

THE UNIVERSITY OF NAIROBI



APPLICATION OF WEB-GIS AS A TOOL IN HMIS
CASE STUDY: BURUBURU ESTATE.

by

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**Project Report submitted to the Department of Geospatial and Space Technology
in partial fulfillment of the requirements for the award of the degree of
Master of Science in Geographic Information Systems**

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CERTIFICATION

This is my original work and has not been presented for a degree in any other university.

Signature:  Date: 30/08/2010
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This project has been submitted for examination with my approval as a university supervisor

Signature:  Date: 1/9/2010
Supervisor's Name: Dr. Faith Karanja

DEDICATION

To my mum and dad, Mr. and Mrs. Ivullu.

ACKNOWLEDGEMENTS

To my God, for giving me the strength and the ability to carry out this study.

Many thanks to my supervisor Dr. Faith Karanja of the University of Nairobi, for her valuable advice, patience and guidance throughout this research study. To Mr. Lwanga of the University of Nairobi, for giving me tips on data collection. To Anastasia and Job for technical assistance.

To beloved mum, Mrs. Deborah Ivullu, for tirelessly cheering me on and being there for me financially. I wouldn't have gone this far without you mum; you are my pillar of strength.

ABSTRACT

This study focused on the development of Web-GIS for Health Management Information System that provides empowerment to health consumers; i.e. citizens, patients, their families and caregivers by enabling these citizens to have more choice and control over their own healthcare. The aim being to provide information about health services, facility location and other health related information in order to enable patients to make decisions about their healthcare and that of their families. Patient empowerment involves citizens taking an active role in their own health management. It emphasizes the importance of individual involvement in health decision making. Consumerism therefore promotes the people's right to choose healthcare goods, products and services they purchase. It was noted during this study that consumers want better quality, speedy services, more choices, appropriateness of care, and affordability of healthcare services.

The web based technology employed also enabled the Web-GIS HMIS to be accessed by many users despite their location. The embedded database using GIS technology to provide users with solutions on their queries.

GIS was a vital tool in providing health facility location information through embedded Google maps. The map served a vital role in equipping the user with direction information and orientation once they are on the ground trying to locate the facility especially through relating existing features close to the facility of interest as shown on the map.

Despite the fact that this system has been designed with the patient as the user in mind it also contains information that could help health manager in health management matters for instance, it shows facility inventory and distribution which can help in the determination of equity resource allocation when evaluating health system performance. It also provides information like distribution of health facilities, number of doctors in each facility and patients attended per facility per day.

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LIST OF ABBREVIATIONS

GIS	Geographical Information Systems
HIS	Health Information System
HMIS	Health Management Information System
PHRIO	Provincial Health Records Information Officers
DHRIO	District Health Records Information Officers
XML	Extensible Markup Language
LHS	Left Hand Side
CDF	Constituency Development Fund
GOK	Government of Kenya
NSHIF	National Social Health Insurance Fund
MDGs	Millennium Development Goals
UN	United Nations
SQL	Structure Query Language
SSA	Sub-Saharan Africa
PAHO	Pan-American Health Organization
WHO	World Health Organization
NCC	Nairobi City Council
U.S.	United States
API	Application Programming Interface
KML	Keyhole Markup Language
KEPH	Kenya Essential Package for Health
MOH	Ministry of Health
SMS	Short Message Service

CHAPTER 1: INTRODUCTION

1.1 Background

There are several GIS related health care initiatives that have been conducted in Kenya.^[1,2,3,4] However, a gap was identified in the dissemination of health care information in regard to an overlook on a critical health care stakeholder; the patient. It was noted that, despite the various GIS related health care research studies, initiatives and GIS related health care databases^[1,4] that have been developed in Kenya, none of them has focused on directly addressing the needs of the health service consumer, particularly in availing and empowering the patient with relevant health care information that patients can use in making proper health care decisions. This project was carried out to fill the identified gap and address those patient related information needs in Kenya's health care system.

