 cases, 16-50 cases, 51-100 cases and > 100) and used to show the distribution of cholera in the study area as also used by (5). The categorizations enable quick identification of wards with low and higher cases as well as those areas at risk due to higher prevalence. The total occurrences for each year throughout the study period were presented using the categories, inception of 2012 that the data got missing.

3. Results and discussion

3.1. Spatial Distribution of Cholera Infection

The spatial distribution of cholera reported cases in the study area revealed how cholera cases are spread out across the wards in the metropolis within the study period. From figure 1-9, spatial distribution of reported cholera cases across Kano Metropolis revealed that cholera is endemic in the metropolis, throughout the study period (2010-2019). The cases reported in each Local Government Area for this period revealed Dala and Kano Municipal to have the highest number of cases (16% and 15% respectively) while Tarauni has the least number of cases (5% of the total cases). It is evident that cholera cases were reported throughout the study period, with some months having higher number of occurrence than the other. In 2014, the whole wards in Kano Metropolis recorded cholera cases with July and January being the two peaks. Increase in cholera cases for some Local Government Areas could result from the settlement dynamics as well as increase in human population which could probably leads to the deterioration of the physical environment as population in the urban centers tend to be higher than that of the rural area. From previous studies, it is revealed that most residents in Dala community are prone to communicable and non-communicable diseases due to high population density with poor planning system (6). This finding is also in line with that of (5) who in their study on cholera assessment in Kano State reported that 'excepting 2011 and 2019, cholera cases concentrated in urban local government areas of the state, of which both Dala and Municipal are part of.

Dala is the most densely populated local government area in Kano Metropolis occupying an area of about 36KM² with high population of about 566334.3641. Housing condition of an environment has a profound influence on the populace health, efficiency, social and economic values of any society. The LGA is characterized by a lot of informal housing (6) and informal dwelling can trigger cholera occurrence as the disease is easily transmitted in a congested environmental setting. It was also observed from previous studies that Kano municipal has high records of temperature, congestion and improper method of waste disposal (Buba and Muhammad, 2019), which could probably contribute to the spread of diseases in the area.

