Spatial Distribution of Cholera Epidemic in Balanga Local Government Area of Gombe State, Nigeria.

[1]Mashkurah Ahmed Usman, [1]Dalibi Jamilu Haruna, [1]Umar Yusuf Abdullahi, [1]Mahdi Faiza Doho & [1]Yahaya Bako Sade

Department of Geography, Federal University of Kashere, Gombe State, Nigeria[1].
Email: umashkurah@gmail.com

Abstract

Cholera epidemic has been a recurrent decimal in Balanga Local Government Area of Gombe State Nigeria. The study assesses the spatial distribution of cholera epidemic in Balanga local government area using the base map, hotspot location and cholera epidemic information. The study employed geospatial analysis technique using GPS in order to know areas that have high cholera cases (hotspot), if overpopulation causes spread of cholera, what are the sources of water in the study area, what are the causes and symptoms duration of cholera in the study area and possible measures to be taken to reduce the impact and spread of the epidemic in the study area. The study revealed that there are hotspots and coldspots in the study area. Swa has the highest hotspots followed by Cham ward while coldspot areas include Tallase and Gelleng with little or no recorded case at all. 37% of the respondents have between 1-5 number of people per household infected, 36% of the respondents have between 6-10 number of people infected, 12% of the respondent has between 11-15 number of people, 16% of the respondents have 16-20 number of people infected. 5% of the respondents have access to tap water, 11% of the respondents use borehole water while 49% of the respondents use well water and 35% uses stream water as their sources of water supply in the study area. Contaminated food and contaminated water were the cause of cholera and symptoms last up to five days. Residential houses should be buffered at least 1000m away from source of contamination.

Keywords: Arc GIS, Cholera, Contamination, Hotspot, People

Introduction

Cholera is a disease characterized by profuse diarrhea accompanied with a severe dehydration loss of electrolyte, caused by toxigenic vibrio cholerae, a serologically diverse, environmental and gram-negative rod bacterium (Shaimada *et al,* 2020). In the absence of appropriate treatment, there is a high mortality rate. Cholera is a major public health concern, death-to-case ratio and ability to occur in epidemic and pandemic forms (Morris *et al*, 2015). Cholera is responsible for an estimated 120,000 deaths globally every year (Seminario *et al,* 2014)

Cholera outbreaks in developing countries are usually recurring annual events marked by high fatality rates, especially in countries with inadequate public health systems (Feikin, Tabu & Gichuki, 2020). Although it may be difficult to prevent a disease like cholera from occurring in an area, the spread and burden of the disease can be controlled and managed effectively through early detection, reporting, verification and case management. During outbreaks, a sensitive disease surveillance system is required for the early detection and reporting of cases, including analysis of the surveillance data for appropriate decision-making to guide targeted public health intervention, (WHO, 2019).

During the 19th century, cholera spread repeatedly from its original reservoir or source in the Ganges delta in India to the rest of the world before receding to South Asia, six pandemics were recorded that killed millions of people across Europe, Africa and the America (WHO 2019). The

seventh pandemic, started in 1961 in South Asia, reached Africa in 1971 and the America in 1991 (Talavera & Pérez, 2019). The disease is now considered an endemic in many countries and the pathogen causing cholera cannot currently be eliminated from the environment. Regions of the World where Cholera is currently prevalent are Africa, Asia and parts of the Middle East. Imported cases occasionally occur in richer countries in travelers returning from endemic areas (National Travel Health Network and Centre, 2007). Between 2010 and 2014, Nigeria reported over 70,000 cases and almost 3,000 deaths from presumptive or confirmed cholera (WHO, 2014). In 2018, there was a fresh cholera outbreak in Balanga, which killed 13 people, while 500 others were hospitalized and treated at primary health care in Balanga local Government area of the state and attributed the cause of the outbreak to the damaged five hand pumps in the community which forced the people to seek unsafe alternative source of water (Punch, 2018). Based on the cases mentioned above none of the researchers were able to analyse the spatial distribution of cholera in Balanga Local Government Area, Gombe State Nigeria using Geographical Information System in order to know areas that have high cholera cases (hotspot), if overpopulation causes spread of cholera, what are the source of water in the study area, what are the causes and symptoms duration of cholera in the study area and possible measures be taken to reduce the impact and spread of the epidemic in the study area.

