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GEOSPATIAL ANALYSIS OF THE GROWTH DISTRIBUTION OF TYPHOID FEVER CASES IN LAGOS STATE

(A Case Study of All General Hospitals in Each Local Government Area of Lagos State)

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ABSTRACT

The fundamental objective of this project is focused on the application of GIS in the analysis of the growth distribution of typhoid fever cases in Lagos state using the general hospitals in the state as case study. The study highlights the need for GIS as a tool for analysis and decision making as well as an information management vehicle with rich potential for the healthcare industry. It also highlights GIS analysis or display of environmental health data in explaining disease patterns in terms of relationships with social, institutional, technological and natural environments. The development of the GIS attribute database in the arc-view GIS environment was achieved with structured data sets of typhoid fever cases acquired from the records offices of the various general hospitals in Lagos state. The spatial locations of the general hospitals were obtained with a GPS receiver and a digitized map of Lagos state showing Local Government Areas in the state was also applied in the analysis; thus, specifying GIS as a link between maps and databases. Finally, analysis were drawn on queries performed using query facility in the arc-view GIS environment on the created structured GIS database of the general hospitals in order to obtain comprehensive results and achieve the objectives of the study.

Keywords: GIS, Data, Spatial, Attribute, Sickness, Typhoid.

INTRODUCTION

Typhoid fever, also known as **typhoid**,[1] is a common worldwide illness, transmitted by the ingestion of food or water contaminated with the feces of an infected

person, which contain the bacterium *Salmonella enterica*, serovar Typhi.[2][3] The bacteria then perforate through the intestinal wall and are phagocytosed by macrophages. The organism is a Gram-negative short bacillus that is motile due to its peritrichous flagella. The bacterium grows best at 37°C / 98.6°F – human body temperature. This fever received various names, such as **gastric fever**, **abdominal typhus**, **infantile remittant fever**, **slow fever**, **nervous fever**, **pythogenic fever**, etc. The name of "typhoid" comes from the neuropsychiatric symptoms common to typhoid and typhus (from Greek τ□□ος, "stupor")[4].

The impact of this disease fell sharply with the application of modern sanitation techniques. Public health management needs information on various aspects like the prevalence, distribution and growth rate of diseases, facilities that are available in order to take decisions on either creating infrastructural facilities or for taking immediate action to handle the prevailing trend and so on. These decisions need to be taken based on the observations made and available data. The data is voluminous since it relates to public health covering the whole state and the entire population; hence, it is extremely difficult to understand the real content. The data is required to be presented in a way that the temporal and spatial nature of the problem can be brought out in a focused manner. Spatial variations in health related data is well known and its study is a fundamental aspect of epidemiology. Most epidemiological data have references to location and time.

Advanced spatial analysis includes the combination of different data layers. Health authorities for instance may be interested in the estimates of the number of children in a certain age group that may be exposed to a particular disease, say typhoid fever in the disease endemic area. The availability of statistical and other information in spatially referenced form and the functions provided by a GIS could allow analyses that were previously too expensive or impossible to perform. Geographic Information System (GIS) is an innovative technology, ideal for generating data suitable for analysis both with respect to space and time. It is an integration of computer hardware, software and geographically referenced data. The purpose of using GIS is that maps provide an added dimension to data analysis, which helps in visualizing the complex patterns and relationships. GIS for public health distribution and growth rate analysis could be a useful decision support tool in formulating heath schemes in more realistic and need based manner.
A few typical questions that can be answered by GIS are:

- Can we identify areas where a particular disease is prevalent?

- Can we get some clues about the possible factors that are responsible for a particular disease?
- Where to give additional sanctions for facilities and staff?
- Where to locate a government hospital or health centre?
- Where the areas water related diseases are prevalent?

The application of GIS to growth rate analysis and management of a disease like typhoid fever will bring has the benefit of large data communication and processing in addition to its effective and efficient decision making tool for health practitioners and managers.