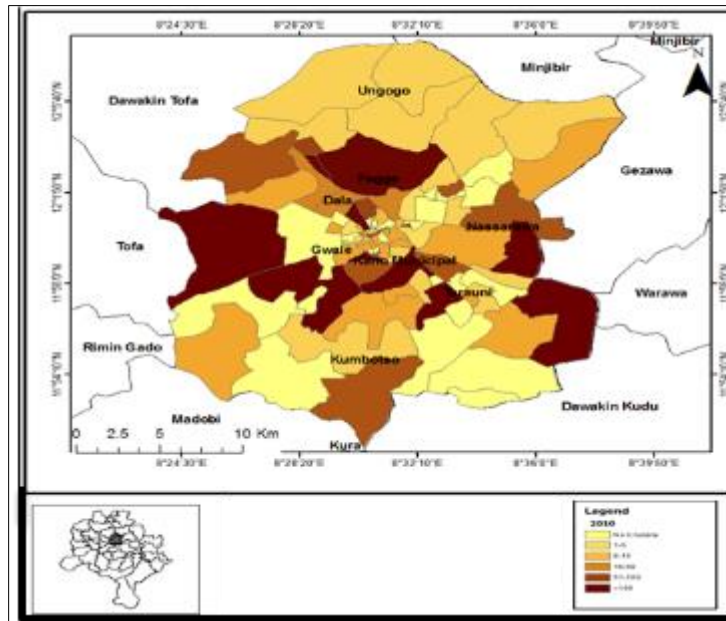


Figure 1 2010 Kano Metropolis Ward Cholera cases

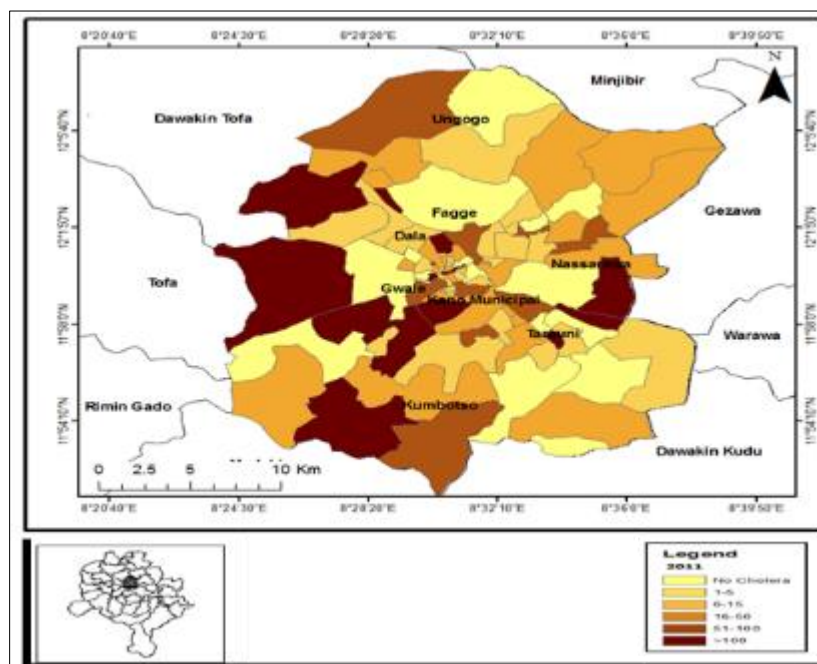


Figure 2 2011 Kano Metropolis Ward Cholera cases

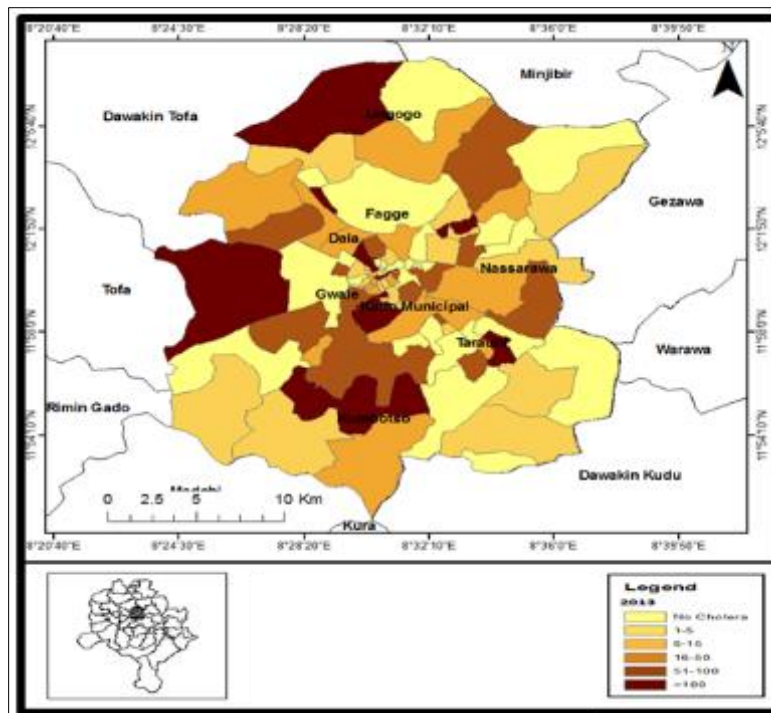


Figure 3 2013 Kano Metropolis Ward Cholera cases

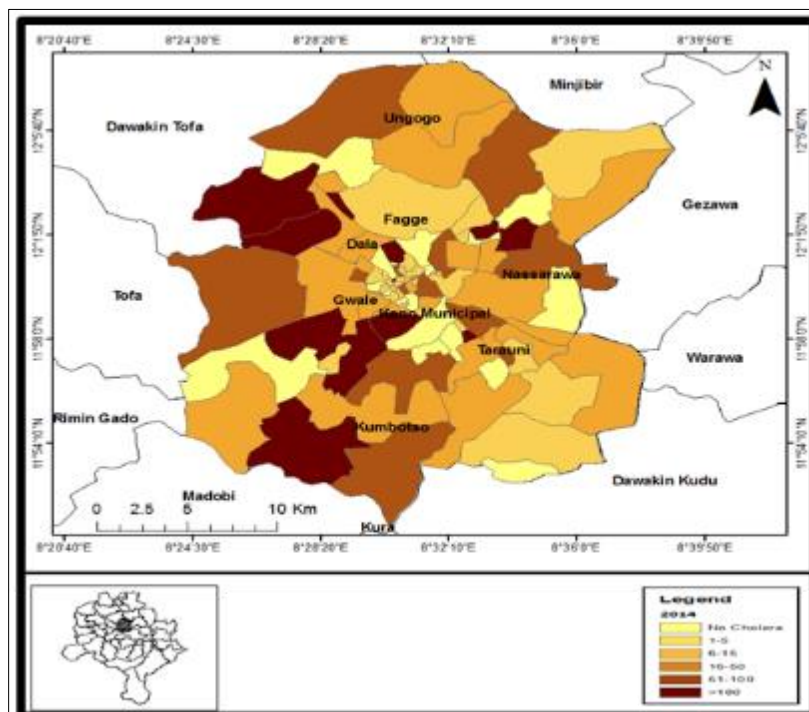


Figure 4 2014 Kano Metropolis Ward Cholera cases

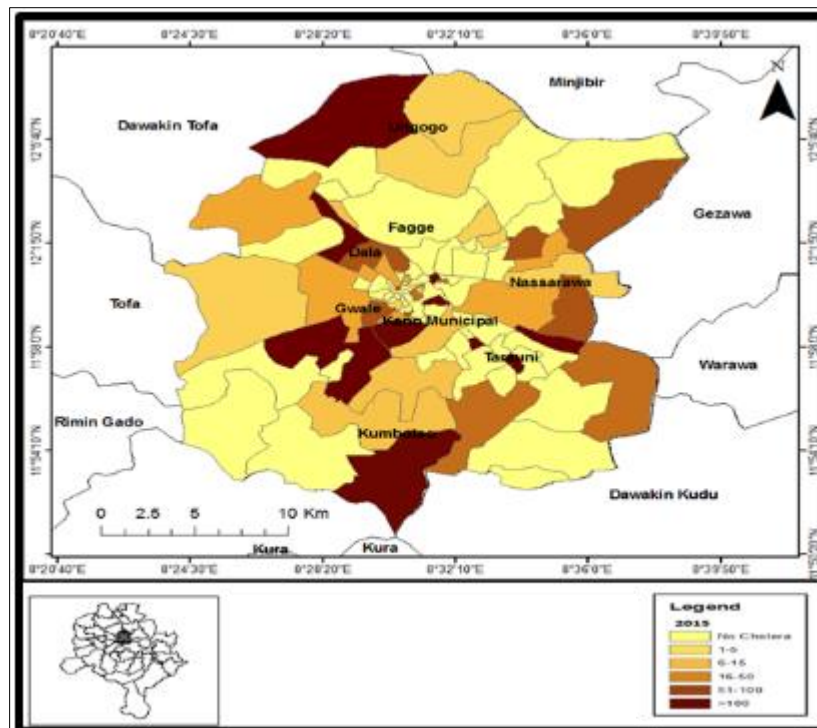


Figure 5 2015 Kano Metropolis Ward Cholera cases

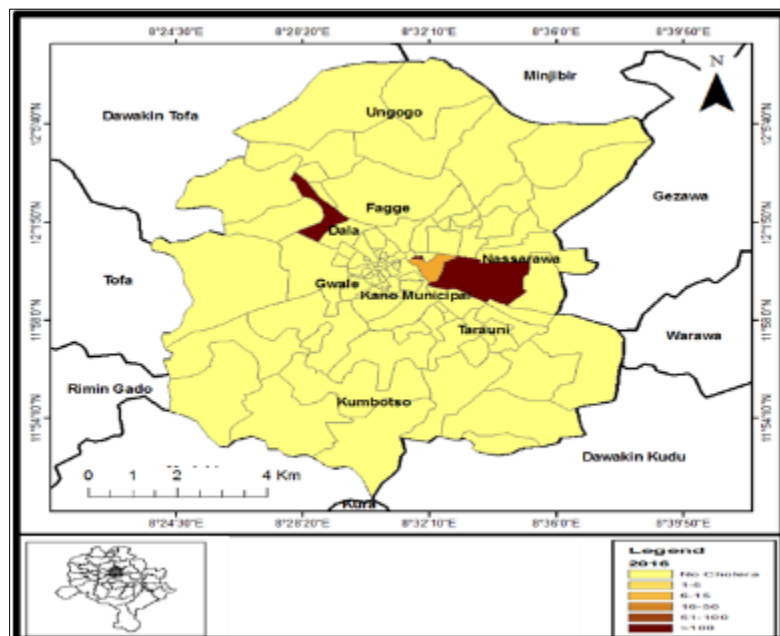


Figure 6 2016 Kano Metropolis Ward Cholera cases

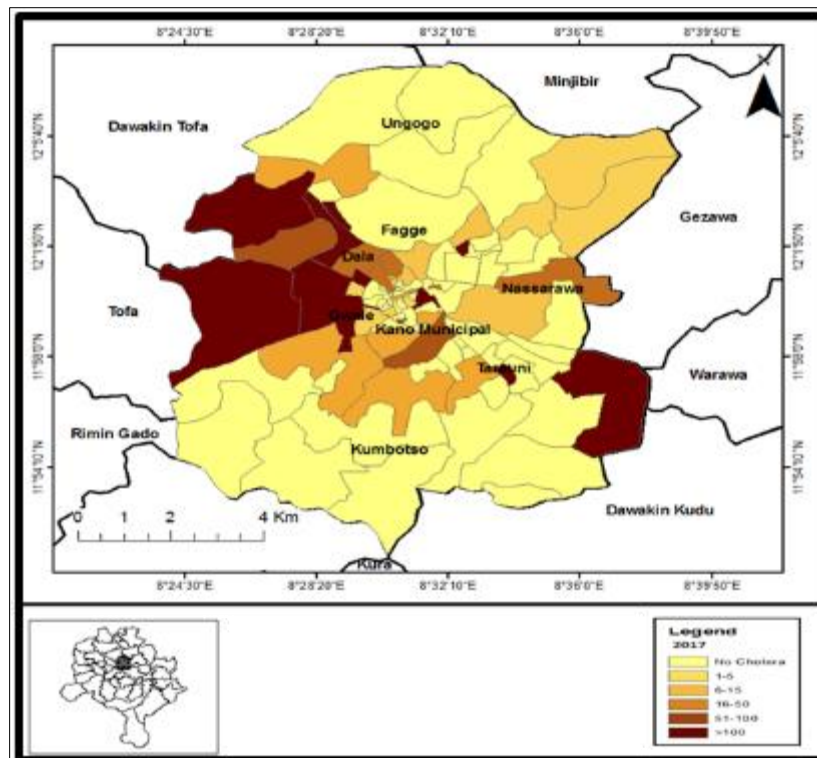


Figure 7 2017 Kano Metropolis Ward Cholera cases

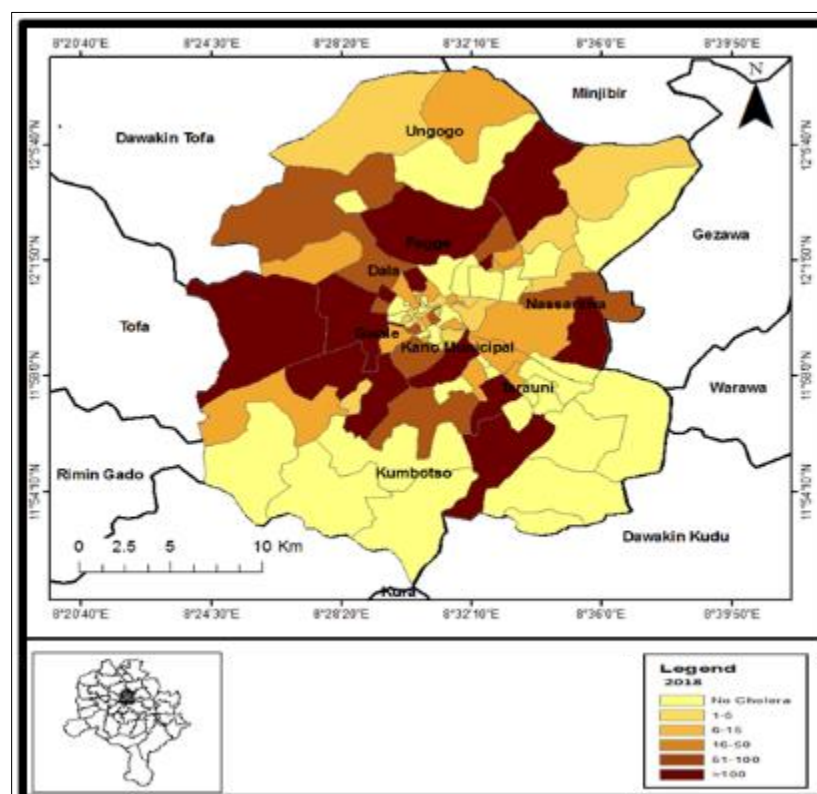