Description of the Study Area

Balanga Local Government Area is located in Southeast of Gombe State, Nigeria. It shares border with Adamawa State to the east and south, to the north by Yamaltu-Deba and to the west by Kaltungo, Shongom and Akko LGA. It is located at latitude 9°58′N and longitude 11°41′E. Its administrative headquarters is in the town of Tallase. It has an area of 1,626 km², density 179.1/km^2 and a population of 212,549 (Balanga LGA Diary, 2017),

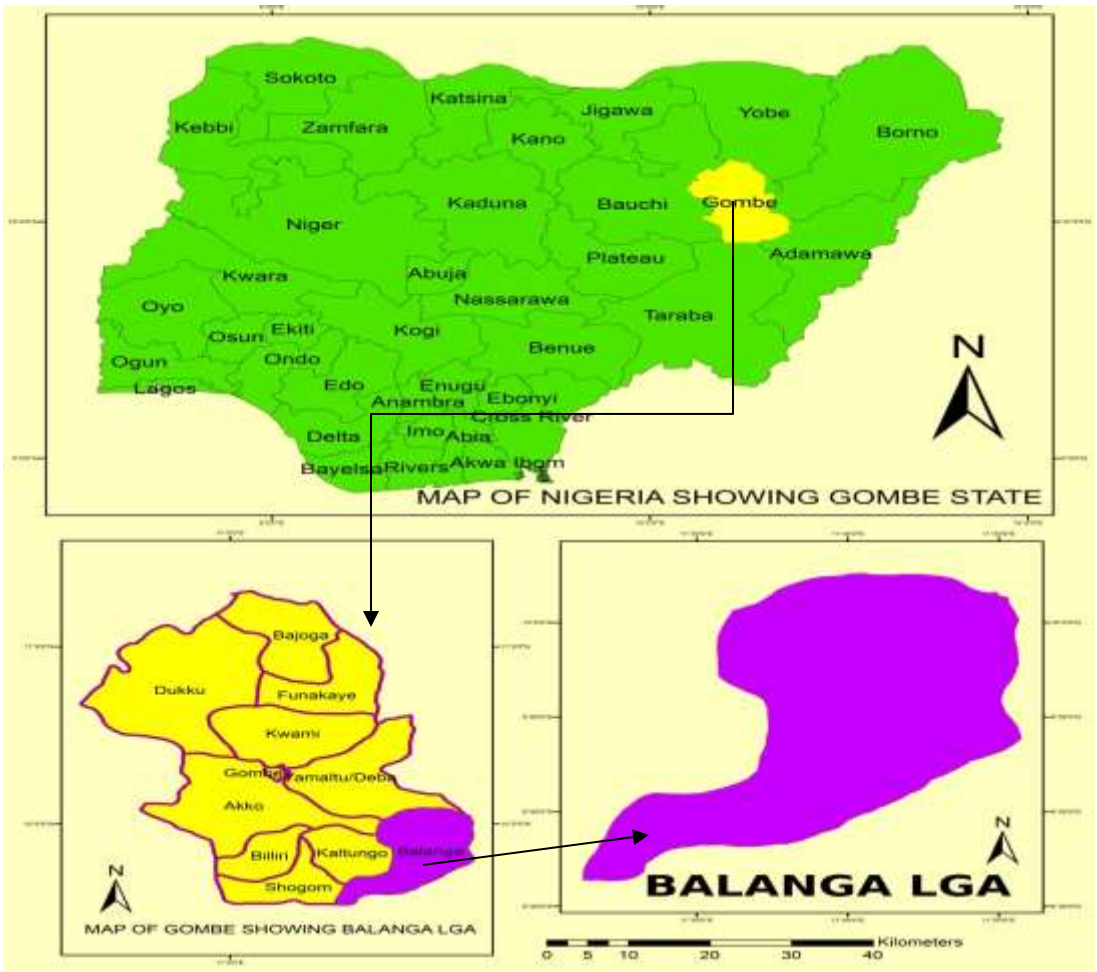

Fig. 1. Map of Nigeria showing Balanga LGA of Gombe

The climate of Balanga is typical continental of Northern Nigeria, which is characterized by two distinct seasons, dry and wet. The daily mean temperature ranges from 27ºC to 29ºC and in August about 17ºC. This is because the rainy season has a moderating effect on the temperature during winter. On the cool Harmattan, wind comes with fine dust from the Sahara Desert. The climate in Balanga is determine by the annual cycle of air masses humid air penetrate from the south from January-August while, dry air from the Sahara Desert move in the opposite direction takes a westerly cause North of the equator. It is the main source of rainfall in Nigeria. Balanga experience about 5-6 month of rainfall annually (Samuel, 2020).

