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Mapping the Prevalence of Pneumonia in Abuja Federal Capital Territory Nigeria using GIS

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Abstract *- The Federal Capital Territory (FCT) of Nigeria, Abuja, has experienced a lot of explosion of population in recent years. This has led to complicated health issues like the prevalence of epidemic and endemic diseases. A proper understanding of this disease prevalence is essential; knowledge of the spatial occurrence of these diseases is a must for rational planning and management. This study aimed at mapping the spatial distribution of pneumonia occurrence in FCT Abuja, Nigeria, to identify the rate of occurrence and rate of change over the years. Data on pneumonia occurring in the FCT were collected from the Health and Human Services Secretariat of the Federal Capital Territory Administration (FCTA). The administrative map of Abuja and the Area Councils were digitized to obtain shapefiles of the boundaries of the area councils. A geospatial database was created, and pneumonia occurrence in the study area was mapped using choropleth maps and bar graph in the ArcMap 10.7 environment. The results show that Bwari and Abuja Municipal Area councils recorded the overall highest cases of Pneumonia over the 8-year study period. The trend analysis of pneumonia occurrence in Abuja suggests a progressive decline in the number of cases recorded with an average decrease rate of -16.15%.*

Keywords — *Geographic Information System, Spatial Spread, Pneumonia.*

I. INTRODUCTION

The Federal Capital Territory (FCT) of Nigeria, Abuja, has experienced a lot of explosion of population in recent years. This has led to complicated health issues like the prevalence of epidemic and endemic diseases. A proper understanding of this disease prevalence is essential; knowledge of the spatial occurrence of these diseases is a must for rational planning and management.

Community leaders searching for innovative methods for health care management have begun to recognize the power of a Geographical Information System (GIS) in various management activities ranging from determining intervention strategies to formulating health care reforms. Through the geo-coding process, a GIS allows personal health data to be examined spatially so that patterns can be discerned.

The tremendous potential of a GIS to benefit the health care industry is just now beginning to be realized. Both public and private sectors (including public health departments, public health policy and research organizations, hospitals, medical centers, and health insurance organizations) are beginning to harness the data integration and spatial visualization power of a GIS (Cromley and McLafferty, 2002).

GIS plays a critical role in the decisions on where and when to intervene, improving the quality of care and accessibility of services, finding the most cost-effective delivery modes, and protecting patient confidentiality while satisfying the needs of the research community on data accessibility. The GIS technology has been used in public health care for epidemiologic studies, as in tracking the sources of diseases and their spread in the communities such that authorities can respond more effectively to outbreaks of diseases with appropriate intervention measures to the at-risk population. GIS Applications in public health include tracking of child immunizations, conducting health policy

research, and establishing health service areas and districts.

Over the second half of the twentieth century, the world has seen enormous health improvements. However, developing countries have benefited unequally from health gains, with many, especially in Sub-Saharan Africa (SSA), continuing to experience high mortality (Mills and Shillcutt, 2004). Mills and Shillcutt (2004) noted that children bear a major burden of ill health, with infectious and parasitic diseases the main killers; Adults also experience substantial premature mortality. Within countries, poorer groups have considerably worse health than the better off. Analysis of avoidable mortality highlights the importance of communicable disease, which represents around 90% of all avoidable mortality in almost all age/sex groups.

Mapping infectious diseases is a very old idea. It is sometimes claimed that the geographical patterns and transmission of infectious diseases like yellow fever, cholera, measles, or malaria have been fully understood. Because effective treatments have been found and used for years, people tend to take it for granted that these diseases are not as serious as they used to be (Tao, 2010). However, little has been done about pneumonia. Tao (2010) further observed that people often pay more attention to researching new infectious diseases like HIV/AIDS, SARs, and avian influenza. As a result, mapping those old infectious diseases fell out of favor in the second half of the twentieth century, possibly superseded by lab research. Pneumonia has been identified as one of the major killer diseases of children in sub-Saharan Africa. This study aimed at mapping and analysis of the spatial distribution of pneumonia occurrence in FCT Abuja, Nigeria using GIS, to identify the rate of occurrence and rate of change over the years.