The general hospitals in Lagos state covered are;

- Lagos Island general hospital
- Epe general hospital
- Agbowa general hospital
- Isolo general hospital
- Gbagada general hospital
- Surulere general hospital
- Orile Agege general hospital
- Ikorodu general hospital
- Ajeromi general hospital
- Ikeja general hospital
- Badagry general hospital

LITERATURE REVIEW

Typhoid fever is an infection of the intestines that affects the whole body. It is caused by a bacterium called **salmonella typhi** (*s. typhi*) which is found in the stools of infected persons. In developing countries, typhoid fever often occurs in epidemics. In recent decades, typhoid fever has largely disappeared from industrialized countries but remains a serious public health problem in several Asian regions of the former U.S.S.R., in parts of South-East Asia, Africa and South America.

According to W.H.O. estimates, the annual global incidence of typhoid fever is at 0.3%, corresponding to about 16million cases of which approximately 600,000 end in death. In some developing countries of Asia and Africa, the annual incidence may reach 1% with case fatality rates as high as 10%. About 70% of all fatalities from typhoid fever occur in Asia. Hospital based data and passive surveillance studies in

endemic areas have shown that the incidence of typhoid fever peaks between the ages of 5 and 12 years. Improved living conditions and the introduction of antibiotics in the late 1940s resulted in a drastic reduction of cases and mortality due to typhoid fever in industrialized countries. Typhoid is spread when a person drinks or eats food and water contaminated by human waste (stool or urine) containing *salmonella typhi* bacteria and closely associated with poor food hygiene and inadequate sanitation. Following ingestion, the bacteria spread from the intestine to the intestinal lymph nodes, liver and spleen via the blood where they multiply. The bacteria can be identified from the stool, blood or urine of an infected person.

Asymptomatic carrier of typhoid fever i.e. a carrier suffering no symptoms but capable of infecting others are common in disease-endemic areas and are important sources of infection. In 1907, Mary Mallon (known as "Typhoid Mary") became the first American carrier to be identified and traced. According to the centres for disease control, approximately 5% of people who contract typhoid continue to carry the disease after they recover. They continue to harbour *s. typhi* in their intestinal tract and gall bladder for months or years (chronic carriers).

METHODOLOGY ADOPTED

The methodology adopted involved the use of some ideal GIS hardwares and user friendly software packages to actualize this study. The strong point of the system on which the project was developed is to integrate database operations such as query and statistical analysis with visualization and geographic analysis of maps i.e. managing attributes that require spatial analysis, (Aangeenbrug, 1991).
The software packages used are;

- Arc-view GIS 3.2a
- Microsoft Excel

DATA ACQUISITION

The efficiency and effectiveness of a GIS project will depend largely on the quality of initial field data captured. The sets of data acquired for this project are spatial (map or geographic) data and attribute (non-spatial) data associated with the spatial data. An analogue map of Lagos state was acquired; the map was scanned, georeferenced and digitized. The map contains information on the Local Government Areas (L.G.A.) of the state while the attribute data which are the typhoid fever cases were collected from the records office of the various general

hospitals in Lagos state. The ground survey technique with the aid of a Garmin 12XL GPS (Global Positioning System) receiver was used to acquire the positions of the various general hospitals, (Clarke, 1991; Ezeigbo, 1998; Omogunloye and Adediran, 2007).

The spatial and attribute data collected for the purpose of this project are:

- The L.G.A. map of Lagos state
- Names of the various general hospitals and the L.G.A. of location
- The position coordinates of the general hospitals in Lagos state
- The monthly and yearly typhoid fever cases figures of each general hospital over a period of 8 years from 1997-2004.

SYSTEM DEVELOPMENT

System development involved building or creating the physical structures of the proposed system based on design specifications. Thus, activities carried out at this stage included digitizing of map features; inputting relevant attribute data into the database; checking and editing the captured data; creation of files (both spatial and attribute data files; data processing; data display and output, (Antenucci, et al., 1991 and Omogunloye, et al., 2008)..

DATABASE DEVELOPMENT

Data Classification: This entails defining the particular kind of data required in the database after taking into consideration all necessary parameters. The data required depends on how one wants to use map data and get output. There are no in-built solutions for any spatial problems in the system; it depends on the analyst, (Burrough, 1986 and Carter, 1989).