Temperature with the hottest months are march and April which recorded up to a temperature of about 40-42° C and receive the mean annual rainfall of 321.4mm/annum (Omorogbe *et al*., 2017). The Balanga River rises in the Luguda plateau, some 30km southeast of Tallese town. It flows in Northwest direction toward the town of Putoki, several tributaries join the river mainly on it right bank. The river flow east-ward for about 10km before turning sharply north-north, west-ward to the dam site near Balanga village. The river joined Kaltungo River 25km below the dam site (Samuel, 2020). The application of geospatial analysis enables a system for establishing the relationship and interaction between the various spatial factors responsible for the distribution pattern of cholera in the study area. The use of primary and secondary data was used to achieve the objects of this study.

Materials and Methods

Data obtained were analyzed using GIS software Arc Map software for Geo-referencing, Digitizing, buffering, Geo-visualization, Area calculation, Study area maps production. Five (5) wards of Tallese, Swa, Kulani, Gellengu, Bambam ward in Balanga LGA, in order to have spatial information about the epidemic All vector data (i.e. line and point features) were sampled and arranged in separate attribute table entered into Microsoft excel and then saved as Comma Separated Values (CSV) format and imported into the ArcGIS environment. A database was created in Microsoft excel which include name of the cholera cases, locations and wards in the study area. Some data were eliminated either because of vague descriptions of locations or because they could not be confirmed. The database was converted into map layers within ArcGIS. Administrative map of Balanga served as the base map. The coordinates of the sites of the cases were overlaid on the base map of the study area in a GIS and the spatial distribution of cholera was created.

Questionnaire was administered on household heads, which served as the researchers' target population. A sample size of one hundred (100) respondents was drawn using Taro Yamenis formula. The sample was chosen by simple random sampling technique. The researchers personally trained two field assistants on the methodology of collection through the questionnaire. On-the spot administration of the questionnaire was done as the researchers waited for the respondents to complete the questionnaire and return same, to avoid bias and duplication of responses from them. For the non-literates, the questionnaire was read out and interpreted to them in their local dialect.

Balanga LGA has about 212,549 people, but the projected population is estimated to be 291,200 as of 2020 with the growth rate of about 2.3%. Twenty (20) copies of the questionnaire were distributed to each of the five sampled wards in Balanga LGA.

Given the Taro Yamene (1964) Formula

$$n = \frac{N}{(1 + N(e^2))} \quad (1)$$

Where

n = Sample Size

N = Sampled population

e = Level of precision or confidence level at 0.05 significance

where$n = \frac{653}{(1+6553(0.05^2))} = 100$

Judgemental sampling technique was used in selecting and mapping out areas such as Tallase, Swa, Kundiyo, Gellengu, Bambam in the study area. These areas were already known to be highly affected with cholera.

