**Web-Based Geographic Information System for
Location Based Healthcare Service Delivery within Akure
Metropolis**

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14

Web-Based Geographic Information System for Location Based Healthcare Service Delivery within Akure Metropolis

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Crossref

Abstract

Purpose: This research project addresses the pressing issue of healthcare access within Akure Metropolis, Nigeria, through the development of a web-based Health Geoinformation System (HGS). Akure, like many urban centers in developing countries, faces significant challenges in healthcare delivery, including uneven distribution of facilities and limited access to reliable health information. In response to these challenges, this study leverages Geographical Information System (GIS) technology to create an innovative solution aimed at enhancing accessibility and information dissemination. Grounded in the context of Nigeria's healthcare system, the research identifies the need for an integrated approach to address the complex spatial dynamics of healthcare provision.

Materials and Methods: Methodologically, the project combines primary data collection on the characteristics of health facilities in Akure with secondary data sources, including existing health records. A total of 100 healthcare facilities were located and identified for this study, with comprehensive information collected through three sets of questionnaires directed to healthcare facility managers and professionals, hospital management bodies, and the public. The data collection process employed Binary Logistic Regression to test research hypotheses, with charts utilized to represent public responses to the posed questions. Spatial representation and analysis were central to this study, with techniques such as Nearest Neighbor Analysis employed to assess the distribution and accessibility of health facilities.

Findings: The results from this analysis revealed significant spatial patterns and disparities in healthcare facility distribution within Akure Metropolis. Notably, the study found that a developed web-based system having userfriendly functionalities like facility search, mapping, and route selection, among others, aids individuals in making informed decisions about their healthcare options.

Implications to Theory, Practice and Policy: The results underline the potential of web-based systems to enhance healthcare access and decision-making processes in urban areas like Akure and further emphasize the significance of incorporating GIS technology into healthcare service delivery.

Keywords: _Healthcare Service Delivery; GeoDatabase, I18, R58; Health Geo-Information System (HGS), I19_

1.0 INTRODUCTION

Health Information Records management according to the National Hospitals Office (NHO) healthcare records management steering committee (2007), is the systematic and consistent control of all records in which they are held throughout their lifecycle. Systematic records need to be managed in a planned and methodical way; consistent approach records of the same kind should be managed in the same way (Yaya, J.A., Asunmo, A.A., Abolarinwa, S.T., Onyenekwe, N.L., 2015). Whether a record is in electronic format or on paper, the management of such records must be consistent, as consistency in managing records over time is always vital, whether those resources are adequate or scarce (Yaya *et al.,* 2015). This is to say that all records, encompassing documents, both active and inactive, formal and informal, irrespective of their storage medium, are subject to systematic and consistent control throughout their lifecycle. In the Nigerian healthcare system, data is mostly collected, processed, and stored in paper-based, legacy, and proprietary systems that are heterogeneously developed. Legacy systems are an old and outdated systems designed to meet hospital goals and needs from an earlier time and do not allow for interaction with newer systems (Oluwaseun *et al.,* 2015). Though these systems have passed through many stages of historical development, including a series of policies and plans that various governing administrations have introduced and implemented (Sedenu *et al.,* 2016). Sadly, these health facilities are inadequate for meeting the demands and needs of the teeming public. Different government administrations in Ondo State, mission bodies, private individuals, communities, industries, and traditional practitioners all together provide health services to the populace (Ojajuni *et al.,* 2013). The fact remains that if the inhabitants of Nigeria are to attain well-being in all its entirety, certain levels of health care facilities must be put in place across the country.

Some identified challenges in health care service delivery include (i) a lack of a detailed webbased health information system for access to information on health services. This factor makes it harder to get essential healthcare information on medical services. Without such a system, individuals may struggle to accessing reliable and current information on healthcare facilities that are open, the services they provide, and where they are located. (ii) lack of a web-based platform for communication between the health service providers (Hospital managements and Medical Practitioners) and the public. This is a noteworthy difficulty, as there are no effective channels of contact for inquiries, scheduling appointments, or disseminating crucial health updates or advisories. (iii) There is no GIS-based application platform that will enable data visualization on health information within the study area. Geographic Information System (GIS) technology has the potential to improve healthcare, but as of right now, the study region lacks a GIS-based application platform. A platform like this could make it possible to visualize data on health information, such as the geographic distribution of healthcare facilities, population health trends, and service accessibility, which would help users and healthcare professionals make well-informed decisions. (iv) Most health care facilities within Akure do not give detailed information on their working hours, waiting times, cost of services, quality, and availability of old and new services online.

The goal of this research is to develop a web-based health geoinformation system for locationbased health care service delivery within Akure Metropolis with a view to provide ease of access to

healthcare. The following research questions providing the impetus that enables the research aims to be achieved: (i) What are the working procedures that can be implemented to create and develop a web-based health geoinformatics system for location-based health care delivery? (ii) What challenges do individuals face in locating and accessing other information on nearby health care service providers for easy choice? Programming codes and computers were utilized to develop a web-GIS for location-based health care service delivery. The system uses GIS functionality tools to assess the location of health care facilities, as well as an open-source map API for online health care accessibility. The testing and implementation of the tools were undertaken by different groups of people in the study area in other to check the validity of the research.

2.0 LITERATURE REVIEW

The review of concepts in this research focused on health information systems, healthcare care systems in Nigeria, access to health care, geographical information system (GIS), database management system and location-based services. The emphasis on Geographic Information System (GIS) technology integrates the use of spatial analysis and geospatial data visualization. Additionally, GIS in healthcare has roots in theories of spatial epidemiology, which explore the spatial distribution of diseases and healthcare resources. Urban planning theories inform aspects of this study related to understanding spatial patterns of healthcare facility distribution and addressing disparities in healthcare access within urban areas like Akure Metropolis.

The development of the Health Geo-Information System (HGS) is guided by theories related to information systems, particularly those focusing on the design and implementation of web-based platforms for healthcare information dissemination and communication. Yaya *et al.,* (2015) stated that whether a record is in electronic format or in paper, the management of such records must be consistent, as consistency in managing records over time is always vital, whether those resources are adequate or scarce. This is to say that all records that include all documents, active and inactive, formal ones and informal regardless of the medium in which they are held is the systematic and consistent control of all records throughout their lifecycle.

In the case of the Nigerian healthcare system, data is mostly collected, processed, and stored in paper-based systems, legacy systems, and proprietary systems that are heterogeneously developed. The legacy systems are an old and outdated systems designed to meet hospital goals and needs of an earlier time and does not allow for interaction with newer systems. The proprietary systems relate to the HIS software or program used, made, or marketed by one having the exclusive legal right to it. Thus, the exchange of information and communication between health care service providers and health care practitioners is poor (Oluwaseun *et al.,* 2015). The insertion of decision support tools in the Health Information System (HIS) is an advancement that has helped to greatly improve evidence-based decision making in many parts of the world today (Bates *et al.,* 2003). The national health care system in Nigeria is decentralized into a three-tier structure with responsibilities at the federal, state, and local government levels. The three tiers are involved in the day to day running of the health sector (WHO, 2005). There are also agencies, parastatals, and departments that are instituted by the government in ensuring that health care is enhanced (WHO, 2005). Health can also be quantified by the length of a person's life and the quality of their life, directly or indirectly. This is so because a human's health directly affects the amount of enjoyment

of goods and leisure and indirectly determines productivity. Ojajuni *et al.,* (2013) reported that, from statistical evidence, they inferred that the private and other institutions provide most of the health care while the government provides less. Fortney *et al.,* (2000) have analyzed and compared the accuracy of methods for calculating the availability and accessibility of health care services using a range of alternative measures. They used a sample of patients, some healthcare providers, and mental health specialists in Arkansas. Results from the study suggest that GIS tools can greatly improve measurement accuracy.

Wachs and Kumagai (1973) showed how location-allocation methodologies, when available on a number of GIS platforms, can be utilized and essential for the assignment of patients to their closest hospital and to identify facilities with poor service. A gap that they identified from their studies was the need to consider other models for the allocation of patients to hospitals other than travel time. Gulliford *et al.,* (2002) explained four facets in which access to health care can be looked into and concluded by saying the availability of services and barriers to utilization need to be evaluated in the context of man's different perspectives, health needs, and sociocultural settings.

GIS supports a range of spatial analysis functions. Spatial analysis covers the techniques that use both the locations and the attributes of features. Geographical analysis helps researchers to overlay health, population, and environmental data, thus enabling them to evaluate and quantify relationships between health-related variables and environmental risk factors at different geographical scales. Since 1993, WHO's public health mapping and GIS programme has been leading a global partnership in the promotion and implementation of GIS to support decisionmaking for a wide range of infectious diseases and public health programme (W.H.O, 2000). Zhang *et al.,* (2013) added their input by saying that GIS provides maps and routing services, computing, analysis, and geocoding for location-based services. GIS applications are built upon the fundamental foundations of GIS and its database management systems; having good knowledge of these foundational aspects is important for designing location-based services. The challenges posed by having a full understanding of the basics have caused delays and problems in the adoption and development of Location Based Services (LBS).

Any collection of related data items of entities having the same attributes may be referred to as a 'DATABASE'. A mere collection of data does not make it a database; the way it is organized for effective and efficient use makes it a database (Gunjal, 2003). The relationships between the many individual records stored in a database can be expressed by several logical structures. DBMSs are designed to use these structures to execute their functions (Turban, 1993). Wingerath *et al.,* (2019) state that some of the most commonly used examples of DBMS are MySQL, Oracle, etc. They are used in various applications. Various operations are performed by a DBMS, such as database creation, storing data in it, updating data, creating a table in the database, and a lot more. Location-based services, according to Virrantaus (2002), can be defined as services utilizing the ability to dynamically determine and transmit the location of persons within a mobile network by means of their terminals. A fundamental component of the LBSs is also the content. Content is the data that are used by the LBS to provide location-based information or functionality for the users. Minakakis (2003) considered early strides in the development of location-based services and stated that the degree of fitness between the system's technical capability and the marketing strategy employed will be a crucial driver in the LBS evolution. The observations made earlier show that the business

environment in which LBS is operational is a dicey and complex one, having to also deal with many stakeholders at a time. Even with all that, since the inception of Location based emergency services in the mid-1990 as a first LBS system, a wide range of LBS system application have been developed and launched (Ryschka *et al.,* 2016).