The lack of an enabling environment in Kenya's health sector system in form of a publicly available, accessible and easy to use Web-GIS Health Management Information Systems (HMIS) that provides hands on information to patient's health related needs and inquiries in regards to issues like choice of a health facility based on health services offered, operational hours and consultations fee, also promoted the need for this study to be conducted.^[1,4]

Accurate health information is the cornerstone of effective decision-making and reliable assessment of disease burden and resource needs.^[5,6,7] The Division of Health Management Information Systems (HMIS) works with the Provincial Health Records Information Officers (PHRIO) and District Health Records Information Officers (DHRIO) to maintain a list of health facilities in Kenya.^[8] Though this data is available, it does not include most of the health care facilities in level 1 and 2 of health care delivery in the Kenya Essential Package for Health (KEPH).^[9]

The populated health facility list contains, the unique identifying code of each facility that should be used on all health information systems, studies and surveys, the administrative boundaries of province, district, division, location and sub-location, constituency, The official address, phone numbers and email and the name of the in-charge (if known), The classifications of the facility including the facility type, owner and operational status and the major services that are offered.

Central to a fully operational HMIS is a basic inventory of all functioning health facilities and the services they provide. Such an inventory requires a spatial dimension, allowing facilities to be linked to the populations they serve and other proximate determinants of health such as environment, poverty and education. This spatial linkage can be provided by GIS. The use of GIS for health services planning is widespread in developed countries^[10,11,12] but there are few examples of their development and operational use in resource poor settings in Africa.^[1]

In Kenya, a map of health facilities was produced in 1959 but not up-dated until 2003.^[9] Since then, there has been an expansion in funding and resources in the health sector following the election of a new government in 2002 that promoted the establishment of a constituency development fund (CDF) to fund local development projects including the building of new health centers and dispensaries where need. To reflect these changes and map the equity of expanded service provision since 2003, a spatial audit of public health facilities in Kenya against high resolution population density maps projected to 2008 was undertaken.^[1]

In Kenya's health care system basic primary care is provided at primary healthcare centers' and dispensaries. Dispensaries are run and managed by enrolled and registered nurses who are supervised by the nursing officer at the respective health centre. They provide outpatient services for simple ailments such as the common cold and flu, malaria and skin conditions. Those patients who cannot be managed by the nurse are referred to the health centers. Sub-district, district and provincial hospitals provide secondary care, i.e. integrated curative

and rehabilitative care. Sub-district hospitals are similar to health centers with the addition of a surgery unit for Caesarean sections and other procedures. District hospitals usually have the resources to provide comprehensive medical and surgical services. Provincial hospitals are regional centers which provide specialized care including intensive care, life support and specialist consultations. Third level care is provided at the general hospitals Moi and Kenyatta, located in Nairobi. Gaps, which regularly appear in the system, are filled by private and church run facilities.^[13]

The best quality of care is found at national referral hospitals, which represent the apex of the healthcare system and provide diagnostic, therapeutic and rehabilitative services. The two public national referral hospitals are Kenyatta National Hospital in Nairobi and Moi Referral and Teaching Hospital in Eldoret. The equivalent private referral hospitals are the Nairobi Hospital and the Aga Khan Hospital, also in Nairobi.^[13]

GIS technology is increasingly being used in many areas of health care research and planning.^[14] One important area in which GIS is increasingly being applied in, is in the design and evaluation of health care programmes.^[10] GIS is the most appropriate technology for; analyzing of spatial data, establishing linkages, visual thinking, visual communication and manipulates map data.

1.2 Problem Statement

There is lack of a patient related Health Management Information System in Kenya's health system in form of a publicly accessible web-GIS HMIS that can provided hands on information to patient and other care givers through querying the system to retrieve health facility related information that can help in making decisions like choice of a health facility based on health services offered, consultation fee, type of facility and operational hours. This information is currently not available to the residents in the Buruburu community and to the entire Kenyan population.

1.3 Objectives of the Study

The main objective of this study is to create a web-based GIS healthcare Management Information System (HMIS) that is efficient and accessible for Buruburu estate.

Specific objectives:

1. To identify indicators that define health facilities.
2. To develop a GIS database for healthcare facilities combining both spatial and non-spatial attributes.
3. To develop a Web-based GIS for Healthcare Management Information System (HMIS).
4. To determine ways to validate the web application

1.4 Justification of the Study

The Web-based GIS information system created an enabling environment for the residents of Buruburu Estate; the chosen area of study, to access health related information at a click of a button on performing a search based on predefined controlled input criteria. The success of the Web-GIS HMIS in the pilot area; Buruburu, will then be used as a basis for lobbying health managers to initiate the development of a similar nation wide Web-GIS HMIS.