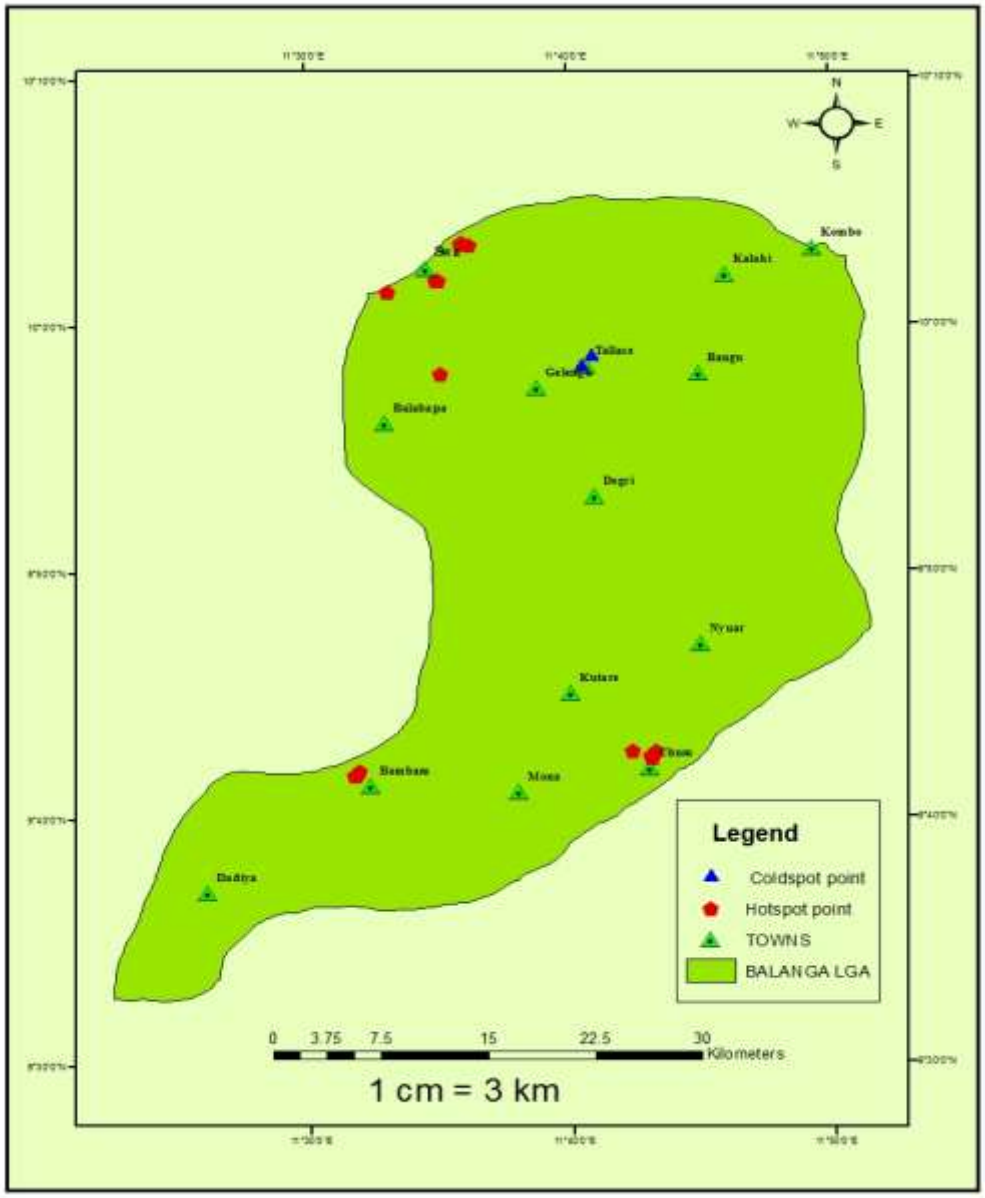

Figure 2: Hotspot and Coldspot in the study area

Source: Author's Work, 2024

Data in Figure 2 above show that hotspot areas are predominantly in the upperpart area of the map where n the study area while little or no recorded cases within the middle part of the study and few hotspots at the lower region of the map on the study area. The results reveal that Swa ward has the highest hotspots followed by Cham ward while coldsport areas include Tallase and Gelleng with little or no recorded case at all. Based on observation the hotspot in Swa ward mainly lies at the border of the study area which has access to streams and wells as their major sources of water which is usually unclean and help spread cholera diseases.

The household size result of the respondents analyzed with cholera cases in figure 3 shows that 37% of the respondents have between 1-5 number of people per household infected, 36% of the respondents have between 6-10 number of people infected, 12% of the respondent have between

11-15 number of people infected while 16% of the respondents have 16-20 number of people infected. Based on observation it is clear that the number of people with the highest percentage lies between 1-5 and the lowest number of people per household (12%) is between 11-15 as such the result has shown that the spread of cholera disease is not due to overcrowdings or overpopulation but poor source of water and contaminated foods.