Many scientists have investigated spatial distributions, patterns, and patterns and developed database systems for health care services, employing GIS. Abdulkader (2018) explored the creation of an important and useful tool in planning and evaluating any health care system using GIS; Mushonga *et al.,* (2017) developed a prototype health facilities web GIS platform, to facilitate data collection, visualization, and reporting; Sedenu *et al.,* (2016) analyzed the spatial distribution pattern of primary healthcare facilities in Ile-Ife, Osun, Nigeria, using geospatial techniques; Khennie, (2013) worked on the use of GIS to investigate the spatial distribution pattern of health care centres in Lagos Island and created databases and maps; Musilimu, (2013) examined the accessibility characteristics of urban populations to health facilities using Ilesha as a case study and mapped the spatial distribution of health facilities; Adesola, (2009) research designed and implemented a web-based information system for the National Health Insurance Scheme (NHIS) using an object relational database approach; Andrei, (2015) study, focused on the use of gazetteers for accessing open street maps and data collection from mobile location-based applications and the internet. His study created web-based and mobile applications providing a fun way of doing health exercise. Despite these studies, none have been able to analyze or research the state of health information systems in the Akure health sector, as well as the use of web GIS for location based health care service delivery within Akure.

This research develops geospatial tools for a web-based health information system for location based health care service delivery. Many scientists have investigated spatial distributions, patterns, and patterns and developed database systems for health care services, employing GIS. Abdulkader (2018) explored the creation of an important and useful tool in planning and evaluating any health care system using GIS; Mushonga *et al.,* (2017) developed a prototype health facilities web GIS platform, to facilitate data collection, visualization, and reporting; Sedenu *et al.,* (2016) analyzed the spatial distribution pattern of primary healthcare facilities in Ile-Ife, Osun, Nigeria, using geospatial techniques; Khennie, (2013) worked on the use of GIS to investigate the spatial distribution pattern of health care centres in Lagos Island and created databases and maps; Musilimu, (2013) examined the accessibility characteristics of urban populations to health facilities using Ilesha as a case study and mapped the spatial distribution of health facilities; Adesola, (2009) research designed and implemented a web-based information system for the National Health Insurance Scheme (NHIS) using an object relational database approach; Andrei, (2015) study, focused on the use of gazetteers for accessing open street maps and data collection from mobile location-based applications and the internet. His study created web-based and mobile applications providing a fun way of doing health exercise. Despite these studies, none have been able to analyze or research the state of health information systems in the Akure health sector, as well as the use of web GIS for location-based health care service delivery within Akure. This research develops geospatial tools for a web-based health information system for location-based health care service delivery.

3.0 MATERIAL AND METHODS Study Area

The study area (Figure 1) Akure also referred to as the Sunshine City and is situated in South Western Nigeria. Akure is the administrative and economical capital of Ondo State, Nigeria. One of the 18 local governments area in Ondo state. Akure as a whole comprises of both Akure South and Akure North, Akure South LGA has its headquarters located in the town of Akure and it is located within Latitudes 7° 5' 30" N and 7° 21' 00" N and Longitudes 5° 5' 00″ E and 5° 22' 00" E. it has an area of 331 km² and a population of 353,211 at the 2006 census. Akure North LGA has its headquarters in Iju/Itaogbolu with an area of 660km². It is located at Latitude 7°15'49.75" N and Longitude 5°18'40.90" E. Akure has an average elevation of about 350m (1,150 ft) It is bordered by Idanre in the South, Ifedore in the West, Owo in the East and Ikere in the North. Akure is about 700km Southwest of Abuja and about 311km North of Lagos State. The average weather (climate) is hot and humid; It is located in the tropic rainforest zone of Nigeria. The driest month in Akure is December; there is 14 mm and 0.6 inch of precipitation in December. Most of the precipitation here falls in September, averaging 242 mm (9.5 inch). With an average of 27.1 °C/80.8 °F, February is the warmest month. August is the coldest month, with temperatures averaging 23.2 °C/73.8 °F. The precipitation varies 228 mm/ 9 inch between the driest month and the wettest month. Throughout the year, temperatures vary by 3.9 °C /7.0 °F (Climate Data, 2022).
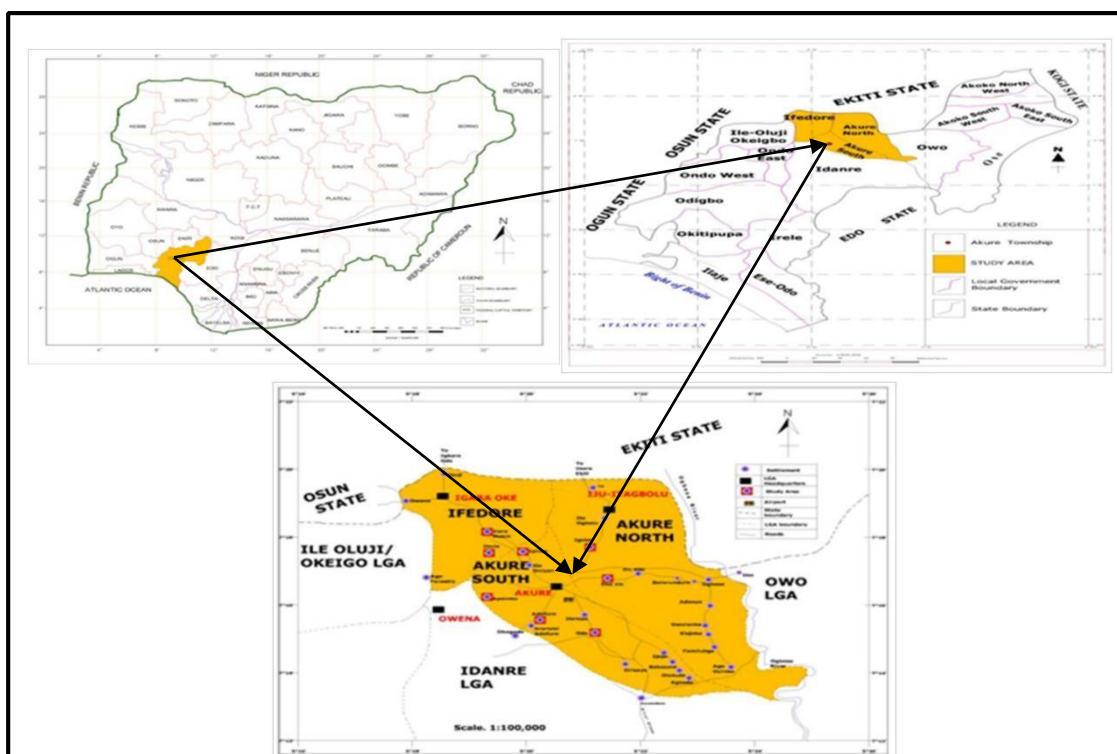
Figure 1: Study Area

Source: Owoeye and Akinluyi, (2018).

Data Collection and Processing
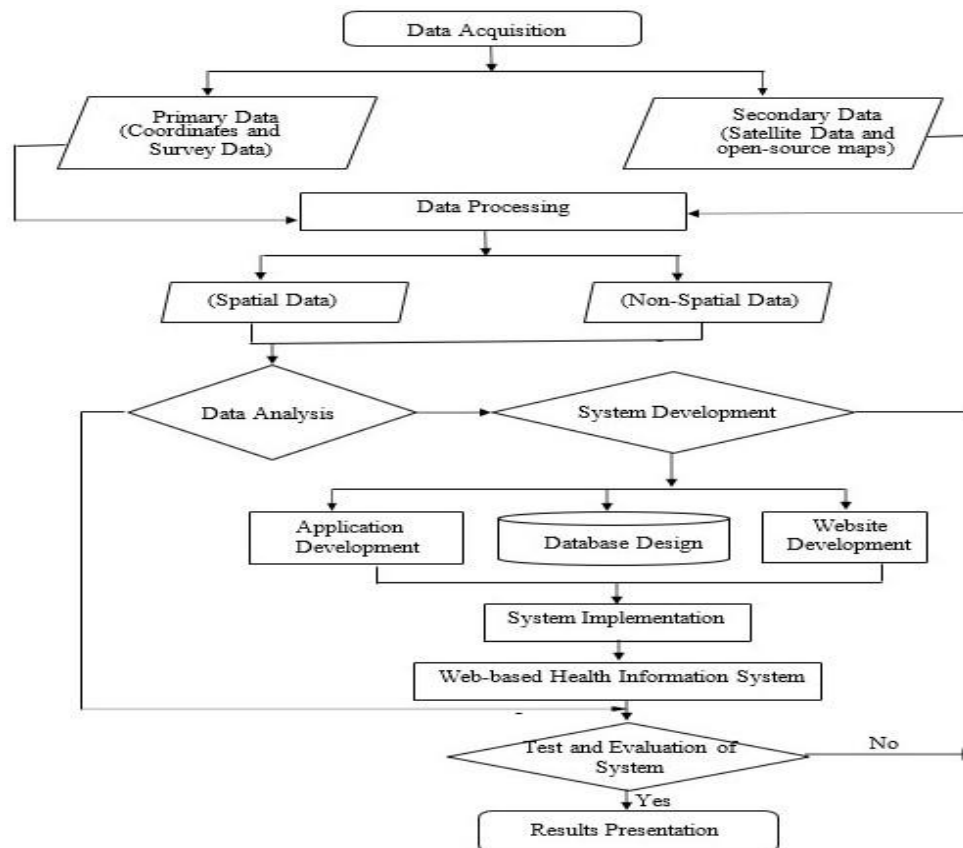
Figure 2: Flowchart Framework of Research Methodology

The data acquired for this research were classified into two categories which are; primary and secondary data, the primary data were obtained from the questionnaires administered to health care officials at the Ondo State health management board, Akure branch and other health agencies in the study area. As well, GPS coordinates of health facilities in the study area were recorded. Binary Logistic Regression (BLR) was employed to test the hypothesis; if online health geoinformation system (web-based system) will have significant influence on access to health care in Akure or not. Secondary data such as health facilities data, policies in place by government were acquired from the Ondo State Hospital Board, primary health care board as well as from the Ondo State ministry of health Akure branch. A database was designed which allowed the web-based system to be built. The database design stage involves; the evaluation of user needs which was implemented by collecting and arranging important data for each user. This was implemented using response from questionnaires and oral interviews of health management staff; conceptual database was implemented for describing how different entities in the system are related to each other;

implementation of conceptual web-based system information flow for online interaction between the patients, health practitioners, and health facilities.

