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The Roles of Geographic Information System on the Spatial Pattern of Health Care Facilities in Ilorin, Kwara State of Nigeria

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Abstract

This work is on the assessment of the distributional pattern of health facilities using GIS in Ilorin, Kwara State of Nigeria. It illustrates the invaluable potential of Geographic Information System analysis in supporting decision making. The locations of 79 health care facilities which consist of hospitals, clinics and pharmacies were ascertained using Global Positioning System (GPS) and their addresses were collected from the Ministry of health to create a database using Microsoft excel. Parameters such as ownership and category were also included in the database. The analogue map was collected from geospatial solutions ltd. ArcGIS 9.3, was employed in analyzing these data. The database created was imported from Microsoft excel to ArcGIS environment where attribute data was linked to the spatial data. The linking of these two types of data made it possible to examine the spatial distribution of the facilities which in turn revealed their patterns. A query was conducted to ascertain the healthcare facilities that are privately owned. The creation of zones of interest also known as buffering was carried out to determine the facilities that are within 1km walk. Finally, after analyzing the data, the healthcare facilities were seen to be unevenly distributed. The facilities were concentrated in the core indigenous areas of Ilorin. This spatial distribution of healthcare facilities in Ilorin gave rise to a nucleated pattern. This therefore means that since the health service providers cluster at a point, people needing the health services will have travel through all forms of stress to utilize the health services. Thus, the location of subsequent health facilities should be encouraged to spread out so as to minimize the friction of distances to the health seekers.

Keywords: *Roles, GIS, Spatial Pattern, Healthcare Facilities, Ilorin, Nigeria*

1. Introduction

Health is considered as a crucial component of human wellbeing (Philips, 1990). It is defined with reference to World Health Organization (WHO 1947, 1948) as not merely the absence of disease or infirmity, but also as a state of complete physical, psychological and social well-being.

The need for healthcare varies in space and so the organization of provision necessarily has a spatial component. In Nigeria, healthcare system is divided into three, namely: the primary secondary and tertiary health cares (Osa, 1992). Generally, Social scientists investigate health and health care services with a view to understanding people's perception, behavior and experience in the face of health care, their coping strategies and functioning of health care facilities in relation to their effects on people. Essentially, geographic accessibility to a great extent determines the use of health care services while factors such as urban spatial form can influence equitable provision of health care services than others (Hodge and Gatrel, 1976 cited in Raheem, 1999). Distance to health care facilities was recognized as a significant barrier to health care access in the U.S in the 19th century (Hunter, Shannon and Sambrook, 1986). By the middle of 1970, many attempts were made to measure spatial accessibility of health service locations,

identify areas of provider shortage and reveal social disparities in spatial accessibility in both rural and urban areas (Normill, Erickson, 1970).

The implications of spatial separation between health care facilities and health care consumers have been a major theme in medical geographical research (Shannon et al 1969, Pyle 1976, Stock 1983). Thus, Geographers of medical persuasion have employed a variety of measures to evaluate the impact of distance factor in the use of facilities (Raheem, 1999). This study therefore focuses on the roles of GIS for the examination of location of health facilities, patient distribution and characteristics in Ilorin, Kwara State with a view to support better health care planning. A GIS is described as a set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from real world for a particular set of purposes (Burrough, 1986). GIS has a geo-coding function that enable the conversion of any address data into point coverage. The concept of overlay analysis in GIS, manipulates spatial data organized in different layers to create combined spatial features e.g. spatial temporal distribution of human and physical factors. Digitized data from existing maps can provide layers (roads, networks, residential districts and land use) on which data can be overlaid. The Network Analysis function of GIS defines the shortest path between patient location and health care center.

Essentially, the challenge in many countries is to reach the whole population with adequate health care services and to ensure their utilization (Park, 2002 cited in Akingbola, 2009). However, despite the "health for all" declaration by WHO (World Health Organization), health care services continue to be either sub-standard or low in access, expensive or under-utilized (Park, 2002 cited in Akingbola, 2009). Available health services are unevenly distributed. Tertiary hospitals in secured areas where large populations concentrate and without adequate first- contact capacity in their proximity, tend to be overcrowded with patients suffering from common conditions (WHO, 2010). Conversely, many peripheral primary health care (PHC) facilities are under used, because of the poor services they provide, lack of access, competition by alternative provider (perhaps backed by NGOs or charities). User fees have been identified as a leading cause of low utilization of health services. Informal charging by health workers may also deter service consumption (WHO, 2010). It has however also become evident that there are inadequate data and information to formulate and implement appropriate policies and programs to manage these challenges (Onokerhoraye, 1999).

