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APPLICATION OF GEOSPATIAL TECHNIQUES IN THE LOCATIONAL PLANNING OF HEALTH CARE CENTERS IN MINNA, NIGERIA

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Abstract
Access to health care is an important component of an overall health system and a major indicator of growth. Health care planning and Geographic Information System (GIS) are two relevant fields that depend upon spatial data. GIS plays an essential role in helping public health organizations to understand population health and make decisions with the powerful tools and situation that GIS technology provides. The purpose of the study to investigated the spatial distribution of health care centers in Minna, Nigeria with a view to use Geographic Information System (GIS) technique in health care management and planning. The method is a qualitative research that is used in making decisions in order to have a strong understanding of government policies and programs. Beyond the many uses of a GIS in health applications, the greatest power of a GIS lies in its ability to integrate information from disparate sources. Traffic disturbances and poor road network were observed to be the major factors militating against effective health care facilities location in the study area.

Keywords: Geographic Information Systems, Healthcare, Planning, Remote Sensing, Research

1. Introduction
The degree of accessibility of health care institutions is one of the most significant indicators for measuring the efficiency of the health care system (Gatrell and Elliott 2009). Health care is conventionally regarded as an important determinant in promoting the general health and well-being of people around the world, access to health care varies across countries, groups and individuals, and is largely influenced by social and economic conditions as well as the health policies in place.
Health care has many definitions and meanings as it is more than the absence of disease. To some, health care and health-oriented services is hospital or medical care, while to others it may mean a plethora of other ‘health’ oriented services, from primary health care right through non-medical services or complementary and alternative medical care. Health care is the diagnosis, treatment, and prevention of disease, illness, injury, and other physical and mental impairment in humans. Health care is delivered by practitioners in medicine, optometry, dentistry, nursing, pharmacy and allied health and other care providers. It refers to the work done in providing primary care, secondary care, and tertiary care, as well as in public health.

Similar to defining health care, access to health care is complex and may mean many things to different people. It is not limited to the availability of care, the ability to get to and pay for available care, or the act of seeking and utilizing available care. Potential or realized access is influenced by many other social and geographical aspects (i.e., terrain and topography of the location of the health care centres). Empirical studies in both developed and developing countries have linked inadequate access to healthcare facilities with increasing avoidable and preventable deaths (Law and Morris, 1998; W.H.O, 1998). The importance of healthcare to human can never be over-emphasized. Ogundare (1982) likened health to food in importance to individual existence, and opined that the concern and attention that any government pays to health could well determine the well-being of the people.

Access to health care is an important component of an overall health system which has a direct impact on the burden of diseases that affect many countries in the developing world. In investigating the level of provision of central facilities (like healthcare), emphasis has shifted from mere provision to the degree of accessibility of people to these facilities. Barton and Isourou (2000) echoed this emphasis in their observation that “human beings are the centre of concern for sustainable development and they are entitled to a healthy and productive life in harmony with nature”. Since the goal of any development effort by the government is to improve the well-being of the generality of the people it governs, making adequate planning for healthcare delivery will be a right step in the right direction. It is in recognition of the importance of healthcare facilities to sustainable development that various levels of government in Nigeria (Federal, State, and Local) always budget huge amounts of money for the health sector.

GIS (Geographic Information System) is a valuable tool to assist health research planning, monitoring, and evaluating health systems. GIS can be defined as the science and technology related to the gathering, storage, manipulation, analysis, and visualization of georeferenced data (Burrough, 2001). The use of Geographical Information System (GIS) for the measurement of physical accessibility is well established and has been applied in many areas including retail site analysis, transport, emergency services, and health care planning (Wilkinson, et al., 2006; Albert et al., 2000; Cromley and McLafferty, 2012).

In the context of health care planning, the ability of GIS to identify the geographical extend of health facility catchment area, which correspond to the area which contain the population utilizing this facility, is a particularly important analytical capability. Location of health facilities, patient distribution, and characteristics are spatial data that are dealt with during local health care planning, such task can be made with the aid of different GIS functions and models (Abubakar et al., 2008).

GIS and Remote sensing have capabilities that are ideally suited for use in infectious disease surveillance and control, particularly for the many vector-borne neglected diseases that are often found in poor populations in remote rural areas. Since 1993, World Health Organization (WHO) public health mapping and GIS programme has been leading a global partnership in the
promotion and implementation of GIS to support decision making for a wide range of infection diseases and public health programme (WHO, 2000). The World Health Organization (2004), describes GIS as “an excellent means of analyzing epidemiological data, revealing trends, dependencies and interrelationships that would be more difficult to discover using traditional tabular approach”.