This information was designed and represented in a tabular structure and the operational database of the health information became fully functional. The ultimate goal of database management is to provide the users easy access to the database. There is server side and a client side. The server side of the system managed the MySQL, POSTgre-SQL with POST GIS spatial extension for the backend database, which included the ESRI ArcMap Geodatabase. It processed requests, integrated and managed data from various sources, implemented business logic, managed system security, and hosted web services. On the client side, activities included managing the user interface of the web-based system for interactions with users such as patients and health practitioners. It displayed data from the server in a user-friendly format, including maps and facility details. Interactive features allowed for searching health facilities and viewing routes. The client side also handled data input from users and performed client-side. The database built for the system are the ESRI ArcMap Geodatabase and MySQL and POSTgre-SQL spatial database with POST GIS spatial extension which was required for developing the application embedded with geospatial tools for a web-based and location-based health information system. MySQL was used for the backend database.

Application Development

"Ruby On Toad" and "PhP" programming language platform was used from architecture, design, development, integration and deployment. On creating the admin, data center and GIS code structure, the line of code was used via a pitch to web-patched index, so as to enable PhP use relational Toad plug-in on PhP data solution platform. The system also makes request for map tiles from the open street map tile or the google map service (Google Maps API). These map tiles show the road networks, boundaries and other major point of interests. The frontend development packages that was used are HTML, CSS, and JavaScript. While the backend packages are; PHP, APACHE Server/Xammp, and Database. Table 1.0 shows the GIS hospital service system in Ruby and PHP.

Table 1: GIS Hospital Service System in Ruby & PHP

| Project Name:	GIS Hospital Service Web System Project
Language/s Used:	Ruby-On-Toad, PHP
Version (Recommended):	8 and 9
Database:	MySQL on XAMP
Type:	Web Application, Website
Developer:	GIS Source Code
Updates:	0

4.0 FINDINGS Geographical Database of Health Information and Health Facilities within Akure Metropolis

The resulting geodatabase from this research allows for query, data storage and manipulation like every other complete geodatabase. The database carries robust information on all the health facilities considered in this research. The geodatabase has fields for serial no, State, Local government Area (LGA), Notation for each facility, Ward information, Facility Registration

identification number, and government facility code. It also has field for facility name, facility level (Primary, Secondary or Tertiary), Ownership information (Public or Private), Address, Location Information (Latitude, Longitude, Easting, and Northing), Contact Information (Telephone Number), Facility contact email. The geodatabase is such that allows for future update and editing of its records. Using this spatial database complex geospatial queries was generated and can be generated in the future. The geodatabase's client/server architecture supports multiple users simultaneously and lets them view, edit, and query the database without conflict.

Maps Showing Facilities in Akure Spatial Distribution of Health Care Facilities within Akure Metropolis

Figure 3 is a properly grided map showing the spatial distribution of some health care facilities within Akure, Ondo State. It also shows the survey boundary between Akure North and Akure South. One hundred (100) facilities were considered, each of the facility has been represented in the spatial map. The map overlay also shows the major and minor road networks within Akure. This road network helps to show the linkages in accessibility of each of the facility from each other. It also shows there are more facilities in areas that have roads and are accessible. Though as observed from our map, most of the facilities considered are located at the city center. The spatial map showing distribution of the health care facilities considered in this research can be seen I Figure 3.
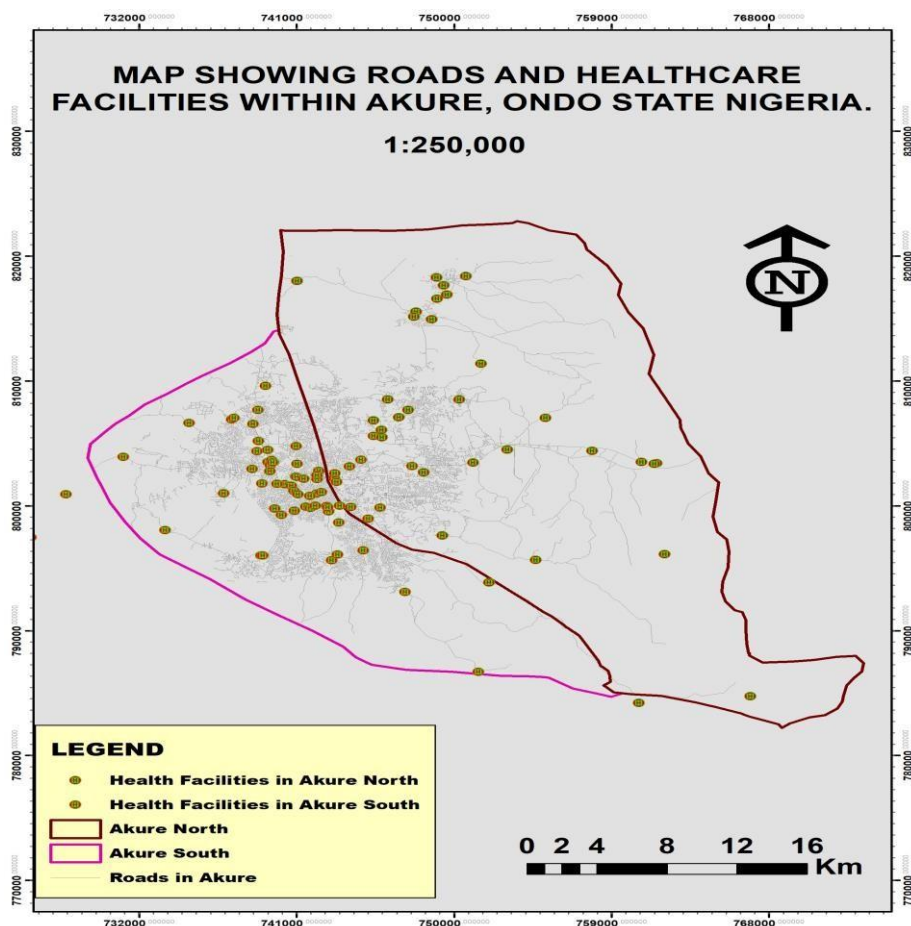
Figure 3: Showing Map of Akure with Roads and Some Healthcare Facilities

Results of Query Analysis

Query analysis were done by attribute of classes (types) of health care facilities or Location of the health care facilities. The results can be seen in Figure 4a and 4b.

Query by Attribute: Public and Private Health Care Facilities within Akure, Ondo State Nigeria

This involved a selection process from the geodatabase of health facilities by their ownership. Information on the Ownership of health facilities is an important factor to some persons in their choice for health care.

SYNTAX

SELECT * FROM Health Geodatabase Features WHERE:

Ownership = 'Public'

Same syntax is repeated

SELECT * FROM Health Geodatabase Features WHERE:

Ownership = 'Private'

The health facilities in Akure have both Public (government) and the Private (Individuals, Religious bodies or Corporate organizations) ownership. Only one hundred (100) facilities were considered. The number of public facilities captured are 55 and they are represented in blue as can be seen in the legend. The private health facilities captured are 45 in number and are represented in green as indicated in the legend. From the spatial map, it is observed that most of the health facilities are centered in the city center, there are more private health facilities in the city center than public facilities. It can be deducing that there's more development and more population at the places where we have more health care facilities. Some persons would prefer a private facility to a public facility, which offers a particular service even with same cost implications and vice versa dependent on personal preference. While some would prefer a government facility due to its relative cheaper rates. The result from this query operation was presented in figure 4.

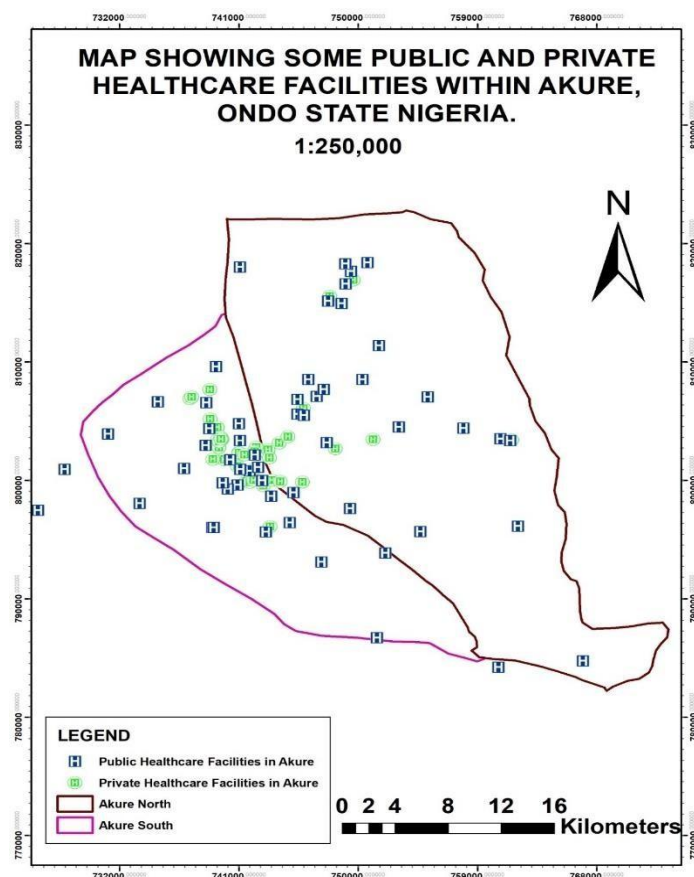**Query by Attribute: Primary, Secondary and Tertiary Health Care Facilities within Akure, Ondo State Nigeria**

This involved the process of searching and retrieving records on health facilities from the geodatabase by their level. The resulting map can be seen in figure 4b. The query operation was done by entering the SQL query expression that matched the selection criteria.