II. MATERIALS AND METHODS

A. Study Area

The study area is Abuja, the Federal Capital Territory (FCT) of Nigeria. The FCT stretches across approximately 8,000 square kilometers with a geographic location of latitude 7º25'N and 9º20'N and longitude 5º45'E and 7º39'E. It is bordered on the north by Kaduna state, on the west by Niger state, on the east by Plateau state, and on the South-west by Kogi. The geographic location of Abuja is shown in figure 1. The FCT is made up of three urban Area councils, namely Bwari, Gwagwalada, Abuja Municipal Area Council (AMAC), and three rural area councils, namely: Abaji, Kwali, and Kuje.

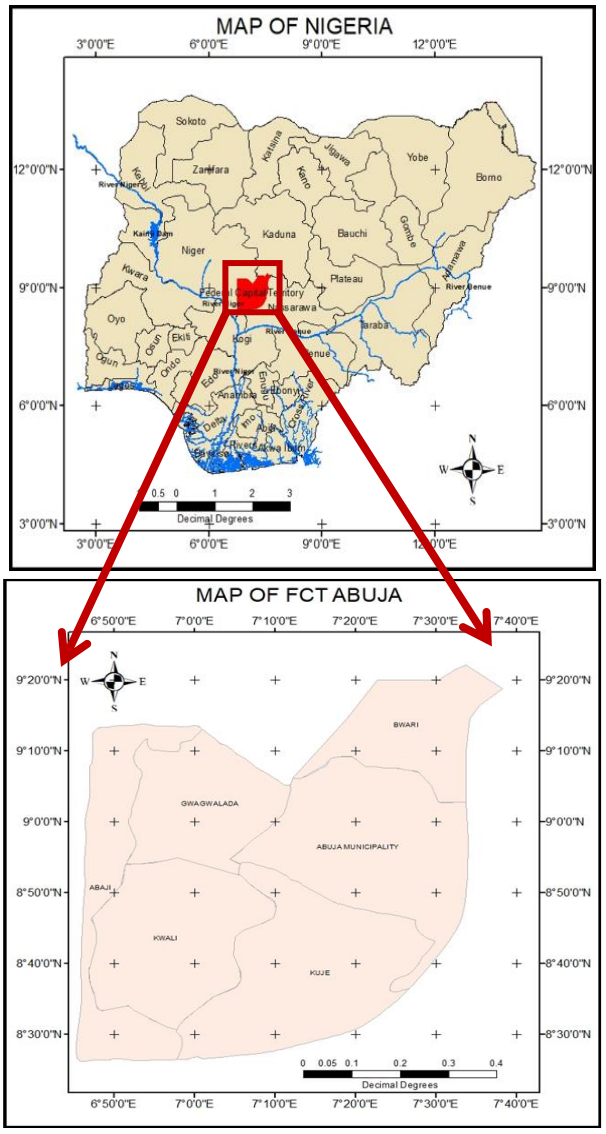


Figure 1 Map of Nigeria and Map of the study area

B. Data Type and Acquisition

i. The administrative maps of Nigeria, Abuja, and the area councils were sourced from the office of Abuja Geographic Information System (AGIS).

ii. Data on Pneumonia occurrences was sourced from the Health Department of the Federal Capital Development Authority (FCDA).

To obtain this data, an introduction letter, an application letter, and a research proposal were sent by the researchers Public Health Department of the FCTA. The Health Research Ethics Committee of the FCTA issued an "Ethical Clearance Letter" to the researchers with approval number

FHREC/2019/01/89/16-09-19; with this ethical clearance letter, the researchers approached the Department of Health Planning Research and Statistics (HPRS) of the Health and Human Services Secretariat (HHSS), where an eight-year data on Pneumonia (from 2011 - 2018) were given to the researchers using the Integrated Disease Surveillance and Response (IDSR) form.

C. Software Requirements

The following software was used for achieving the goal of this project:

a. ArcGIS 10.7 handles multiple tables and relates them to each other with ease, and allows manipulation and query using appropriate commands. This was used for geospatial database creation, thematic mapping, and visualization of the spatial distribution of pneumonia occurs in the study area.

b. Microsoft Offices; Microsoft word was used for typesetting of the reports, and Microsoft Excel was used for the creation of tables.

D. Procedure

Data on Pneumonia occurrences were used to create multiple tables for each year starting from 2011 to 2018 and for each area council. The administrative map of Abuja and the Area Councils were digitized to obtain shapefiles for boundaries and various classes of roads, railway lines, waterways, and boundaries of the Area Councils. The shapefiles and tables were used to create a geospatial database in the ArcGIS 10.7 environment.