Database design and creation: The database design process is called data modeling; this is the process of analyzing and modeling real world entities and their inter-relationships in such a way that maximum benefits are derived while utilizing a minimum volume of data. This stage involves creating a practical structural design of the database. For small GIS projects, it may be sufficient to store geographic information as simple files. However, for this project with large data volumes, the use of a well structured relational database was developed directly in the arcview environment to help store, organize and manage data, (Coppock, et al, (1991).

There are many different designs of DBMS's, but in GIS the relational design has been the most useful. In the relational design adopted for this project, data were

entered and stored conceptually as a collection of tables in the arcview GIS environment and saved as dbf files (recognized format by arcview). The dbf files were converted to shape files for spatial analysis and application, (Huxhold, 1995). The attribute database tables generated consists of fields; each field has field definition containing field type (e.g. numeric, string, Boolean, date), field size, field width etc. The records or attribute data are stored under each field, the kind of record e.g. numeric or string is determined by the field type defined in the field definition window, (Goodchild, 1992). Common fields in different tables are linked together. This simple design is widely used primarily because of its flexibility, with very wide deployment in applications both within and without GIS and it allows for database updating, (Omounloye and Makanjuola, 2009).

DATA PROCESSING

Data set are manipulated or processed to obtain the desired information. The GIS system enables the processing of both spatial and attributes data, results can also be analyzed. The analysis required depends on the type of information desired. The data processing involves the retrieval, display, manipulation and analysis of data as well as results presentation, (Healey, 1991; Hearnshaw, 1993 and Maguire, 1991).

RESULTS AND ANALYSIS

The end result of a GIS is a detailed map and linked attribute tables in shape file formats. Once the geographic information/data is entered in to GIS environs, simple queries and analytical questions can be performed and results obtained quickly. The results achieved in the course of this study are the queries, charts and attribute tables which are created for the purpose of proper analysis of the cases.

DATABASE QUERY RESULTS AND ANALYSIS

The query builder facility in the arcview GIS was used to perform several queries on the attribute database tables to show the functionality and the use of the GIS created.

The queries performed and shown are as follows:

Query 1: Shows Ajeromi General Hospital with the highest typhoid fever cases in 2004

Query 2: Shows Orile Agege General Hospital with the lowest typhoid fever cases in 2004

Query 3: Shows Ikeja General Hospital with the highest typhoid fever cases within the period of study (1997 to 2004)

Query 4: Shows Ajeromi General Hospital with the highest typhoid fever cases between the ages of 15-49years in 2004.

The query results obtained are to aid in decision making and these results are dependent on parameters set up in the attribute database tables especially structuring of the tables. The results intended to be achieved determines how the user will structure the tables.

Based on the structuring of the attribute database tables, query results from **Queries 1 and 2** showed hospitals with reported high and low cases of typhoid fever in the past one year 2004; results also shows Ikeja general hospital as the hospital with the highest reported case within the period of study i.e. 1997 to 2004. The results do not actually indicate that the whole population of the patient cases recorded resides in the L.G.A. where a general hospital is situated. For instance, **Query 3** shows Ikeja general hospital records the highest case of typhoid fever between 1997 and 2004 but in the actual sense, Ikeja L.G.A. where the hospital is located does not account for all the population of patient records within that period; Ikeja general hospital serves a number of L.G.As. void of general hospitals within its vicinity. Similarly, civil servants who work in Ikeja but do not live there, also visit the general hospital for treatment.

The query results enable analysis to be made on areas in need of medical facilities, allocation of funds to each hospital and possible extension of new facilities (hospitals) in the near future.

GROWTH RATE ANALYSIS

The analysis of the growth rate of typhoid fever with the application of GIS can be done by generating charts and graphs from the attribute database in order to study the growing or falling trend of the cases of the disease. A number of charts were produced, displayed and analyses were based on the graphical interpretation of these charts.

Chart 1 displays the monthly growth rate of typhoid fever within the period of study (1997 to 2004). The result shows that over this period, there is a rise and fall in the monthly cases of the disease. A close study of the chart shows a rise

towards the end of the year i.e. between September and December. The chart shows that the highest data was recorded in September while the lowest was recorded in January between the periods i.e. 1997 to 2004. Based on the amount of data acquired, it implies that typhoid is prevalent towards the end of the year since more cases were recorded at this time.

