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A Web-Based Spatial Distribution of Malaria in Nigeria

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ABSTRACT

Malaria is a mosquito disease of global concern with 1.5 to 2.7 million people dying each year and many more suffering from it. Malaria is most prevalent in the developing countries of the world. GIS and related spatial analysis methods provide a set of tools for describing and understanding the changing spatial organization of health care, for examining its relationship to health outcomes and access, and for exploring how the delivery of health care can be improved. This paper presents a system developed to spatially query the distribution of malaria in Nigeria. The system was developed using Hyper Text Markup Language 5 (HTML5) and Cascading Styling Sheets (CSS) for styles of the pages designed. After the design, the system was implemented and tested via the WAMP server which serves as a local server for hosting web applications without the use of internet access. Google map was used as a mapping service application to ensure that the geographical locations are displayed with the aid of the Google Map Maker. The result of the tests performed on the system showed that the system processed data adequately; the coverage of data stored showed the effectiveness of the system in data storage and retrieval. The simple interface design proved to be user-friendly for all users that handled the system. The system will also go to a long in solving the problem of poor health care system for malaria patients as access to information and statistics on malaria occurrence is made real-time. Also, the display on the map enhances easy-to-read and easy-to-understand environment for any authorized user to make decision related to malaria. In conclusion, the system has capacity to monitor malaria distribution and spatially query distribution of malaria in Nigeria. The system will go to a long in solving the problem of malaria in Nigeria so that patients can have access to information and statistics on malaria occurrence is made real-time. Also, it will be used by public health workers to monitor the distribution of Malaria in Nigeria

Keywords: Spatial Analysis, Web, Malaria, Distribution, Systems, Environment & Retrieval.

Aims Research Journal Reference Format:
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1. INTRODUCTION

Malaria is a life-threatening parasitic disease transmitted by female anopheles mosquitoes. Most malaria infections particularly in the sub-Saharan Africa are caused by the parasite called Plasmodium falciparum. It is a major cause of death and threatens 2.4 billion people, or about 40% of the world's population living in the world's poorest countries and more than one million deaths are attributable to the disease annually (World Health Organization (WHO), 2000). According to Alnwick (2002), the word malaria comes from the Latin word 'mal aria' (bad air). In 1880, scientists discovered the real cause of malaria as a one-celled parasite called plasmodium. It was later discovered that the parasite enters the human bloodstream through the bite of a female Anopheles mosquito, which needs blood to nurture her eggs. Once the parasite is in the blood and following a period of incubation, the person starts to have a fever, which is the most typical symptom of malaria, as well as cough, headache, diarrhea, and muscle pain (Rang *et al*., 2003).

In areas of Africa with stable malaria transmission, such as Nigeria, infection during pregnancy is estimated to cause as many as 10,000 maternal deaths each year, 8-14% of all low-birth-weight babies, and 3-8% of all infant deaths (WHO, 2012). In Nigeria, malaria prevalence is as high as 80-85% and is the most common cause of outpatient visits to health facilities. With a case mortality rate ranging from 8-12.5% in infants and children, malaria accounts for 30% of child mortality in the country and is consistently recorded as one of the five leading causes of childhood mortality (Akpan, 2006). Malaria has been identified as one of the major causes of poverty, sickness and death in Nigeria (Department for International Development, DFID, 2008).

Available records in Lagos State, Nigeria, alone show that malaria is the most relentless killer disease (WHO, 2010). Fifteen percent of admissions in Lagos State hospitals and over 50% out-patient cases were involved in malaria treatments (WHO, 2010). Statistics across Nigeria shows similar trends (Thompson, 2004) and the distribution of malaria in Nigeria.

There has been a growing interest in the ministry of health and other health sector institutions in the use of Geographical Information Systems (GIS) as a tool to strengthen the analytical, management, monitoring and decision-making capacity in public health, as well as a tool for advocacy and communication between technical personnel, policy makers and the general public (Epidemiological Bulletin, 2008). However, the use of GIS in public health generally and more specifically in the control of malaria was largely limited due to two major problems: the prohibitive cost of hardware and the great complexity of GIS software that made it extremely time-consuming as well as costly to extract information relevant to the practical demands of disease prevention and control (Adebayo *et al.*, 2009). With the plummeting prices of hardware and simple new devices now available, applications have been developed to provide greater access to simple, low-cost geographic information and related data management and mapping systems for public health administrators at all levels of the health system (McKeldin, 2012).

Some Organizations such as World Health Organization (WHO), United States Agency for International Development (USAID), Public Health Agency of Canada (PHAC) had developed some system for health mapping, disease elimination, disease surveillance and as monitoring systems (WHO, 2005; PHAC, 2005). They cannot be used in Nigerian since there is a variation in climate, weather conditions, socio-economic factors, infrastructural development differences, etc. Thus, there is a need for a system that can capture data that is relevant to Nigerian malaria distribution and spread. So there is a need for a disease surveillance system. In order to develop a good disease surveillance system that would be able to capture future disease data in Nigeria a GIS data model was proposed (Adebayo *et al.,* 2009). The application of GIS in malaria surveillance in Nigeria can move Nigeria towards the possibility of reducing of malaria infections and related deaths. GIS also provides a means of an effective and efficient information system, which captures information relevant to malaria surveillance and related deaths. This paper is necessitated by the need of employing GIS for monitoring malaria incidence in Nigeria. The paper developed a system that will allow spatial query of distribution of malaria in Nigeria.

The aim of this study is to develop a Geographical Information System (GIS)-based information system which will be used by public health workers to monitor the distribution of Malaria in Nigeria.

2. MALARIA

It is estimated that malaria threatens the lives of 40% of the world's population and is a public health problem in more than 90 countries (World Health Organization, 2012). Malaria is an important public health problem with 300 to 500 million clinical cases reported annually. It has been estimated that a child dies of malaria every 40 seconds with a global loss of 2000 young lives each day (Sachs and Malaney, 2009). The majority of deaths occur among the poorest fifth of the world's population and in sub-Saharan Africa malaria contributes to a loss of 15% of all disability-adjusted life-years (Guerrantet *et al.*, 2002). Poor people living in poor quality housing, usually in rural areas, are at increased risk of disease and also have less access to medical facilities and personal protection (World Health Organization, 2001a). Sub-standard housing can create opportunities for vector mosquitoes to enter the houses and increase possible contact between infected vectors and humans. Malaria has thus been characterized as a "social disease" and thus amenable to human intervention. Investment and tourism are also threatened in these areas and possible income thus lost f or indigenous population. Malaria affects many aspects of social and economic endeavors including fertility, savings and investments, agricultural choices, schooling and mobility (Sachs and Malaney, 2002).