This web GIS HMIS will endeavor to fill the information dissemination gap and address those patient related information needs identified in regards to the availability of health care information to the patient. It will also uphold some of the MOH defined patient rights including; right to accurate information, right to timely service; right of choice of health provider or service, right to personal or own opinion and right to emergency treatment anywhere.^[15]

1.5 Scope and Limitations of the Study

The study covered a small geographical area in Madaraka division. It was used as a pilot study to show case the already increasing in need and the benefit of developing a nation wide Web-GIS HIMS addressing patients information needs. Lack of financial support, short project duration; three months, necessary high level of expertise in GIS lead to the inability to design a national Web-GIS HMIS covering the entire country of Kenya.

1.6 Overview of the Methodology

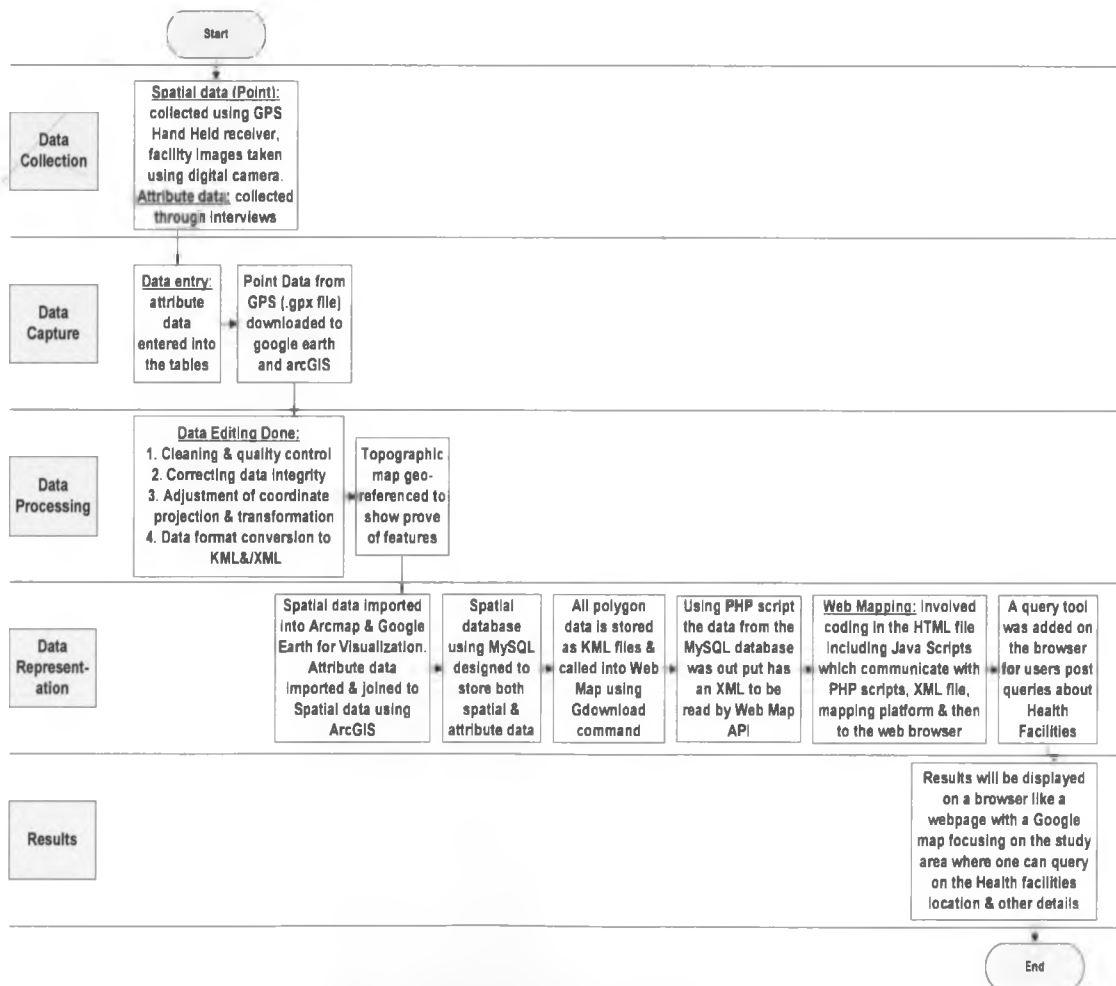


Fig. 1.1: Methodology Flow Chart Diagram

1.7 Organization of the Report

The final report will be organized in chapters and it will essentially consists of five chapters each having several sub-topics discussed under it as outlined in the table of content; Chapter one will generally cover the introduction of the problem generally. Chapter two will give an outline of the literature review. Chapter three will feature the methodology that will be used in attempting to solve the problem, Chapter four will show the results achieved after implementing the methodology, analysis and discussion. Finally chapter will consist of conclusions and there after recommendations.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The Government of Kenya has addressed the issue of inequalities and poor performance in a number of policy documents. The efforts made under the First Health Sector Plan (1999-2004) did not contribute towards improving Kenya's health status. In 2005, the Second Health Sector Strategic Plan was implemented. This will run until 