Aim and Objectives of the Study

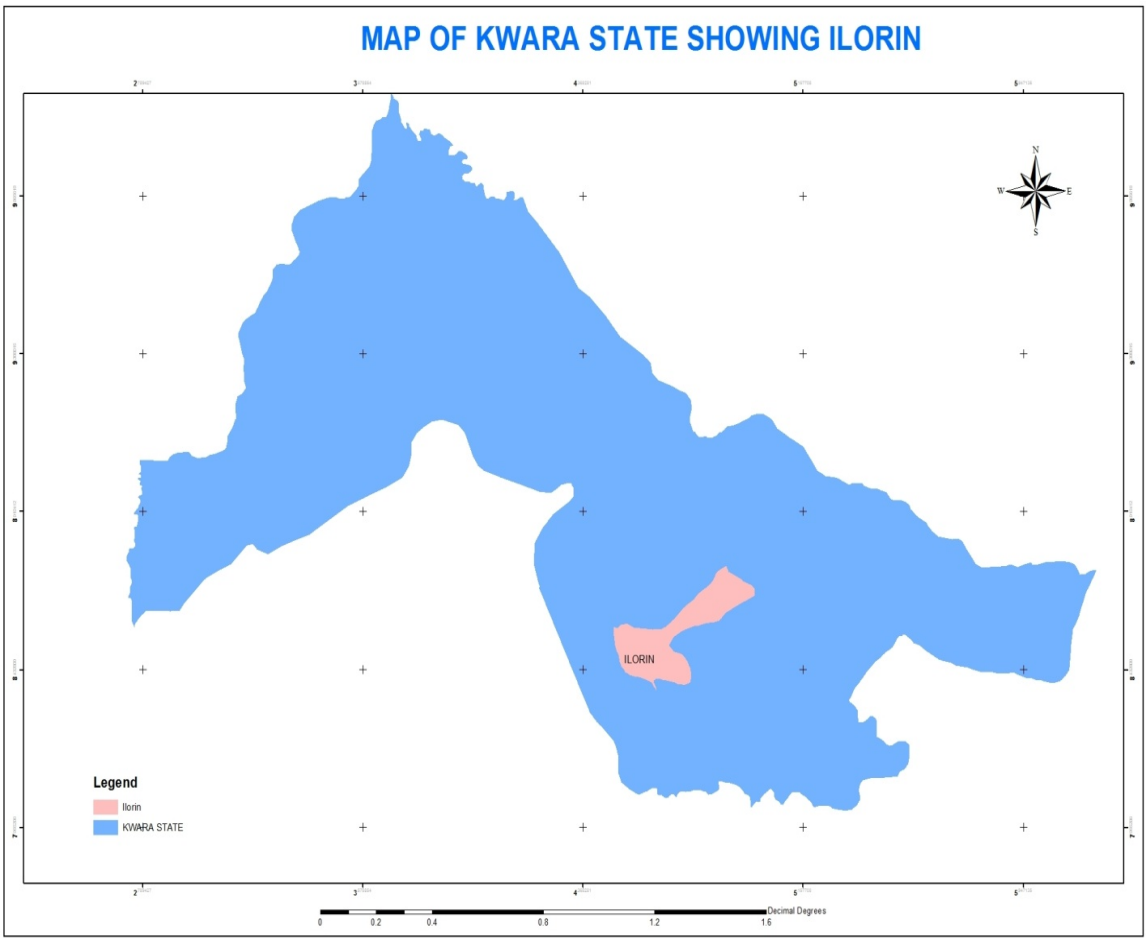
The prime focus of this paper is on the roles of GIS on the spatial pattern of health care facilities as well as provide necessary data for future health planning efforts in Ilorin, Kwara State of Nigeria. This can be accomplished through the following secondary objectives by seeking to:

(i) produce a digital road network map of the study area,
(ii) create a database for the healthcare facilities,
(iii) access the location and spatial distribution of health care facilities,
(iv) determine the pattern of health care facilities distribution; and
(v) suggest location of future health care facilities.