Chart 2 displays the total cases of typhoid fever based on age distribution. A study of the chart shows a rise in the cases of the disease from the age bracket of 0-4years to 5-14years and the highest case is between the age of 15-49years while there is a fall in cases at ages >=50years.

Pie chart 1 shows that the highest percentage of 23% of total typhoid cases was recorded in Ikeja while the lowest (1%) was recorded in Agbowa, a small town in the outskirts of Lagos state where general hospital was established recently and as a result only 2004 records data were available.

A study of **Table 1.0** shows that total cases of typhoid fever dropped from 1,738 in 1997 to 1,551 in 1998, representing a decline of 11%. Total typhoid cases grew by 22% from 1,551 in 1998 to 1,890 in 1999. An impressive decline in the cases was recorded in the year 1999 from 1,890 to 1,450 in the year 2000, representing a fall of 23%. Over the period of this study (1997 to 2004), an average of 2,657 total cases of typhoid fever was recorded. A study of the records gathered shows an escalating growth of 94% from 2000 to 2001 rising from 1,450 cases to 2,817 cases. From 2001 to 2002, a rise of 29% was recorded; from 2002 to 2003, a rise of 8% was recorded and 2003 to 2004 recorded the lowest growth rate of 7%. From the foregoing analysis, an average annual growth rate of 34.5% of typhoid fever cases was obtained between 2000 and 2004.

CONCLUSIONS AND ACKNOWLEDGEMENT

The concept of developing a GIS system for health managers is based on effective and efficient administration and a readily available comprehensive, up to date and reliable sets of disease data. This study identified GIS as a powerful decision support tool for administrators and professionals in all discipline with a unique ability to assimilate data from widely divergent sources to analyze trends over time and to spatially evaluate impacts caused by developments.

The measurement of the frequency, distribution, growth and determinants of disease require GIS application for easy understanding, interpretation and implementation of outcome of results. Although, mapping of disease can be relatively straightforward, interpreting spatially referenced disease data can sometimes be challenging. Regardless of the difficulties in data acquisition, map representation, scale, statistical analysis, interpretation and utility of results, the study of disease distribution and growth rate may well be the most challenging and fascinating research area.

Record keeping in the various general hospitals has not been digitized and difficult to accessed, (tables 1.0 and 1.1). Therefore, the authorities of all the general hospitals in Lagos state with the assistance of the Lagos state health ministry can make provisions for health data to be readily available by upgrading record keeping facilities in the general hospitals through provision of networked computer systems. Easy access to disease data from the general hospitals will encourage further researches especially in areas of disease distribution growth rate.
Massive campaigns, awareness programs, vaccine administration and improved health care facilities should be provided in Ajeromi-Ifelodun Local Government Area especially. This is based on results established from query 1 which shows Ajeromi general hospital with the highest cases of typhoid fever in 2004. The same strategies should be employed in Ikeja L.G.A., which recorded the highest cases between 1997 and 2004 (query 3). Sustainable programs and preventive measures to maintain the low rate (Pie chart 1) of typhoid fever in Epe, Badagry, Ikorodu and Agbowa Local Government Areas should be implemented.