2.1 Malaria in Africa

The degree of efficiency of malaria vectors to transmit malaria from one human to another is an important factor defining the distribution of malaria in Africa. Anopheles gambiae is predominantly found in sub-Saharan Africa and has the reputation of being a very effective vector (Gallup and Sachs, 2001). The upsurge of malarial disease following systematic programme neglect recently resulted in large African malaria epidemics (Nchinda, 1998). The Southern Africa Development Community (SADC) Malaria Control Strategy (Durrheimet *et al.*) and the Abuja Declaration (2000) was initiated to enable countries to strategically tackle malaria and implement evidence based interventions (World Health Organization, 2008). Malaria intensity in the southern region of Africa varies from holo to hypo endemic. Seasonal variation and epidemics characterize unstable malaria while intense transmission throughout the year is typical in areas of stable malaria. In sub-Saharan Africa, up to 30% of outpatient and 40% of inpatient episodes are due to malaria infection. Children under 5 years and pregnant women are the worst affected by malaria in stable malaria areas of sub Saharan Africa (World Health Organization, 2008).

High-level chloroquine resistance in Africa is widespread but chloroquine is still used in some countries as first line treatment (Kaona and Tuba, 2007; White*et al*., 1992). Effective, cheap drugs are needed and combination therapy is currently considered as the best alternative. The use of Artemisinin derivatives is currently being explored and this raises hope of future effective malaria therapy (Barneset *et al*., 2002; Koornhof, 1999). Multiple control interventions have been attempted in this part of the world due to the massive burden of the disease with limited success. The HIV/AIDS epidemic in Africa has also strained primary health care services to the limit. Insecticide treated nets and residual house spraying have been the major vector control interventions implemented in malaria endemic areas of Africa. The latter intervention has been evaluated as being more cost-effective in areas with low seasonal risk (Guyattet *et al*., 2004). A problem facing malaria control programmes is the rapid development of insecticide resistance. Resistance of Anopheles funestusto pyrethroids impacted dramatically on malaria in South Africa (Hargreaveset *et al*., 2010).

2.2 Malaria in Nigeria

Malaria is a major public health problem in Nigeria where it accounts for more cases and deaths than any other country in the world. Malaria is a risk for 97% of Nigeria's population. The remaining 3% of the population live in the malaria free highlands. There are an estimated 100 million malaria cases with over 300,000 deaths per year in Nigeria. This compares with 215,000 deaths per year in Nigeria from HIV/AIDS. Malaria contributes to an estimated 11% of maternal mortality (Akpan, 1996; Thompson, 2004; US Embassy Nigeria, 2011; United States Agency for International Development (USAID), 2011; National Population Commission (NPC) National Malaria Control Programme (NMCP) and ICF International, 2012).

The malaria situation in Nigeria is very burdensome and it impedes human development. It is both a cause and consequence of underdevelopment (Department for International Development (DFID), 2008). The degree of malaria infestation varies from region to region in Nigeria. This spatial attribute of malaria infestation across regions necessitate the needs for malaria mapping among researchers. The mapping of patterns in the spatial distribution of features has been of great significance in virtually all fields. The primary aim in the mapping process is to bring out hidden relationships among variables (Oluwafemi *et al*., 2013). Measures should be introduced to increase the financial allocation to the affected states by the federal ministry of health with a few to reducing the effect of malaria infection in the states located in the high infection zones (Onwuemele, 2014).

2.3 Spatial Database and GIS-based systems

Spatial technology is a field of information technology that acquires, manages, interprets, integrates, displays, analyzes and uses datasets focusing on the geographic, temporal and spatial reference. Spatial technology includes wide array of the technologies such as Geographic Information System (GIS), Remote Sensing (RS) and Global Positioning System (GPS). GIS is defined as an information system that is used to input, store, retrieve, manipulate, analyze and output geographically referenced data or spatial data. All methods of collecting information about earth without touching it are forms of remote sensing. Satellites, radars and aerial photographs are the different ways of acquiring remotely sensed data GIS is an umbrella term which integrates wide range of datasets available from different sources including RS and GPS. Therefore, GIS is often termed as core of spatial technology having built-in power to analyze integrated dataset and to present the results as useful information to assist decision making.

2.4 Spatial data

Spatial Data are data that have some form of spatial or geographic reference that enables them to be located in 2- or 3-dimensional space (Heywood *et al*., 2008). There are five (5) main spatial data types namely; Point, Lines, Regions, Partitions (maps) and Graphs (networks). Applications of Spatial Data include; Geographic Information Systems (GIS), Computer-Aided Design/Manufacturing, Multimedia Databases. Providing analysts and decision-makers with timely access to reliable epidemiological, social demographic measures and environmental health measures at a high spatial resolution is a key priority to facilitate evidence-based decision-making (Brownson *et al.* 2009; Gudes *et al.* 2010; Jacobs *et al.* 2012). Various studies have been undertaken that used GIS technology and spatial data analysis in evaluating health data (Levine *et al*., 2009; Rushton *et al*., 2006). Spatial analysis is a useful tool to explore health data, map and identify patterns, generate new hypothesis, and provide evidences about existing hypothesis (Boscoe *et al*., 2004). In the western developed nations, data from malaria registry can be fully used to find association between occurrence of malaria incidents with geographical and demographic factors (Higgs *et al*., 2005).

2.5 Existing spatial database systems in Healthcare

An innovative project in Missouri examined the effectiveness of a community health center in improving access to care among needy, low-income residents (Phillips *et al*., 2000). GIS was used to compare the actual areas served by the center with the areas targeted for service to determine if the intended target population was adequately served. The comparison showed significant gaps in service.

By overlaying data from an assessment survey on health needs, the authors were able to identify areas of poor access and unmet need—areas with high priority for new clinic services and outreach. For emergency medical services, effectiveness is measured in real time. Performance varies over time and space, with clear implications for health outcomes. A GIS developed for southern Ontario linked data on ambulance locations with a data set containing the location, time of day, response time, and type of call for each ambulance call (Peters *et al.*, 1991). The system allowed analysts to display maps of response times by type of call and responding ambulance, and to identify calls and locations with unusually high response times. Maps and graphs provided a foundation for recommending improvements in ambulance deployment.

In the United States, the effectiveness of health care is also influenced by structural and technological changes in medical care, including, for example, the shift from fee-for-service to managed care and the growth of telemedicine and evidence-based medicine. The effects of these changes vary from place to place. Geographical analysis of new organizational forms in health care is illustrated by Kronick *et al.* influential article (Kronick *et al.*, 1993), which appeared in the New England Journal of Medicine. Using geographic data and concepts, they showed that managed competition is only viable in metropolitan areas that have enough population to support competing managed care plans and enough independent health care organizations to provide the competition necessary to keep costs down. Outside these areas, in vast territories of the United States, managed competition was not seen as a workable policy for improving health care delivery. And for this reason, spatial database is important in healthcare sector.

2.6 Related Works

Having extensively carried out the review of a number of literatures on area of development of geographical information system for malaria monitory system, quite a number of information was gotten. Laari (2011), studied the spatial analysis of malaria epidemiology in the amanse west district. The spatial dependency of the malaria risk was explored using Poisson variogrs and the risk was used to create surface maps from 2004 to 2009 to identify areas at high risk. Bayesian geostatitical approach was then used to correlate the relationship between the elevation and the disease risk. The risk map created in this study, which integrates Poisson statistical methods showed areas at risk, especially in the central portions of the district capital. It also showed an average of 20% rise yearly from 2004 to 2009. The results in the semi-variogram analysis with an average range of 2000m showed that the disease incidence was local and not global. The local nature of the disease occurrence gives credence to the fact that the covariates used which were rivers/streams, forest, temperature, rainfall and elevation had different and independent influence on the malaria prevalence. Areas which were more than 2km away from the water source (rivers/streams) recorded relatively higher cases except for some few within 1km of the Offin and Oda rivers. There was a varied effect of elevation with the disease prevalence as evidenced in the Bayesian regression model. There was a general trend of high disease incidence between 1-3 km from the forest edge.