The Study Area

Ilorin, the capital city of Kwara state, Nigeria is the study area. It lies between latitudes 8^0 30^i and 8^0 50 N, and longitudes 4^0 20^i and 4^0 35 E of the Greenwich meridian. It occupies an area of about 1,792.3km^2.(fig 1). Ilorin has two main weather conditions annually. The wet season begins towards the end of March when the tropical maritime air mass is prevalent and ends in October, often abruptly. Dry season begins with the onset of tropical continental air mass, which is predominant between the months of November and February. The months of December and January are usually cold- dry months. The daily average temperatures are in January 25^0C, May 27.5^oC and September 22.5^oC, while the corresponding rainfalls are; 0mm, 75mm and 150mm respectively (Balogun, 2003). The mean annual total rainfall is 1200mm (Olaniran, 2002).

Fig1: Map of Kwara State showing the study area. Source: The Authors, 2011



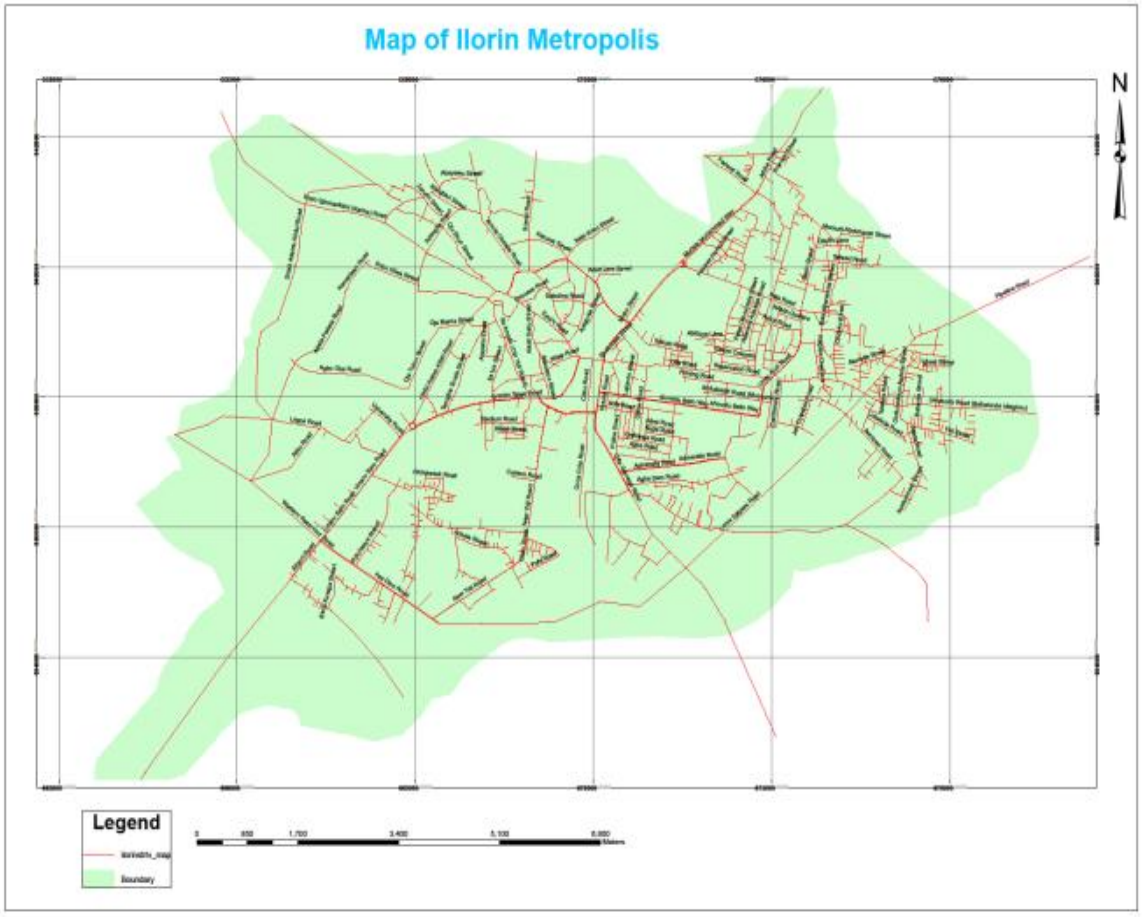


Fig 2: Map of Ilorin Metropolis. Source: The Authors, 2011.