ESRI (2019) noted that most database design guidelines promote organizing databases into multiple tables, with each focusing on a specific topic instead of having one large table containing all the necessary fields. The essence of having multiple tables is to prevent duplication of information in the database because information about a phenomenon is stored only once in one table. When a database contains only tables, it is only but a database, but when these tables are associated with shapefiles or geographic features displayed on a map, the database becomes a geospatial database.

ArcGIS allows for the association of records in one table with records in another table through a common field, known as a key. We joined the table of data to a layer based on the value of a field that can be found in both tables. The name of the field does not have to be the same, but the data type has to be the same; numbers were joined to numbers, strings to strings, and so on. The procedure was perform using the join "tool" accessed by right-clicking a layer in ArcMap, as shown in figure 2.

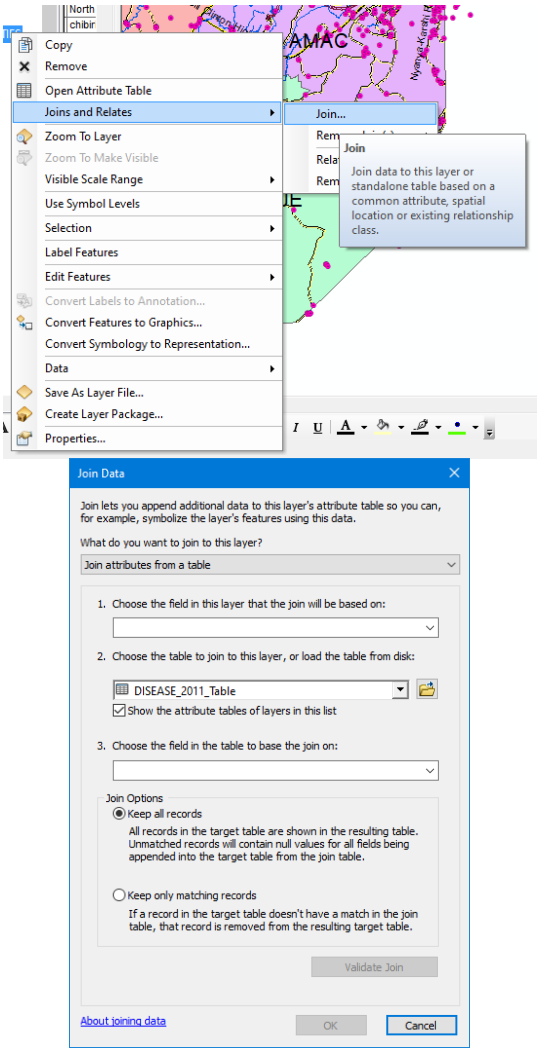


Figure 2 Join and Relate Tool in ArcMap for joining the table to layer in the database

After creating the database and populating it with the necessary data from the tables and the layers, the occurrences of Pneumonia over the years in the study area were mapped using choropleth maps and bar graph in ArcMap 10.7 environment. A choropleth map uses graded differences in shading or color or the placing of symbols inside defined areas on the map to indicate the average values of some property or quantity in those areas (see Figures 3 and 4 for the process of creating choropleth maps and create graph wizard).