Ambachew, M. Y. (2012). This study reviewed 44 antimalarial efficacy studies conducted in Ethiopia from 1974 to 2011. The analysis of results indicated that chloroquine as the first-line antimalarial drug for the treatment of malaria due to Plasmodium falciparum had a 22% therapeutic failure in 1985. Chloroquine was replaced with sulfadoxine-pyrimethamine in 1998, more than 12 years later, when its therapeutic failure had reached 65%. Sulfadoxine-pyrimethamine at the time of its introduction had a treatment failure of 7.7%; it was replaced after seven years in 2004 by artemether-lumefantrine; by then its treatment failure had reached 36%. Almost eight years after its introduction, isolated studies show that the efficacy of artemether-lumefantrine has decreased from 99% in 2003 to around 96.3% in 2008. Though this decrease is not statistically significant (chi-square 1.5; P=0.22) and has not reached the threshold of 10%, it is plausible that its efficacy may drop further.

Persaud, H. (2013). Studied the monitoring community health using a web-based GIS application and malaria treatment in ethiopia: antimalarial drug Efficacy monitoring system and use of evidence for policy to Monitoring and assessing health problem trends require health specialists to access high quality information in order to identify and prioritize problems, develop and evaluate policies and actions, organize the delivery of clinical health services, guide research and development, and contribute to the development of standards and guidelines. This enables public health planning, management, and monitoring. HARC is a non-profit organization in the Coachella Valley, collecting a wealth of data and information; but it lacked an effective or efficient approach to communicate the information with its clients. Their data were contained in a 700-page report on health indicators and disparities in Coachella Valley. Presenting data in a user-friendly format through the developed application made it easier for people to locate data for specific populations and to produce clear and easy-to-understand maps. HARC will also be able to increase awareness of the health problems faced by communities in Coachella Valley. HARC and its clients will use the application to view, query, print, and share information on health indicators, behavior, and disparities in the Coachella Valley.

3. METHOD
In order to develop the system, Adobe Dreamweaver® Integrated Development Environment (IDE), Hypertext Markup Language (HTML), WAMP and Google Map® Application Programming Interface (API) to implement the spatial GIS service.

3.1 Prototype Implementation of the system
This section of the research presents the prototype implementation of geographical information system for malaria distribution in south-western Nigeria. The malaria information system allows for information relating to malaria patients to be stored, accessed, retrieved and monitored. As a result, distribution of malaria in south-western region, gender, ethnic groups and occupation is evaluated and preventive measures are taken.

3.2 The Interfaces
The interfaces of the system are those components that allow for interaction between the users (administrator, medical personnel, non-government organization and the government agencies) and the system without the user knowing the underlying functions, working, and the operations of the system. The interfaces built include the following:

i. The Home page;
ii. The User registration page;
iii. The Login page;
iv. The Patient registration page;
v. The Patient transfer page;
vi. The admin page;
vii. The malaria distribution page;

The home page
The home page is the first interface that the user views the moment the user have access to the malaria information system see figure 4.1. The home page is where the users can be able to access the buttons to navigate to every other part of the system. For all registered users who want to perform any activity on the system, the user must click on the menu button (login) in order to log in and perform any necessary functions required.

The User registration page
This module is the module which allows all the users to send registration request to the admin (in the case the administrator) by entering their personnel details and necessary identifications indicating the type or category of user they belong to. In this module, each user is required to enter their name(s), username, password, e-mail address agency/hospital name, user type, identification type, identification image and passport. The user then wait for his or her request to be approved by the administrator of the of malaria information system. (Figure 4.2)

The Login page
The Login page module is the module that enables the approved users of the malaria information system to log in the system to perform all authorized activities within the jurisdiction of their user type. This module has the username, password and user type boxes. It also has a provision for the users that are yet to be registered to do so. The login module is shown in Figure 4.3