SYNTAX

SELECT * FROM Health Geodatabase Features WHERE:

Facility Level = 'Primary'

Same syntax is repeated

SELECT * FROM Health Geodatabase Features WHERE:

Facility Level = 'Secondary'

Same syntax is repeated

SELECT * FROM Health Geodatabase Features WHERE:

Facility Level = 'Tertiary'

The facility level is one of the factors considered in choice of health care facility to visit. Primary health care facilities do not perform major surgeries so a patient who needs the service of a surgeon will choose to visit a Secondary or Tertiary facility. From the legend of figure 4b, it can be observed that Primary healthcare facilities are represented in red, while secondary facilities are represented in blue. The only tertiary healthcare facility considered in this research is represented in green. From the map it is observed that the primary health facilities are more in number while the secondary facilities are majorly clustered around the city center. From this it can be infer that Akure has all the health facility levels but they have more primary health care facilities than Secondary or Tertiary facilities.

Query by Attribute: Primary Health Care Facilities with Public Ownership within Akure, Ondo State Nigeria

This involved the process of searching and retrieving records on health facilities from the geodatabase by their level. The Figure 4c shows the results of query operation in the selection records from two different fields in the geodatabase. Records of Primary health care facilities with public ownership were selected with the syntax

SELECT * FROM Health Geodatabase Features WHERE:

Facility Level = 'Primary' AND Ownership = 'Public'

This query selects primary health facilities with public ownership and a layer can be created from the selection. It was observed from Figure 4b and 4c that most of the primary health care centers considered in this research are government owned.

Figure 4a: Spatial Distribution of Public and Private Health Facilities within the Study Area
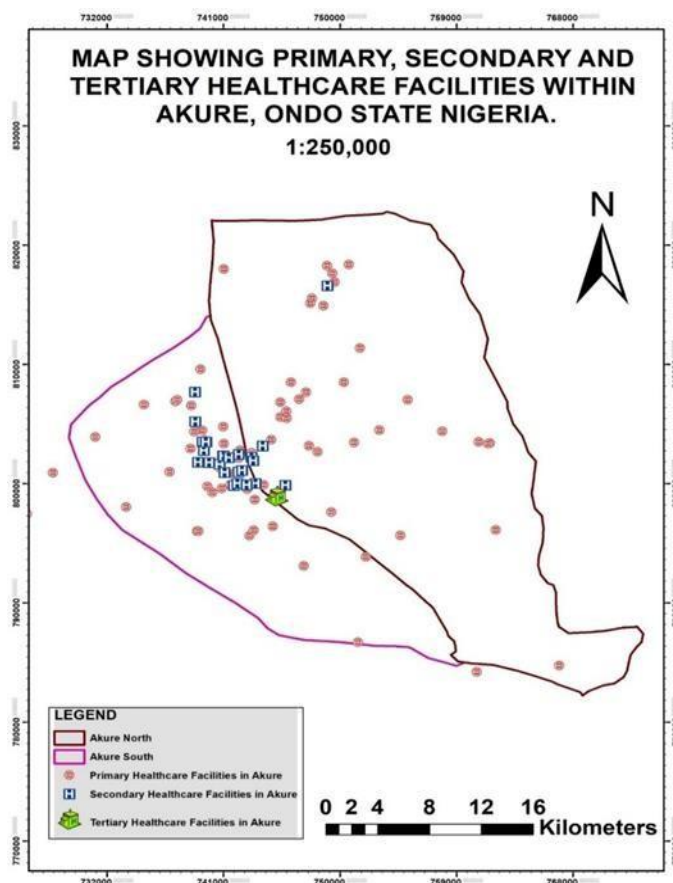
Figure 4b: Spatial Distribution of Primary, Secondary and Tertiary Health Care Facilities within the Study Area
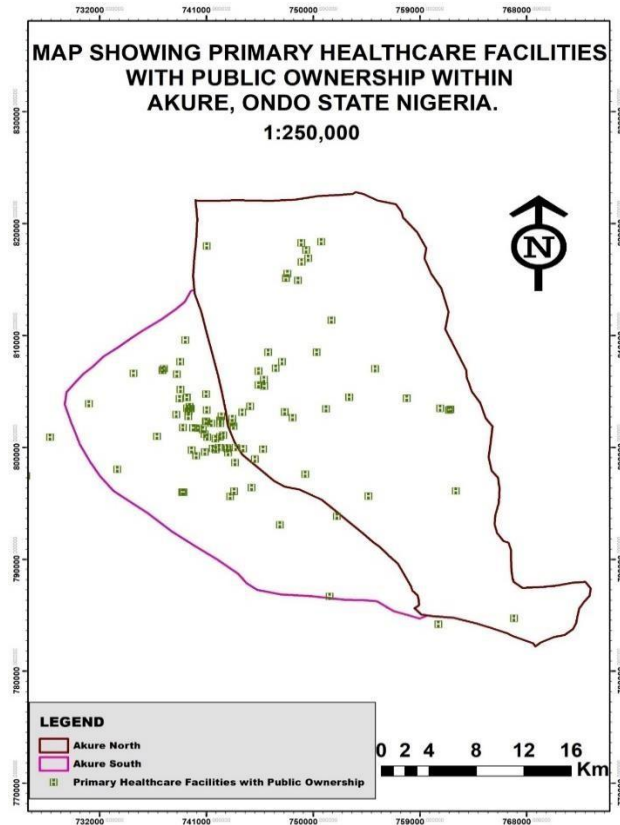
Figure 4c: Spatial Distribution of Primary Healthcare Facilities with Public Ownership within the Study Area

Statistical Analysis

Null Hypothesis (H_o): Online health geoinformation system (web-based system) will have significant influence on access to health care in Akure.

Alternative Hypothesis (H_1): Online health geo-information system (web-based system) will not have significant influence on access to health care in Akure.

Binary Logistic Regression

This test was carried out to test the null hypothesis.

Table 2: Showing the Result of Omnibus Tests of Model Coefficients Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	4.549	1	.033
	Block	4.549	1	.033
	Model	4.549	1	.033

From the Omnibus Table the model has a significance level of 0.033, which is less than the 0.05.

P-value (0.033) ≤ α (0.05).

There is a statistically significant association between the response variable and the term. This implies that, the null hypothesis (H_o) is accepted and therefore the alternative hypothesis is rejected. The finding shows that the aim of this research is important and is relevant in improving healthcare service delivery within Akure. Online health geoinformation system (web-based system) will has significant influence on access to health care in Akure and so web-based GIS for location-based health care service delivery will have positive significant influence.

Multiple Response Analysis for Public Response Form Table 3: Showing the Results of Frequency Table for All Responses in the Public Questionnaire

	QUESTIONS	RESPONSES		RESPONSE IN PERCENTAGE	
		YES	NO	YES	NO
A.	You are fully aware of all the healthcare services available within Akure?	182	318	36.4%	64.0%
B.	Are you aware of the location of a Primary healthcare in Akure?	376	119	75.2%	23.9%
C.	Are you aware of the location of a Secondary healthcare in Akure?	259	233	51.8%	46.9%
D.	Are you aware of the location of a Tertiary healthcare in Akure?	145	341	29.0%	68.6%
E.	Distance and travel time affect your choice of healthcare facility to visit.	362	137	72.4%	27.6%
F.	I get information on new services being rendered by hospitals around me.	271	229	54.2%	46.1%
G.	I access information on cost of healthcare services before i visit the hospital?	172	327	34.4%	65.8%
H.	I prefer to visit a private hospital rather than a government owned hospital	284	215	56.8%	43.3%
I.	Can you access healthcare providers or healthcare services online?	177	320	35.4%	64.4%
J.	Do you access healthcare providers or healthcare services through the phone?	240	259	48.0%	52.1%
K.	Online health geoinformation system will enhance healthcare services delivery within Akure Metropolis.	453	26	90.6%	5.2%
L.	Would you be willing to share your location to your trusted doctor for response in times of emergency.	418	81	83.6%	16.3%

