Spatial and Temporal Variability of Cholera Prevalence in Lagos State, Nigeria

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Abstract

The paper analysed the spatio-temporal patterns of cholera occurrence in Lagos State, Nigeria between 2001 and 2011. This is necessitated by the paucity of modern mapping attempts of the disease. Data used included relevant geo-spatial data, reported cases of cholera (2001-2011), population figures, topographical sheets (1:50,000), and relevant base maps of the state. The trend analysis showed that the highest cases of cholera were reported in 2004, 2005, and 2011 with 176, 78, and 41 cases respectively. The lowest occurrences were reported in 2010, 2002 and 2009 with 4, 5, and 7 cases respectively. The spatial analysis shows that highest occurrences were recorded in Ikorodu (112); Apapa (27); and Ojo (25) LGAs; while the lowest cases were reported in Surulere (2) and Alimosho LGAs (1). The disease occurrence followed a combination of contagious, relocation and hierarchical diffusion processes. The study concluded that cholera occurrence in Lagos exhibited spatio-temporal dynamics.

Keywords: Cholera prevalence, spatio-temporal, variation, Lagos State, Nigeria.

Introduction

Cholera is a highly contagious disease that causes diarrhoea, severe dehydration and possibly death. The World Health Organisation (WHO) reports on the state of Nigeria and other developing countries indicated that they suffer from diseases such as polio, malaria, sleeping sickness, whooping cough and periodic outbreaks of cholera (UNICEF, 2007). The geographical distribution of any major disease forms an important basis for locating appropriate interventions for its control and a means of monitoring their effectiveness. It also provides a possibility for identifying ecological factors with which the disease may be associated.

According to Rytokonen (2004), the goals of disease mapping are: to describe the spatial variation in disease incidence to formulate an etiological hypothesis; to identify areas of high risk in order to increase prevention; and to provide a map of disease risk for a region for better risk preparedness. The early work of Hägerstrand (1968) on "waves of innovation" is the basis that many medical cartographers and geographers use for mapping spatial diffusion. The diffusion of disease can be described in four patterns: expansion diffusion, contagious diffusion, hierarchal diffusion and relocation diffusion. Cromley and McLafferty (2002); further added network diffusion and mixed diffusion as other forms of diffusion. The prevalence of infectious diseases in a given population, with varied geographic and demographic settings, need to be analysed over the spatial and temporal domain in order to build dynamic models that provide a global insight of disease spread behaviours**.**

Despite the rate of occurrences, there have not been studies to map the prevalence of cholera in Lagos State regardless of availability of data to reveal the spatial and temporal patterns of the disease occurrence. This has become imperative in order to provide a framework for effective control of the disease in the State. Hence the prevalence of cholera was analysed for the entire Lagos state using the technology of remote sensing and Geographic Information System giving rise to the spatial heterogeneity of cholera distribution at the different geographic locations in the state.

The Study Area

Lagos State is situated in the south-western corner of Nigeria. The State lies within Latitudes 6° 23'N and 6°41'N of the Equator, and Longitudes 2°42'E and 3°42'E of the Greenwich Meridian (see Figure 1). The total landmass of the State is about 3,345 square kilometres, which is just about 0.4% of the total land area of Nigeria. Most of the land in Lagos State has an elevation of less than 15m above sea level. Lagos state comprises 20 Local Government Areas (LGAs) and several Health Care Centres designated in different strategic areas of the LGAs. These Health Care Facilities (HCFs) provide primary health care for the population in the state. The total number of Health Facilities in Lagos State is 979 and they are functional in reporting disease prevalence and outcome on monthly basis.

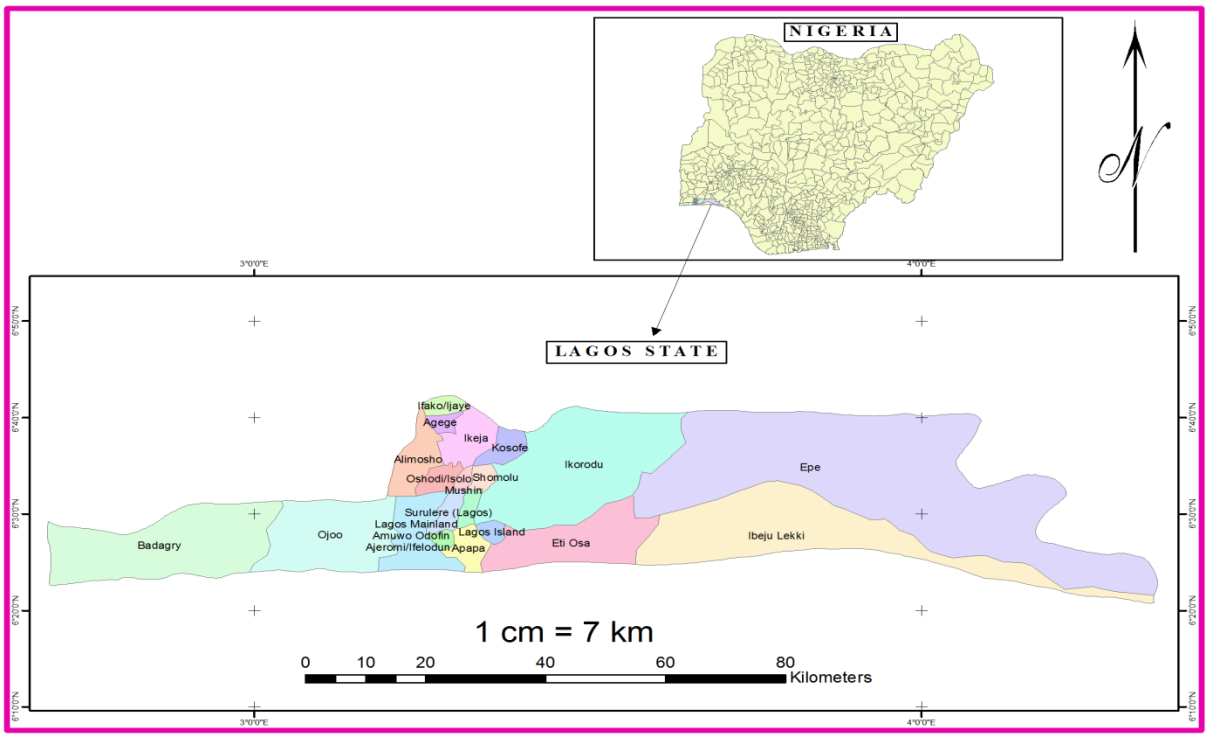

Figure 1: Lagos State in Nigeria

Methodology

The main data for this study was secondary data. Primary data employed involved the use of Global Positioning System (GPS) receiver to obtain the coordinates of relevant phenomena and also ground-truthing to corroborate the data collected from the health ministry. The secondary data included reported cases of cholera in Lagos State between 2001 and 2011 obtained from the Lagos State Ministry of Health and topographical maps (scale 1: 50,000) covering the study area. Other secondary data included the administrative and political maps obtained from the various Local Government Town Planning Offices; the population figures of the LGAs obtained from the records of the National Population Commission (NPC).

Inferential statistics and Geo-spatial techniques were used to analyse the data collected. Geo-spatial techniques such as overlay operations were used to analyse change detection. Trend analysis and interpolation were used to show variations and estimation of cholera prevalence. The results are presented using charts and maps.

Database Design and Construction

The database design for this study was adapted from Kufoniyi (1998) "design and construction phases of a spatial database". The reality here is represented by the cholera disease. The total reality of cholera infection distribution cannot be modelled, thus the integrated extent of reality modelled were analysed conceptually. The specific requirement is to provide a framework for measuring the distribution of cholera over the study area.

The overall model was defined to consist of two types of databases. The tabular database such as points of infection location and spread database managed by Database Management System (RDBMS); Microsoft Access (MS) while the GIS database such as cartographic database managed by Geo-relational GIS Software; ArcGIS.

The Entities identified in this study includes: Cholera, Patient, Settlement, Health centre, and Agency (National Agency for Disease Research). Their attributes and relationships are represented in the entity relationship diagram (see Figure 2). The conceptual data is translated into relational database structure as it is derived from the entity relationship (Kufoniyi, 1998). The Conceptual Model adopted is the entity relation model (see Figure 3). The logical design is the tabular representation of the conceptual data model to reflect the pattern of data in the computer system. The physical design model adopted finally translated the entities in MS Access and ArcGIS for analyses.