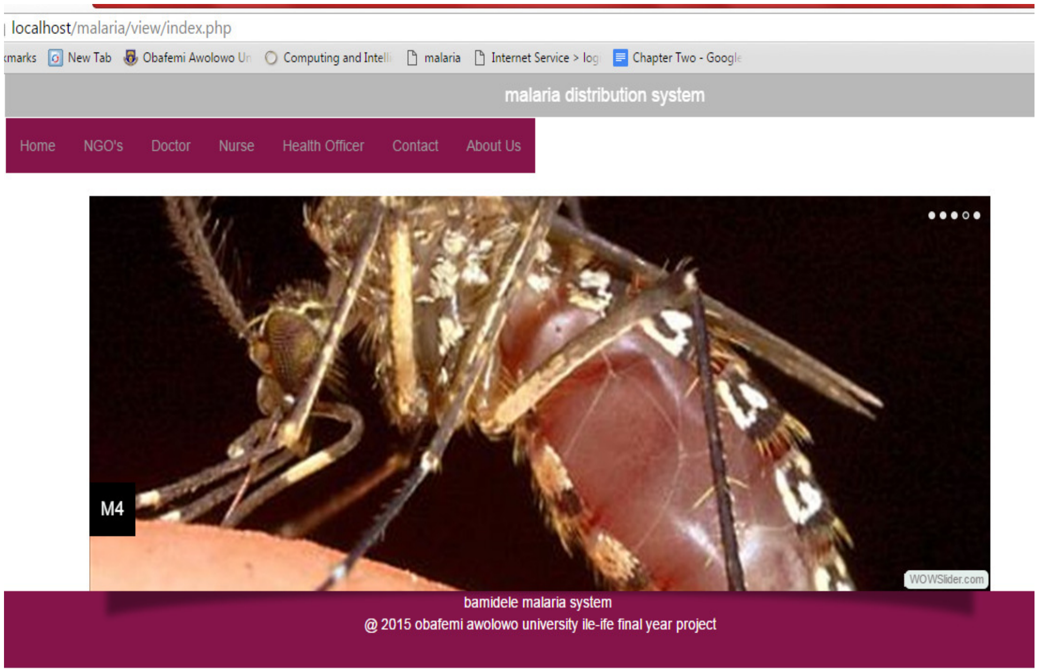

Figure 4.1: Home Page

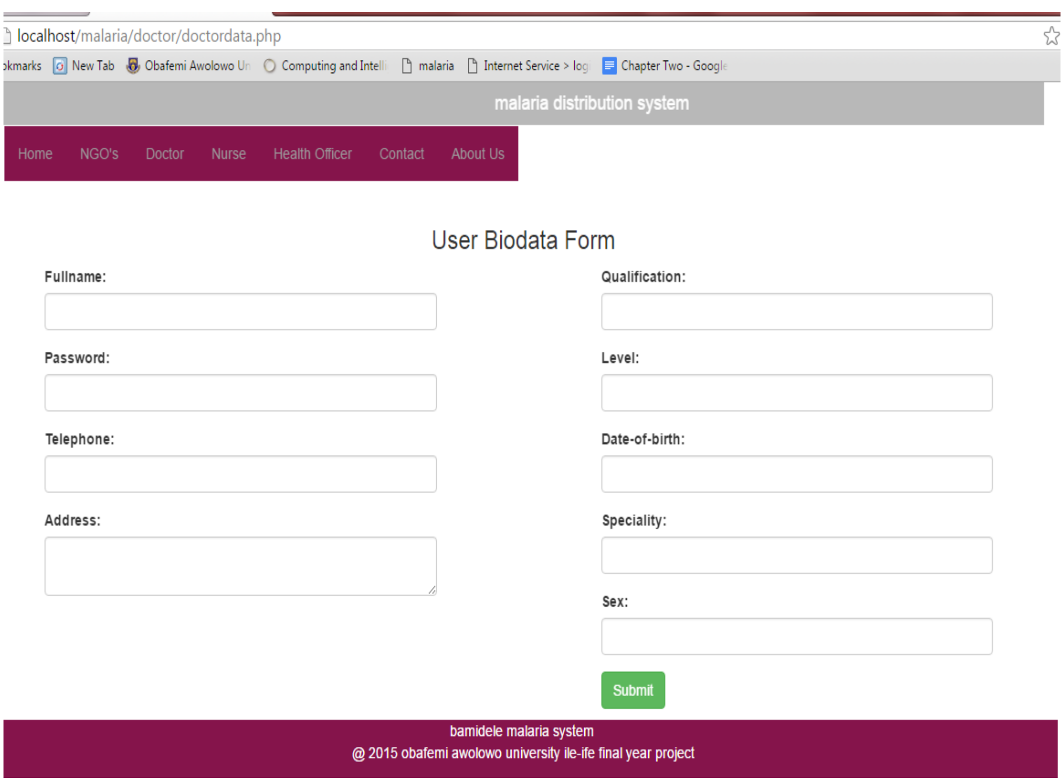

Figure 4.2: User Registration Page

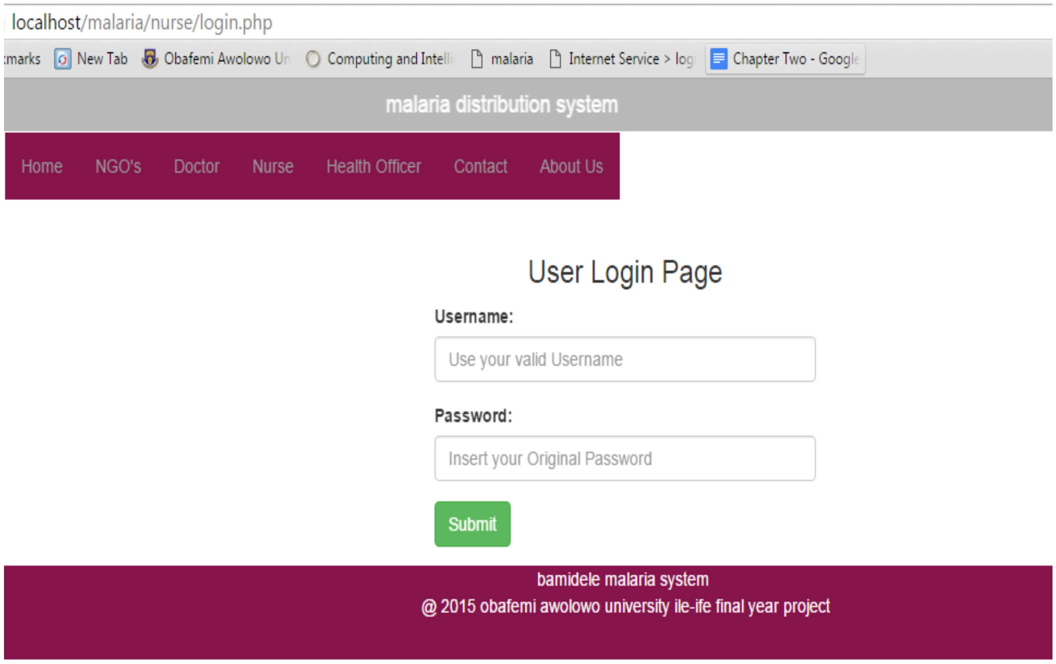

Figure 4.3: Login Page

The Patient registration page

The Patient registration page module is a module that enables any authorized user type that is Doctor to register any one diagnosed with malaria disease. The doctor will key in the surname of the patient in the search box to verify in the patient already exist in the database and if already exist then the doctor needs not to re-register the patient. However, if the patient does not exist in the database, the doctor key is the name, residential address, occupation, ethnic group, state of origin, residential town and state, marital status, sex, date of birth and year of disease diagnose. The disease information of the patient is also entered. All of these are shown in figure 4.4 depicting the patient registration module.

The Patient transfer page

This is the page where the information of any malaria patient that is transferred from one hospital to another for one or more reason is bee handle. Any patient that is to be transferred must have been registered in the database. See figure 4.5 for the patient transfer module.

The admin page

This is the module that performs the administrative functions such as modifying site pages, adding events, and customizing the contact database. Administrator can log in and access the admin *backend* – an area reserved for site and account administration, and not seen by ordinary members or visitors to your site. The administrator have been granted the technical ability to perform certain special actions on malaria distributive system, including the ability to block and unblock user accounts from editing, edit fully protected pages, protect and unprotect pages from editing, delete and undelete pages, rename pages without restriction, and use certain other tools. Figure 4.6 shows the admin module of the malaria system.