2010. In order to improve the funding of the healthcare system and to give more Kenyans access to better healthcare, the Ministry of Health is planning to introduce a National Social Health Insurance Fund (NSHIF). This is a social insurance scheme to which everyone will contribute. Kenya's Health services are provided through a network of over 4,700 health facilities countrywide, with the public sector system accounting for about 51% of these facilities.^[13]

2.2 What is Health Information Management Systems?

HMIS is a system that provides information to patients to support their decision-making process and integrates data collection, data processing, reporting, and use of the information necessary for improving health service effectiveness and efficiency through better management at all levels of health services.

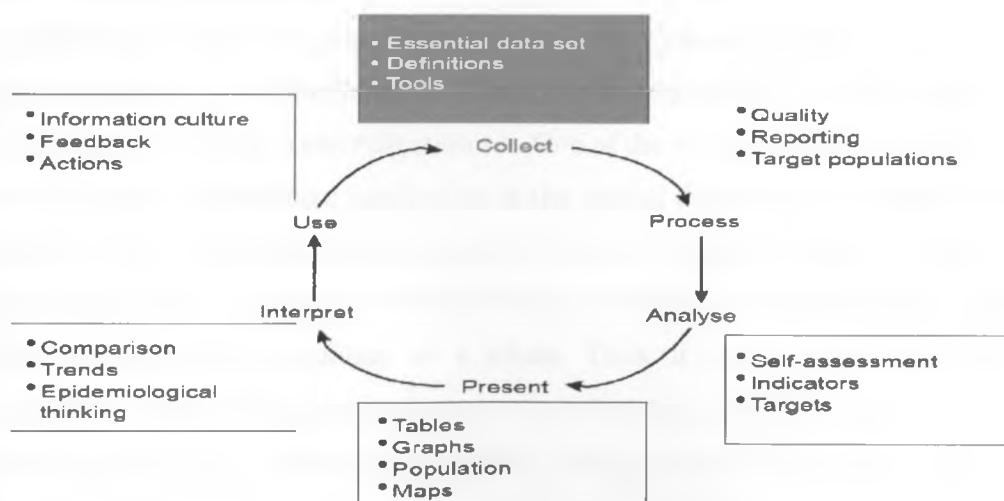


Fig. 2.1 Health Information Cycle^[16]

2.3 Why Develop Health Management Information Systems

2.3.1 Health Related Millennium Development Goals

The international development agenda is now driven largely by eight millennium development goals. Countries are supposed to achieve the various stipulated MDG goal by the year 2015.^[17,18] Three are health related MDG goals; goal 4: reduction of child mortality; goal 5: improvements of maternal health; and goal 6: combating HIV/AIDS, malaria and other major diseases. The failure of health systems in low-income countries to deliver equitably appropriate preventive and curative health interventions continues to be a major constraint to achieving these three millennium development goals.^[19] An important indicator of whether a health system is equitable is the level of the population's access to and use of health services.^[20] The development of a HMIS will help Governments in low-income countries access to meaningful information that will enable situation analysis to be carried out to show the current status as far as health related goals are to be achieved and the intervention measures to be put in place to improve the situation.