Ilorin is one of the fastest growing urban cities in Nigeria. It has a population of 40,990 in 1952 and 208,546 in 1963 and 1982 respectively. In 1984, the population rose to 480,000 with areas of about 200km (Oyegun, 1985). The population of the town was estimated to be 465,738 and 717,258 in the year 1990 and 2000(Andress, 1982). The increase in the population of this area has attracted more houses (new housing estates e.g Irewolede, Adewole estates among others (see fig2).

2. Materials and Methods of Study

This work utilized data from direct fieldwork investigations as follows: Healthcare Facilities, Attribute data of the healthcare centers i.e. services rendered, ownership, e.t.c., the spatial distribution of healthcare facilities and the pattern of health care facilities. Geographic data and Information are the heart of GIS. The importance of GIS database Creation and Design stemmed from data demands of database which are closely interrelated and thus needs to be structured for easy integration, interpretation and retrieval (Healey, 1991 cited in zubair, 2011). Thus, a well designed spatial database helps in achieving reliable information, storage and retrieval at will, up- to- date and well defined functions of updating information,

as well as the provision of analytical functions which allow (spatial) query and reality modeling or simulations to be accomplished.
The design phase has four parts, which are: view of reality, conceptual data modeling, logical design and physical design especially as explained below

View of Reality: As a result of the irregular and constantly changing realities, each person creates his or her own subjective model of the real world. The arrangement of the common real world model determines which data need to be acquired.

Conceptual Model: The conceptual design is a concise description of the data requirements of the users and includes detailed descriptions of the data type, relationships and constraints.

Logical model: Logical design is a phase in database design. The conceptual data model is transformed into data structure capable of being represented in the computer. In a relational data model the data are separated into tables. Each table contains item called field. Fields are objects (attributes of entities). The logical design is meant to provide redundancy free dataset.

Physical Data Model: This is the stage at which the data is being mapped into the implementation software. It defines the specific storage structure and access paths to the database.

Table 1: physical data modeling for Health care facilities

Attribute	Data type	Width
Facility Name	Text	20
Location	Text	15
Ownership	Text	10
Category	Text	10
x- coordinate	Integer	10
y- coordinate	Integer	10

Source: The Authors, 2011.

3. Materials and Methods of Study

The data generated have been analyzed using descriptive analysis and Geographic Information System. Descriptive analysis was employed to describe the main features of the data collected and to summarize the data set. Also, tables and charts were also used to give overall sample size and number of hospitals. GIS analysis employed cut across the overlay analysis and data integration. The map of the study area was overlayed with the distribution of the Health facilities to determine their pattern. The overlaying of all the key variables allowed the study to view these relationships simultaneously in the geographic space of the study area.

The Overlay Analysis in GIS makes possible the integration of data having different geographies example, the road map of a city can be overlayed with the map showing districts where health centers exist.

Point pattern analysis
This can also be called dot maps. It was used to display the distribution of health events as data locations. It is useful for delimiting areas of case occurrences, identification of contaminated environmental sources, visual inspection of spatial clusters, and analyzing health care resources distribution too.

Buffer analysis

The buffer analysis was used to analyze the distances and to suggest future locations of health facilities. Essentially, buffer analysis is tool which has been to find regions that are directly connected to a specified object and useful for finding regions of space that are nearest to each of a set of irregularly distributed sample locations.

4. Data Analysis and Discussion of Results

Data base of the health care facilities

A vector representation scheme of the health care facilities (points) was adopted as primitives. The schema was created using 6 fields which are; Facility name, Location, Category, Ownership, and x and Y coordinates of the health care facilities. This constitutes the database shown in table 2 below.