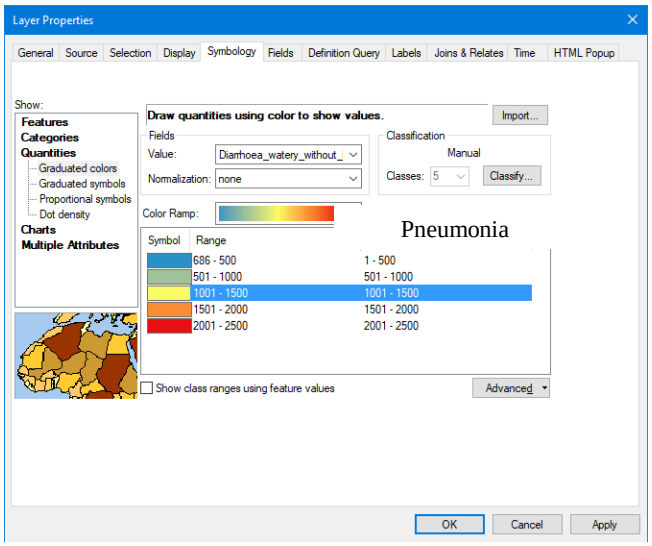


Figure 3 Process of mapping communicable diseases using choropleth maps

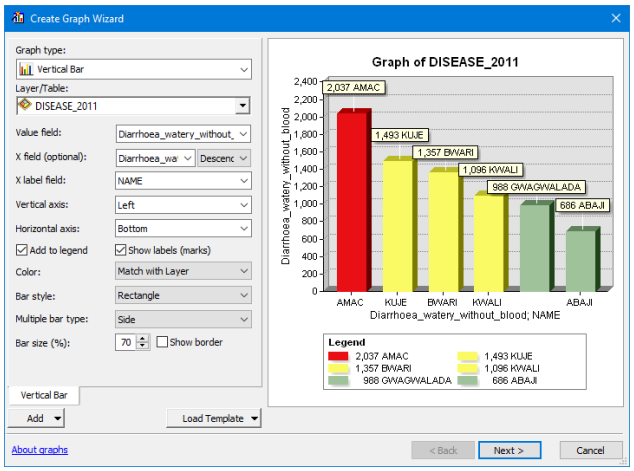


Figure 4 Process of mapping communicable diseases using create graph wizard

Results and Discussion:

Prevalence and rate of occurrences of Pneumonia

Mapping the incidence and prevalence of diseases has always been a part of public health, epidemiology, and the study of diseases in human populations (Koch, 2015). Disease mapping is often carried out to investigate the geographical distribution of diseases in each region.

According to the WHO and CDC&P (2010), Pneumonia is one of the principal causes of morbidity and mortality in the African Region. They further defined Pneumonia in children as "a child presenting with cough or difficult breathing with 50 or more breaths per minute for infant age 2 months up to 1 year and 40 or more breaths per minute for young child 1 year up to 5 years". Data available shows that pneumonia affects mostly children within the age ranges of between 0 – 28 days, 1 – 11 months, 12 – 59 months.

Pneumonia is one of the diseases classified as endemic diseases by WHO in 2014, and the results obtained indicate that the Kwali area council recorded the highest cases of Pneumonia with 703 and AMAC had the second-highest cases of Pneumonia in 2011 with 625 cases respectively. Bwari and Gwagwalada area council recorded about 469 and 323 cases, respectively, while the Kuje Area Council recorded about 251 cases and Abaji recorded the least number of cases with 73 cases (see Figure 5).

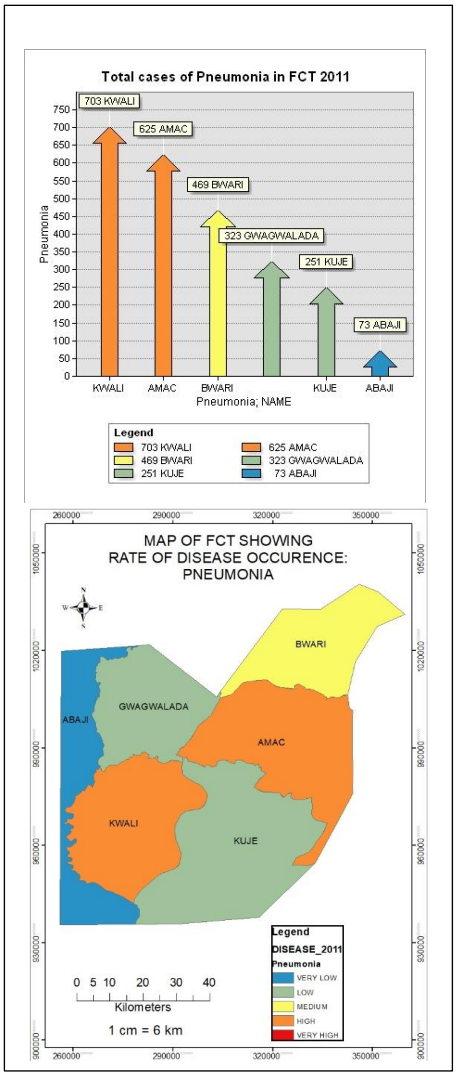


Figure 5 Total cases of Pneumonia in FCT 2011

In the year 2012, there was about a 10.44% decrease in the rate of occurrence of Pneumonia in the study area. Kwali area council recorded the highest cases in the year 2012 with a total of 636 cases, with Abaji also recording the lowest number of cases with 157 (see Figure 6). Bwari, Abuja Municipal, and Gwagwalada recorded 482, 388, and 288 cases, respectively.