2.4 GIS as a Decision Support Tool in HMIS

GIS refers to a computer-based system for storing, analyzing, and displaying map and database information. GIS technology is becoming a vital tool in healthcare applications.^[21] It is increasingly being used in many areas of health care research and planning.^[14,22] Its benefits include database management, planning, risk service area mapping, location identification etc. One of the reasons for this sudden surge of GIS usage in healthcare application is the spatial dependency of health related factors and limited resources for every health requirements need to be addressed in spatial domain in order to identify what is needed at individual location rather than looking into a problem as a whole. Thus, it has become important to recognize local healthcare needs given the healthcare demands, social status and services that are available in the locality. This is where GIS could function as a very important tool.^[21]

The increasing availability of remotely sensed data sets and other digital databases, combined with declining hardware and software prices and improvements in GPS accuracy, have encouraged widespread use of GIS in health care. On the contrary due to poor infrastructure, expertise and cost constraints many developing countries suffer from a lack of reliable statistics. GIS can help significantly in this area by filling the gaps. GIS is therefore considered an appropriate technology for developing countries.^[21] The main components of GIS include;^[23]

Hardware. For instance a computer unit which is the device that the user interacts with directly to carrying out GIS operations by typing and or clicking and which after performing the user defined transaction returns information by displaying it on the screen.

Software. A program that runs either locally for a user using a standalone computer or remotely for a user whose computer is in a network environment.

Database. A collection of tables containing meaningful data that meet user needs. This consists of a digital representation of the Earth's surface built to for problem solving.

People. People in GIS range for GIS experts like programmers to the consumers of GIS products; users.

Procedures. These are organizational procedures that dictate lines of reporting, control points and other mechanisms for ensuring GIS activities meet organizational needs.

The main basic functions of GIS are data acquisition and pre-processing, database management and retrieval, spatial measurement and analysis and graphic output and visualization.

2.5 Why Web GIS for HMIS

A paper map shows only spatial data such as lakes, roads, and vegetation. A Geographic Information System (GIS) goes further by linking attribute data to spatial data.

When GIS data and functionality are made available over the Internet, the system is referred to as a 'Web GIS'. With Web GIS, users do not need to purchase and install expensive GIS software in order to access and work with maps and databases. Also, users do not need to become experts in sophisticated GIS applications, since the functionality is made available through a regular web browser and an integrated Viewer with a simple, user-friendly interface.^[24]

2.6 Benefits of Web-GIS HMIS

The World Health Organization (WHO) argues that investment in health management information systems (HMIS) now could reap multiple benefits, including:^[25]

- Maps can be created dynamically and served over the web.
- Empowering individuals and communities with timely and understandable health-related information, and drive improvements in quality of services.

2.7 Challenges of Web-GIS HMIS

Bandwidth; Web maps usually need a relatively high bandwidth to load.

Privacy issues: With detailed information available and the combination of distributed data sources, it is possible to find out a lot of private and personal information of individual persons.

Quality and accuracy issues; Many web maps are of poor quality, both in symbolization, content and data accuracy.

Complex to develop; Despite the increasing availability of free and commercial tools to create web mapping and web GIS applications, it is still a complex task to create interactive web maps.

Reliability issues; The reliability of the internet and web server infrastructure is not yet good enough especially if a web map relies on external, distributed data sources, there is no guarantee on availability of the information.^[26]

2.7.1 Constraints in Health Care Systems

Health care systems in sub-Saharan Africa face increasingly diverse and complex health problems, rapidly growing populations, and severe resource constraints. Rational allocation of scarce resources is difficult and is dependent on the size of catchment populations. Expensive hospital-based health care systems are protected by strong vested interests, reorientation is mainly rhetorical, and primary health care is making only slow progress. Health care management and the use of health information at the local level are restrained by highly centralized decision-making processes. Several other weaknesses further restrict the usefulness of the health information system in Kenya. Some highly desirable information such as population-based epidemiology, service quality data, and socio-cultural information is not being collected. Problems also exist in the flow of information from the field, including delays, non-reporting, non-response, and a generally unsatisfactory quality of generated data. Moreover, current reporting is largely restricted to acute and brief illness episodes in people fit and affluent enough to seek care at a health facility; those who live far away, are too sick to travel, are worried about cost implications, or are chronically sick and disabled and have little to benefit from a visit remain "invisible," neglected by the service system and overlooked by planners. Much of this is known by the local community, but unknown to the health care system and its staff.^[13]

Operational constraints also hamper the implementation of a comprehensive HMIS, including getting the coding right, technical support, and data storage and use.