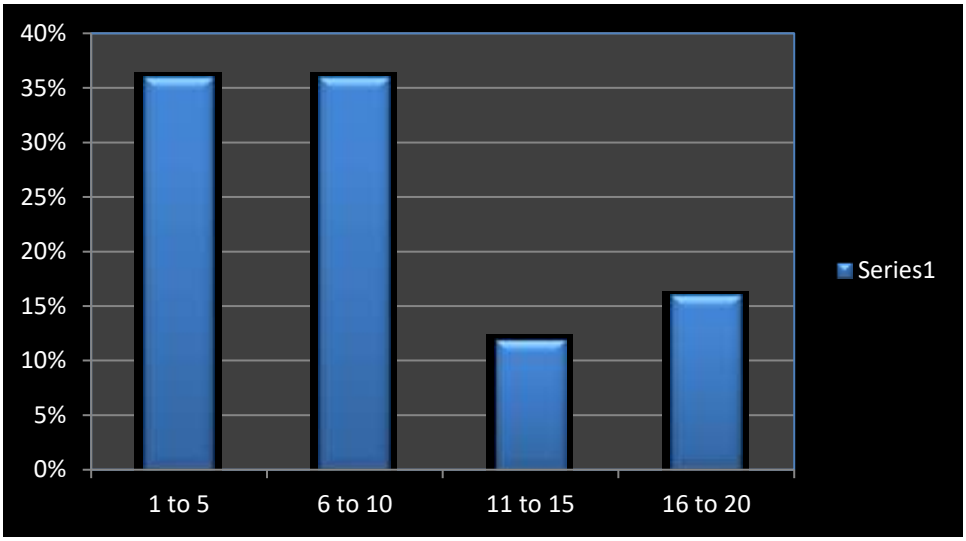

Figure 3: Percentage of household size
Source: Authors field work, 2023

Based on the analysis above this suggests that smaller households (1–5 people infected) are slightly more common in cholera cases, whereas larger households with 11–15 infected individuals are the least common among respondents. This also reflect variations in household size, transmission dynamics and reporting patterns within the study area.

The source of water analyzed in figure 4 shows that 5% of the respondents have access to tap water, 11% of the respondents use borehole water while 49% of the respondents use well water and 35% use stream water. This shows that well water is the most available source of water while the tap water appears to be scarce in the study area.