2. Method

2.1 Study Area

Minna is situated in Northern Nigeria between latitude 9°38’50”N to 9° 40’30.51”N and longitude 6°32’26”E to 6°37’2.51”E, (Figure 1). It has an average elevation of 272 m above sea level.

![Figure 1: Map of Niger State showing Minna](source: Ministry of Lands and Housing (2012))

This is a qualitative research that is used in making decisions in order to have a strong understanding of government policies and programs. Type of data is: (1) Primary data: The primary data for this research work includes the coordinates of the Hospitals in Minna gathered on field using a Global positioning system (GPS) unit and questionnaire administration. (2) Secondary data: The secondary data for this research includes the use of journals, relevant literatures, internet, Street guide map and Administrative map.

2.2 Spatial Analysis

**Digitizing:** Digitizing is a common method for capturing and converting analogue spatial data (a map) to a digital format. The coverage created is a digital representation of any information
taken from the source map. Basically, this involve importing into an ArcGIS working environment a base map, usually raster map, and different shape files created according to the number of layers. The main aspects of this study that was digitized were the street guide map, Map of Niger State and Map of Nigeria.

**Georeferencing:** The primary function of the map is to portray accurately real-world features that occur on surface of the earth. Handling spatial information requires the establishment of a spatial reference system to which all spatial measurement must relate. Georeferencing is therefore the representation of the location of real world feature within the spatial frame work by which the positions of real-world are measured, computed, recorded and analyzed. The concept of representing the physical shape of the earth by means of a mathematical surface and the realization of these concepts by the definitions of the goods and ellipsoid are fundamental to Georeferencing.

**Proximity analysis:** Proximity Analysis is an analytical technique used to determine the relationship between a selected point and its neighbors. Buffer analysis for example is used for identifying areas surrounding geographic features. The process involves generating a buffer around existing geographic features and then identifying or selecting features based on whether they fall inside or outside the boundary of the buffer. This tool can identify features that are closest to one another and calculate the distances around and between them. With these tools, you can monitor events in an area, find the area served by a facility, or find the features affected by an activity.

**Average Nearest Neighbor Analysis:** The Average Nearest Neighbor Distance tool measures the distance between each feature centroid and its nearest neighbor’s centroid location. It then averages all these nearest neighbor distances. If the average distance is less than the average for a hypothetical random distribution, the distribution of the features being analyzed are considered clustered. If the average distance is greater than a hypothetical random distribution, the features are considered dispersed.

**Spatial Analysis by Queries:** Database query can be referred to as the selection of various combination tables for examination; it involves the retrieval of information stored in the database using structured query language (SQL). SQL is a database sublanguage for querying and modifying relational databases. This is done using the ‘Select by location’ query dialog box. The Select by Location dialog box lets you select features based on their location relative to other features. For instance, how many hospitals are within 100 meters of an interconnecting route? Answering this type of question is known as a spatial query. We have a wealth of information relating to the health facilities. All these information were inputted in the attribute tables of the shape file during edit sessions on Arc Map. In doing this, fields were first created on the attribute table. The following data were collected and used in the development of the database: (1) The study area map, (2) List showing health centre names and addresses, (3) Health care centre coordinates

The data were entered into Microsoft Excel, saved and then imported into ArcGIS 10.1 as an event theme. All the necessary information for each health centre was entered into its layer’s/theme’s attribute table. This was done by adding required number of fields (columns) to the table and entering the data for all the health centers in their corresponding records (rows). Queries were performed using the query builder.
3. Results/Discussions

Figure 2: Map of Minna, showing the spatial distribution of health facilities
Figure 3: Proximity analysis from spatial query

**Average Nearest Neighborhood Analysis**

If the index (Average Nearest Neighbor ratio) is less than 1, the pattern exhibits clustering. If the index is greater than 1, the trend is toward dispersion. Results of the average nearest neighbor analysis showed an average nearest neighbor ratio of 1.120895.
Figure 4: Average nearest neighbor analysis from ArcGIS
Results from nearest neighbor analysis using Euclidean distance:

\textbf{Observed Mean Distance:} 635.585601

\textbf{Expected Mean Distance:} 567.034089

\textbf{Nearest Neighbor Ratio:} 1.120895

\textbf{z-score:} 1.034317

\textbf{p-value:} 0.300988

Distance measured in Meters
Access to health care is well recognized as an important facilitator of health and maintaining a population’s well-being. Currently the use of GIS in health care is expanding and is used to understand health disparities, aid health care service delivery, planning health care management strategies or meeting health needs of a population. More recently, GIS has also been used to examine and measure health care service accessibility (Dermatis et al, 2016, McLafferty, 2003 and The World Health Report, 2008).