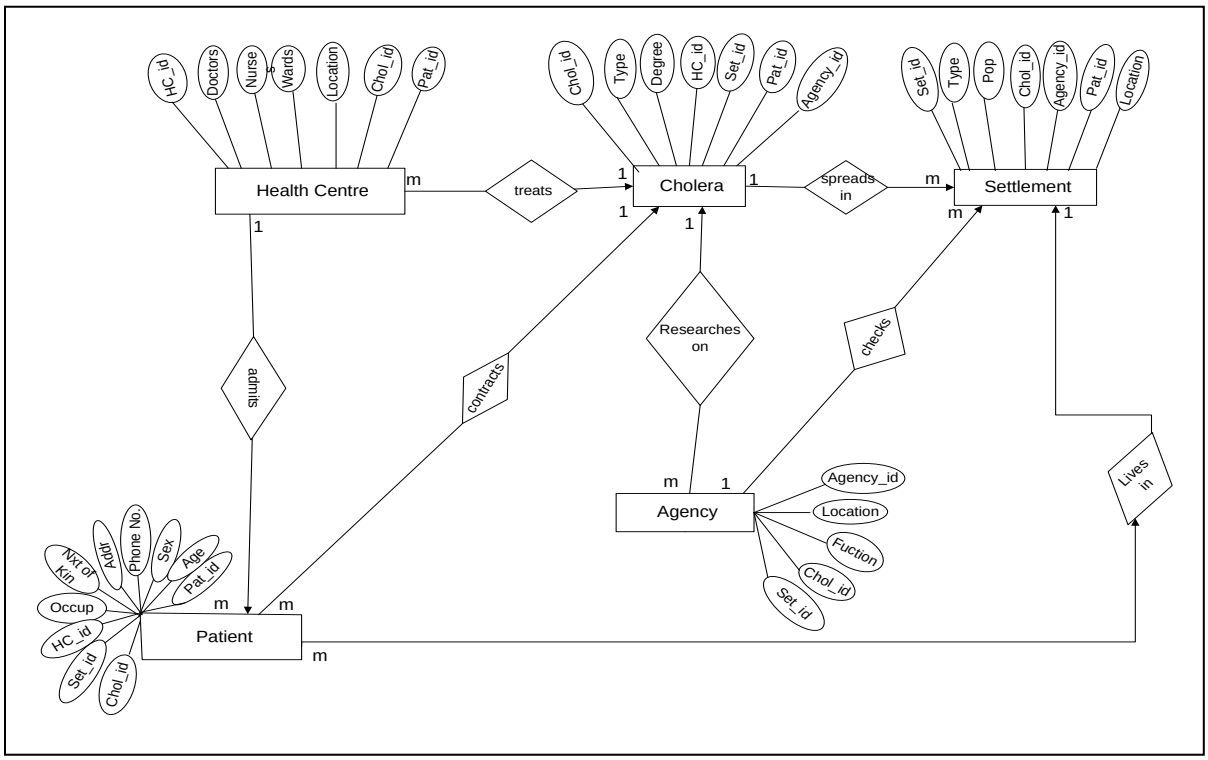

Figure 2: Entity Relationship Diagram

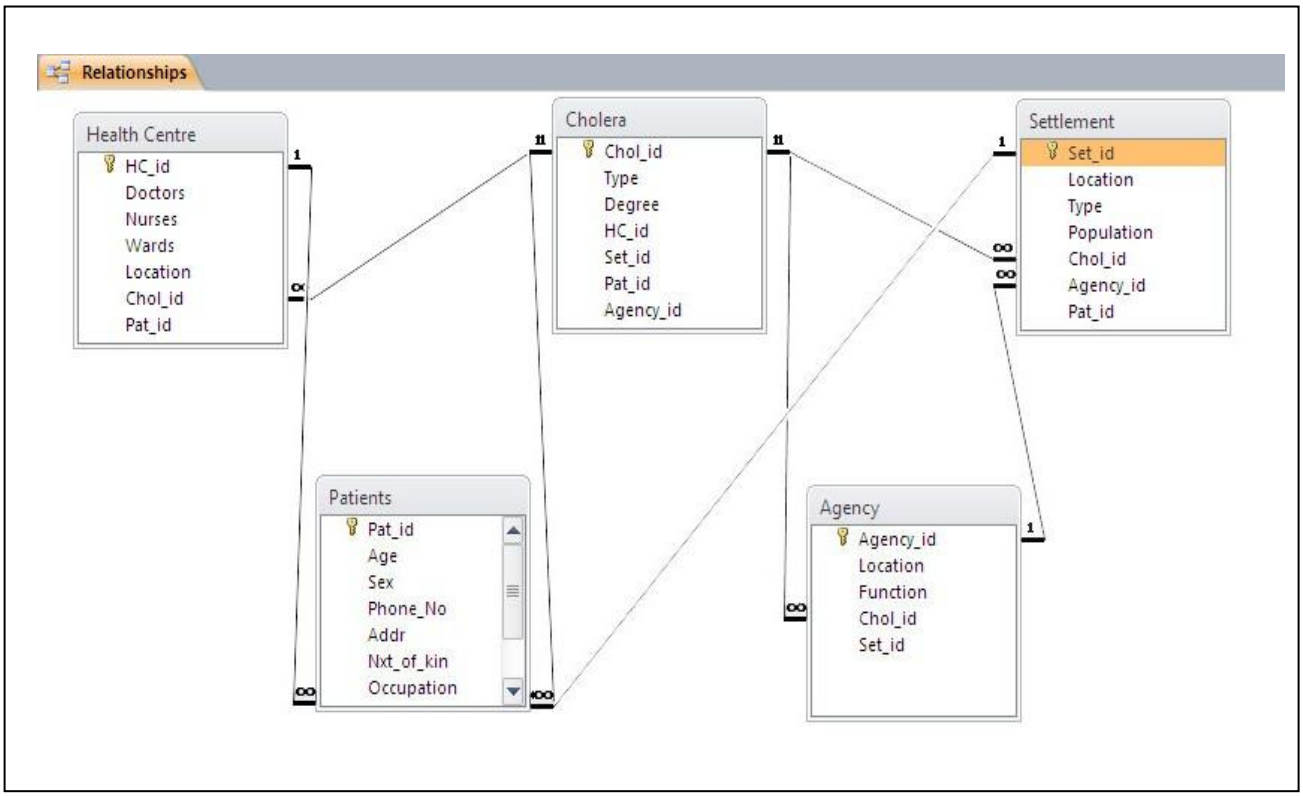

Figure 3: Entity Relationship Model

The trend of occurrence of cholera in Lagos State

Three hundred and seventy five (375) reported cases (see Table 1) of a disease among a population of over 5,000,000 in eleven years does not have a striking impression. However, when one considers the teaming population of those susceptible, the modes of transmission, the diffusion processes and other non-congenial environmental conditions; then one will tend to take a more cursory look at the patterns of occurrence of the disease.

Cholera occurrence in the state exhibited a temporal variation. In Agege LGA, the disease is not at an alarming level, with a prevalence value of 0.00022 of the total population of people in the LGA at risk of cholera. The trend analysis of Lagos Island indicated that there is an increased level of cholera occurrence in the LGA, and its prevalence was 0.01767. Cholera was first recorded in the LGA in 2004 with an occurrence of 14 cases. Cholera Prevalence in Amuwo Odofin LGA was 0.00251 which indicated that cholera is not in high prevalence in the LGA. In Lagos mainland, the trend (see Figure 4) implied that there is high cholera occurrence in the LGA with prevalence of 0.00348.

The occurrence trend in Surulere LGA implied that there is an increase of cholera prevalence in the area; the R^2 =0.25 when the trend line is analyzed; the prevalence was 0.00040. Meanwhile, Ikorodu LGA displayed a downward slope in the trend analysis and R^2 = 0.030 indicated a controlled level of cholera occurrence. The prevalence of cholera in the LGA was 0.02091 and the total occurrence of cholera was in 2004 (112 cases) see Figures 4 and 5. The prevalence of cholera in Alimosho LGA was 0.00016, the trend line displayed an upward slope with R^2 = 0.22; indicating that there is increased cholera occurrence in the LGA (see Figure 5). Ajeromi Ifelodun LGA displayed a gentle downward slope with R^2 = 0.001 and prevalence of 0.00161 (see Figure 5). Also, the trend analysis of Oshodi/Isolo LGA is presented in Figure 5. It displayed an upward slope that indicated that there is an increased level of cholera occurrence in the area. The prevalence was 0.00048 and the R^2 = 0.367. The trend line for Ojo LGA displayed a gentle downward slope with R^2 = 0.037 and prevalence of 0.00936 (see Figure 5).

The trend for Eti-Osa LGA followed an upward slope (as presented in Figure 5) which indicated that there is cholera occurrence in the LGA with R^2 = 0.038; The prevalence was 0.00869. Apapa LGA displayed a downward slope which signified that there is a controlled level of cholera with R^2 = 0.051 and prevalence of 0.02346 (see Figure 5). Badagry LGA presented a gentle downward slope with R^2 = 0.033 and the prevalence was 0.00456, the highest occurrence of cholera was recorded in 2004. The slope indicated that there is a gradual decrease in the prevalence of cholera in the LGA. The Cholera prevalence in Ikeja LGA was 0.00255 and the R^2 = 0.084. There was a gentle downward slope on the trend analysis of Mushin LGA with R^2 = 0.001 at 0.00316 prevalence.

Death cases as a result of cholera prevalence in Lagos State was analyzed and presented in Figure 6. At R^2 = 0.021, the highest death occurrence as a result of cholera was in 2005 (202 death cases) and the lowest death cases were in 2009 (16). The downward slope presented in Figure 6 for the study implied that there were controlled level of cholera prevalence in the study area.