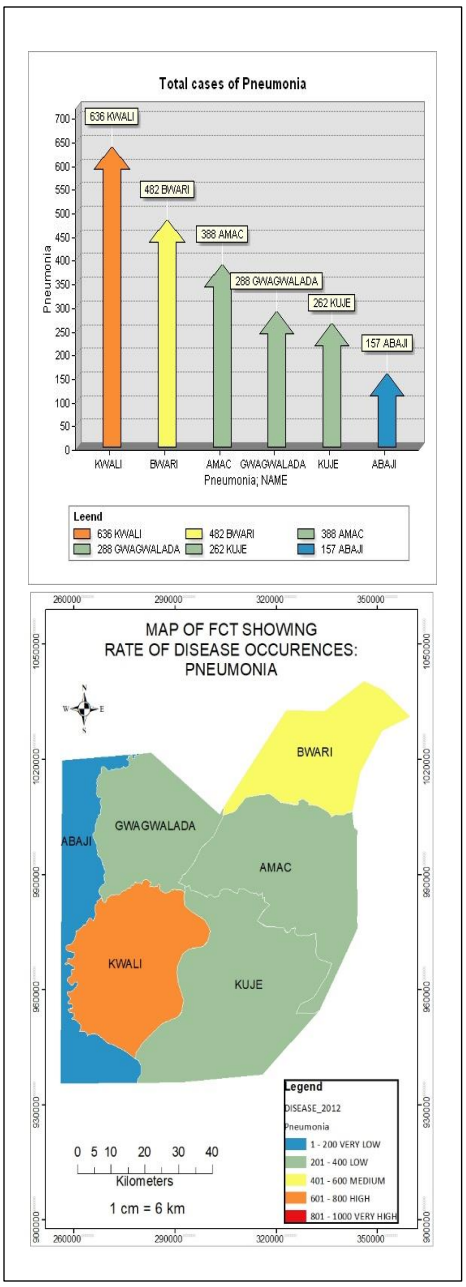


Figure 6 Total cases of Pneumonia in FCT 2012

In the year 2013, the Bwari area council recorded the highest occurrence rate for the series with 1103 cases; this was followed by AMAC, which recorded 608 cases. Gwagwalada, Kuje, and Kwali recorded 416, 353, and 134 cases, respectively, while Abaji recorded the lowest figure for the year with 117 cases (see figure 7).

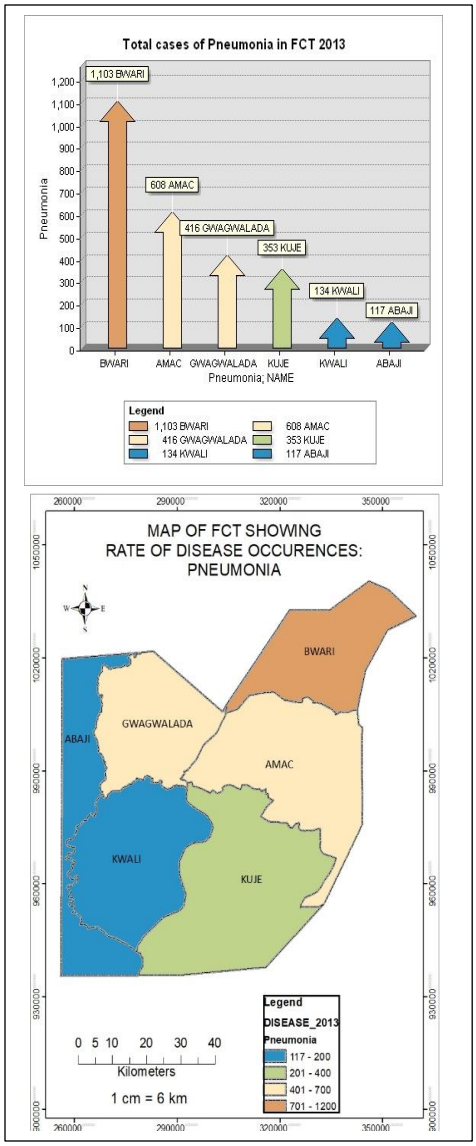


Figure 7 Total cases of Pneumonia in FCT 2013

In the year 2014, Bwari and Abuja Municipal recorded the highest number of cases of Pneumonia with 691 and 591 cases, respectively; these two area councils are urban area councils with many modern and equipped healthcare facilities. Gwagwalada, Kuje, and Abaji recorded 288, 245, and 240 cases, respectively. Kwali area council recorded the lowest number of cases with 172 cases (see figure 8).