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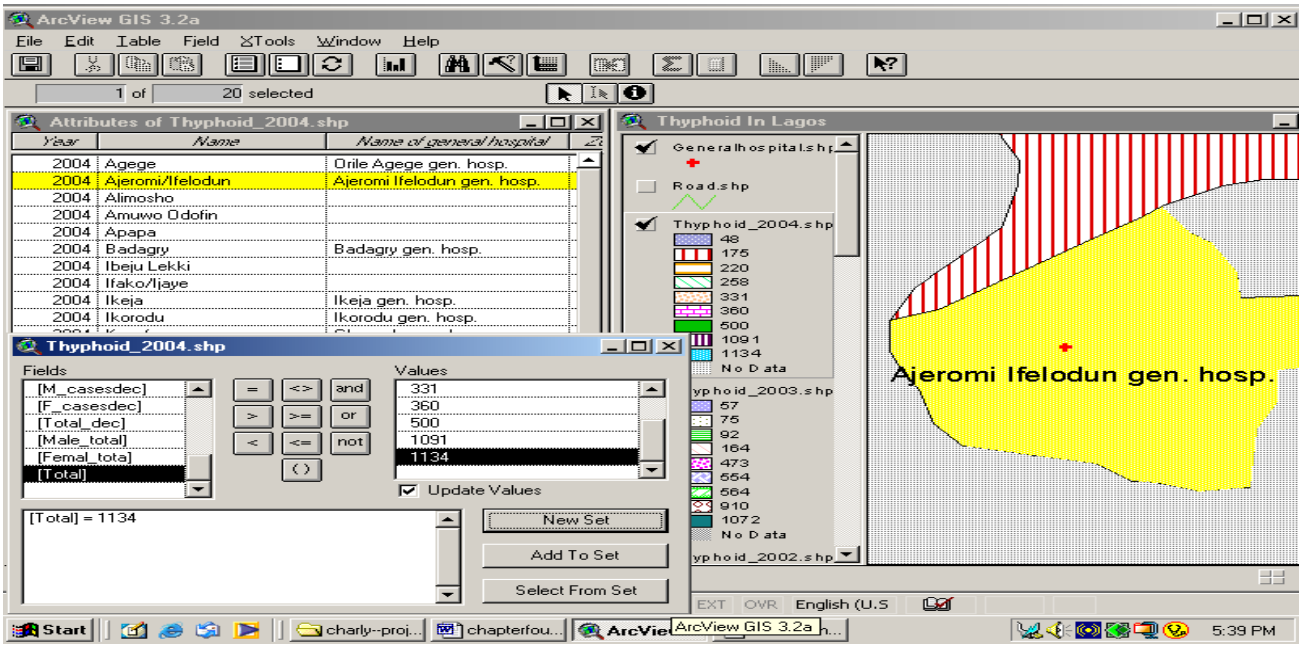
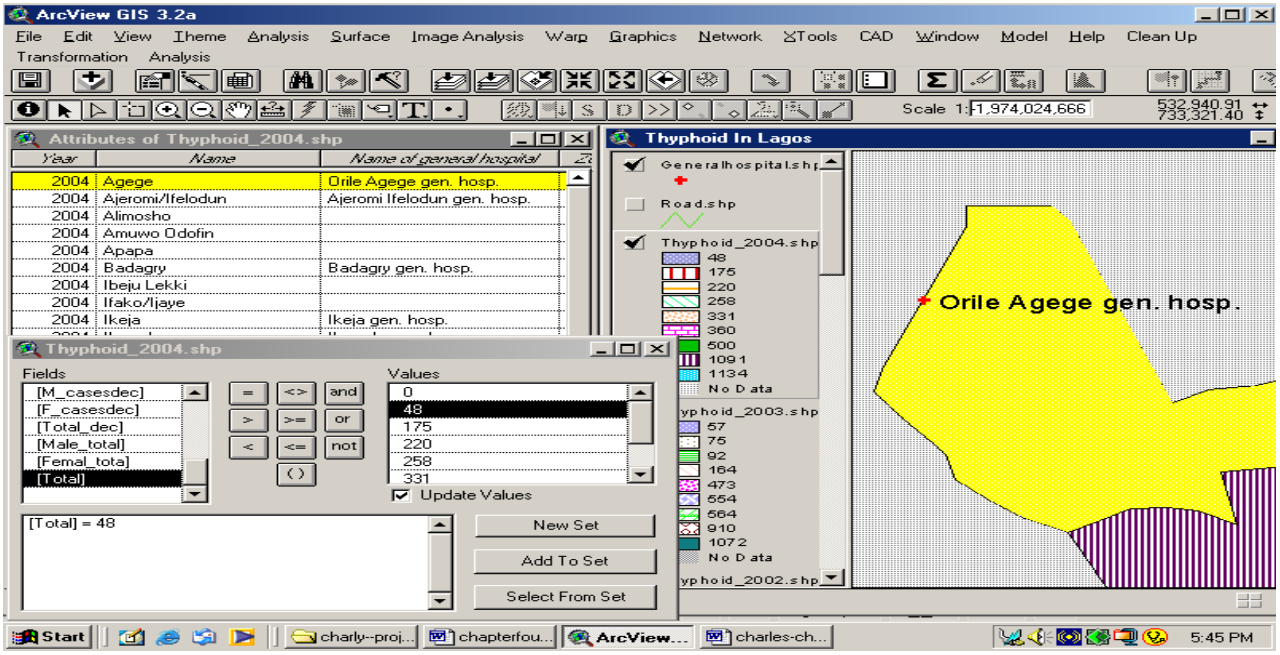