Table 1: Total Occurrence of Cholera in Lagos State between 2001 and 2011

LGA	Year											
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Lagos Mainland	0	0	0	0	0	0	0	0	0	0	14	14
Lagos Island	0	0	0	14	0	0	2	0	1	0	20	37
Amuwo Odofin	0	0	0	6	2	0	0	0	0	0	0	8
Oshodi	0	0	0	0	0	0	0	0	1	0	2	3
Agege	0	0	1	0	0	0	0	0	0	0	0	1
Shomolu	0	0	0	7	3	0	0	0	1	0	3	14
Apapa	0	0	27	24	0	0	0	0	0	0	0	51
Surulere	0	0	0	0	0	0	0	0	0	0	2	2
Ikorodu	0	0	0	112	0	0	0	0	0	0	0	112
Alimosho	0	0	0	0	1	0	0	0	1	0	0	2
Ajeromi	0	0	0	0	11	0	0	0	0	0	0	11
Badagry	0	0	0	10	1	0	0	0	0	0	0	11
Ojo	0	0	25	0	15	0	0	16	0	0	0	56
Ikeja	0	5	0	0	1	0	0	0	2	0	0	8
Mushin	0	0	0	0	20	0	0	0	0	0	0	20
Eti-Osa	0	0	0	0	0	0	20	0	1	4	0	25
TOTAL	0	5	53	173	54	0	22	16	7	4	41	375

Source: Lagos State Ministry of Health, 2001-2011.

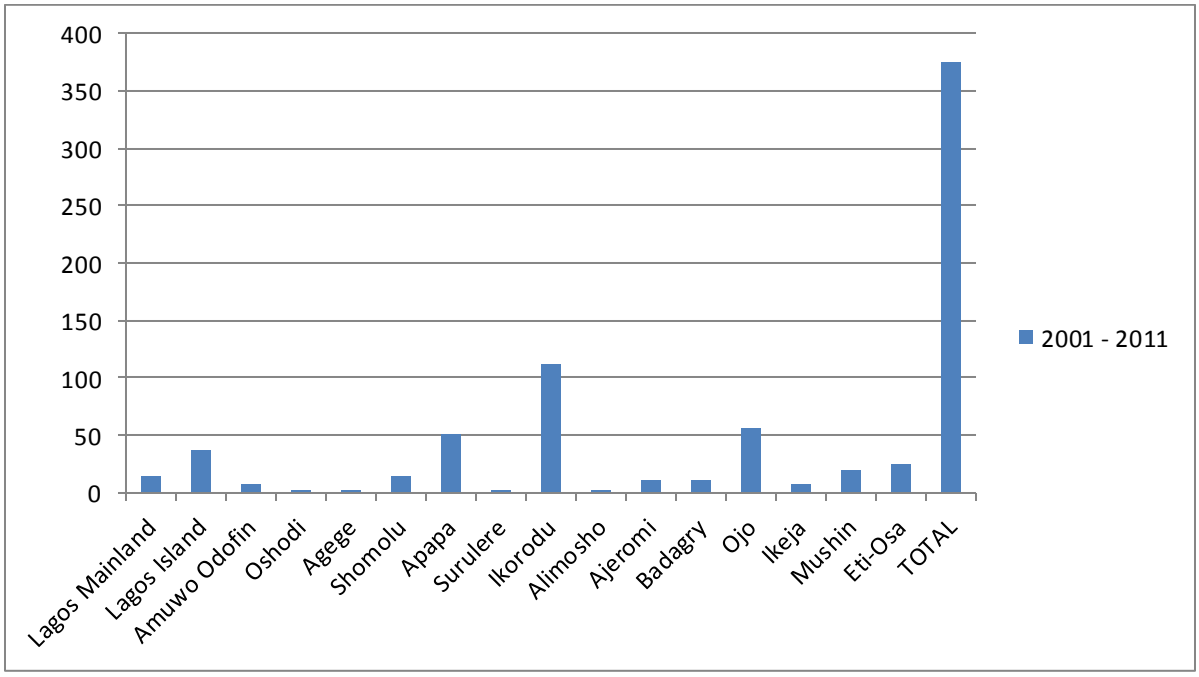

Figure 4: Summary of the Occurrence of Cholera in Lagos State
Source: Lagos State Ministry of Health, 2012.

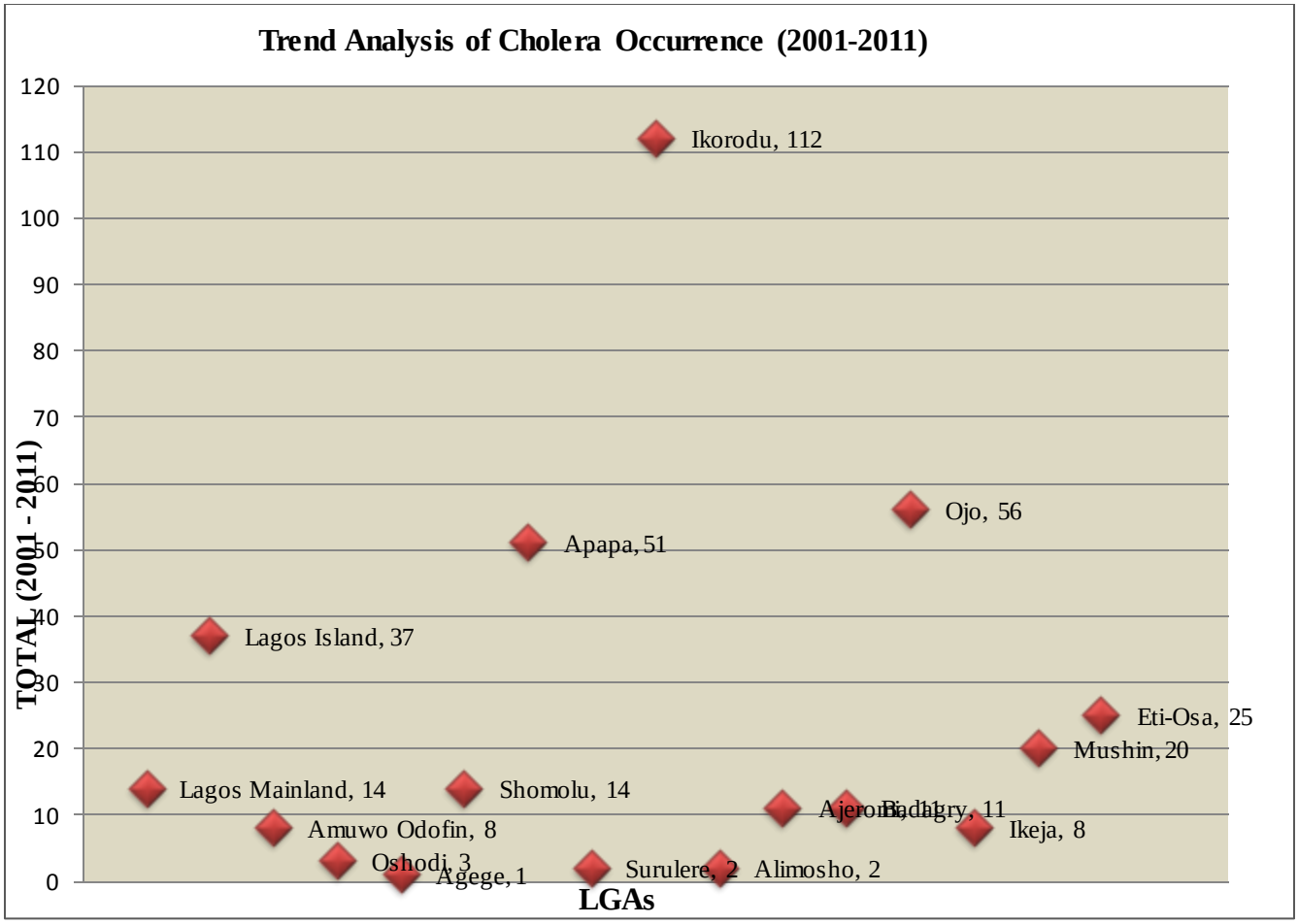

Figure 5: Trend of Cholera Occurrence of Cholera in Lagos State

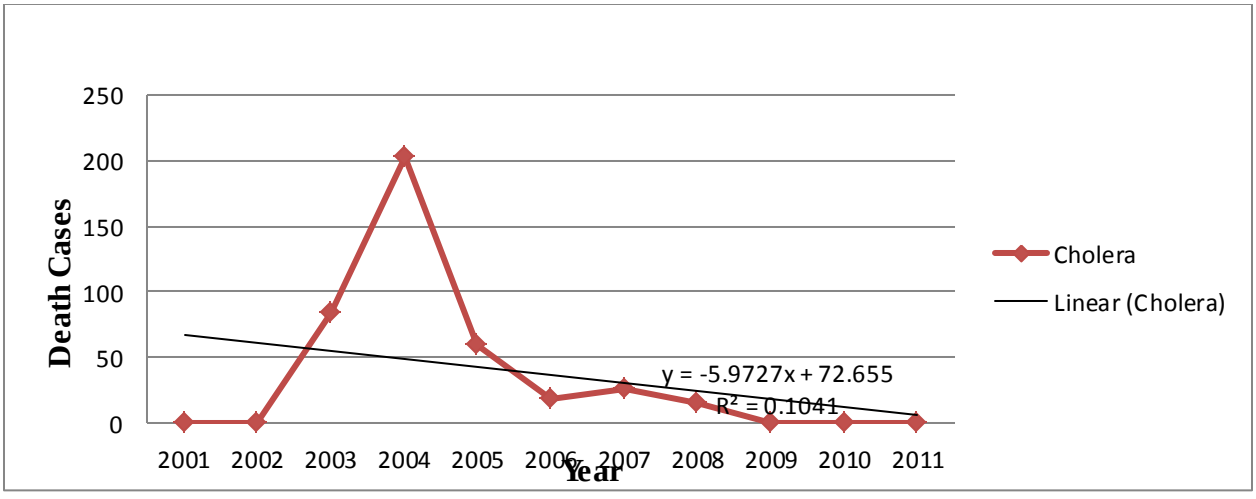

Figure 6: Trend Analysis of Death Cases in Lagos State, 2001-2011

Spatial Patterns of Cholera Prevalence in Lagos State

Cholera incidence per hundred (100) persons of the population was calculated for the different LGAs with reported cases. Prevalence = {(number of cases/population)*100} for the communities under study. The database information forms part of the attribute table of the already georeferenced topographic map of Lagos State. The attribute table is linked to the map by 'join and relate' to produce output map representing spatial patterns of cholera prevalence in the State. Prevalence of cholera in Lagos State is ascertained in the Table 2 with available data on reported cases.