2.8 Effective, Quality and Accessible Health Care

2.8.1 Health Care Facilities Utilization

In India a study on health care services was done in the city of Pune in 2009. GIS was employed to assess optimal location of hospitals and clinics, the relationship between existing locations and health care needs, population distribution in relation with availability of hospitals and clinics, analyze the health care services already existing in the city and to study the area covered by each health centre using network analysis. With the help of GIS they found that; hospitals in Pune city though sustainable needed an apt update in terms of their numbers.^[21]

2.8.2 Catchment Populations

The Kenyan population is heterogeneous with ethnic, religious, and socioeconomic differences influencing illness concepts and demands for health care. However, the only available information on the local population is the Census of Population, normally conducted every 10 years, which does not coincide with the actual catchment populations served by health facilities. The health information system should reflect these circumstances, but available data are almost exclusively about care-seeking clients and their service utilization. A need exists for a more precise and complete description of the catchment population and health situation. It is important to generate this information at village, community, and division levels. Three interrelated problems are prominent. First, health care planning and programming are highly centralized and largely incremental in nature. Second, most staff are poorly prepared for management and planning responsibilities, particularly at and below the district level. Third, existing health information systems are unsatisfactory both as tools for planning and as a basis for local community development and action. The use of geographic information systems for determining catchment populations may help to alleviate some of these inherent problems.^[13]

2.8.3 Access to Health Care Facilities

Distance is a crucial feature of health service use and yet its application and utility to health care planning have not been well explored, particularly in the light of large-scale international and national efforts such as Roll Back Malaria.^[2] As distances to the nearest health care facility increases, roads play more of a role in determining accessibility, because an increasing proportion of people make use of public transportation.^[27] The resulting catchment boundaries constitute a line of equal travel time between neighboring clinics.

Improved access to primary health care is required for the successful attainment of at least three of the United Nation's (UN) Millennium Development Goals, that is, goal 4: reduction of child mortality; goal 5: improvements of maternal health; and goal 6: combating HIV/AIDS, malaria and other major diseases. The effective delivery of health care in developing countries and development of the systems to provide it, remain problematic. Knowledge and understanding of health care usage and population distribution is vital for health resource allocation and planning. Good health system management depends on informed decisions regarding resource allocation. These decisions however occur in the absence of data that allow the pattern of resource allocation to be assessed. This analysis of resource allocation is an area in which GIS significantly contributes in through its ability to 'layer' multiple data sets from different data sources.^[22]

Modeling distances travelled to government health services is an evaluation that was conducted in Greater Kisii, Bodo, Kwale and Makueni districts in Kenya in 2006. It was aimed at describing measures of spatial access to medical treatment, as part of the millennium development goals to reduce the burden of HIV/AIDS, tuberculosis and malaria. Extrapolation of the results from the best-fit model in study districts to the national level showed that approximately six million people are currently incorrectly estimated to have access to government health services within 1 hour. Simple Euclidean distance assumptions, which underpin needs assessments and against which millennium development goals are evaluated, thus require reconsideration.^[3]

Another similar evaluation was conducted in the same study area named above on defining equity in physical access to clinical services using GIS as part of malaria and monitoring in Kenya. Equity in service provision is increasingly being used as a measure of health system performance.^[20,28,29,30] Equity manifests itself in the distribution, access to and utilization of health services between population groups.^[28,31] Access to health services is influenced by many behavioral, cost and distance factors and utilization of health services is increasingly being viewed as a function of accessibility.^[28,32,33,34,35,36]

2.9 Databases for Health Management

Accurate health information is the cornerstone of effective decision-making and reliable assessment of disease burden and resource needs.^[5,6,7] For HMIS to function well, a reliable inventory of health service providers is critical. The spatial referencing of service providers to allow their representation in a geographic information system is vital if the full planning potential of such data is to be realized.^[1]

2.9.1 National Health Facility Database in Kenya

In 2003 a national database of government, mission, non-governmental organization, local authority and private sector health service providers was completed and assembled.^[1]