Figure 8 2018 Kano Metropolis Ward Cholera cases

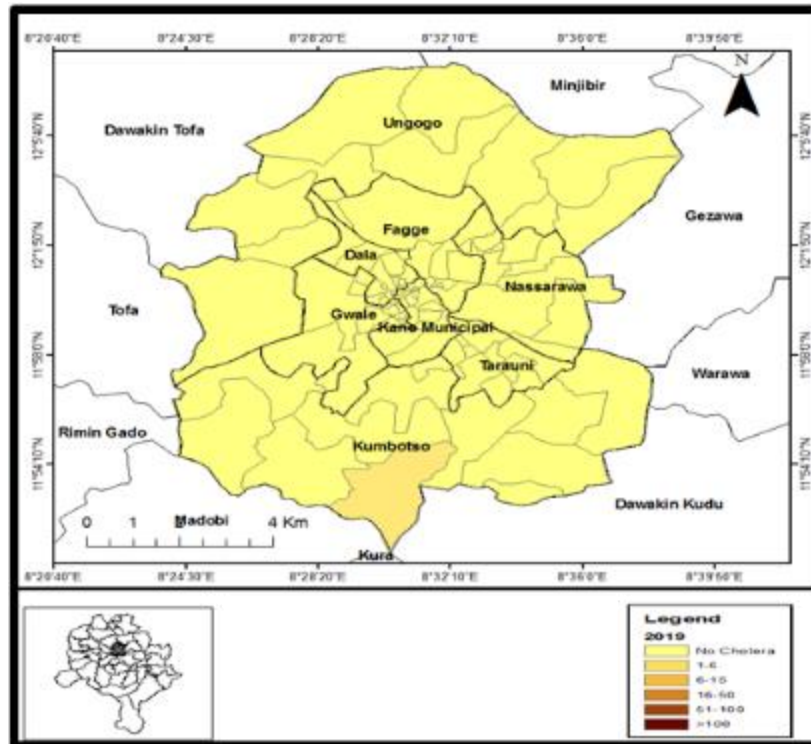


Figure 9 2019 Kano Metropolis Ward Cholera cases

Cholera is endemic throughout the study period in the whole Local Government Areas, with varying numbers of cases. From the spatial distribution of cholera cases above, it is observed that some wards within the Local Government Area in the Metropolis recorded consistent high cholera cases (e.g Gwammaja, Dala, Rijiyar Lemo, Dorayi etc) whereas others have low number of cases on record (e.g Adakawa, Yammata, Challawa, etc). Also, some wards have inconsistent cases, that is, there are fluctuations in the number of cases throughout the study period, (some of these wards have high cases in some years then low cases in other years, alternatively e.g Kabuga, Gandun Albasa etc), whereas ward like Na'ibawa in Kumbotso Local Government Area has an exceptional case, which is bad for the period of study.

Cholera is a water borne disease and can easily be transmitted in an area with poor environmental condition and high population density; this is because high population can put pressure on the available resources of which water is one. The three major sources of water in the study area are piped borne, well water and borehole. Piped – borne water is provided in most parts of the study area, but are not in adequate supply, and as such majority sources their water from wells and boreholes (6) which might not be treated thereby putting the people at risk of contracting infectious diseases. Some of these well are open and most at times, hygiene is not put into consideration in terms of utilization, as people can stand the chance of contracting the disease as a result of human activities around water source that can lead to contamination of water bodies. Some of these areas with consistent high cholera cases could possibly result from improper solid waste management as proper solid waste management is an important aspect of urban infrastructures that can ensure the protection of human health and the environment at large.