Cholera prevalence described cholera situation in relation to population at risk. It is not enough that a disease occurs; the number of persons infected relative to the total population defines the prevalence of the disease. Some LGAs have high recorded cases of cholera occurrence but however records lower prevalence. Ojo LGA recorded a high occurrence of 56 cases as the total number of occurrence of cholera in the area within the study period, and recorded a low prevalence of 0.00936 while Lagos Island LGA recorded 37 cases and a high prevalence of 0.01767. The implication is that the size of the population defines the extent of prevalence of cholera in relation to the amount of occurrence.

Table 2: Cholera Prevalence in Lagos State

S/N	LGA	Total No. of cases (Btw 2001-2011)	Population (2006 Census Figures)	Prevalence = No. of Cases * 100 / Pop
1.	Badagry	11	241093	0.00456
2.	Ojo	56	598071	0.00936
3.	Amuwo	8	318166	0.00251
4.	Alimosho	2	1277744	0.00016
5.	Agege	1	459939	0.00022
6.	Ifako-Ijaye	-	427878	-
7.	Ikeja	8	313196	0.00255
8.	Oshodi-Isolo	3	621509	0.00048
9.	Mushin	20	633009	0.00316
10	Surulere	2	503975	0.00040
11.	Ajeromi-Ifelodun	11	684105	0.00161
12.	Apapa	51	217362	0.02346
13.	Lagos Island	37	209437	0.01767
14.	Lagos Mainland	14	317720	0.00441
.15.	Shomolu	14	402673	0.00348
16.	Kosofe	-	665393	-
17.	Ikorodu	112	535619	0.02091
18	Eti-Osa	25	287785	0.00869
19	Ibeju- Lekki	-	117481	-
20.	Epe	-	181409	-

Source: Field Survey, 2012.

In 2004, the highest occurrence of cholera was recorded in Ikorodu (112) with a population of 535,619 in the area. The highest record of cholera prevalence was also recorded for the area as 0.02% of the population at risk of cholera in that year. Apapa LGA recorded 51 cases of cholera between 2001 and 2011. Study revealed that 0.02% of the total population of 217,362 is at risk of cholera. Within the same period, the lowest number of occurrence of cholera was in Agege LGA (1) and the units at risk were described as 0.0002% of the total population of 459,939 people in the LGA.

Cholera Occurrence in Lagos State from 2001 to 2011

The spatial patterns of occurrence of cholera in Lagos State are presented in Figures 8 to 18. There was no record of cholera occurrence in 2001(see Figure 8). The occurrence of cholera in Lagos State began in 2002 with 5 cases recorded in Ikeja LGA. The spatial pattern of occurrence was thus established with only Ikeja having cholera in relation to other LGAs (Figure 9). In 2003, only Ojo LGA displayed a spatial occurrence pattern in relation to other LGAs as the only occurrence of 25 cases was recorded for the area. This was a high occurrence as presented in Figure 10. While the study accounted for several occurrence of cholera in 2004, seven LGAs presented a spatial pattern of low, medium and high occurrences (see Figure 11) with Ikorodu presenting the highest occurrence of 112 cases and indicating deep brown colour to refer the intensity of high occurrence in relation to the medium and low occurrences of shomolu and Agege LGAs. The map showing the spatial pattern of occurrence for 2005 is Figure 12 where Mushin and Surulere LGAs exhibited

spatially high patterns. There was no occurrence in 2006 (see Figure 6) as the spatial pattern followed the pattern of 2001. The spatial pattern of 2007 displayed Ikeja LGA at a high intensity compared to other areas as presented in Figure 14.

The only occurrence of 16 cases were recorded in Eti-Osa LGA in 2008 and the spatial pattern as presented in Figure 15 indicated a high level of occurrence in relation to other LGAs which have no occurrence at all. In 2009, Lagos Mainland, Oshodi Isolo, Shomolu, Alimosho, and Eti-Osa LGAs displayed medium spatial patterns. The highest occurrence was recorded for Ikeja LGA and the pattern established a medium level of occurrence as shown in Figure 16. Year 2010 recorded only 4 cases in Eti-Osa LGA and the pattern established a high spatial pattern of occurrence in relation to other LGAs having no record of cholera occurrence; this is presented in Figure 17. A high spatial pattern was established in Lagos Island and Lagos Mainland LGAs. Oshodi/Isolo, Shomolu and Surulere LGAs displayed a medium spatial pattern in relation to other LGAs as a result of the 2, 3 and 2 cases recorded for the areas respectively; this is presented on the map in Figure 18.

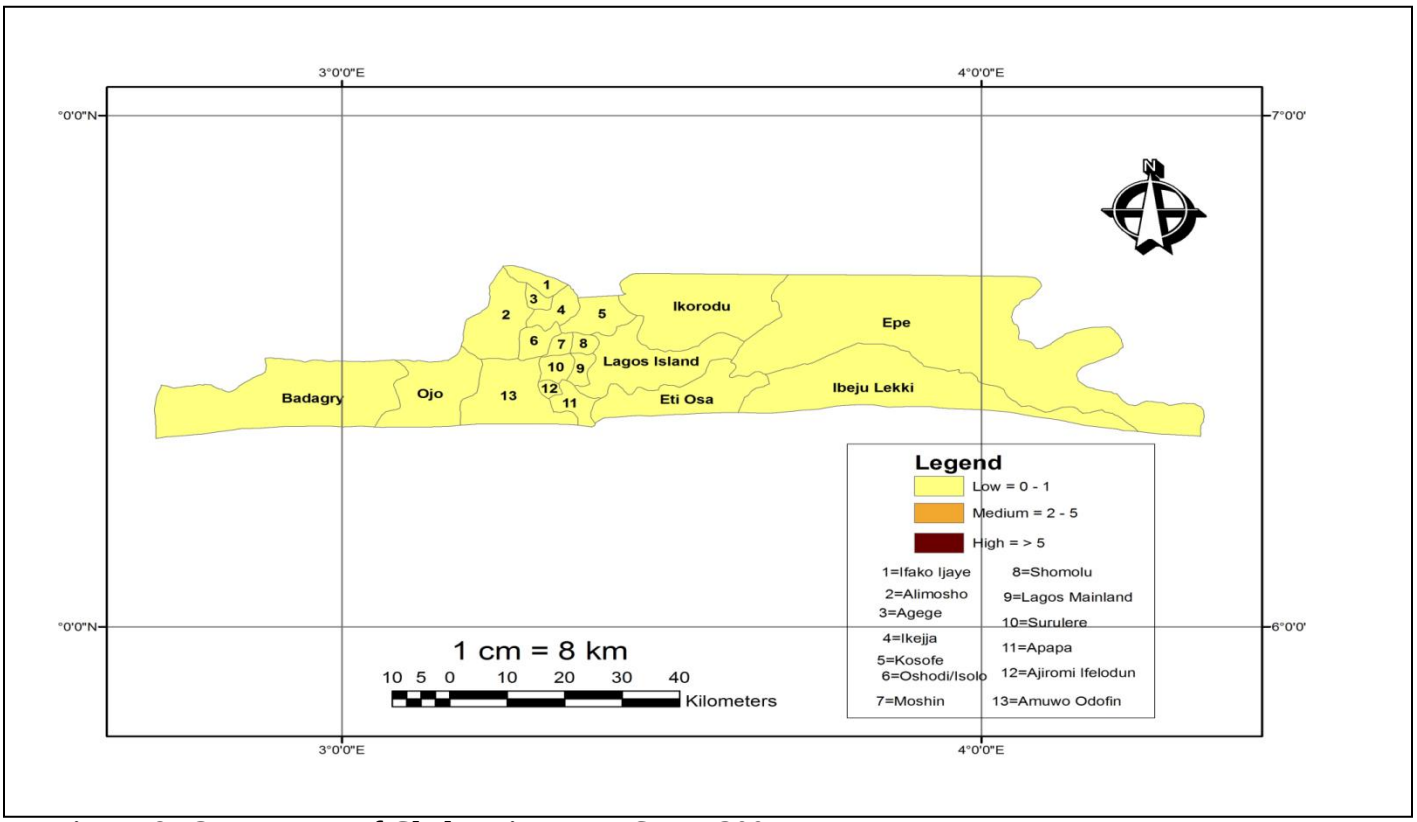

Figure 8: Occurrence of Cholera in Lagos State, 2001.