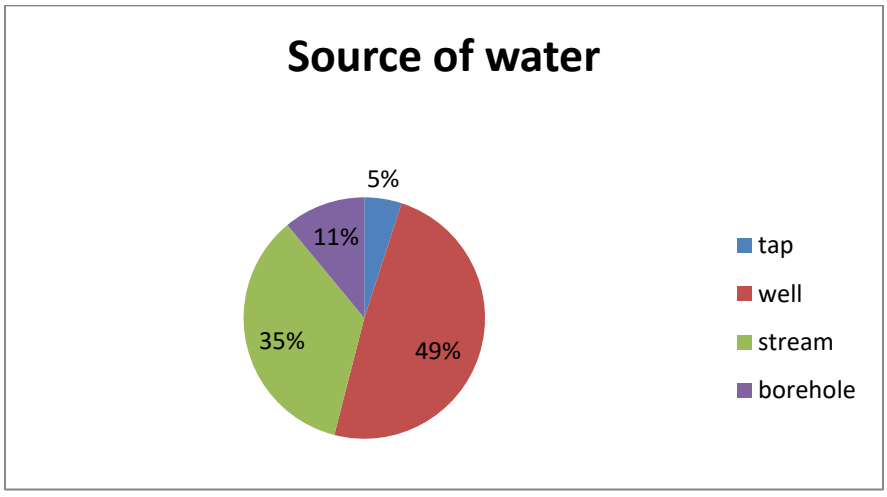

Figure 4: Percentage of source of water
Source: Authors field work, 2023

The data collected in respect to causes of cholera outbreak and contaminated food show that 30% of the respondents strongly agreed, 44% agreed, 22% strongly disagreed while 4% of the respondents disagreed with the causes of cholera. Data from contaminated water show that 27% of the respondents strongly agreed, 51% of the respondents agreed while 17% of the respondents strongly disagreed and 5% disagreed with the causes of cholera. Whether people infected with cholera often have diarrhea and if this highly liquid stool often refer to as "rice-water" contaminates water used by others, disease transmission may occur, 32% of the respondents agreed, 42% of the respondents strongly agreed and 17% of the respondents disagreed while 9% strongly disagreed. From the result of the analysis in the questionnaire it was discovered that 29% of the respondents agreed that cholera has affected their household, 71% of the respondents did not agree that cholera affect their household. Most people have to rely on drinking water from wells and streams especially in the rural and suburban communities. These sources of water are not treated and might lead to waterborne diseases such as cholera, typhoid fever, diarrhea, hepatitis and guinea worm (Abubakar *et al,* 2021). Cholera symptoms persisted and result of the analysis shows that 38% of the respondents said one day, 23% said it persisted for two days, 29% of the respondents said three days, 8% of the respondents said it persisted for four days while 2% of the responses said it persisted for five days.

The figure below shows the vulnerability of individuals living around the source points of the disease to ascertain these settlements prone to cholera. Based on observation, most of the recorded cases are within the boundary areas close to streams and rivers both in the upper and lower parts of the study area. The result shows that Swa and Talasse have the highest number of cholera occurrence while areas like Nyuar, Kombo, Kalaki, Degri and Kutare do not record any case. Based on observation, most of the recorded cases lie within the boundary area close to streams and rivers both in the upper and lower parts of the study area.