The number of cases of Pneumonia for the years 2015, 2016, and 2017 are shown in Figures 9, 10, and 11, respectively. While Abuja Municipal recorded the highest cases in 2015 and 2017, the Kwali area council recorded the lowest figures in the three years with 140, 102, and 34 cases, respectively**.**

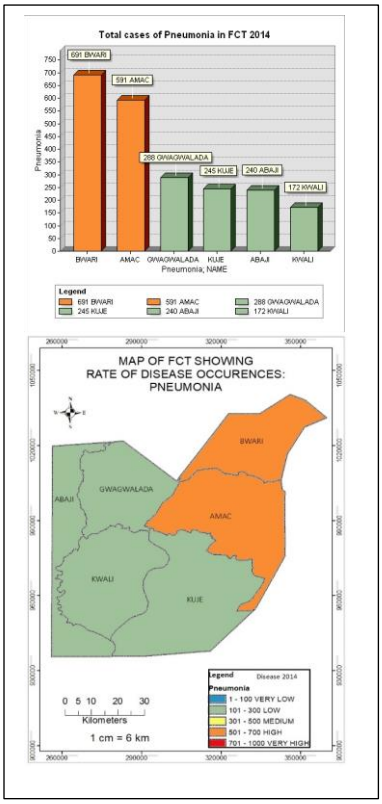


Figure 8 Total cases of Pneumonia in FCT 2014

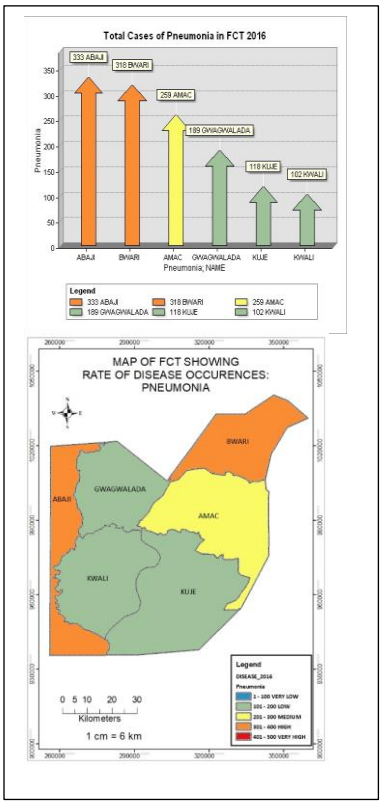


Figure 10 Total cases of Pneumonia in FCT 2016

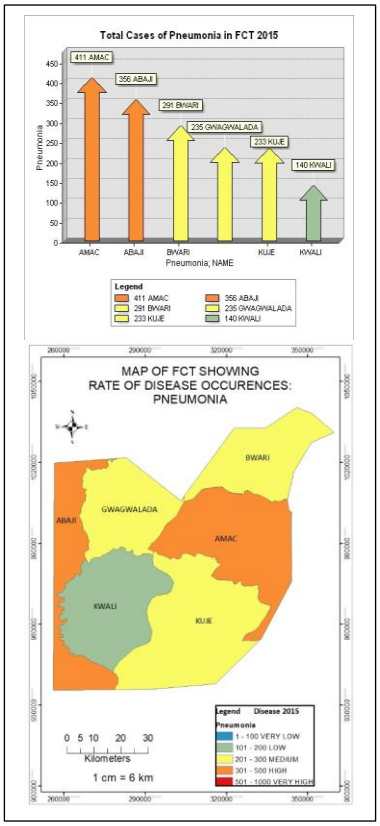


Figure 9 Total cases of Pneumonia in FCT 2015

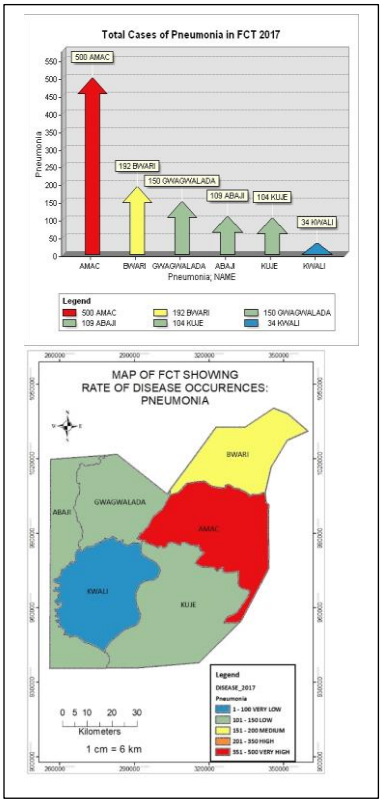


Figure 11 Total cases of Pneumonia in FCT 2017