By 2007 there had been no concerted effort to update a single list of health service providers across Kenya with a unique spatial identifier. However, since the first facility audit and mapping exercise there have been several notable improvements in information available on both the existence of service providers and their location that could be used to update and improve the database constructed in 2003. The launch of Google Earth in June 2005^[37] meant that iteratively the imagery of Kenya had improved, allowing visualization of buildings

and roads when streamed at high resolutions. This added capacity to locate structures in space was used to triangulate crude coordinates provided from hand-drawn maps and other less reliable sources to visualize building structures likely to be health facilities and re-positioned more accurately. Over a period of three months in 2008 these combined sources were used to re-configure an updated inventory of health service providers and improve the resolution of geo-referencing. No new information was available on the private sector, a prolific and hard to enumerate source of health care in Kenya. The analysis presented here therefore considered only the public sector providers.^[1]

2.9.2 Databases for Equitable Health Service Planning

While high-income countries are able to fund and integrate new information tools to guide national health policy, low-income countries who bear the majority of the global burden of disease, have inadequate and poorly performing HMIS. Many countries in Sub-Saharan Africa (SSA) have embraced the need to develop broad health sector reforms linked to poverty reduction strategies.^[4]

Developing a framework for equitable and effective resource allocation for health depends upon knowledge of service providers and their location in relation to the population they should serve. The last available map of health service providers in Kenya was developed in 1959. A health service provider database was built from a variety of traditional government and opportunistic non-government sources and positioned these facilities spatially using global positioning systems, hand-drawn maps, topographical maps and other sources. Efforts to recreate a comprehensive, spatially defined list of health service providers identified a number of weaknesses in existing national health management information systems which with an increased commitment and minimal costs can be redressed to enable geographic information systems exploit more fully facility-based morbidity data, population distribution and health access models to target

resources and monitor the ability of health sector reforms to achieve equity in service provision.^[4]

In 2004 a study was done on the creation of defined database for equitable health services planning in low-income countries in Kenya. It described the efforts in the reconstruction of the national map of health service providers in Kenya using all available information. Since independence in Kenya (1963) continuous attempts have been made to create an equitable health care system. The last available map of health service providers in Kenya was developed in 1959. The study also highlighted the current HMIS problems facing Kenya and similar countries in the region and explored how these might be resolved through coordinated efforts using GIS applications by demonstrating the simple use of GIS data to highlight disparity in physical access to health service.^[4]

2.10 Success Stories on Web-based HMIS

UNHCR's Health Information System (HIS) was designed to monitor and evaluate refugee public health and HIV programmes. The aim of developing the system was to improve the health status of people of concern to UNHCR, through evidence-based policy formulation, improved management of health programmes and, ultimately, direct actions that improve refugee health. At the start of 2010, UNHCR's HIS became operational in 18 countries in Africa and is used to monitor health services provided to some 1.5 million camp-based refugees.^[38]

In Denmark free choice of hospitals was introduced on the public agenda in the early 1990s. Similarly, in Norway free choice of hospital was implemented in the whole country on January, 2001. In addition, information has increased such as national quality indicators and a public web page to make the choice easier for the patient. In other EU countries, social insurance systems are seeking to circumscribe patient choice (France, Germany). The purpose is to encourage use of 'preferred providers' to improve quality and moderate cost. The French Parliament adopted a 'Patients Rights and Quality of the Health Care System' law

in 2002. Under this law, patients are responsible for decisions regarding their health status having been provided with extensive medical information leading to informed and free consent and thus become partners with health professionals. Patient empowering is in first line of the principles inspiring health policy at Member States and the European Commission. Linked to the overall development of eHealth it can be detected a growing number of applications aiming to support patient empowerment policies.^[39]

South Africa has a well developed HMIS, whose core is based on the District Health Information System. In 2005, South Africa through University of Oslo initiated the development of District Health Information Software Version 2 (DHIS 2) which is a Free and Open Source Software (FOSS) for HMIS. This application is currently the national standard in South Africa and being used in all the health facilities in the country. It is platform independent, can run on both on-line and offline modes, is multi language enabled and integrated with various other applications such as Geographic Information Systems and Excel. Further, this application is being used in many countries in Africa such as Ethiopia, Nigeria, Botswana, Tanzania, Zambia, and, various other countries. In addition WHO and HMN (Health Metrics Network) are currently using DHIS 2 for implementing an integrated solution in the first HMN country - Sierra Leone. While DHIS 2 will be used for the aggregated statistics component of the HMIS, it will be integrated with a free software application called Open MRS for patient based management, and the WHO created Open Health for GIS and Web pivot tables.^[40]

CHAPTER 3: METHODOLOGY

3.1 Study Area

Buruburu estate is the largest middle class residential area covering approximately 3.3 Km² and 7 kilometers due east of the city center of Nairobi. Built in the 1970s and 1980s it is situated in Makadara constituency. It comprises of five phases; phase one being the oldest, phase two, phase three, phase four and phase five completed in 1982 (see fig. 3.2).