Table 2: Database of the healthcare facilities

Attributes of Health Care Facilities

FID	Shape *	Facility_N	Category	Ownership	Level_of_H	Easting	Northing
0	Point	Tuyil	Pharmaceutical	Private	Seconadry	671060	937132
1	Point	Aromokeye	Pharmaceutical	Private	Primary	671992	937548
2	Point	Temidayo	Pharmaceutical	Private	Primary	672343	937801
3	Point	Ayo	Pharmaceutical	Private	Primary	672495	939216
4	Point	Gbolafunmi	Pharmaceutical	Private	Primary	672358	939314
5	Point	Fiolu	Pharmaceutical	Private	Primary	671180	939986
6	Point	Bawa	Clinic and Maternity	Private	Primary	670804	938361
7	Point	Ike Olu	Clinic and Maternity	Private	primary	671301	938540
8	Point	Doctor's	Hospital	Private	secondary	671388	938696
9	Point	Olufade	Health center and Maternity	Government	Primary	670972	938751
10	Point	Asman	Maternity Hospital	Private	secondary	669429	938809
11	Point	Omolara	Clinic and Maternity	Private	Primary	669930	938851
12	Point	Ekundayo	Clinic and Maternity	Private	Primary	669197	937675
13	Point	M&D	Maternity and Dispensary	Government	Primary	669106	937044
14	Point	Aderemi	Clinic and Maternity	Private	Primary	666707	935508
15	Point	Ilupeju	Clinic and Maternity	Private	Primary	667139	935158
16	Point	Adeyi	Hospital	Private	Secondary	667505	938455
17	Point	Ibukun Oluwa	Maternity and Dispensary	Private	Primary	670277	940196
18	Point	Fatimah Memorial	Clinic and Maternity	Private	Primary	669779	942061
19	Point	Omowunmi	Clinic	Private	Primary	670634	940871
20	Point	Ajisafe	Optical Services	Private	Primary	674929	941593
21	Point	Bola	Clinic and Maternity	Private	Primary	674929	941593
22	Point	Olutayo	Hospital	Private	Secondary	675144	942234
23	Point	Ela Memorial	Medical center	Private	Secondary	675648	940728
24	Point	Iyanu Oluwa	Hospital	Private	Secondary	675598	940272
25	Point	DaySpring	Hospital	Private	Secondary	677622	937881
26	Point	Oyin Folorunsho	Clinic and Maternity	Private	Primary	677404	937881
27	Point	Anchor	Hospital	Private	Secondary	676255	938097
28	Point	Ife Olu	Hospital	Private	Secondary	674169	936022
29	Point	Royal Care	Clinic and Maternity	Private	Primary	674277	936022
30	Point	FogoFolu	Hospital and Maternity	Private	Primary and Secondary	672479	939003
31	Point	Amao Megida	Hospital	Private	Secondary	673248	938754
32	Point	Goshen	Clinic and Maternity	Private	Primary	672806	938713
33	Point	Femi	Hospital	Private	Secondary	671624	936603
34	Point	Sadiku	Hospital	Private	Secondary	671487	937784
35	Point	Alao	Hospital	Private	Secondary	668190	938692
36	Point	OOrelope	Hospital and Ultra Sound Diagnosis	Private	Primary	668702	939036
37	Point	Akanji Memorial	Hospital	Private	secondary	670983	942097
38	Point	Unity	Clinic	Private	Primary	670828	939966
39	Point	Children Specialist	Specialist Center	Government	Secondary	670976	939641
40	Point	Kosemani	Hospital	Private	Secondary	671111	939196