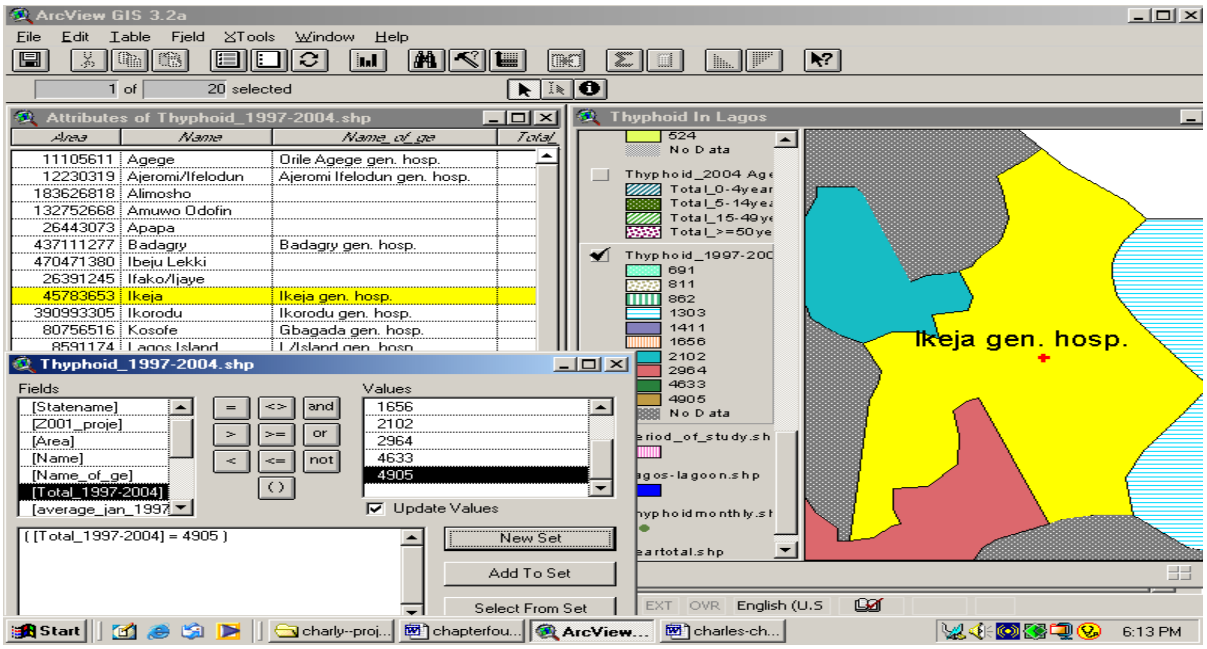
QUERY 1: Shows Ajeromi General Hospital with the Highest Typhoid Fever Cases in 2004-1134 Cases