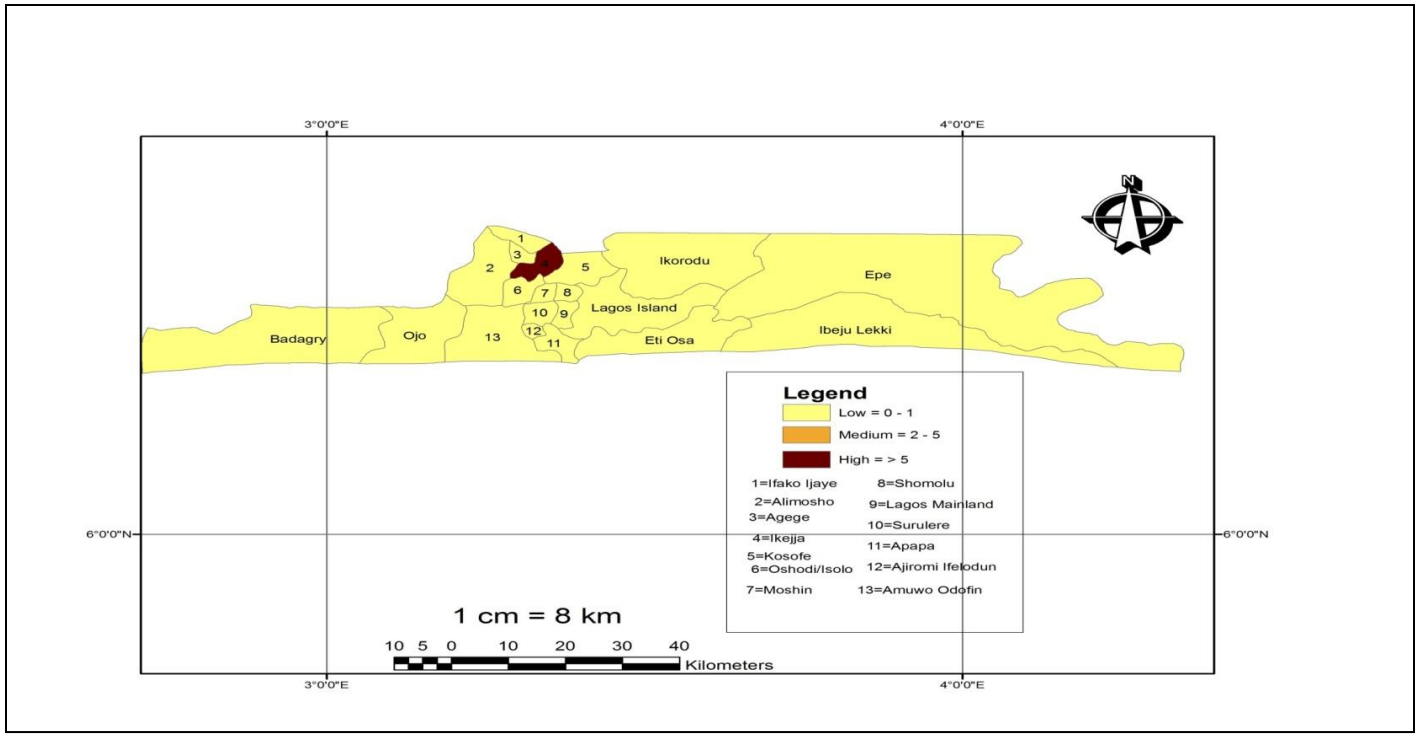

Figure 9: Spatial Pattern of Cholera Occurrence in Lagos, 2002.