Record: 19 Show: All Selected Records (0 out of 81 Selected) Options

Attributes of Health Care Facilities

FID	Shape *	Facility_N	Category	Ownership	Level_of_H	Easting	Northing
41	Point	Queen	Hospital	Private	Secondary	677174	937903
42	Point	Tolulope	Clinic and Maternity	Private	Primary	676241	938354
43	Point	Peace	Clinic and Maternity,Laboratory Services	Private	Primary	671959	939795
44	Point	Ore Ofe	Hospital	Private	Secondary	672007	939871
45	Point	Ajibola	Clinic and Maternity, Laboratory Services	Private	Primary	671967	940113
46	Point	Aduralere Tosho	Clinic	Private		672264	940128
47	Point	Sarfam	Hospital	Private	Secondary	675219	939425
48	Point	Tim	Hospital	Private	Secondary	672837	939308
49	Point	Sabo Oke	Medical center	Private	Secondary	672842	939101
50	Point	Temitope	Hospital	Private	Secondary	672014	939500
51	Point	Teaching Hospital	Maternity	Government	Primary	672372	939243
52	Point	St James Catholic	Clinic and Maternity	Private	Primary	672587	938949
53	Point	Olarewaju	Hospital	Private	Secondary	672566	938676
54	Point	Omolola	Hospital	Private	Secondary	673132	939886
55	Point	Ola Olu	Hospital	Private	Secondary	672630	936573
56	Point	Olotu	Hospital	Private	Secondary	672136	939613
57	Point	Primary Health Center	Health Center	Government	Primary	668001	936672
58	Point	Geri Alimi	Hospital	Private	Secondary	667500	935852
59	Point	Tobi	Hospital	Private	Secondary	669802	937884
60	Point	Surulere	Hospital	Private	Secondary	669669	938100
61	Point	Oyebanji	Hospital	Private	Secondary	670355	937844
62	Point	Olabomi	Hospital	Private	Secondary	670833	937619
63	Point	Hassanat memorial	Hospital	Private	Secondary	670630	937964
64	Point	Femis	Hospital	Private	Secondary	671705	937781
65	Point	Phoenix	Hospital	Private	Secondary	671555	937775
66	Point	Cottage	Hospital	Private	Secondary	666601	936476
67	Point	Civil Service	Hospital	Private	Primary	672780	937768
68	Point	Unilorin Teaching	Hospital	Government	Secondary	668851	937580
69	Point	Zarumi	Health Center	Government	Primary	673793	936556
70	Point	Pakata	Health center	Government	Primary	672675	934294
71	Point	Omoda Basic	Health Center	Government	Primary	673218	936114
72	Point	Ogidi Banni	Health Center	Government	Primary	674295	935588
73	Point	Egbejila	Health center	Government	Primary	665151	934714
74	Point	Idigba	Health Center	Government	Primary	671907	934753
75	Point	Magaji ngeri	Health Center	Government	Primary	671431	937758
76	Point	Alanamu	Health Center	Government	Primary	671840	936565
77	Point	Ago	Health Center	Government	Primary	671841	938259
78	Point	Agbaji	Health Center	Government	Primary	672734	936656
79	Point	Crescent GC	Hospital	Private	Secondary	677210	938041
80	Point	Crescent GC	Hospital	Private	Secondary	677210	938041

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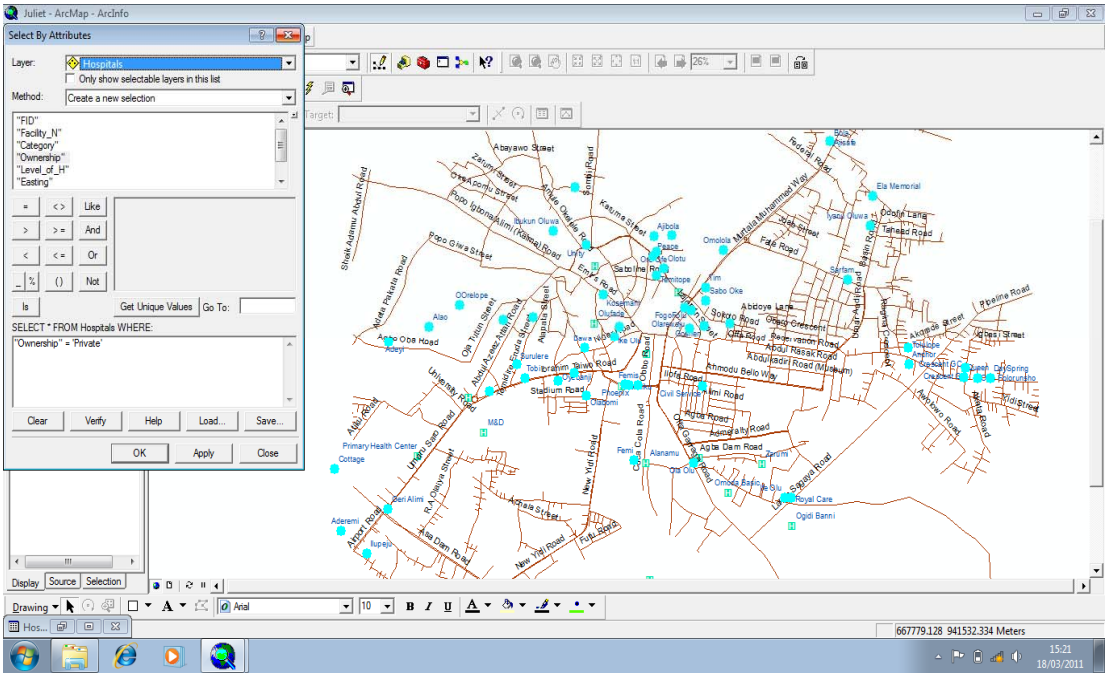
Spatial Pattern of Health Care Facilities in Ilorin

The spatial distribution of the facilities shows great disparity between areas. The health care facilities were seen to be unevenly distributed across space. The facilities were mostly concentrated within the core indigenous areas of Ilorin (see fig3).