QUERY 2: Shows Orile Agege General Hospital with the lowest typhoid fever cases in 2004 – 48 cases



QUERY 3: Shows Ikeja General Hospital with the highest typhoid fever cases within the period of study (1997 to 2004) – 4905 cases



QUERY 4: Shows Ajeromi General Hospital with the highest typhoid fever cases between the ages of 15-49years in 2003. – 581 cases

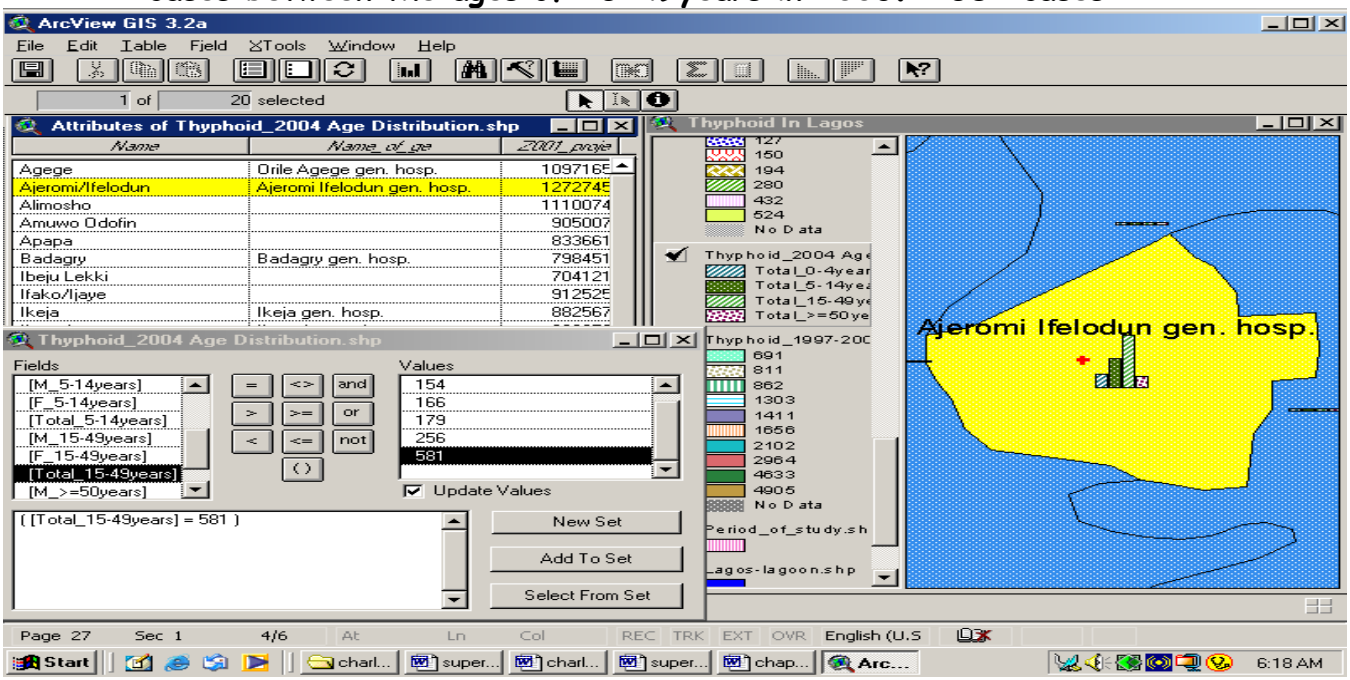


CHART 1: Shows The Total Monthly Growth Rate of Typhoid Fever Cases Within The Period of Study (1997-2004)