**PUBLIC RESPONSE CHART IN PERCENTAGES**
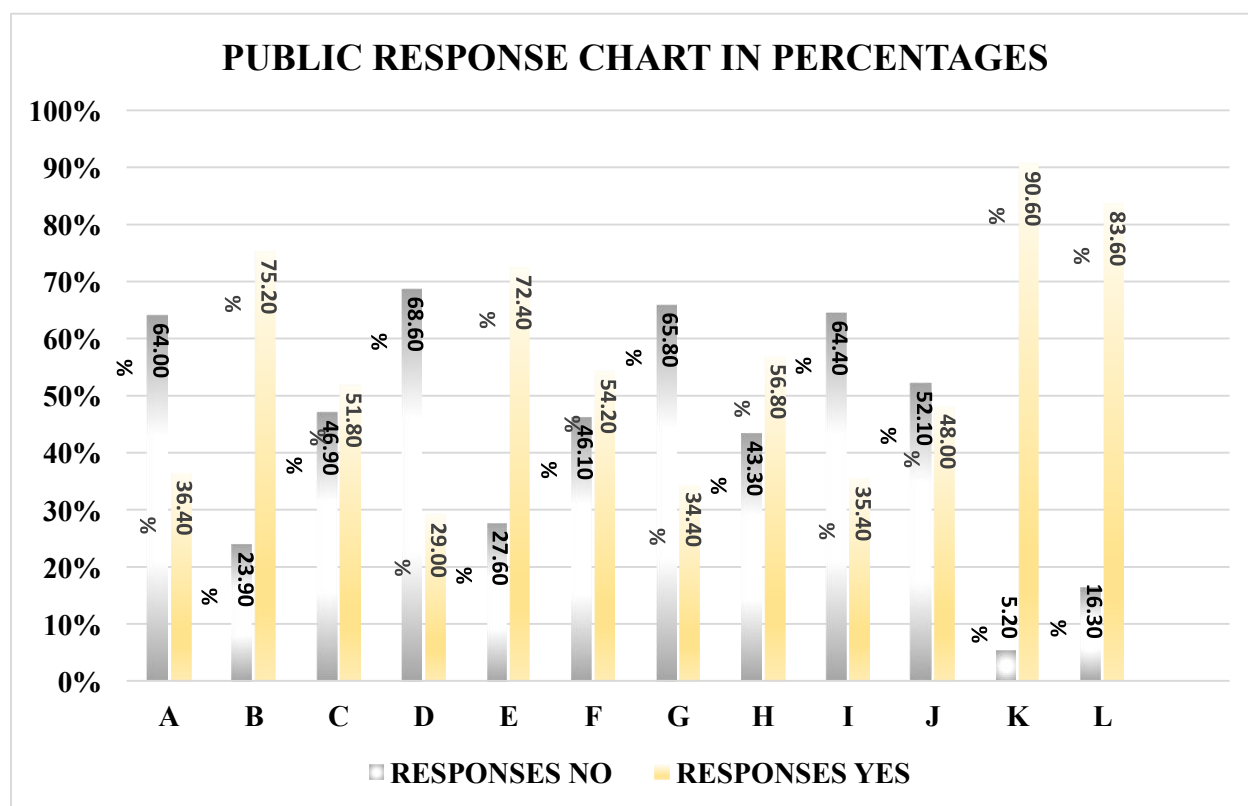
Figure 5: Bar Chart Showing Frequency Distribution in Percentage to the Statements in the Public Questionnaire

From Table and Charts above, the question "Are you fully aware of all the healthcare services available within Akure?" 182 (36.4%) persons responded YES while 318 (64%) of respondents said NO. There is need for more information to reach the populace on healthcare services been rendered within Akure. The statement "Online health geo-information system will enhance healthcare services delivery within Akure Metropolis". Received 453 (90.6%) YES responses and 26 (5.2%) NO responses. This shows that the public believe that if there is proper development of health geo-information systems it will enhance healthcare service delivery within Akure metropolis.

Web Based Application System Capabilities

To access this system, visit www.hospitalservice.com.ng. Figure 6 shows the home page of the website with a title "Healthcare Services (GIS)". It gives different links to the other pages, for example Login page, Search services by location and others. The home page also has provision for push messages like Daily Health tips, News relating to healthcare in general and other functions
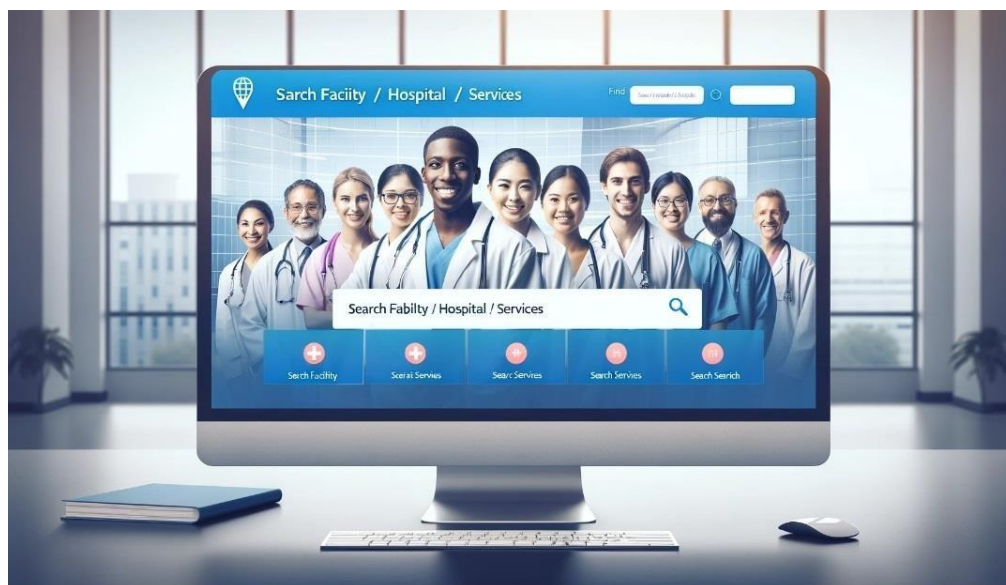
Figure 6: Home Page User Interface for the Web-Based GIS Platform

The Figure 7 shows the interface for the search facility by location and service needed. The search services by location opens the page and requests user to select the State, Local government and select specialty after which the user clicks on search. Then the results are shown on the right-hand side of the page.
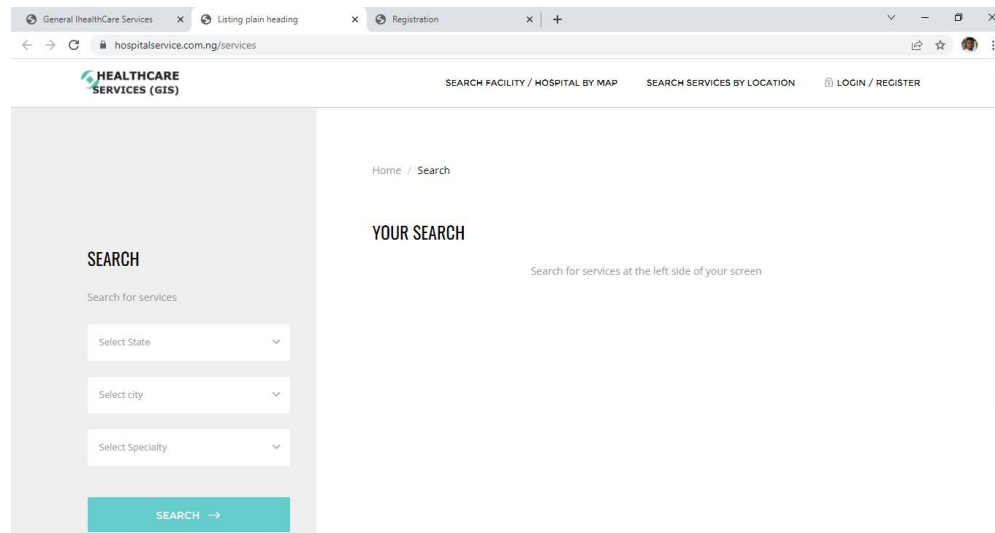
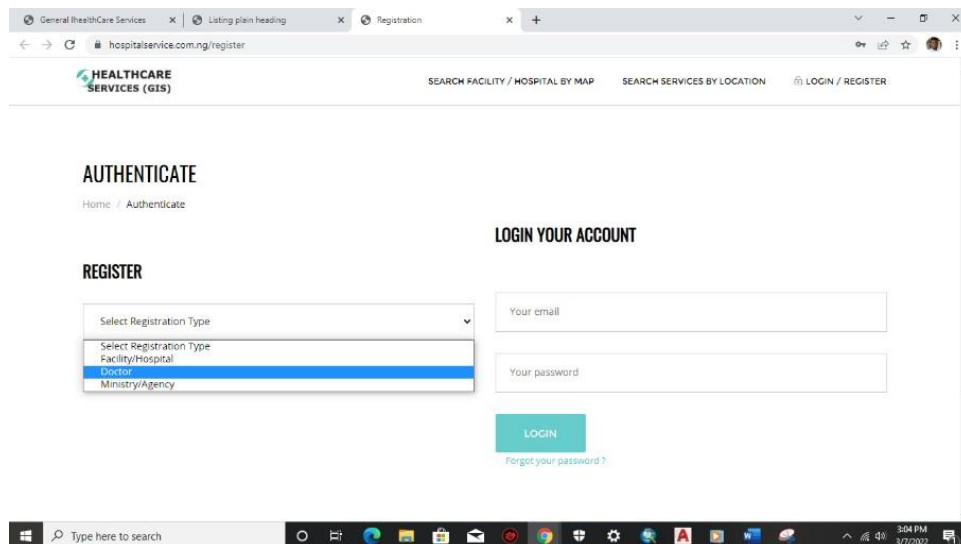*Figure 7: User Interface for Search Healthcare Service by Location*

Registrations and Login

The registration and Login page gives access to users on the system. It also serves as security measures put in place to regulate access to the different users of the system. The registration page requests for information depending on the class of user registering and must be entered corectly, a username and password is also entered. The login page requests for username and password which allows access to the system. The interface for login can be seen in Figure 8, the interface showing

the registration and login page can be seen in Figure 9. The different classes of registration can be viewed in Figure 10.