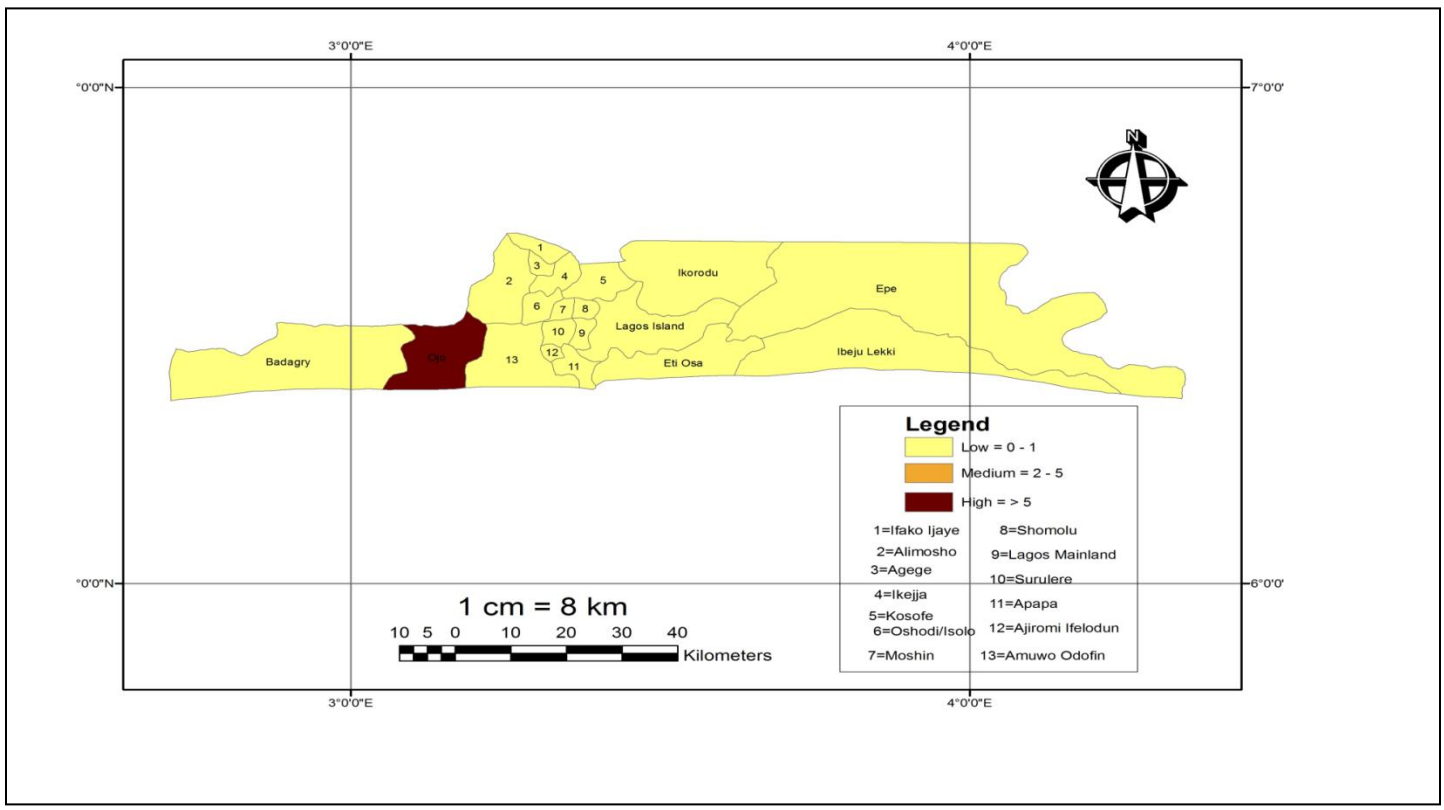

Figure 10: Spatial Pattern of Cholera Occurrence, 2003

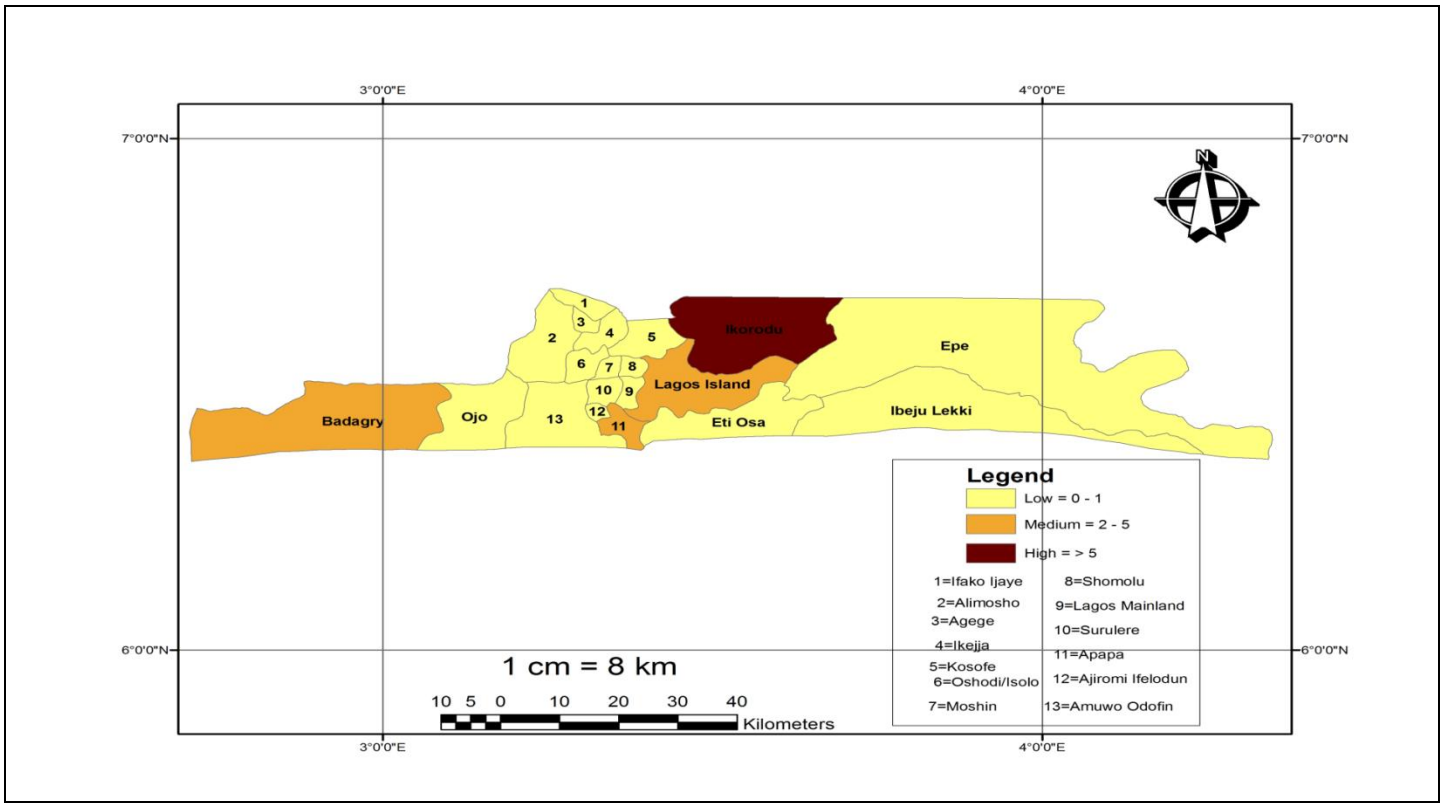

Figure 11: Spatial Pattern of Cholera Occurrence, 2004

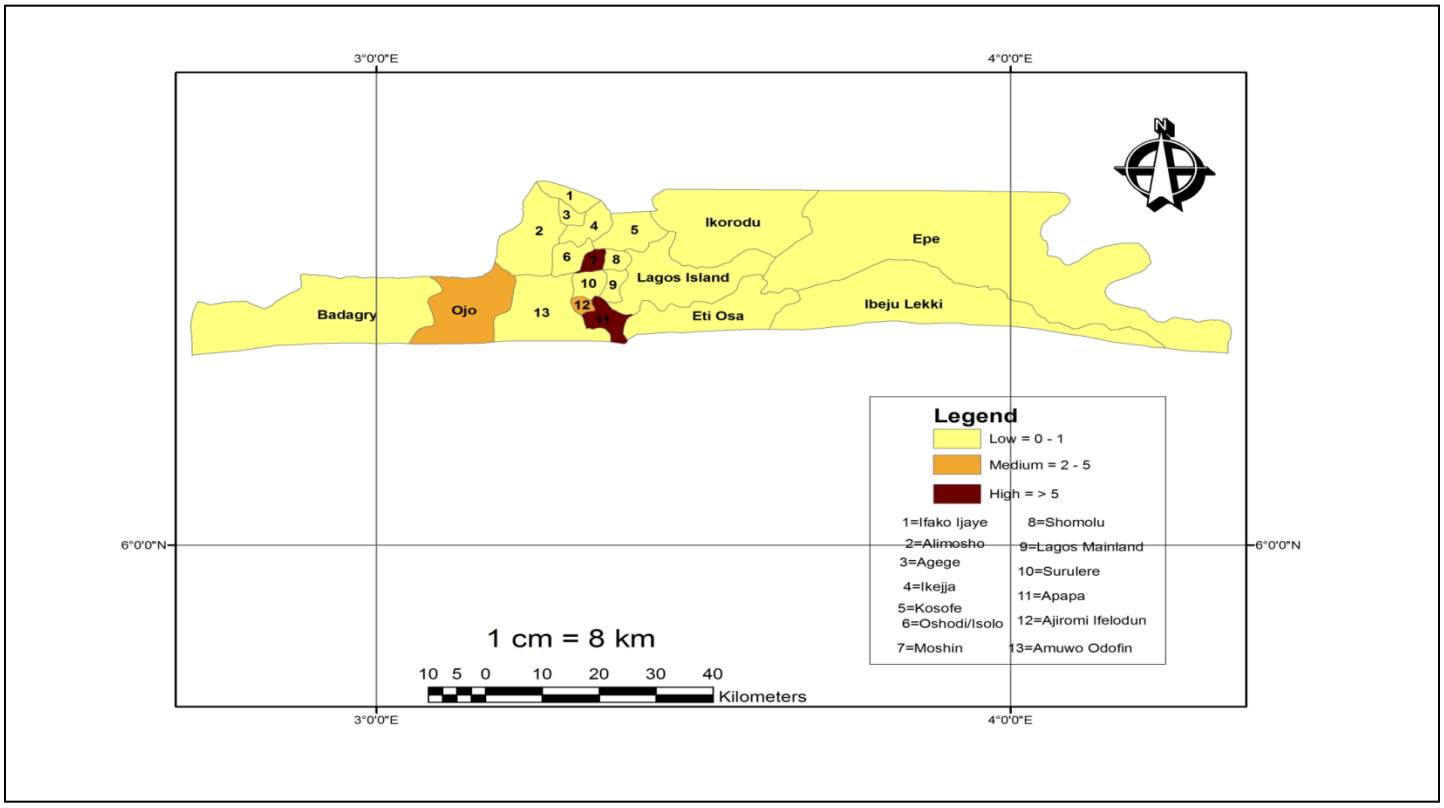

Figure 12: Spatial Pattern of Cholera Occurrence, 2005

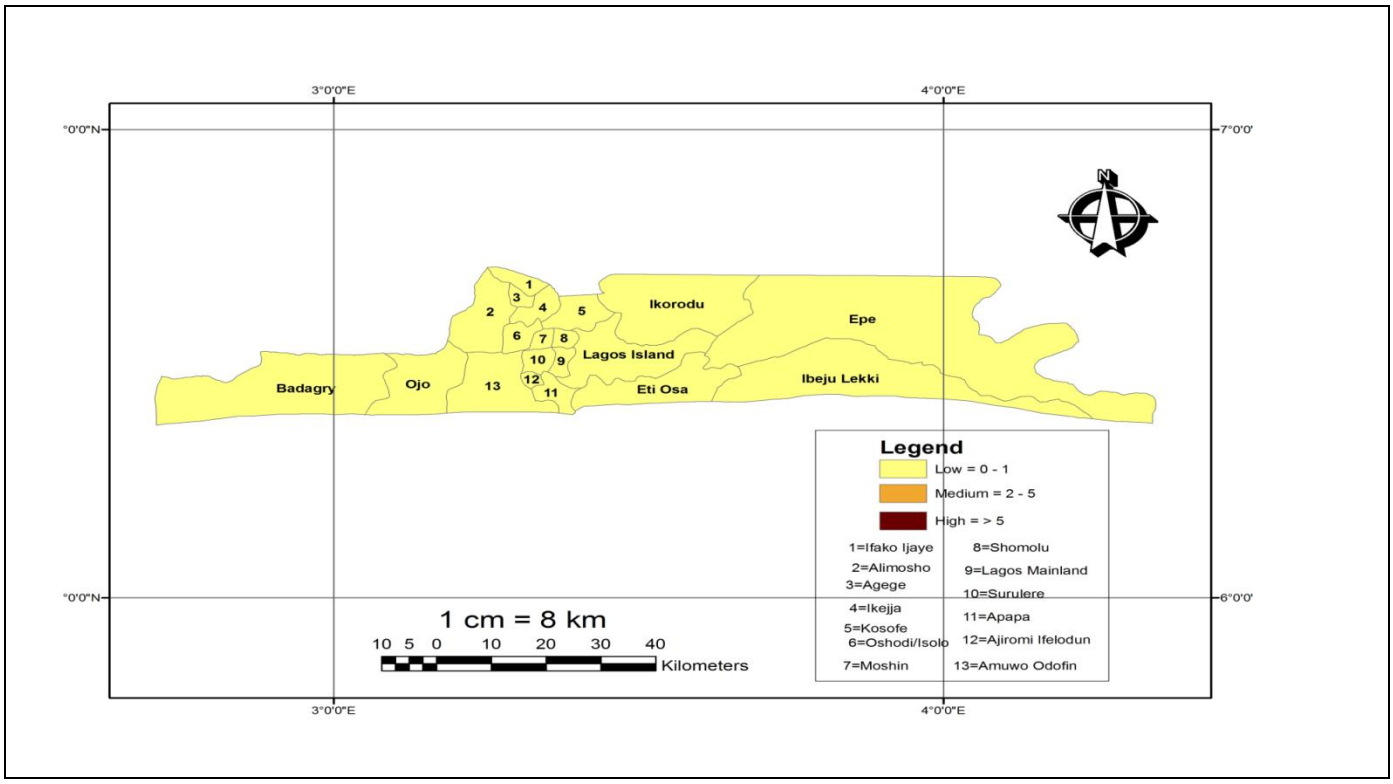

Figure 13: Spatial Pattern of Cholera Occurrence, 2006

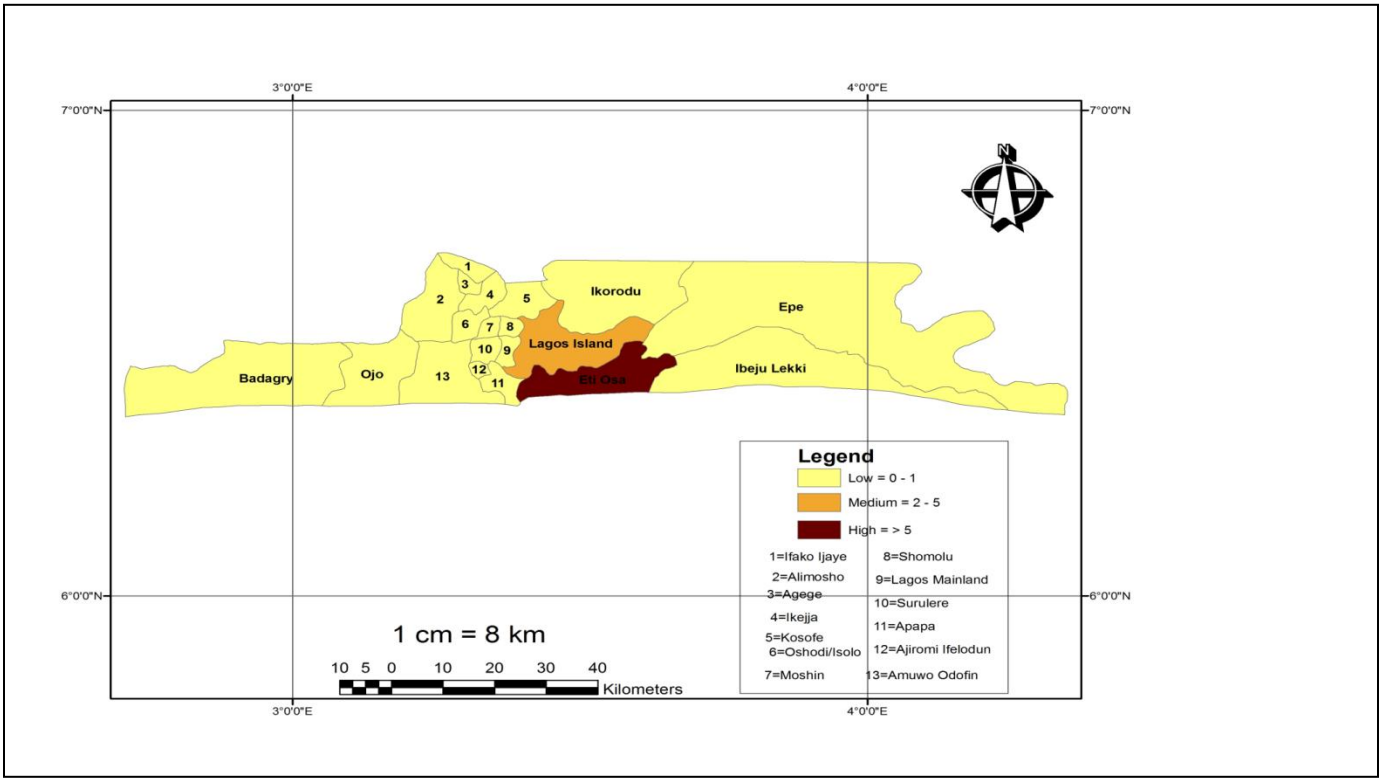

Figure 14: Spatial Pattern of Cholera Occurrence, 2007

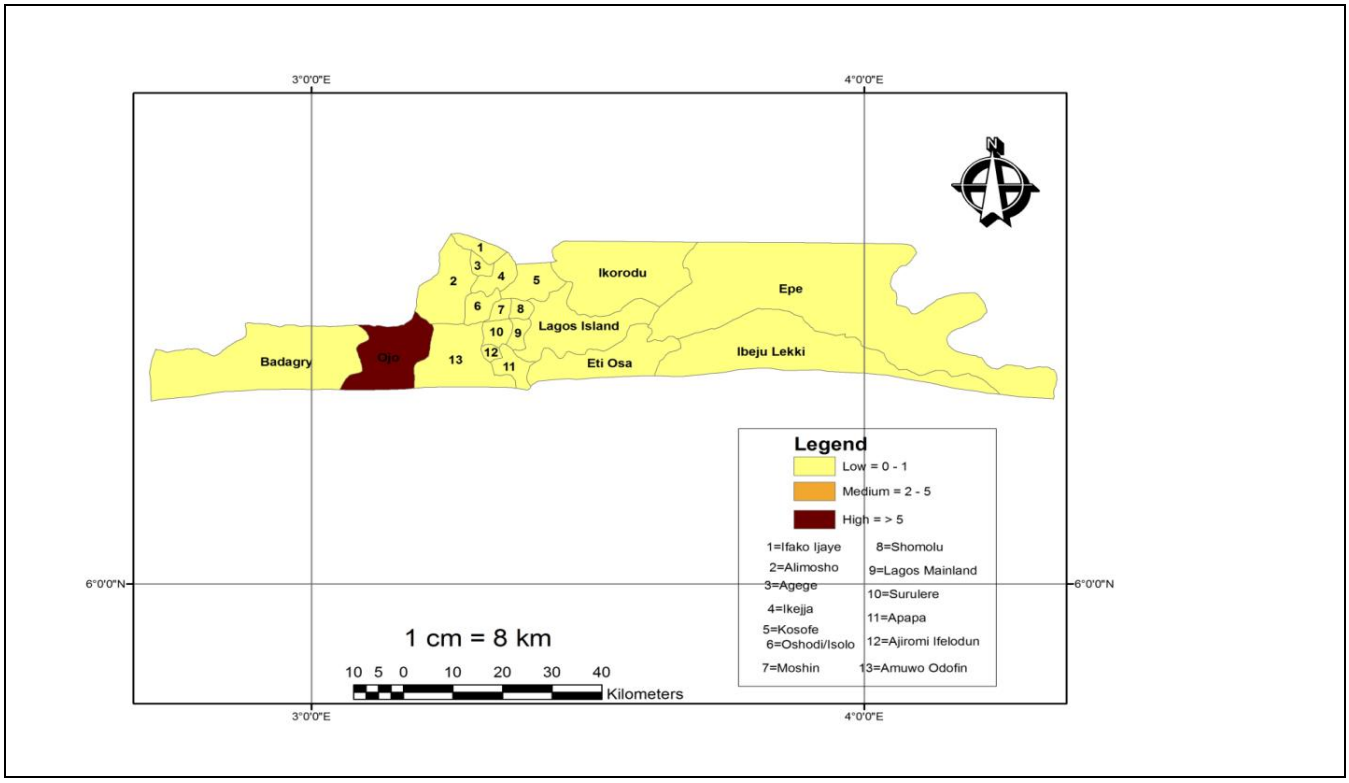

Figure 15: Spatial Pattern of Cholera Occurrence, 2008

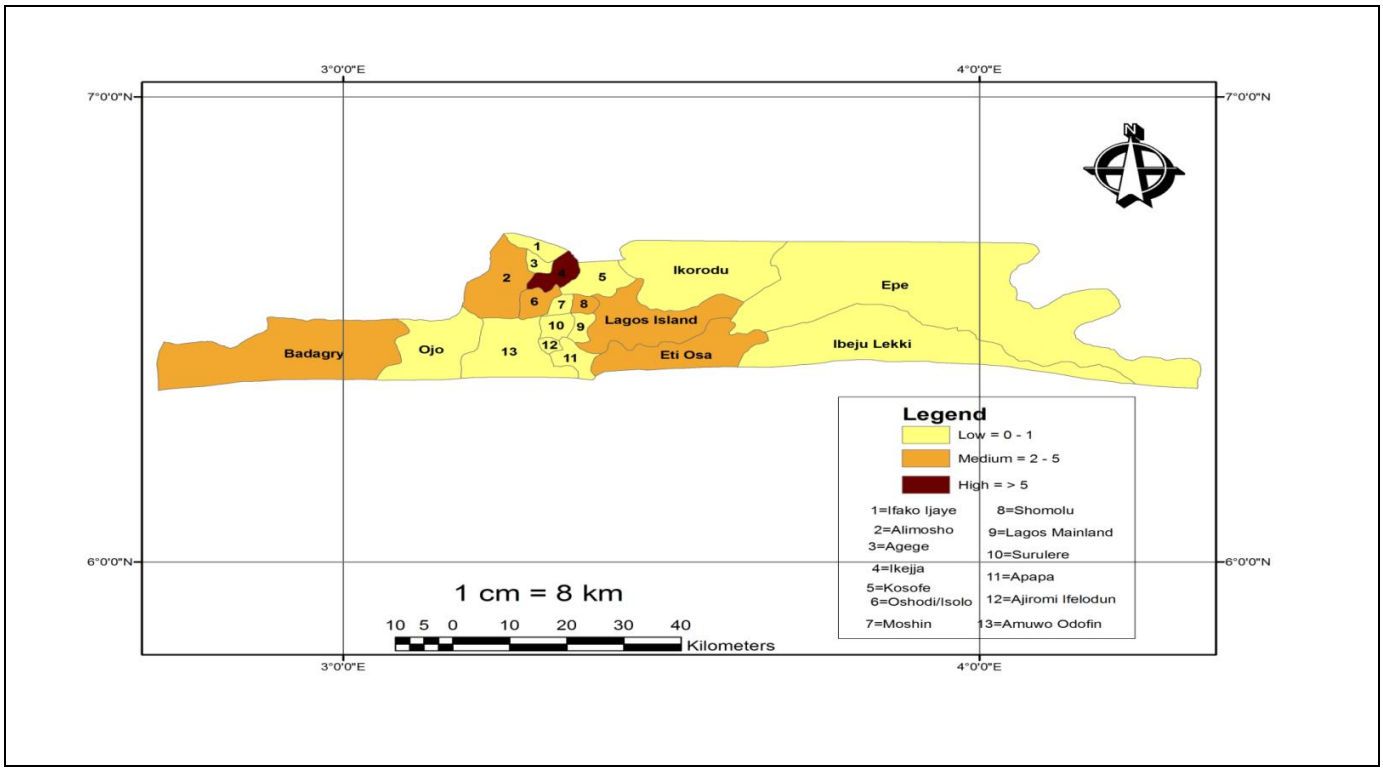

Figure 16: Spatial Pattern of Cholera Occurrence, 2009

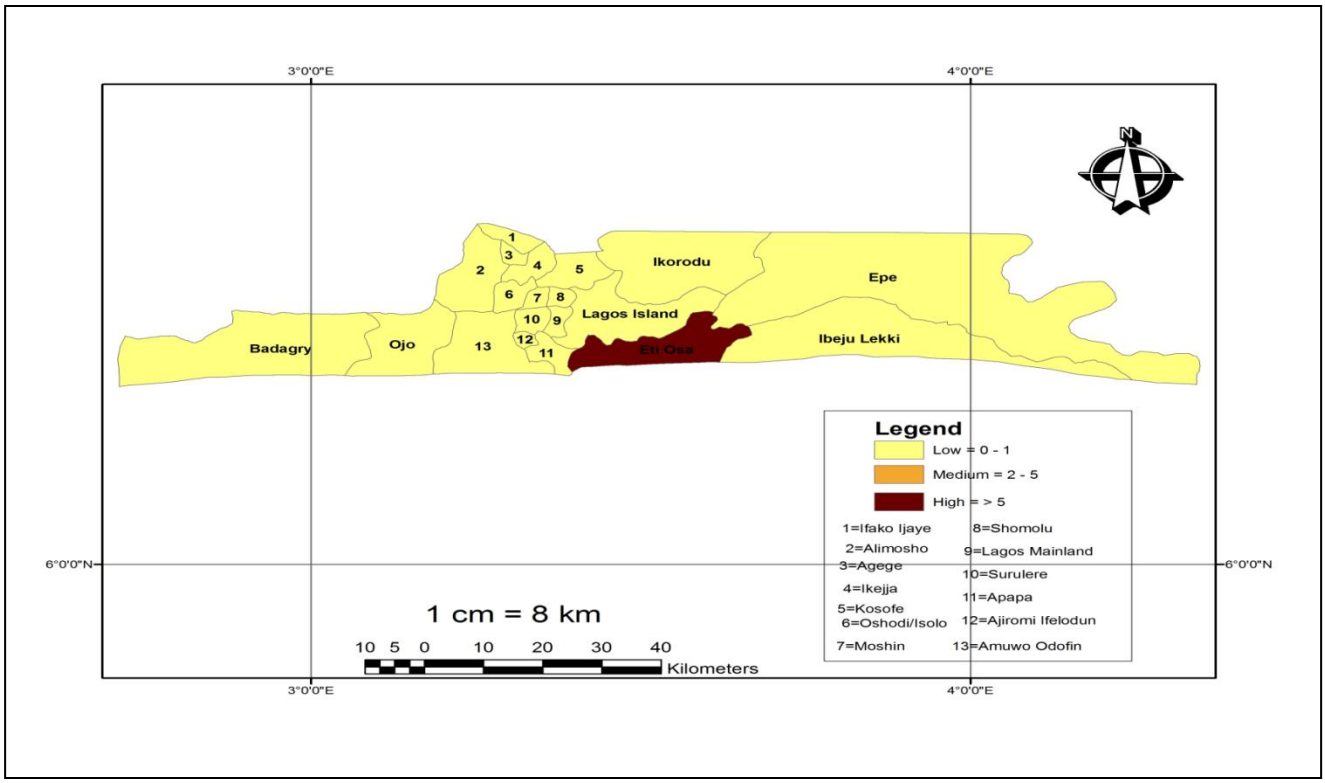

Figure 17: Spatial Pattern of Cholera Occurrence, 2010

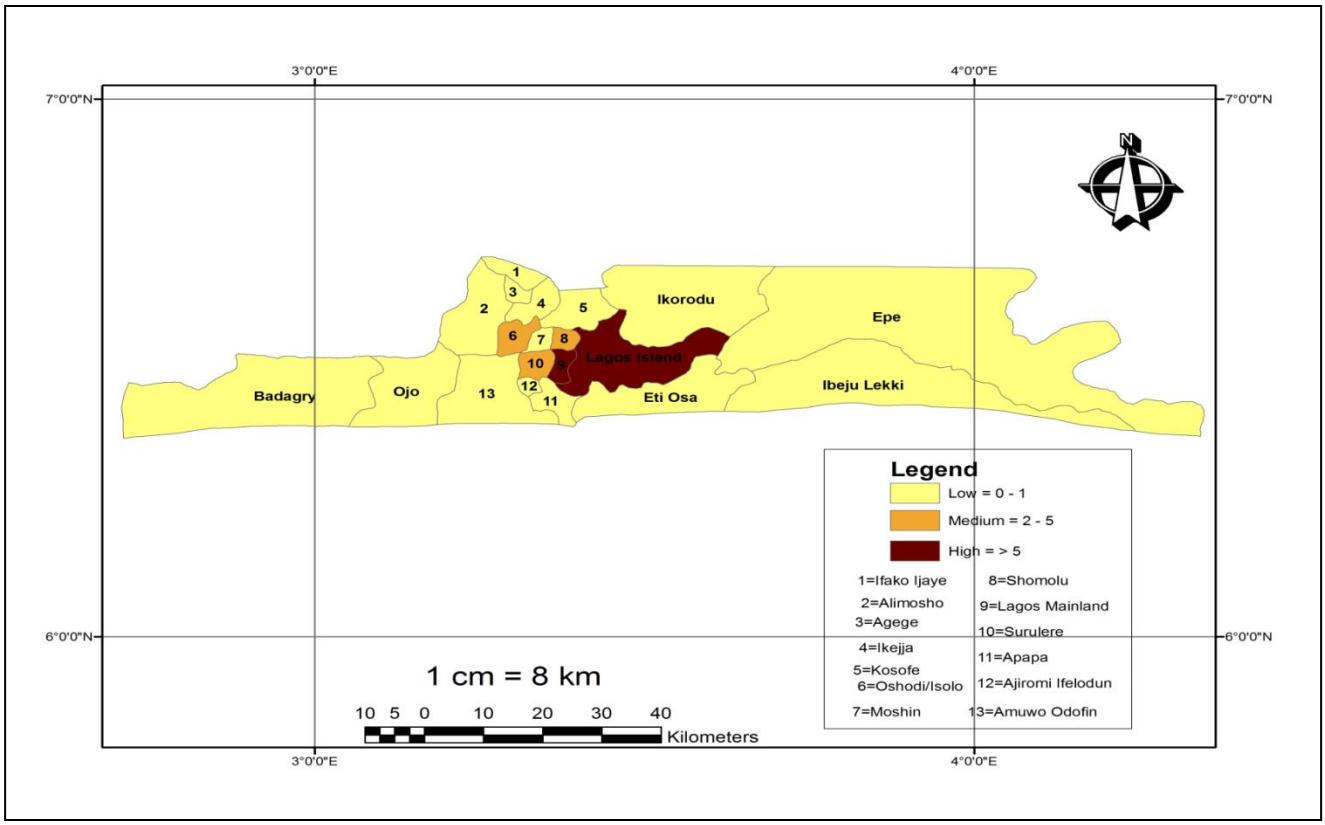

Figure 18: Spatial Pattern of Cholera Occurrence, 2011

Conclusion and recommendations