Proper solid waste disposal can reduce the rate of environmental pollution or contamination. Majority of the Metropolitans have poor method of waste disposal, as most of them dump waste closer to their dwellings and inadequate sanitation facilities can increase the rate of infectious diseases. In Kano Metropolis, some major streets, water ways and even several open spaces (e.g Kabuga opposite Taxi Motor Park, Kofar Ruwa Katsina Road, Gyadi-gyadi Court Road, Unguwa Uku behind Police Station etc) are been used as refuse dump sites and most of these sites are left unattended to for a very long period of time. No house- to- house collection of waste in the study area, and even some areas where large waste bins are provided, the residents hardly use them. The solid wastes are blown around by winds dirtying the environment and blocking drainages during rainfall which is capable of causing flooding (8) and having adverse effects on human health by exposing the residents to both communicable and non-communicable diseases. In some areas, heaps of solid wastes are gathered to have formed mountains with the waste dump sites mostly being along major streets. Some of these municipal waste sites are: Gyadi Gyadi along court road, waste site along zoo road, that of Nai'bawa and Hotoro, Yan Kara dump site at Sabon Gari, to mention but few (8). Most of these dump sites are closer to residential buildings and some street vendors sells cooked food along these areas without considering the unhygienic

environment and as such can pose danger to human health as bacterial are capable of replicating in an unhygienic environment. Wastes can also be seen as nuisance to the environment forming major breeding sites for rodents and several disease-causing organisms (9). Aside these heaps of waste causing both air and land pollution, some disease transmitting agents may spread it over neighbourhood resulting in an unhealthy and unhygienic environment.

In terms of toilet facilities, most of the populations in the study area shares toilet with their respective neighbors. In some cases, two to three houses share one toilet and some children from these household uses dumping site as their toilet, while some household rely solely on public toilets at their proximity. Some household still make use of pit latrines which is unhygienic and can increase the rate of infectious disease (6). Proper solid waste management, good drainage systems, adequate environmental condition, proper toilet facilities, environmental sanitation to mention but few can go a long way to reduce the transmission of contaminated diseases (6). These could possibly be the reasons for consistent low cholera cases in some wards within the metropolis, which if adopted by all could reduce the rate of cholera and other infectious disease transmission in the environment. Poor environmental practices along open defecation can increase the rate of infectious disease in some areas, as in the case of Nai'bawa in Kumbotso LGA that previously had low cholera cases on record but increases in recent years. The cause of high cases is not far from the effects of overcrowding, poor drainage system and inadequate environment management which can possibly increase the burden of disease in the area.

3.2. Yearly Trend of Cholera Cases

The trend (Fig.10) shows increase in cholera cases from 2013, with 2014 having the highest number of occurrences. The case decreases from 2015 downward with slight increment in 2018. The high cases in 2013 and 2014 and the respective case fatality rate could probably be as a result of poor case management as well as care seeking behavior as also observed by (5). Though, Public Health Management in Kano State faulted on environmental factors which include poor waste management, shortage of safe water, improper sanitation and the likes. The overall trend shows that it is declining as depicted by the trend line.