Figure 8: User Interface Showing the Login Page of the Website

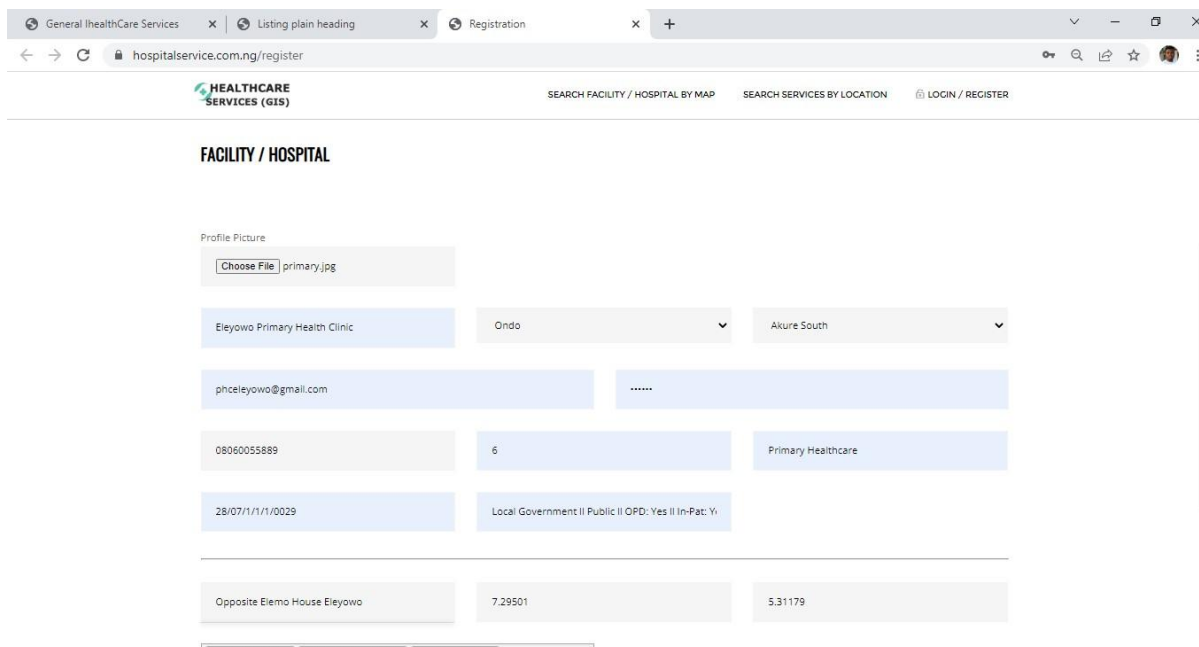*Figure 9: User Interface Showing the Login and Registration Page of the Website*

Figure 10: Showing the Various Classes of Registration Available on the Website

Registration of Facility/Hospital

For registering healthcare facility, user(s) selected a picture of the facility; and enter the name of the facility, the state and Local government. Then user(s) provides username and password, contact email and phone number, facility type and class, other information like, physical address, website if any, number of bed spaces, services rendered, number of staff, longitude and latitude, chief medical director and other important information. The interface for registration of health facilities can be seen in Figure 11.

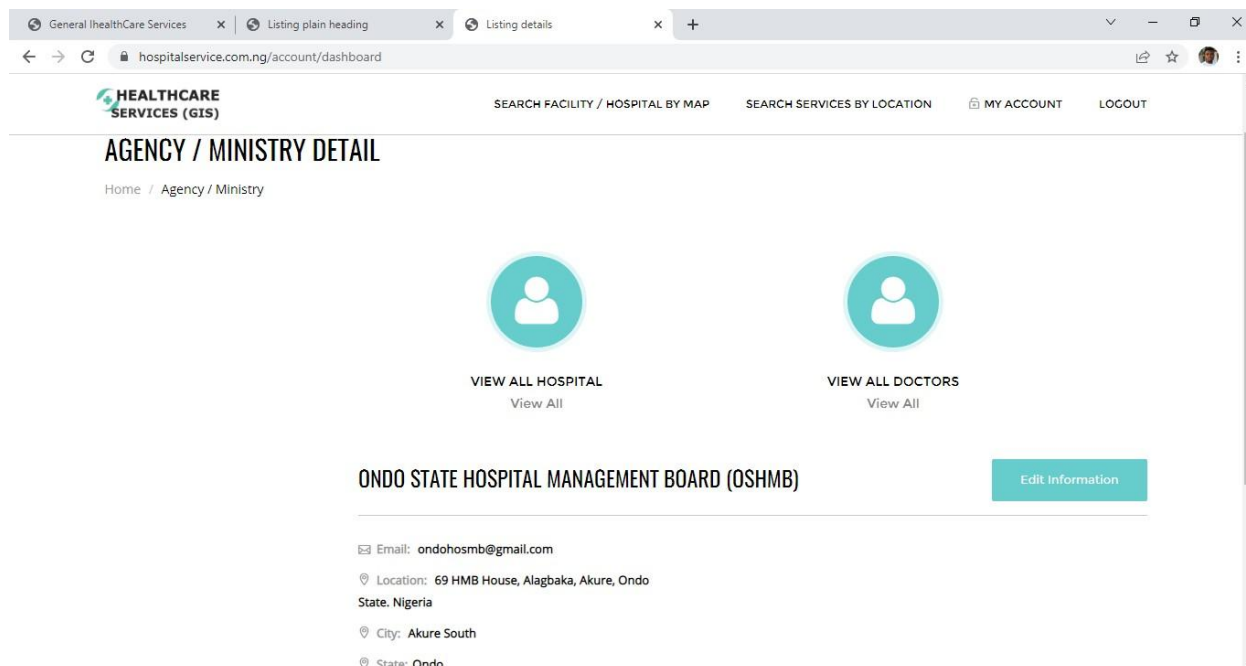*Figure 11: Registration Page for Healthcare Facility*

Registration of Ministry/Agency

The registration for monitoring, agencies or management board was also seamless; the system requires the name of the agency, its physical address, email address, login credentials, state and local government. The regulatory agencies have control over users like health care facilities and healthcare practitioners on the system. They can view and monitor details of the hospitals and doctors; this can be seen in Figure 9. the registration page for ministries, agency or management board can be seen in Figure 12.

Figure 12: Registration of Ministry/Agency/Management Board

Figure 13: Page for Ondo State Hospital Management Board after Login

View All Hospitals

The "View All Hospitals" feature on the web-based Health Geoinformation System allows regulatory agencies to view all hospitals and doctors within their jurisdiction based on specific queries. The interface supports query-based searches, offering tailored results according to the criteria set by the regulatory users. This can be visualized in Figure 14.
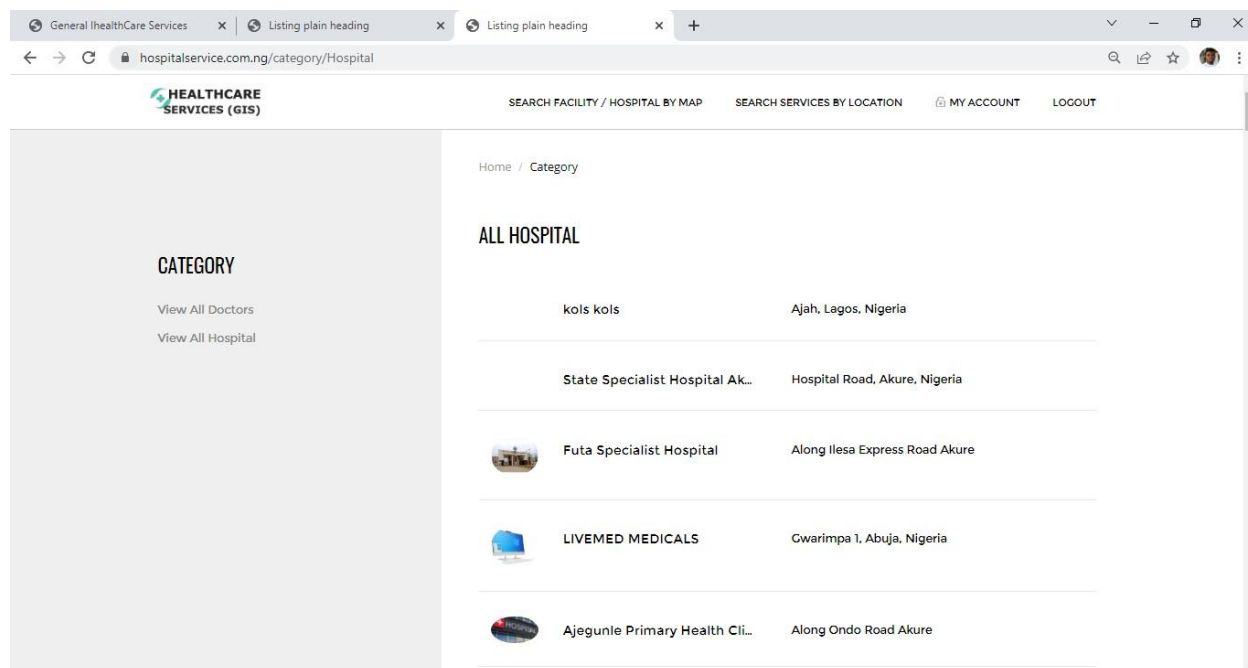
Figure 14: Some Healthcare Facilities Under the Purview of the Hospital Management Board

Specific Hospital Detail

Specific hospital detail can be viewed after searching and selecting. The page opens with a title "Facility detail". This page gives complete details on the facility in question as can be seen in the in the Figure 15 and 16. It also has an embedded map showing the location of the healthcare facility within Akure.
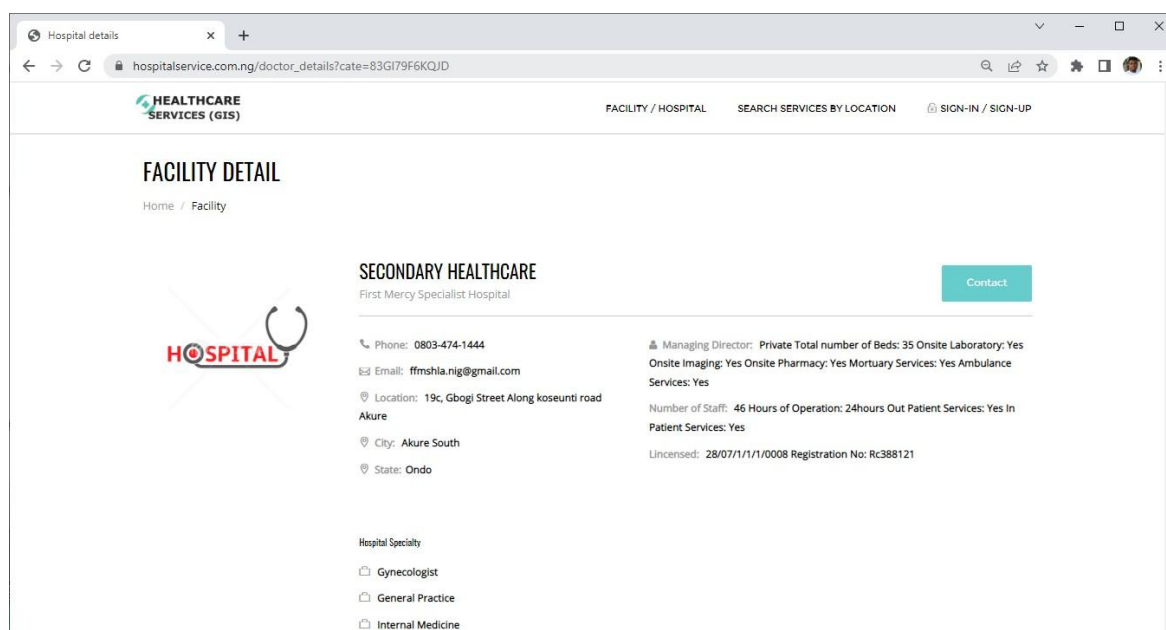