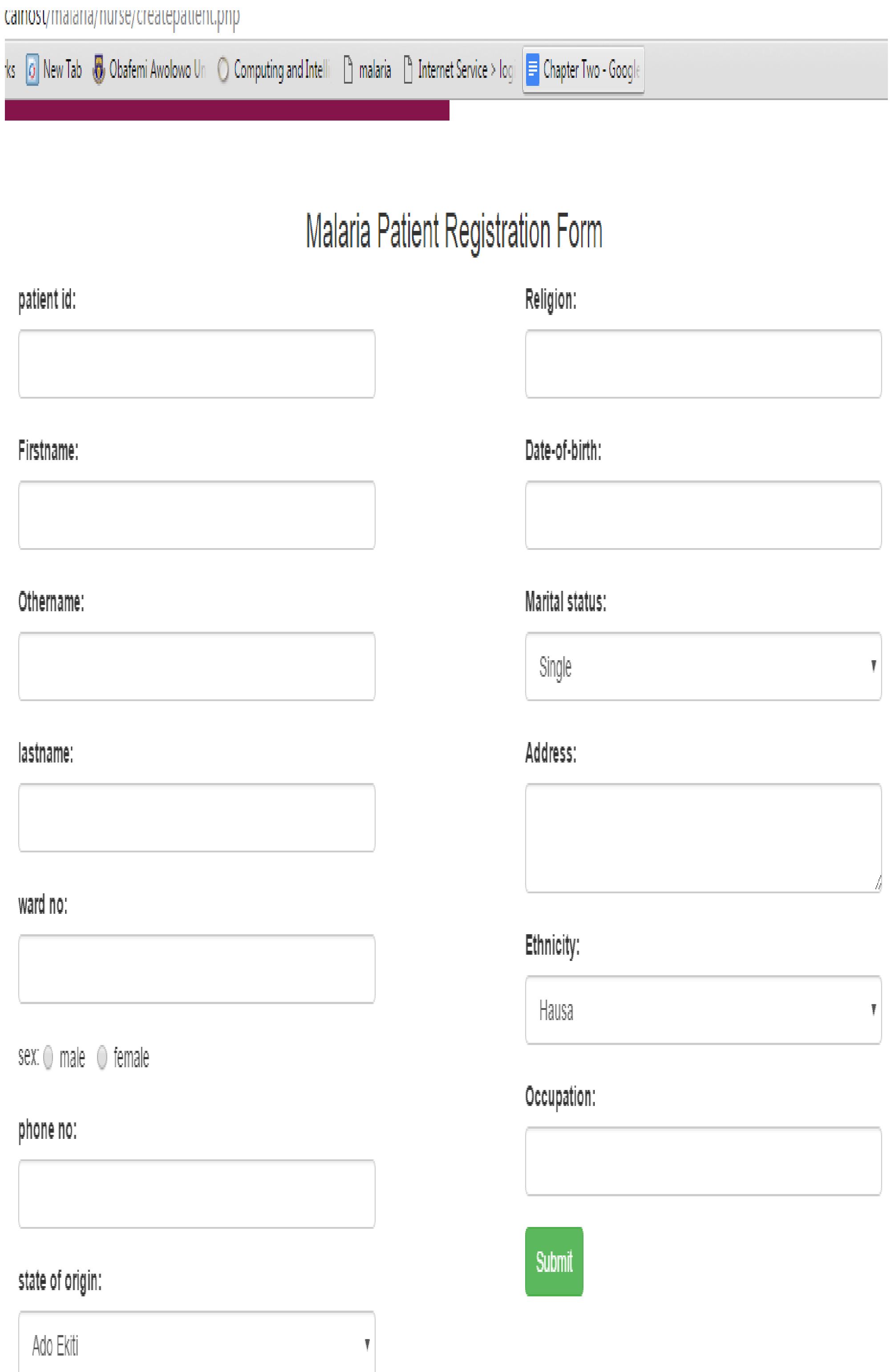

Figure 4.4: Patient Registration Page

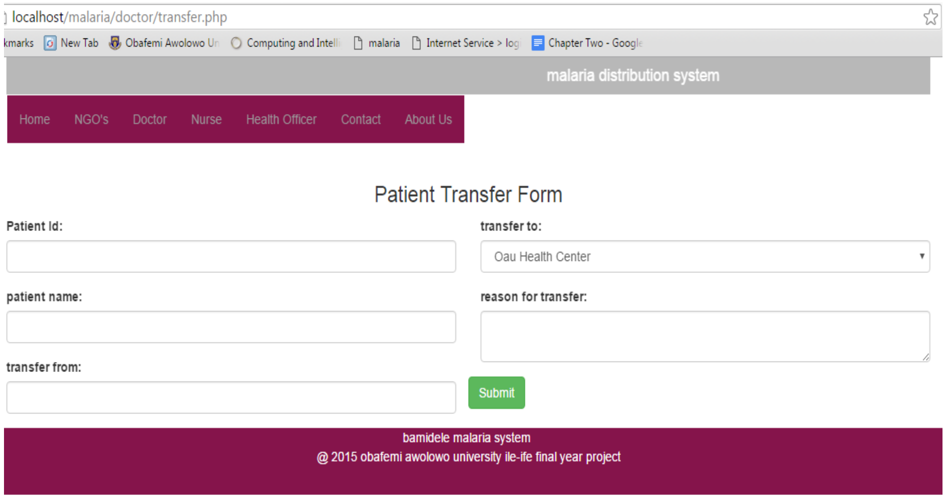

Figure 4.5: Patient Transfer Page

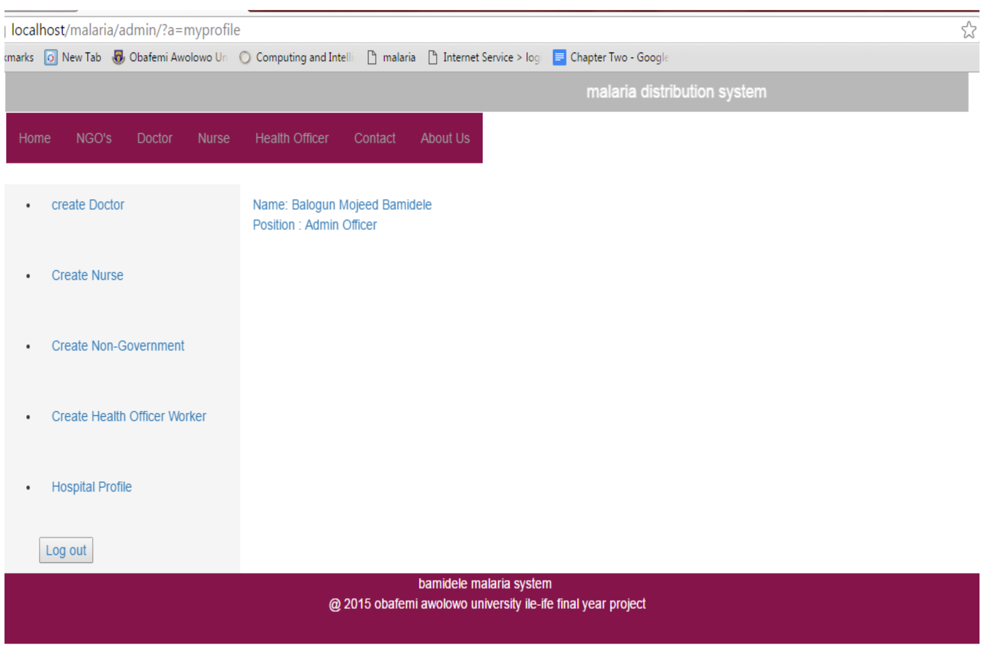

Figure 4.6: Admin Page

The malaria distribution module

The malaria distribution module is simply the geographical display of the spread of malaria in a map of the area of study. The map as shown in figures 4.7 and 4.8 displays the various towns in south-western states of Nigeria that have any record of persons living with malaria and the database. The malaria distribution module can only be functional or available as long as there is internet connection on the device being used to access the malaria distributed system. All authorized users of the malaria distributed can access this module. Figure 4.7 Show the malaria distribution of patients in Osun State also Figure 4.8 Show the malaria distribution of patients in Ekiti State.

4. DISCUSSION OF IMPLEMENTED DATABASE

The Database page shown tables and columns that are created based on entities and attributes that were defined during project requirement. Constraints are also defined, including primary keys, foreign keys, other unique keys, and check constraints. Views can be created from database tables to summarize data or to simply provide the user with another perspective of certain data. Other objects such as indexes and snapshots as shown in figure 4.9 below. The Database consists of several tables such as, Ack, Admin, Appointment, Transfer, Doctor, Nurse, Hospital, Hospital_Type, Local_Govt, NGO, State, Patient_Reg and Searchaddress table. Acknowledgment (Ack) table consists of doctor_id, patient_id, patient_name, hospital_name, reason for transfer and hospital transferring to.