The study has shown both spatial and temporal variations in the occurrence of cholera in Lagos State. The factors of vulnerability to the disease in the state could be environmental and behavioural. Such factors include low levels of personal and environmental hygiene, blocked drainages, indiscriminate dumping of refuse, poor sources of water and burst septic tanks and soak-away. Three hundred and seventy five (375) reported cases (see Table 1) of a disease among a population of over 5,000,000 in eleven years does not have a striking impression. However, when one considers the teaming population of those susceptible, the modes of transmission, the diffusion processes and other non-congenial environmental conditions; then one will tend to take a more cursory look at the patterns of occurrence of the disease.

There should be continuous efforts in promoting cholera campaign programs, orientation and reorientation of stakeholders as the fight is not for the government and health officials alone. Currently, there are only two oral cholera vaccines available: Dukoral, which is WHO prequalified and licensed in over 60 countries and ShanChol, which is licensed in India and is pending WHO prequalification. Each of the vaccines is a 2 dose vaccine and so multiple weeks can elapse before persons receiving the vaccine are protected. Therefore, vaccination should not replace standard prevention and control measures. The campaigns should by necessity reflect spatial peculiarities. It should not be assumed that the same set of strategies will work for the entire state in the same manner. Finally, cholera risk maps should be produced and updated on a regular basis as new data emanates and special attention should be given to low income/high density areas in the disease control efforts.

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