Figure 15: Specific Hospital Detail
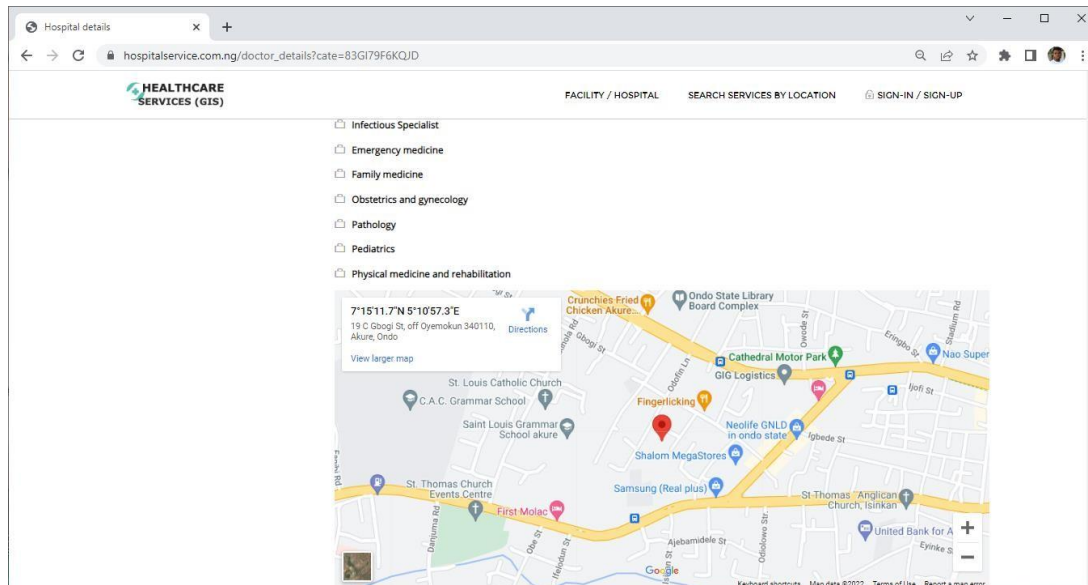
Figure 16: Facility Detail with Map Showing the Health Facility

To get directions to the facility, selection of the get directions button redirected to a google maps page. The page then brings a request to allow access to the user's location as can be seen in Figure 18. Access must be granted before a route can be found. A Close-up view for Directions button is seen in the Figure 17 and Figure 18.
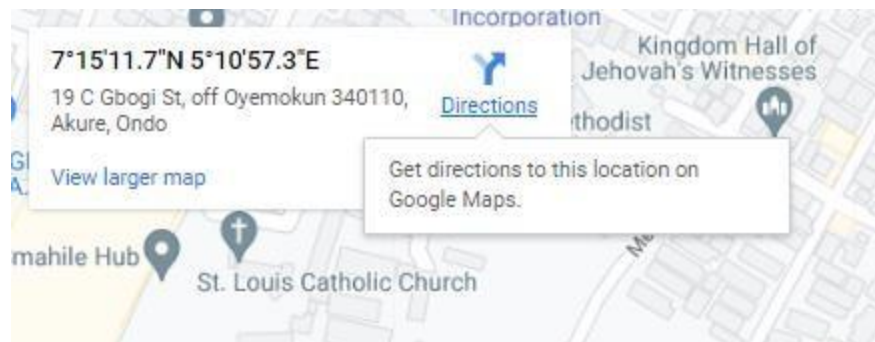
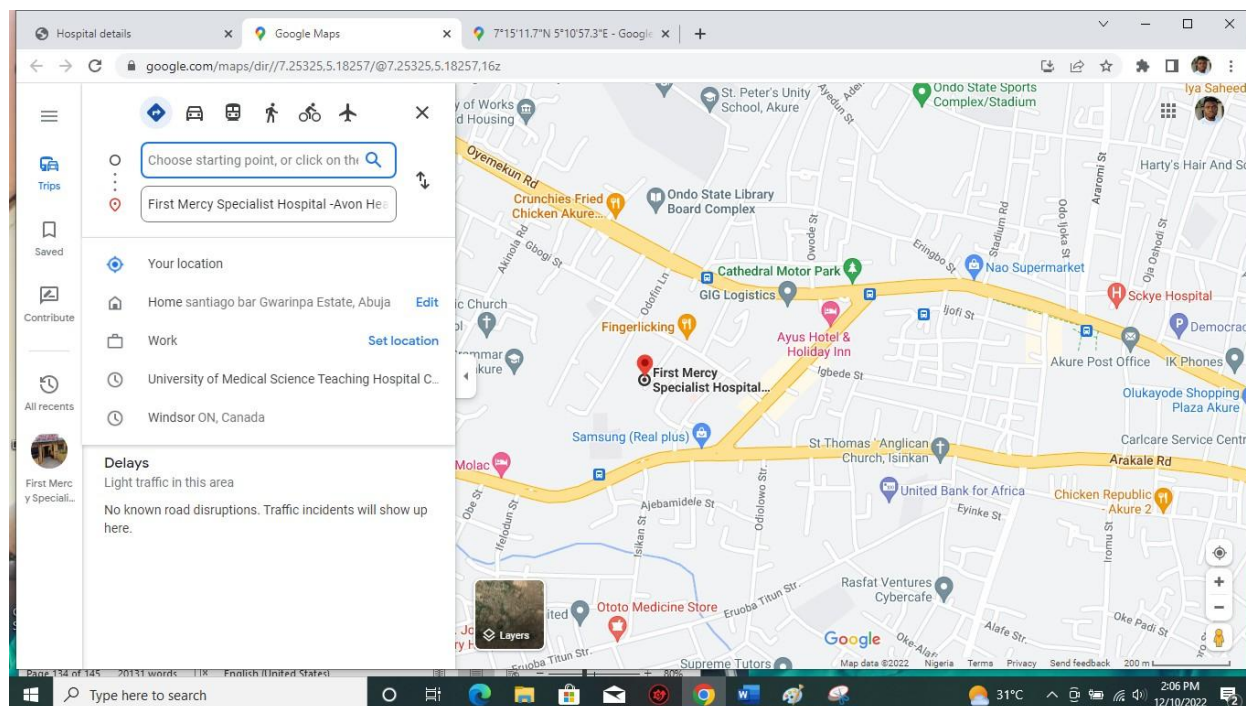*Figure 17: Close-Up View for Directions Button*

Figure 18: Redirected Page with the Facility in View

Print Information on Screen

The web-based system allows for printing of information; this helps in the sharing of information on health facility. The various interface for printing from this web-based system can be seen in Figure 19.
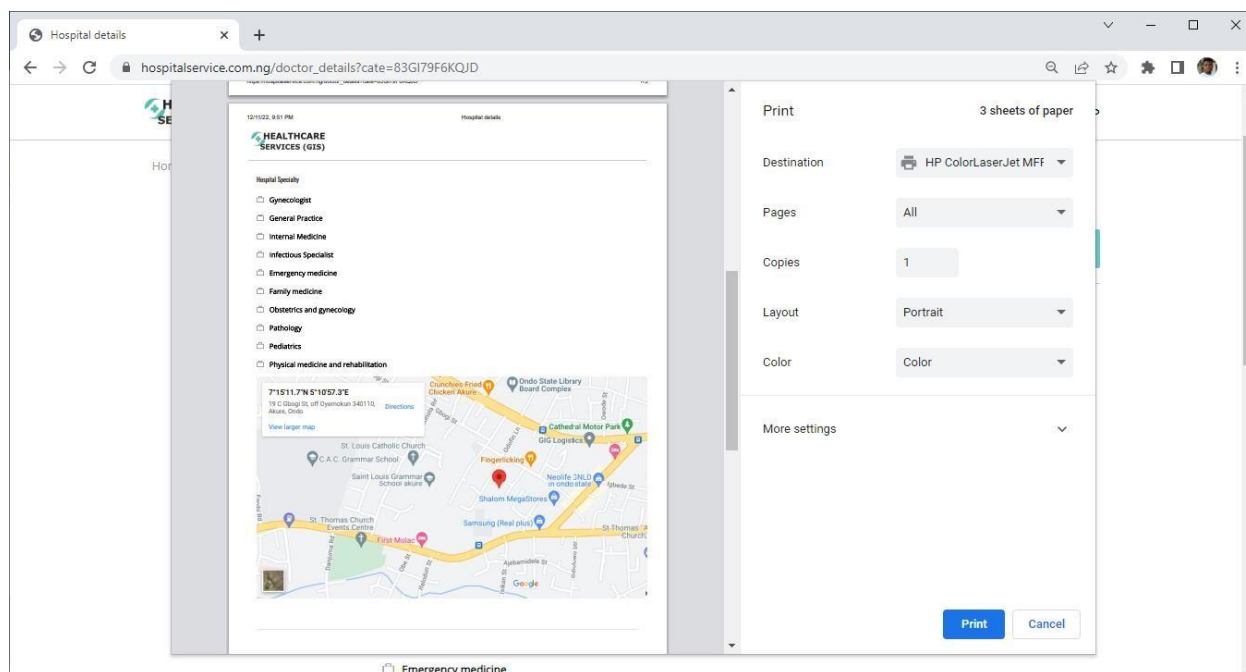

Figure 19: Image the Print Dialogue Box

5.0 CONCLUSION AND RECOMMENDATION Conclusion

This study successfully establishes a web-based GIS system, designed specifically to enhance the delivery of healthcare services based on location within Akure Metropolis. The research, characterized by comprehensive planning, extensive consultations, and rigorous data collection involving both primary healthcare board and the Ondo State hospital management board, culminated in the creation of a detailed geodatabase covering 100 healthcare facilities, providing an interactive platform accessible via personal computers and Android smartphones. The platform features a suite of functionalities including health facility search, in-depth facility information, and various geolocation services, all of which contributes to effortless access to healthcare for the end users. The geodatabase is not only robust and reliable but also flexible, designed to accommodate future updates and changes within the region. The study revealed that though Akure boasts of having all the three levels of healthcare service providers, they do not offer all the health services as mandated by WHO and FMOH. Also, the public are open to the use of a web-GIS enabled platform for easy access to health care facility and for consultations.