Twenty (20) health care facilities in the study area were mapped on field and their locations inputted into the GIS environment for numerous spatial analyses. By visualizing their spread over geographic space, it was possible to perform analysis such as; Average nearest neighbor analysis. Also, it was possible to query these hospitals based on their attribute information and location characteristics (shared topology) with other feature classes. A nearest neighbor analysis showed an average nearest neighbor ratio of 1.120895. Since the index is greater than 1, this revealed a high degree of dispersion of these healthcare facilities within the study area (Chang, 2008).

A study conducted on Mapping of Health facilities in Chikun Local Government of Kaduna State, Nigeria, reveals that the public health centers in Chikun LGA were not equally distributed. Some factors that could be responsible for these inequalities were population size of the people. For example, the areas where the health centers were located predominantly fell within urban Chikun while areas with sparse health centers fell within rural Chikun. Other factors that might have influenced the location were political influence and accessibility of the area to infrastructure. (Abbas et. al. 2012).

A related research on the distribution of Primary Health Care Facilities in Kano Metropolis, Using Geographic Information System (GIS), shows that the existing health facilities is not marching the available demand because most of these facilities were clustered within the radius of Aminu Kano Teaching Hospital (AKTH), areas like Rijiyar Zaki, Jan Block (Red bricks) and areas around Kurna were neglected. In the case of Maternal and Child care, it is only two (2) Comprehensive and only one (1) Maternal and Child healthcare facility which were situated at Gwale LGA. However, distance and time is one of the fundamentals when discussing about maternal health. Lastly, Municipal, Nassarawa and Taraun are well served while Gwale distribution and Dala and Fagge is in contrast of all of the above mentioned, the distribution is very poor in respect with population. (Usman et. al. 2013).

Lekan (2010), conducted a Research on the Distribution of Health Care facilities in Osun State, Nigeria and noticed that, though spatial polarization still exist in the distribution of healthcare facilities and personnel in Osun State, rural/urban dichotomy. The researcher also observed that the pattern of distribution of healthcare facilities and personnel in the state appeared to be significantly better than what was obtained in 2001, spatial gaps are still observed that need to be adequately addressed to enable the state achieve the Millennium Development Goals on healthcare delivery.

Empirical investigations revealed the existence of other factors, in addition to distance, as influencing the patronage pattern of healthcare facilities. For instance, Adejuyigbe (1973) demonstrated that attendance at each medical centre in Ife region is a function of both type of service available there and the distance from other centre providing similar services. Okafor (1990) analyzed the spatial distribution and efficiency of hospital facilities in the old Bendel (now Edo and Delta) State. He found that there were discrepancies between the population distribution and the distribution of hospital facilities. Olajuyin et al (1997) investigated the effect of location on the utilization of healthcare facilities in Irewole Local Government Area of Osun
State, Nigeria. They found that healthcare facilities were unevenly distributed among the settlements and that the distance was a paramount factor.

A study on the spatial distribution of Primary Health Care (PHC) centers in Ughelli South and Warri South Local Government Areas of Delta State, Nigeria, shows that the Primary Health Care (PHC) facilities distribution is clustered. The topography of the area (Swamp terrain) may be a major determining factor responsible for this pattern of distribution because majority of land mass (over sixty percent) of Warri South were not accessible for human settlement. The population ratio to Primary Health Care facilities is between (12,000:1, and 25,000:1). (Agaja, 2012).

Site selection and distribution of health care centers are important components of an overall health system which has a direct impact on the burden of diseases that affect many countries in the developing world. The creation of health care centers database and mapping helps in showing the spatial distribution and information about location and their physical relations to each other. (Abbas et al., 2012). The study of regional variations in the distribution of social amenities (like healthcare) has captured the interest of Geographers, Planners and other Scientists because of their general interest in the spatial variation of phenomena on the earth’s surface. In particular, the question of access to sources of human need or want satisfaction stresses the importance of location and distance. Hence the basis for this study, which is to show the spatial distribution of health care centers in Minna and their accessibility in order to serve as decision support system for managers and planners.

4. Conclusion

Healthcare planning is a challenging field that depends on spatial data such as location and characteristics of health center demand. Today, health’s planners have several tasks to cover to assure that health service is provided at the best location by using GIS. While GIS have been used to great success in the health industry, their full potential has not yet been reached. Beyond the many uses of a GIS in health applications, the greatest power of a GIS lies in its ability to integrate information from disparate sources. The ability to visually assess the locations of objects on the Earth’s surface, rather than trying to interpret numbers on spreadsheets, is a key element leading to the use of a GIS. By integrating GIS into decision making, government stands the chance of making their health care facilities more functional and accessible to the populace.

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