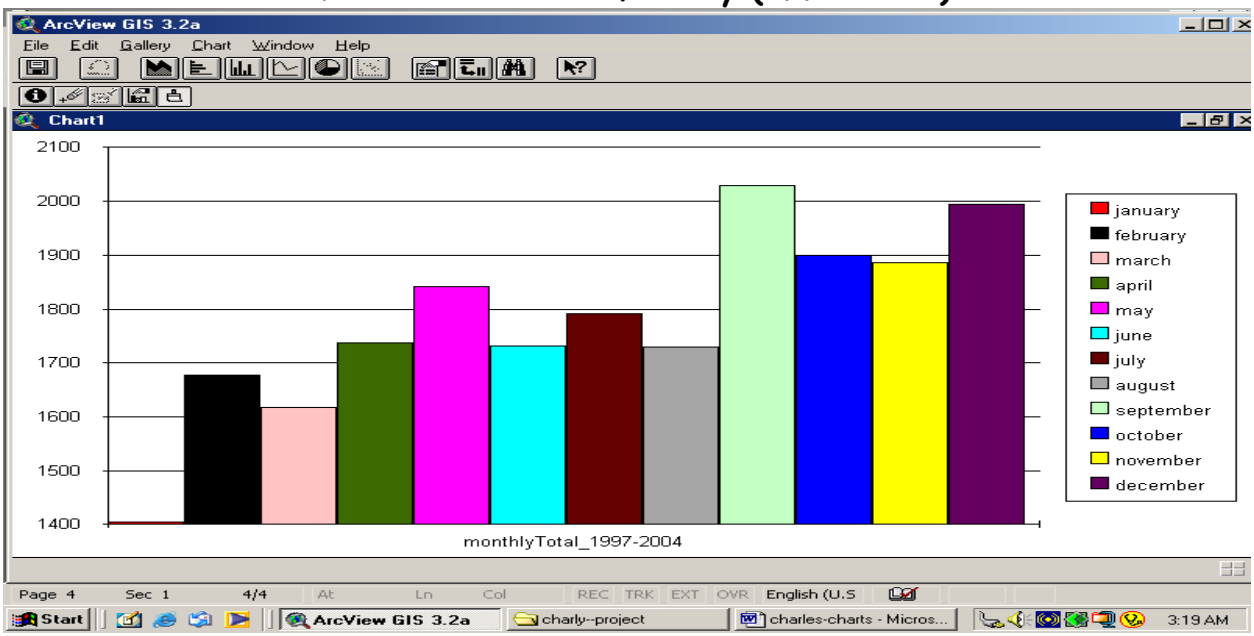
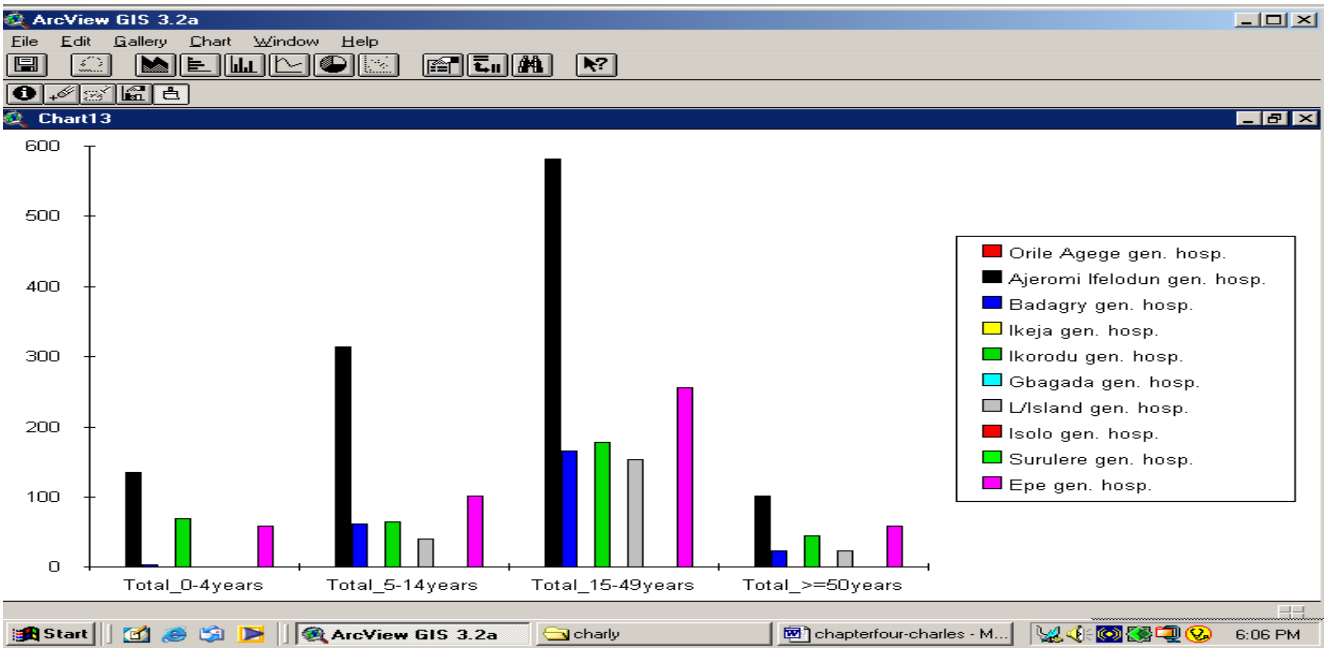


CHART 2: Shows Typhoid Fever Total Age Distribution Cases in Each General Hospital In 2004 – Ajeromi Ifelodun has the Highest for Each Age Group



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