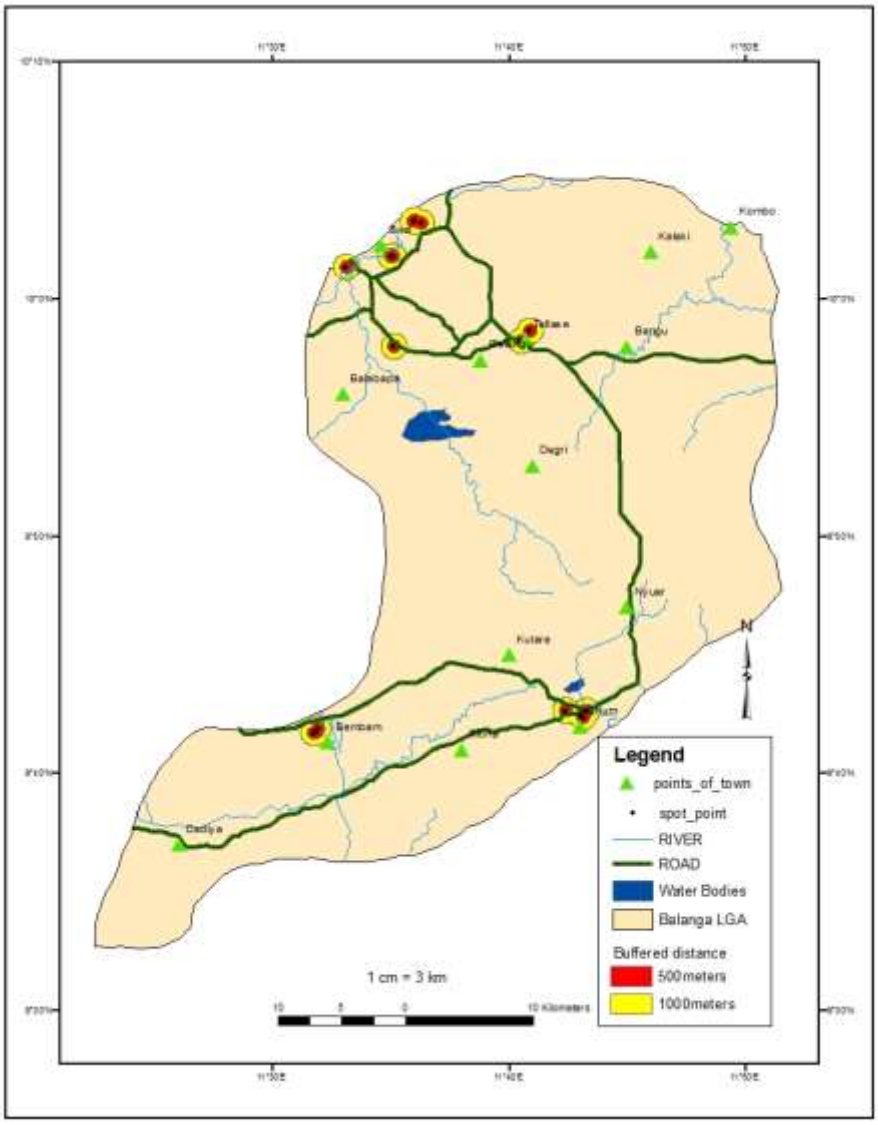

Figure 5: Buffered point of Cholera Occurrence

Source: Author's Work, 2023

A buffer zone of 500m and 1000m was used to ascertain these settlements prone to cholera. Settlements within 500m around the source point are more vulnerable to the contamination of the disease, settlements between 500m and 1000m are less vulnerable. This is based on the idea that the chance of getting cholera or being affected is much lower for places more than 1000 meters away from the source. By mapping disease cases in geographic space, local and national governments can easily identify the triggers, distribution, and spread of disease across geographic regions, optimize planning of intervention locations, and monitor their effectiveness (Olajumoke & Kayode, 2021).

Summary of Result

i. The Result shows that there are hotspots and coldspots in the study area. Swa has the highest hotspots followed by Cham ward while coldspot areas include Tallase and Gelleng with little or no recorded case at all. Most of the hotspot cases lie in the uppermost part of the study area in the map as a result of the presence of river and stream which are sources of water to the people of Balanga LGA which aid in cholera transmission.

ii. The Result shows that there is a spread of cholera across the study area; despite underpopulation the highest household infected has between 1-5 people only. Based on the findings, it was discovered that 37% of the respondents have between 1-5 number of people per household infected, 36% of the respondents has between 6-10 number of people, 12% of the respondents have between 11-15 number of people, 16% of the respondents have 16-20 number of people.

iii. The result shows that 5% of the respondents have access to tap water, 11% of the respondents use borehole water while 49% of the respondents use well water and 35% use stream water as their sources of water supply in the study area.

iv. Contaminated food was analysed to be the cause of cholera as the result shows that 30% of the respondents strongly agreed, 44% agree, 22% strongly disagreed while 4% of the respondents disagreed with the causes of cholera. Contaminated water was analyzed, it shows that 27% of the respondents strongly agreed, 51% of the respondent agreed while 17% of the respondents strongly disagreed and 5% disagreed with the causes of cholera and also 32% of the respondents agreed, 42% of the respondents strongly agreed and 17% of the respondents disagreed while 9% strongly disagreed that transmission is also through rice water contamination used by the infected. Cholera symptom result of the analysis shows that 38% of the respondents said one day, 23% said it persisted for two days, 29% of the respondent said three days, 8% of the respondents said it persisted for four days while 2% of the respondents said it persisted for five days.

v. The result shows that Swa and Talasse has the highest number of cholera occurrence while areas like Nyuar, Kombo, Kalaki, Degri and Kutare do not record any case as such a buffer zone of 500m and 1000m was used to ascertain these settlements prone to cholera in the study area.

Conclusion

This study has explored the potential of the use of GIS for mapping and analyzing Cholera in Balanga L.G.A. Questionnaire and GPS points were collected and transformed into GIS data and were manipulated using several tools. The GIS tools used in this study included, overlays, Average Nearest Neighbour and ArcMap. Simultaneous use of GIS analysis and epidemiological surveillance is an effective method for identifying instances of hotspot. From the result of the study, it can be concluded that most of the hotspot cases are in the uppermost parts of the study area in the map as a result of the presence of stream and wells which are the major sources of water to the people of Balanga LGA. There is a spread of cholera across the study area despite underpopulation as the highest household infected has between 1-5 people only. Contaminated food and contaminated water are the cause of cholera while symptoms last up to five days.

Recommendations

The following Recommendation was proposed:

i. Areas of hotspot should be given serious attention by the government so as to know the exact location of infected areas to ascertain risk transmission areas in order to reduce the number of cholera cases in that particular area.
ii. The government should provide tap water as a source of water to the residents in the study area to reduce infection.
iii. The residents of these areas should keep their environment clean at all times irrespective of number of people per household.
iv. The government should intensify public enlightenment on causes, effects and symptom of Cholera in mosque, churches, schools, and other public places to sensitize the people of its existence.
v. Government should implement laws such as Polluters Pays Principle to help reduce the amount of waste disposed by individuals with residents residing at least 1000m away from a source of cholera spread.

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