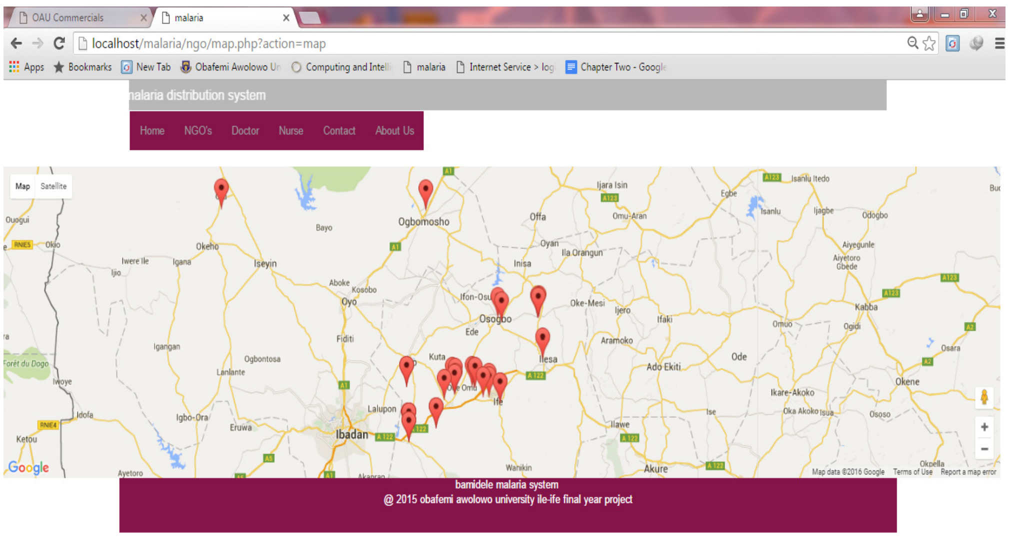

Figure 4.7: Malaria Distribution for Osun State.