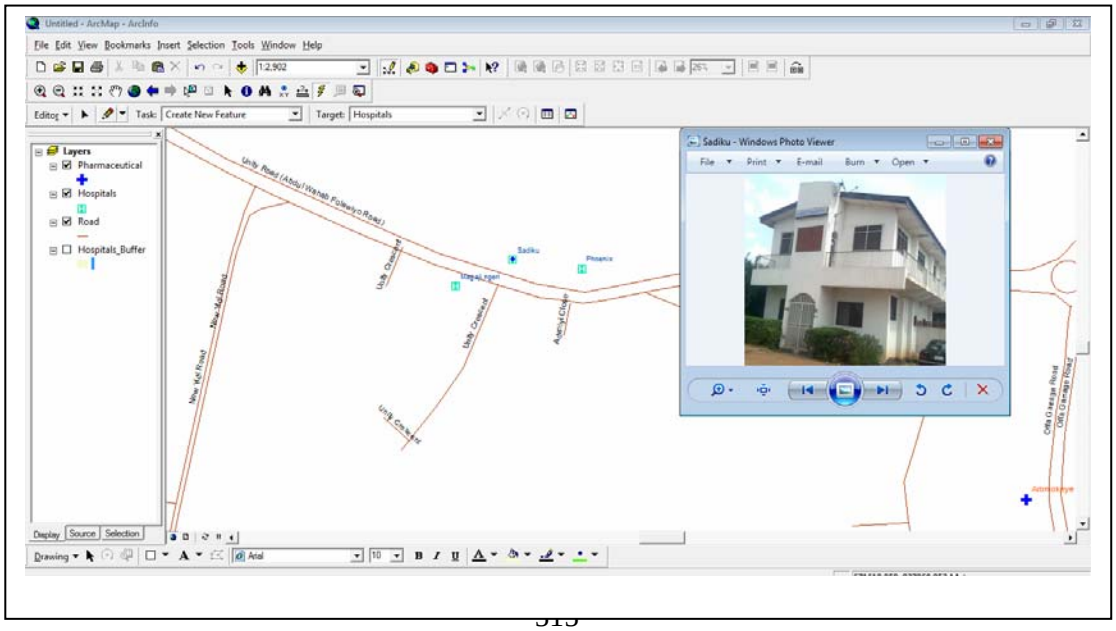
Spatial query for privately owned healthcare facilities

Fig 3: Spatial query for privately owned health facilities. Source: The Authors, 2011



From the spatial query, it is seen that the distribution of privately owned facilities shows unevenness. There is high concentrations of health facilities in areas with high social and economic groups of people because, they maximize profit and also locate where other infrastructure are available, especially electricity supplies.

Essentially, a typical case of a health centre that locate in other to benefit from some social facilities is the case of Dr Sadiku hospital (see fig4)



The Pattern of the distribution of health care facilities

The spatial pattern of health care facilities is concerned with the arrangement of the facilities across a geographical space. This could be in response to series of locational factors such as; easy access to/ from other nearby settlement, availability of good roads, regular electricity supplies, water supply among others. This pattern could either be; dispersed (scattered), Nucleated (clustered) or Linear. Where the facilities are scattered, it is referred to as dispersed, where they are surrounding two sides of important roads, it is referred to as linear, and where they are crowded and route centers are located, they are referred to as nucleated in this study.

The result of the analysis of spatial distribution of the Health care facilities in the study area reveals that due to its unevenness, the spatial pattern of the facilities is seen to be nucleated meaning that they are clustered in the core indigenous areas of Ilorin, Kwara state of Nigeria (see fig 5)..