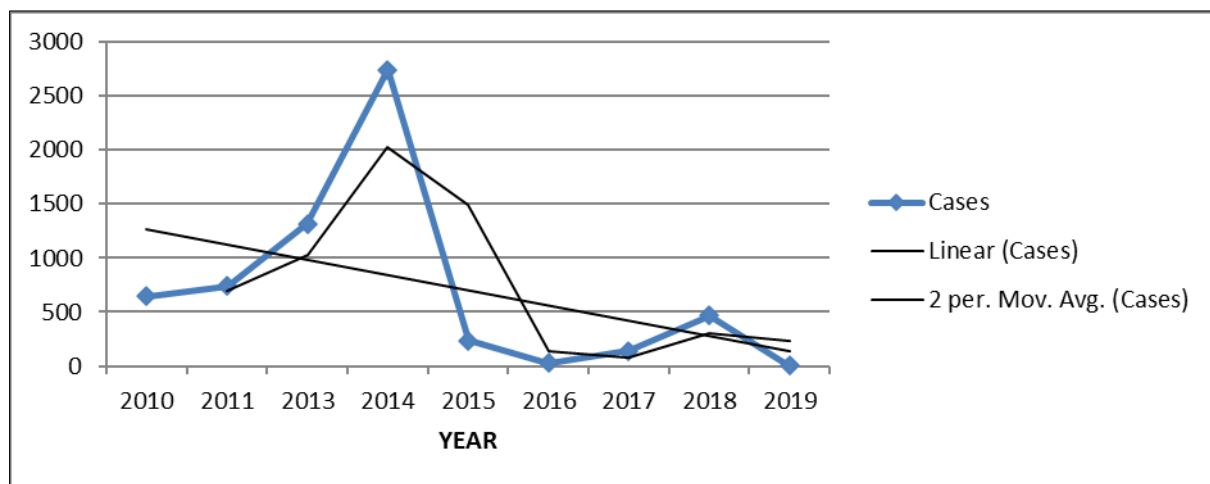


Figure 10 Yearly cholera trend from 2010-2019

3.3. Seasonal Trend of Cholera Cases

Seasonal average of reported cholera cases (Fig. 11), reveals that the Bazara (dry and hot) season has the highest average of cholera occurrence within the study period, followed by Damina (wet and warm) season. This implies that cholera cases in the study area to a large extent occur between March to September, in which the raining season or wet season still fall between, which corresponded with Ngwa et. al (2021) in their study of the micro-hotspots of cholera in Kano State confirming that the disease occurs in both dry and rainy seasons alike, with rainy season having the higher rates of occurrence and a peak in August.

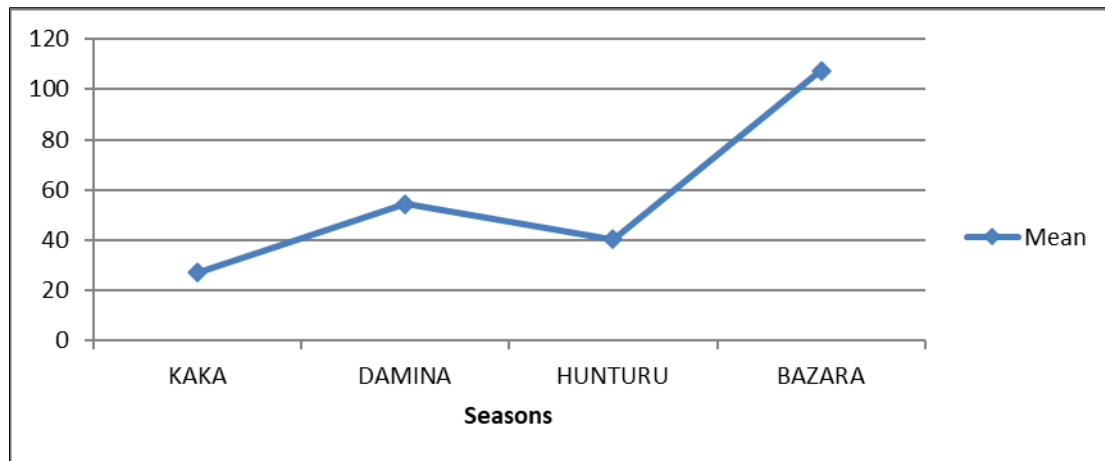


Figure 11 Seasonal average of cholera cases from 2010-2019

The seasonal distribution of cholera from findings in this study is not constant as cholera occurs both in dry and wet seasons (that is, the prevalence of the cholera is sensitive to both the dry and wet seasons) corresponding with the four distinctive seasons in the study area.

3.4. Demographic Characteristics of Cholera Infected Patients

The demographic trend of cholera cases in Kano Metropolis from 2010-2019 shows that male cases slightly outnumbered that of females, which is 54% against 46% accounting for a difference of 474 male cases (Table 1), this slight difference is a reflection of the national population where the difference between the male and female population is just 1.6% (3). This mean that males were infected with cholera disease more than the females, and it was also discovered that cholera death or case fatality rate (CFR) were higher in males than in female patients (3.4% against 2.3%). This could result from high number of male eating outside than female due to the type of job they do that could not probably permit them to go home and eat most of the time. Cholera is related to environmental sanitation and most of the male eat at least lunch outside or from food vendors not putting into consideration under the hygienic condition of which the food was prepared nor the environment in which the food is been sold. In similar analysis of cholera outbreak in Adamawa, (3) found out that there were more male cases than female cases, but discovered high rate of fatality in female than in male, which could result from the roles most female play as care-giver, coming in contact with more infected persons and making them vulnerable to the disease. Elimian *et al*, in their study of large cholera outbreak in Nigeria (2018), also discovered high cases in male than in female, though with just slight difference, and as well-found higher CFR in males (2.12%) than females (1.69%).