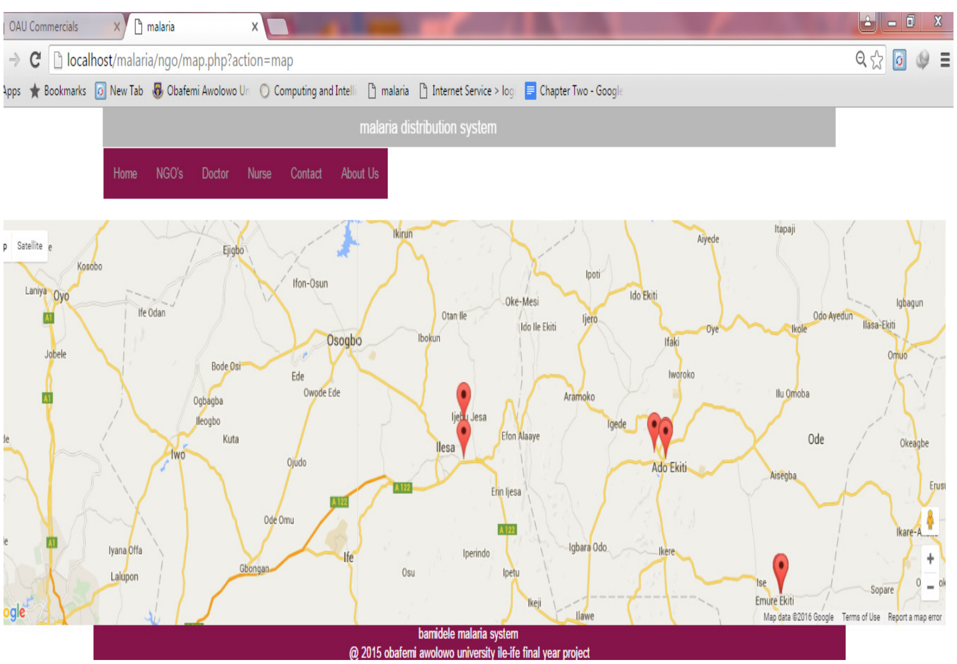

Figure 4.8: Malaria Distribution for Ekiti State

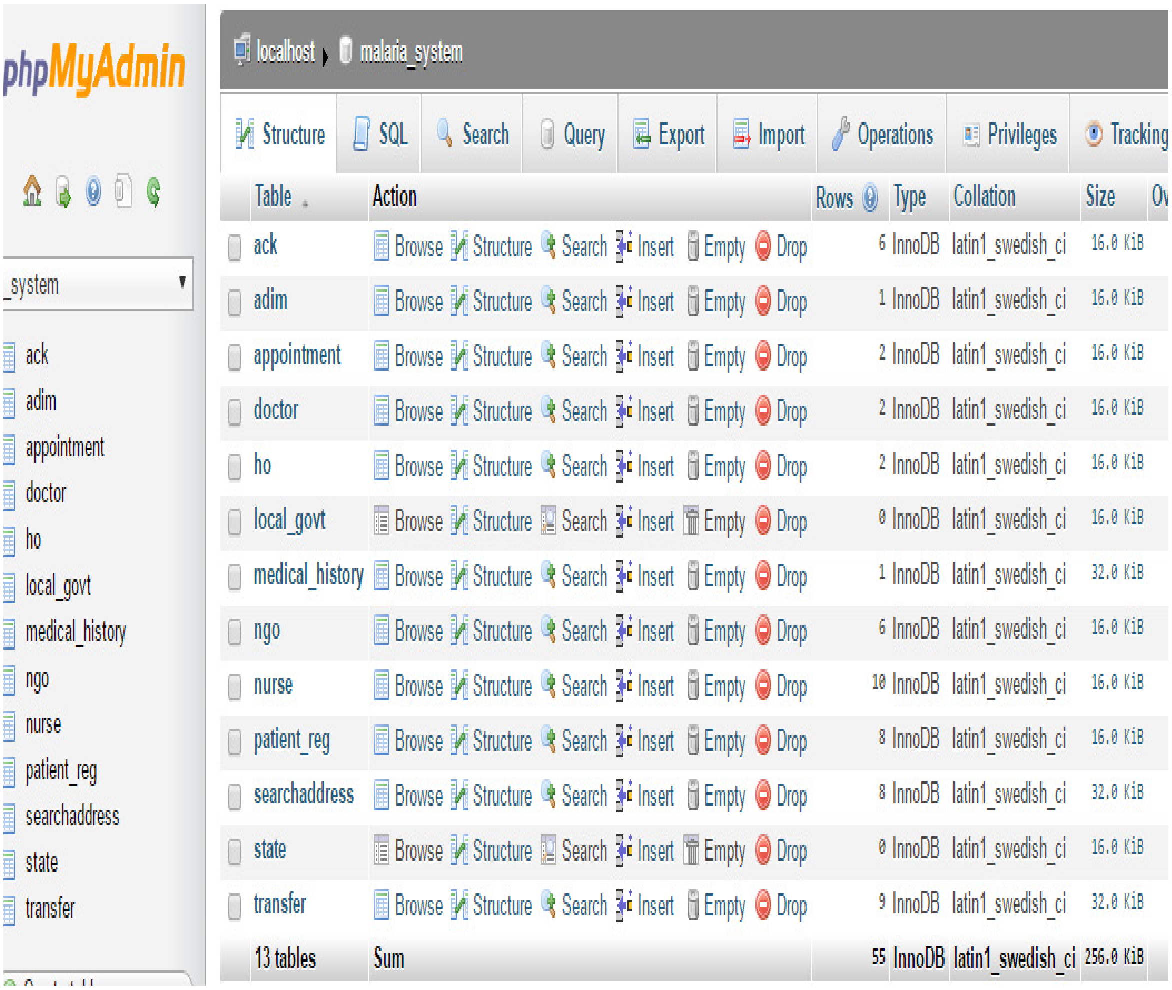

Table	Action	Rows	Type	Collation	Size
ack	Browse Structure Search Insert Empty Drop	6	InnoDB	latin1_swedish_ci	16.0 KiB
adim	Browse Structure Search Insert Empty Drop	1	InnoDB	latin1_swedish_ci	16.0 KiB
appointment	Browse Structure Search Insert Empty Drop	2	InnoDB	latin1_swedish_ci	16.0 KiB
doctor	Browse Structure Search Insert Empty Drop	2	InnoDB	latin1_swedish_ci	16.0 KiB
ho	Browse Structure Search Insert Empty Drop	2	InnoDB	latin1_swedish_ci	16.0 KiB
local_govt	Browse Structure Search Insert Empty Drop	0	InnoDB	latin1_swedish_ci	16.0 KiB
medical_history	Browse Structure Search Insert Empty Drop	1	InnoDB	latin1_swedish_ci	32.0 KiB
ngo	Browse Structure Search Insert Empty Drop	6	InnoDB	latin1_swedish_ci	16.0 KiB
nurse	Browse Structure Search Insert Empty Drop	10	InnoDB	latin1_swedish_ci	16.0 KiB
patient_reg	Browse Structure Search Insert Empty Drop	8	InnoDB	latin1_swedish_ci	16.0 KiB
searchaddress	Browse Structure Search Insert Empty Drop	8	InnoDB	latin1_swedish_ci	32.0 KiB
state	Browse Structure Search Insert Empty Drop	0	InnoDB	latin1_swedish_ci	16.0 KiB
transfer	Browse Structure Search Insert Empty Drop	9	InnoDB	latin1_swedish_ci	32.0 KiB
13 tables	Sum	55	InnoDB	latin1_swedish_ci	256.0 KiB

Figure 4.9: Physical view of the implemented database

Admin table consists of the admin_name, Username and Admin Password. The admin table allow the admin officer to login to the system to perform is normal routine function. The appointment table contains patient_id, ward_no, appointment_date, sex and appointment_time. The Nurse uses the information in the appointment table to create appointment for the patient. Doctor and Nurse tables contain the details of both the doctor and nurse such as; full name, username, password, phone_no, address, qualification, level, date-of-birth, specialty, gender and hospital_id. It grants the doctor the access to login into his/her profile. Hospitals table consists of hospital name, registration number, type_id and local government. Hospital_type table consist the id and type of hospitals we have such as the general hospital, private hospital, health care and teaching hospital. Local government (Local_govt) table consist the name of local government and state_id of each state. Also Non-government officer (Ngo) table consist of ngo_id, username, password, full name, gender, company name, company registration number, company address. Transfer table consists of ten (10) fields, such as Transfer id (tid), doctor id (did), patient id, patient name (pname), transfer from (tfrom), transfer to (tto) and reason for transfer(rfor), active status, created date and modified date. State table consists of five (5) fields, such as state id (sid), state name, active status, created date and modified date. Search address table consists of five (5) fields which include, Search_address, patient id (pid), latitude, longitude and local government.

4.1 Discussion of Results of Implemented System

The proposed malaria information monitoring system was developed as discussed earlier to facilitate the easy storage and monitoring of disease related information which can be easily accessed by Doctor, Nurse and Non-Government Officers who are registered to the system as authorized users. This system will also act as a means of providing effective and timely information concerning the state malaria in Nigeria, given the information found therein. The system also allows users to query information from different locations in South-western Nigeria from the units all to the sector commands. This system will be very useful to Nigeria as a result of the kind of information that is stored in the system. The malaria monitoring system was developed using the adopted data model to gather information comprehensively about malaria patients which will help to monitor and control the widespread of the disease and provide a database for south-western Nigeria for monitoring and controlling of malaria. This will also help in determining the distribution rate of malaria in south-western Nigeria and the prevalence rate of malaria in this region of the country. The proposed system allows for the users to register information, view malaria statistics and malaria distribution in different towns of south-west in Nigeria based on their user type.

Through the malaria monitoring system, the system admin managers and maintenance officers etc. will be able to access the information available in the system as long as they are registered. The information provided to these people may also be helpful in simplifying fresh policies that may help improve the state of malaria disease in Nigerian at large. In overall, the malaria monitoring system can become a central repository to all health across Nigeria with all information relation to malaria and health stored in one single system where analysis can be made to identify the kind of relationship that exist among the data stored. This system will hopefully aid effective and efficient intervention in the rate at which malaria is suing lives of Nigerian citizens. This will improve the standard of health care system. This system will also serve as way of having continuous admission to unpretentious statistics on malaria distribution (either hard copy or on the internet) in the nation.

5. CONCLUSION

Malaria monitoring system is designed to serve as an important platform for users to track down malaria disease in the country. It showed that it will truly serve as reliable information storage and retrieval system of malaria incidence in Nigeria. The system testing showed the effectiveness and user-friendliness of the system in terms of information storage and retrieval time, the malaria monitoring display on the map and the graphical user interface (GUI) design. The system was designed and developed to capture malaria patient's information such as the name, gender, occupation, marital status, ethnicity, malaria type, malaria level, nationality, residential address, state of origin etc. This project has shown that GIS is important to create operational maps which could help the vector control agencies to identify hazard and risk areas for disease control. Risk maps are fundamental for estimating the scale of the risk, and hence the resources needed to combat malaria. They provide standard for assessing the progress of control and indicate which geographic areas should be prioritized. It will also make provision for immunization and mobilization against malaria in the country.