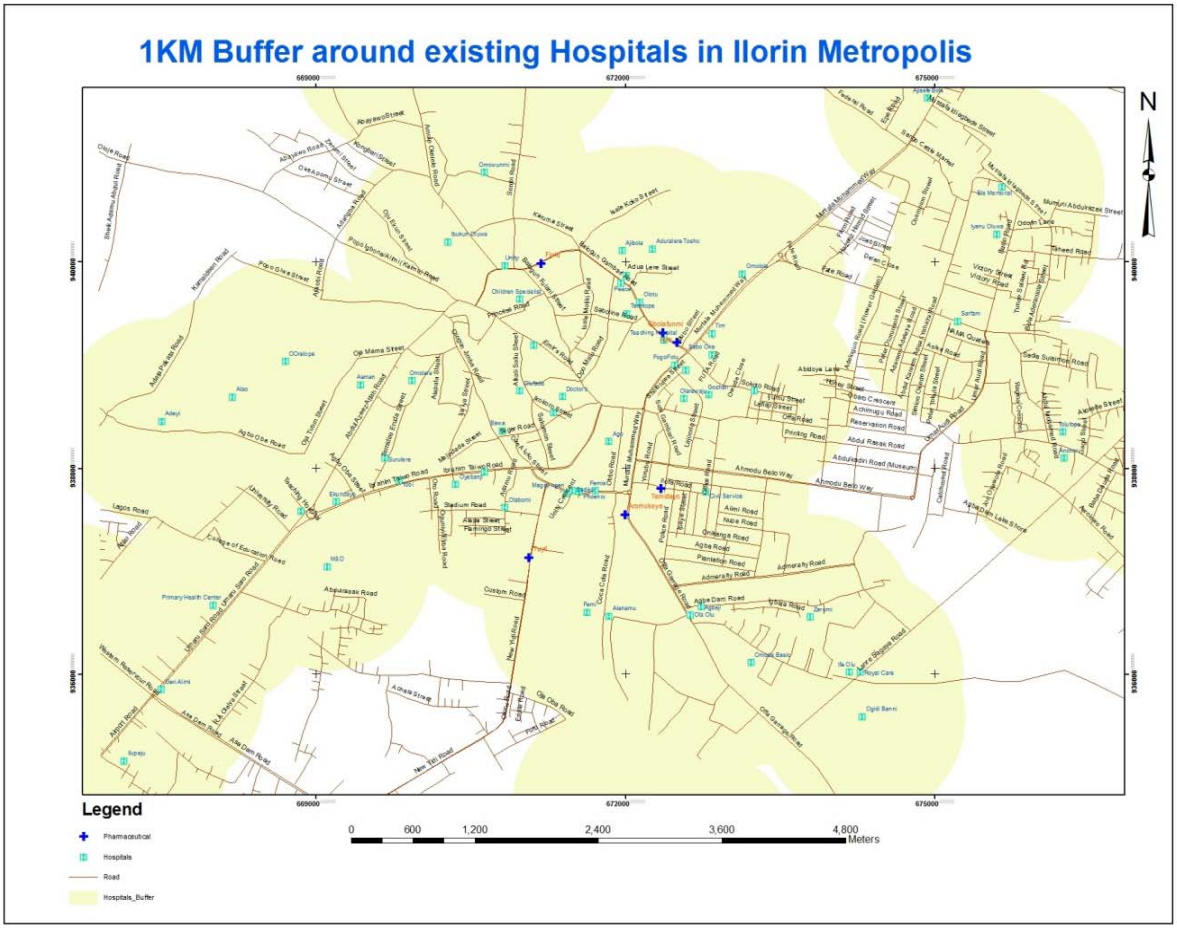


Fig 5: Buffer to show all facilities that are within 1km walking distance. Source: The Authors, 2011

5. Summary, planning Implications and Conclusion

The aim of the study is to use GIS tools to explain the spatial pattern of healthcare facilities as well as provide necessary data for future health planning and provisions in Ilorin, Kwara State. The digital road network map of Ilorin metropolis was produced using ArcGIS 9.3. The coordinates of 80 health care facilities were captured using the GPS. Their locations, level of health, category and ownership were also

determined as well. Some analyses such as overlay analysis and spatial query were carried out to examine the spatial distribution of the health care facilities across the study area as well as determine those privately owned too. The facilities were seen to be unevenly distributed. The accessibility of the health care facilities was determined by carrying out a buffer of 1km radius using the application soft ware, ArcGIS 9.3. .The whole analysis shows that the pattern of the health care facilities in Ilorin metropolis is nucleated. They are seen to be clustered within the core indigenous areas. Greater percentage of people living around, Basin, Achimunga and Awolowo roads which do not have health care facilities will have to walk for more than 1km to get to any health care facility.

By way of conclusion, the position of GPS in the determination of the distributional patterns of health facilities is crucial as it as assist in health planning especially its locational pattern that will assist in the maximum utilization of the facilities.

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