By tackling significant accessibility issues, the web-based Health Geo-Information System (HGS) designed in this study has the potential to completely transform the way healthcare is provided in Akure Metropolis. The web based platform provides residents with convenient access to comprehensive information on healthcare facilities, services, and operating parameters through the use of GIS technology and complete health data integration. This facilitates informed decisionmaking, streamlines communication between healthcare providers and the public, and optimizes patient mobility through route planning functionalities.

The study provides a platform for the management of health records and health facilities by the government agencies with the responsibility for that. Spatial analysis from this research enables stakeholders to identify locations that are neglected and distribute resources more efficiently, guaranteeing fair access to healthcare throughout the city. Incorporating real-time updates into the healthcare system promotes resilience and fosters residents' access to the most recent medical knowledge. The incorporation of user feedback mechanisms ensures that the system remains responsive to the needs of both healthcare providers and users, in that way contributing to the development of evidence-based healthcare policies that prioritize patient-centered care and continuous quality improvement.

This study represents a considerable contribution to the field, offering an innovative solution to the challenges of healthcare accessibility and laying down a vital precedent for future GIS application in healthcare and related fields globally. Furthermore, the research aligns with the findings of Zacharias *et al.,* (2016), and Wang, (2020), highlighting the critical role of GIS in healthcare management, mapping health indices, and understanding the impact of diseases, thus reinforcing the necessity and efficacy of GIS applications in healthcare.

Recommendations

Building on the successful implementation of the web-based GIS system for healthcare service delivery in Akure Metropolis, it is recommended that efforts should be intensified to raise public awareness, and promote the adoption and utilization of GIS technologies in healthcare. Government bodies and healthcare facilities need to actively participate, providing necessary

resources and training to staff, ensuring data accuracy, and maintaining user privacy. Investment in capacity building and continuous improvement of the system is crucial, incorporating new technologies and best practices. Fostering collaborations and partnerships, ensuring accessibility and inclusivity, and encouraging further research and development are imperative steps towards enhancing the application of GIS in healthcare, leading to improved service delivery, better health outcomes, and a stronger, more resilient healthcare system.

Future development and research initiatives for the web-based Akure Metropolis Health GeoInformation System (HGS) may look into different ways to improve its functionality and deal with particular healthcare issues. Improving the telemedicine services on the platform is one such approach that could provide remote access to and consultations with healthcare providers as technology advances. This not only advances theoretical understanding of remote healthcare access but also translates theory into practice by providing practical solutions for improving healthcare accessibility.

Enhancing data visualization and analytics tools could also be a priority in order to help healthcare stakeholders better recognize trends and patterns for the purpose of allocating resources and making decisions. Initiatives could also be launched to involve communities in the mapping of nearby health resources and the addressing of common health problems, such infectious diseases or the health of mothers and children. Involving the community in healthcare planning and decision-making processes is one way that this cooperation advances policy development. Participatory approaches support the larger policy goals of empowering local communities to take charge of their own health and promoting community-based healthcare programs.

REFERENCES

Abdulkader, M., (2018) Using GIS for Determining Variations in Health Access in Jeddah City, Saudi Arabia, *International Journal of Geoinformation. ISPRS Int. J. Geo-Inf.*

Adesola, W. A., (2009) Design and Implementation of a Web-based Information System for National Health Insurance Scheme Using the Object-Relational Database Approach, Global *Journal of Pure and Applied Sciences,* 16 (1), 83-94.

Andrei-Cătălin T, (2015). "Location-Based Web Search and Mobile Applications" Publications of the University of Eastern Finland Dissertations in Forestry and Natural Sciences.

Bates, D. W., Kuperman, G. J., Wang, S., Gandhi, T., Kittler, A., Volk, L., Middleton, B. (2003). "Ten commandments for effective clinical decision support: Making the practice of evidencebased medicine a reality". Journal of the American Medical Informatics Association, 10(6), 523–530. https://doi. org/10.1197/jamia.m1370.

Climate-Data, (2022) Akure Climate (Nigeria) Data and Graphs for Weather & Climate in Akure, Retrieved December 19, 2022, Available at https://en.climatedata.org/africa/nigeria/ondo/akure-46678/

Fortney, J., Rost, K., and Warren, J (2000). "Comparing alternative methods of measuring geographic access to health services," Health Services and Outcomes Research Methodology 1(2), 173–184, 2000.

Gulliford M, Figueroa J, Morgan M, Hughes D, Gibson B, Beech R, and Hudson M, (2002). "What does 'access to health care' mean?" *Journal of health services research & policy. 7. 186-8. 10.1258/135581902760082517.*

Gunjal, B, (2003). Database System: Concepts and Design. Proceedings of 24th IASLIC–SIG-

Khennie, O.O., (2013) Geographic Information System to Investigate the Spatial Distribution Pattern of Healthcare Centres in make Map and Create Database of Primary Health Centers (PHC's) in Lagos Island LGA. Available at https://www.academia.edu/27518323

Mushonga, H.T., Banda, F., Mulolwa., (2017) A Development of a Web-based GIS for Health Facilities Mapping, Monitoring and Reporting: A Case Study of the Zambian Ministry of Health. *South African Journal of Geomatics,* 6 :321–332

Musilimu, A.A., (2013) Spatial Distribution, Pattern and Accessibility of Urban Population to Health Facilities in South Western Nigeria: Case Study of Ilesha.

NHS (2017) Nigerian Health Sector Market Study Report Pharm Access Group page 9-10

NHMIS (2007) National Health Management Information System (NHIMS) Revised Policy Document

NMCP, (2012) National Malaria Control Programme Report, Federal Ministry of Health

NHO Healthcare Records Management Steering Committee, (2007). "National Hospitals Office

Nigerian Federal Ministry of Health (FMOH). (2015). Nigeria Health ICT Phase 2 Field Assessment Findings.

Ojajuni, O.J., Atanlogun, S.K., Akinbohun F., (2013) Population Growth & Health Facilities in Nigeria: A Case Study of Ondo State, *International Journal of Scientific & Technology Research,* 2 (8)

Oluwaseun, O., and Olaronke, I. (2015). Strategies for Managing Information Flow in Nigeria Healthcare System Strategies*, International Journal of Applied Information Systems.* 9(8).

Owoeye, J.O., and Akinluyi, F.O., (2018). Geospatial Analysis of Land Cover Change and Urban Sprawl Trend in Akure Region, Nigeria DOI:10.15406/ahoaj.2018.02.00028

Rao, B. & Minakakis, L. (2003). "Evolution of Mobile Location-Based Services", Communication of the ACM, 46(12), pp. 61-65.

Ryschka, S., Murawski, M., Bick, M. (2016). Location-Based Services. Business & Information Systems Engineering. 58. 10.1007/s12599-016-0430-8.

Sedenu, H.A., Muibi, K. H., Alaga, A. T., Ajileye, O. O., John, O., Kappo A. A., Popoola O. S., and Oloko-Oba O. M., (2016) Spatial Analysis of the Distribution Pattern of Primary Healthcare Facilities in Ile – Ife Metropolis Using Geographic Information System, *JSRR,* 10(1): 1-15.

Turban, E., 1993, "Decision Support and Expert Systems: Management Support Systems", New York: Macmillan Pub. Co.

Virrantaus K, Markkula, J, Garmash A, Terziyan V, Veijalainen J, Katanosov A, and Tirri, H. (2002). "Developing GIS-supported Location-Based Services". *Proceedings of the Second International Conference on Web Information Systems Engineering 2001. 2. 6675 vol.2. 10.1109/WISE.2001.996708.*

Wachs, M. and Kumagai, T.G., (1973). "Physical Accessibility as a social indicator," *SocioEconomic Planning Science 7, 437–456, 1973.*

Wang, F. (2020) Why Public Health Needs GIS: A Methodological Overview. Ann GIS; 26(1): 1-12, Available at https://doi/org:10.1080/19475683.2019.1702099

Wingerath W., Ritter N., and Gessert F., (2019) "Database management," in SpringerBriefs in Computer Science.

W.H.O, (2000). WHO Report on Global Surveillance of Epidemic-prone Infectious Disease. *Department of Communicable Disease Surveillance and Response WHO/CDS/CSR/ISR/2000.1*

W.H.O, (2005) Nigeria: country status Report.

Yaya, J.A, Asunmo, A.A., Abolarinwa, S.T., Onyenekwe, N.L., (2015) Challenges of Record Management in two Health Institutions in Lagos State, Nigeria, *International Journal of Research in Humanities and Social Studies*

Zacharias D., Dimitrios T., Filipos G., and Athina L., (2016) The Utilization of Geographic Information Systems in Healthcare, *International Journal of Health Research and Innovation,* 4(1).

Zhang, S., Xing, T., Tao, L. & Zhang, F. (2013). "OSGIS & FOSS in LBS Design". *Proceedings of the 2013 International Conference on Software Engineering and Computer Science ICSECS2013, pp. 261-264*

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