The year 2018, which was the last year of the study, recorded the lowest number of cases across the six area councils, with no area council having up to 300 cases. Abuja Municipal and Bwari had the highest figures of 299 and 238 cases, while Kuje, Abaji, and Gwagwalada recorded 140, 116, and 115 cases, respectively. Kwali area council recorded the least cases with only 16 cases. Figure 12 shows a general decline from the previous years under study.

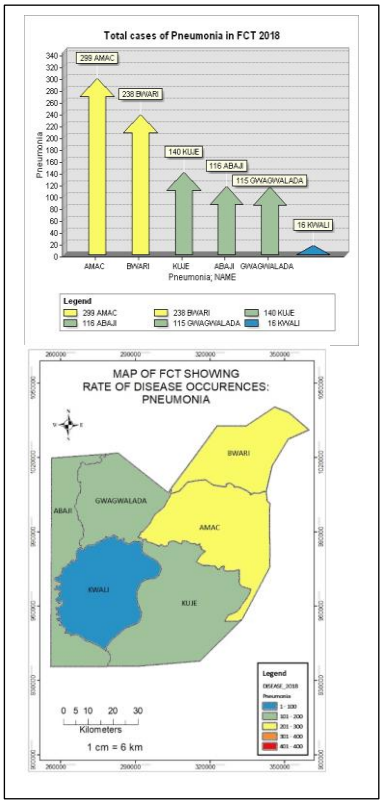
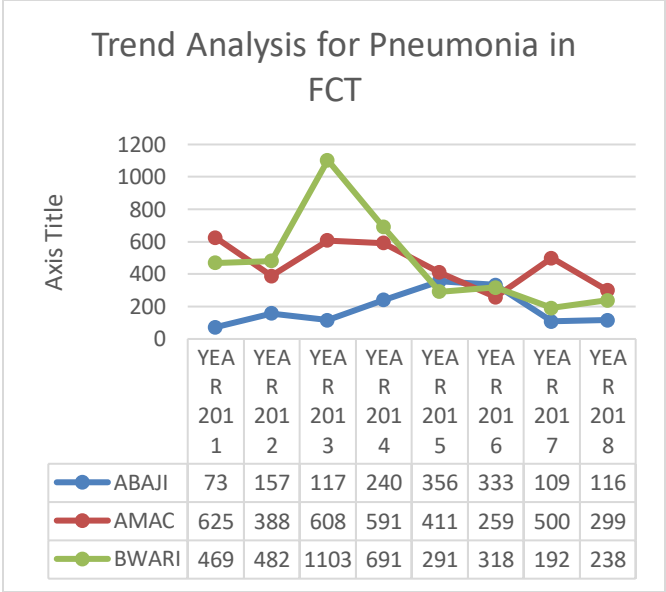


Figure 12 Total cases of Pneumonia in FCT 2018

Trend Analysis

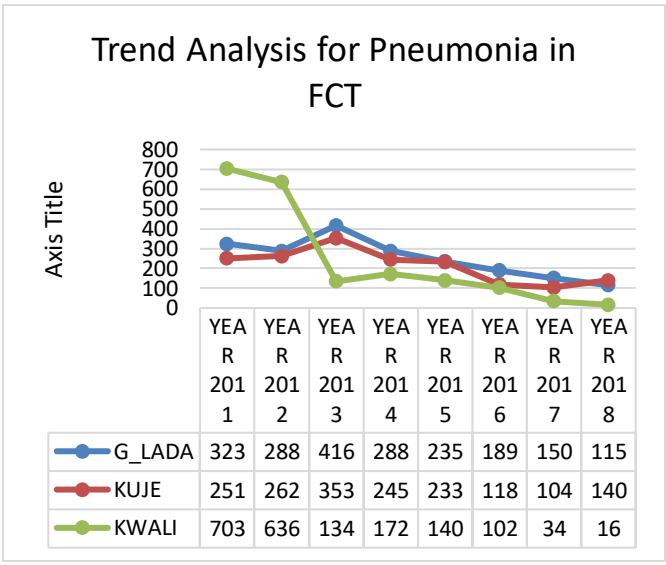
Trend Analysis for Pneumonia in FCT between the year 2011 and 2018 suggests a progressive decline in the number of cases recorded in the study area. The average decrease over the years is calculated to be -16.15%. (see Figures 13 and 14).