REFERENCES

1. Akpan H. (1996). Home Management of Malaria in Children. Malaria Society Niger Newsletter. 1, 8-9.
2. Ambachew, M. Y. (2012). Malaria treatment in ethiopia: antimalarial drug efficacy monitoring system and use of evidence for policy. Unpublished Ph.D. thesis, Department of Health Studies, University Of South Africa, South Africa.
3. Asenso-Okyere, W.K., and Dzator, J. A., 1997. Household cost of seeking malaria care: a retrospective study of two districts in Ghana. Social Science and Medicine 5, 659–667.
4. Asenso-Okyere. W.K., (1994). Socioeconomic Factors In Malaria Controlǁ, *World Health Organization Forum*, 265-8
5. Breman, J.G., Alilio, M. S., and Mills A. (2004). Conquering the intolerable burden of malaria: *what's new, what's needed*: *Am J Trop Med Hyg , 71*(2 supply):1-15.
6. Breman J, Mills A, Snow R, Mulligan J, Lengeler C, Mendis K, Sharp B, Morel C, Marchesini P, White NJ, Steketee RW, and O Doumbo. (2006). Conquering Malaria,Chapter 21. Disease Control Priorities in Developing Countries (2ndEdition).Disease Control Priorities Project. Washington D.C.: The World Bank.
7. Brownson, R.C., Fielding, J.E. and Maylahn, C.M. (2009). Evidence-based public health: a fundamental concept for public health practice. *Annual Review of Public Health 30*: 175-201.
8. Dangermond, J. (2000). Preface. In L. Lang, GIS in health organizations. Redlands, CA: ESRI Press.
9. *Dellicour*, S., Tatem, A.J., Guerra, C.A., Snow, R.W., and ter Kuile, F.O. (*2010*). NewYork, E. P., Dutton. Hay, S.I., Okiro, E.A., Gething, P.W Published: Received from http://dx.doi.org/10.1371/journal.pmed.1000221
10. Fawole, O.I. and Onadeko M.O. (2001). Knowledge and Mana- ement of Malaria in Under Five Children by Primary Health Care Workers in Ibadan South East Local Government Area. *Nigeria. Post Graduate Medical Journal 8(1): 1-5*
11. Gudes, O., Kendall, E., Yigitcanlar, T., Pathak, V. and Baum, S. (2010). Rethinking health Planning: a framework for organizing information to underpin collaborative health planning. *Health Information Management Journal 39(2): 18-29.*
12. Idowu, A. P., Okoronkwo, N., and Adagunodo, R. E. (2009). Spatial Predictive Model for Malaria in Nigeria Electronic Version. *Journal of Health Informatics in Developing Countries, 3(2),30-36*, Accessed from http://www.jhidc.org/index.php/jhidc/issue/view/8s
13. Jacobs, J.A., Jones, E., Gabella, B.A., Spring, B. and Brownson, R.C. (2012). Tools for implementing an evidence-based approach in public health practice. Preventing Chronic Disease 9: 110324.
14. James, L. A.(2000). Humanity's Burden: A Global History of Malaria. Cambridge University Press 978-0-521-85418-4.
15. Jane, C. and Paola, M.(2004) 'Roll Back Malaria Department, World Health Organization, Geneva,'Reducing the burden of malaria in pregnancy, January
16. Kronick R, Goodman D, Wennberg J, and Wagner E. 1993. The demographic limitations of managed care. New Engl. J. Med.328:148–5.
17. Laari, P. B. (2011), Spatial analysis of malaria epidemiology in the amanse west district. Unpublished M.Sc. Thesis, Department of Geomatic Engineering, University of Science and Technology Kwame Nkrumah.
18. Malaria vector control and personal protection: report of a WHO Study Group. Geneva, World Health Organization, 2006 (WHO Technical Report Series, No. 936).
19. Malaria vector control and personal protection: report of a WHO Study Group. Geneva, World Health Organization, 2006 (WHO Technical Report Series, No. 936).Guidelines for the treatment of malaria, second edition. Geneva, World Health Organization, 2010.
20. Meade, M. S., and Earickson, R. J. (2000). Medical geography (2nd ed.). New York: Guildford Press.
21. Menach, A., I., McKenzie, F., E., Flahault, A. and Smith, D., L. (2005). The unexpected important of mosquito ovipostion behavior for malaria: non-productive larval habitats can be sources for malaria transmission.
22. National Center for Biotechnology Information, U.S. National Library of Medicine8600 Rockville Pike, Bethesda MD, 20894 USA, 2012
23. National Institute of Allergy and Infectious Diseases, (2007). U.S. Department of Health and Human Services National Institutes of Health
24. Niaz Arifin ,S.,M.,(2010).' Use of GIS in Malaria Research: Three Case Studie' Geographic information system (GIS).
25. Ogbonna, A. and Uneke, C. J., (2008) Artemisininbased combination therapy for uncomplicated malaria in sub-Saharan Africa: the efficacy, safety, resistance and policy implementation since Abuja 2000.Trans.R.Soc.Trop.Med Hyg.102, 621-627.

26. Oluwafemi O.A, Babatimehin O.I,Oluwadare T.S, Mahmud U.M (2013).Mapping Malaria Case Event And Factors Of Vulnerability To Malaria In Ile ife, Southwestern Nigeria: Using Gis. Ethiop. J. Environ. Stud. Manag. 6(4):2013
27. Onwuemele, O.(2014). An assesment of the spatial pattern of malaria infection in Nigeria, *International Journal of Medicine and Medical Sciences. Vol. 6(2), pp. 80-86,* February 2014. http://www.academicjournals.org/IJMMS
28. Peters G, Hall, G. B., (1999). Assessment of ambulance response performance using a geographic information system.Soc. Sci.Med.49:1551–66
29. Phillips R, Kinman E, Schnitzer P, Lindblom E, Ewigman B. 2000. Using geographic information systems to understand health care access. Arch. Fam. Med.9:971–78.
30. Persaud, H. (2013). Monitoring Community Health Using a W eb-Based GIS Application (Master's thesis, University of Redlands). Retrieved from http://inspire.redlands.edu/gis_gradproj/200.
31. Rushton, G., Armstrong, M., Gittler, J., Greene, B., Pavlik, C., West, M., and Zimmerman, D. (2006). Geocoding in Cancer Research: A Review. *American Journal of Preventive Medicine, 30(2S), S16-S24*. Received From http://dx.doi.org/10.1016/j.amepre.2005.09.011
32. Sara, L. M. 2003. Gis and Health Care. Department of Geography, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801-3671;
33. Thompson, A. (2004). 'Malaria: When Politics Kills'. This Day Newspaper, March 23 United States Embassy in Nigeria (2011). Malaria fact Sheet.
34. United Nations Children's Fund UNICEF.(2000), with the cooperation of the World Health Organization. The Prescriber: Malaria Prevention and Treatment.
35. World Health Organization.(2000),. "$1 to Roll Back Malaria." PartnershipVol1, No 8, , pp 9.
36. WHO guidelines for treatment of malaria. Geneva: WHO; 2006. WHO/HTM/MAL/2006.1108. 2006. Ref Type: Report
37. World Health Organization (2008): World Health Statistics Geneva, World Health Organization, 2008
38. World Health Organization (2010):Guidelines for the treatment of malaria, second edition. Geneva, World Health Organization, 2010. Malaria vector control and personal protection: report of a WHO Study Group. Geneva, World Health Organization, 2006 (WHO Technical Report Series, No. 936).
39. World Health Organization (2012): Malaria vector control and personal protection: report of a WHO Study Group Geneva, World Health Organization, 2006 (WHO Technical Report
40. World Health Organisation (2005). Public Health mapping and GIS, http://www.who.int/health_mapping/en [Accessed 22/Oct 2008.
41. World Health Organisation (2015). 'Guidelines for the treatment of malaria Third edition. Global Malaria Programme World Health Organisation, 20 avenue Appia, 1211 Geneva 2, Switzerland.