3.5. Age-Sex Distribution of Cholera Patients

The age distribution of cholera cases documented from 2010-2019 shows that more than 30% (the largest proportion) of all cholera cases were reported within the age group of 0-14 and that the age group also recorded the larger proportion of fatality (Table 1). This result implies that for the study period, children were more affected with cholera than every other age groups, this is as a result of that age group having the highest population in Kano Metropolis. The 2020 projected population of Kano Metropolis reveal that children (between 0-14) comprise of about 45% of the total population, especially the age group of 0-4 which is the highest in the whole local government areas of Kano Metropolis and as such, the reason behind the high reported cases. More so, children are more vulnerable to infectious diseases than adults, reasons being that; they are exposed to the environment for a longer time, they play outdoor, they are closer to the ground and may likely put some objects in their mouths, they can drink water from any source not mindful of any hygiene practices because it doesn't occur to them at that age and most of them living in an area with poor environmental conditions which is the case of some areas within Kano Metropolis, they eat outdoor with flies perching on their foods which is one of the fastest ways in which cholera is transmitted. Cholera can affect any age group as presented in Table 1, it is not only children's disease (10), as poor environmental conditions, contamination of water point as well as food can increase vulnerability in an endemic area. Age – sex distribution of cholera patients from previous studies can be said to be dynamic (11) as some researcher discovered high cholera cases in females than males and vice-versa and also in different age groups. From the foregoing, it can be resolved that cholera cases as related to age and sex is dynamic.

Table 1 Demographic characteristics of cholera patients in Kano Metropolis (2010-2019)

Age group	Cases			Outcome			CFR by Age(%)	CFR by Sex
	Male	Female	Total	Alive	Died	Unknown		
0-14	1147	742	1889	1813	74	2	3.9	Male = 3.4%
15-19	459	342	801	779	22	0	2.7	
20-24	421	350	771	759	11	1	1.4	
25-29	320	331	651	634	15	2	2.3	
30-34	238	280	518	512	6	0	1.2	
35-39	155	165	320	308	12	0	3.8	
40-44	142	159	301	291	10	0	3.3	
45-49	74	89	163	157	6	0	3.7	Female = 2.3%
50-54	105	125	230	225	5	0	2.2	
55-59	60	51	111	109	2	0	1.8	
60-64	95	89	184	179	5	0	2.7	
65-69	52	42	94	93	3	0	3.2	
70 +	125	154	279	268	10	1	3.6	
Total	3393	2919	6312	6127	181	6	35.8	

Source: Kano State Cholera data base (2010-2019)

From the overall analysis of the demographic characteristics of cholera patients, it was observed that cholera death (CFR) was higher within the age group of 0-14, 35-39, 45-49 then 70 and above. High cholera death among children could possibly results from their immature or underdeveloped immune system making them prone to contracting different kind of diseases, especially infectious diseases. Children, due to their playing activities on ground and moving from one place to the other make them prone to contacting viral diseases and it take longer time for them to recover from it than adult (12). The implication of this high CFR among children is the reduction in the population structure as these younger ones are meant to replace aged or older ones when they're no more. High cholera death among the age group of 35-39 and 45-49 could be as a result of self-medication and lack of reporting cases on time. This is true for most of these age group as they delay in consulting qualified medical personnel and patronizes quark doctors all in the name of receiving home treatment thereby worsening the situation before getting to the hospital, making the condition go beyond the control of those medical personnel and as such, it may lead to death of such patient. The age group of 70 and above also experience high CFR due to decline in their immune function. From research, it is observed that the human immune system declines with age, as the immune system of an aged person cannot function effective as that of those in their youthful age. Effect of aging on immune system is common and they affect the production rate of the naïve B and T cells in the human body and as such reduce the strength of the immune function (13). The implication of this decline in the immune system function is the inability of the body anti-genes to fight various infections and as such the aged people easily die of infectious diseases as it also occurred during covid-19 pandemic that claims more older peoples' lives than any other age group (14). Low CFR in some age group could result from prompt identification of the disease symptoms and reporting to health care as well as early medications which could probably reduce the negative effects of the diseases (15).

4. Conclusion

The study concludes that, cholera is endemic in Kano Metropolis throughout the seasons of the year. It mostly affects infants, children of school age, adolescents and young adults (youthful group). Cholera cases in male outnumbered that of female in the study area which could be as the result of their kind of job that does not permit them to go home and eat most of the times, but eat from the street vendors, and also some of the female affected to be as the result of the roles in the houses of taking care of the children and food handling.

Recommendation

Since cholera is environmental sensitive, improving the environmental quality as well as awareness campaign on the impacts of environmental condition on cholera occurrence will go a long way to alleviate the effects of the disease.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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