The results show that the Bwari area council recorded the overall highest cases of Pneumonia in the 8-year study period. Bwari area council recorded a sharp increase in the number of cases of pneumonia between 2012 to 2013; this was the highest increase in the study area throughout the 8-year study period. Bwari and Abuja Municipal Area Council, with the highest number of healthcare facilities, recorded the highest number of cases of pneumonia; it would have been expected that there should have been a decrease in the number of cases in an urban area council like the Bwari and Abuja Municipal Area Council. (see Figure 4.50 and 4.51



	YEAR 2011	YEAR 2012	YEAR 2013	YEAR 2014	YEAR 2015	YEAR 2016	YEAR 2017	YEAR 2018
ABAJI	73	157	117	240	356	333	109	116
AMAC	625	388	608	591	411	259	500	299
BWARI	469	482	1103	691	291	318	192	238

Figure 13 Trend analysis for Pneumonia for three area councils in FCT



	YEAR 2011	YEAR 2012	YEAR 2013	YEAR 2014	YEAR 2015	YEAR 2016	YEAR 2017	YEAR 2018
G_LADA	323	288	416	288	235	189	150	115
KUJE	251	262	353	245	233	118	104	140
KWALI	703	636	134	172	140	102	34	16

Figure 14 Trend analysis for Pneumonia for three area councils in FCT

A comparative analysis of the percentage change of Pneumonia over the years in the study area is shown in table 1.

Table 1 Percentage Change of Pneumonia occurrence over the years in the study area

Pneumonia Percentage Change over the years								
From	To	Abaji %	Abuja Municipal %	Bwari %	Gwagwalada %	Kuje %	Kwali %	Yearly Totals %
Year 2011	Year 2012	53.50	-61.08	2.70	-12.15	4.20	-10.53	-10.44
Year 2012	Year 2013	-34.19	36.18	56.30	30.77	25.78	-374.63	18.97
Year 2013	Year 2014	51.25	-2.88	-59.62	-44.44	-44.08	22.09	-22.63
Year 2014	Year 2015	32.58	-43.80	-137.46	-22.55	-5.15	-22.86	-33.67
Year 2015	Year 2016	-6.91	-58.69	8.49	-24.34	-97.46	-37.25	-26.31
Year 2016	Year 2017	-205.50	48.20	-65.63	-26.00	-13.46	-200.00	-21.12
Year 2017	Year 2018	6.03	-67.22	19.33	-30.43	25.71	-112.50	-17.86
Area Council Total percentage change		-14.75	-21.33	-25.13	-18.45	-14.92	-105.10	
							Grand Percentage Change	**-16.1516**

The table shows that Kwali (a rural area council) had the highest decrease rate of -105.1%, this is followed by Bwari (an urban area council) with a total decrease rate of -25.13% over the 8 years. Abaji and Kuje recorded the lowest decrease rate of 14.75% and 14.92%, respectively. Abuja Municipal and Gwagwalada recorded 21.33% and 18.45%, respectively. These results show that there is no significant difference between the rural area councils and the urban area councils in terms of the occurrence of pneumonia in the study area.

Conclusions

According to WHO (2010), the disease profile of the world is changing at an astonishingly rapid rate, especially in low- and middle-income countries such as the study area. Other studies have shown that data and information on public health are essential for monitoring the health status of the population, detecting diseases, and triggering action to prevent further illness and to contain public health problems. The need to strengthen disease surveillance and response systems is recognized globally. Hence this study has provided maps explicitly exhibiting the spatial spread of pneumonia in Abuja, Nigeria, in an attempt to understand the vulnerable area councils. This will be invaluable for policymakers to put forward appropriate policies and monitoring mechanisms on the occurrence of pneumonia in Abuja.

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