The population is estimated to be 30,000 people. The figure was inferred by multiplying the estimated on the number of housing units in the five phases in Buruburu Estate which was taken to be 5000 housing units by the estimated number of persons per housing unit which was taken to be 6.

Buruburu estate has remained a key shopping center to its residents and neighboring ones. It is inhabited by business people and professionals and a few expatriates; accommodation is mainly in small, two-storey townhouses. Apart from the existence of Uchumi, Naivas and Tuskys Supermarkets, institutions such as Co-operative Bank, Kenya Commercial Bank and K-Rep have set up branches while others such as Standard Chartered, Equity and Barclays banks have ATM points there. Even the Kenya Meat Commission also has a branch in the area.

In Buruburu a wide range of shops and amenities existing along Mumias South Road these facilities include a petrol station, supermarkets, a foreign exchange bureau and a chemist, as well as a private swimming pool and several pubs and bars. Access to M-Pesa and banking services pay for electricity and water. The shops draw crowds from outside the area, and there is heavy traffic along main roads. The area is served by bus and matatu with a taxi to the city centre charging around Ksh500.

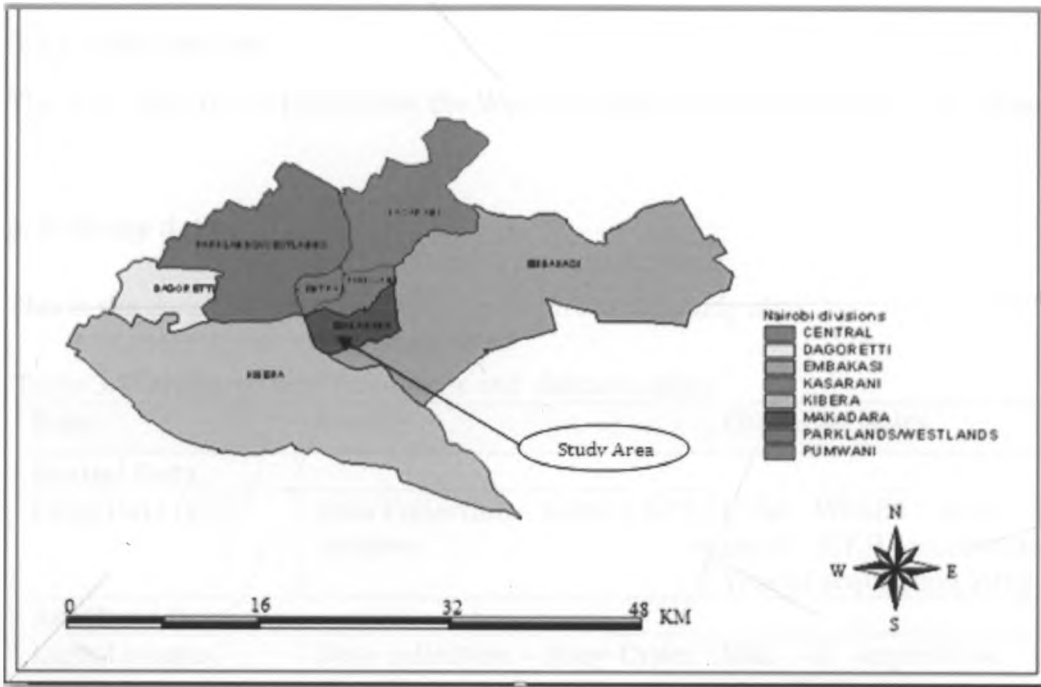


Fig. 3.1: Map Showing Divisions in Nairobi (Source, ILRI data 2006)



Fig. 3.2: Image showing Buruburu Estate (Google Maps, March 2009)

3.2 Data Sources and Tools

3.2.1 Data Sources

The data collected to implement the Web-GIS HMIS system was in two categories;

a. Primary data

This is the data that was directly collected from the study area.

Table 3.1: Primary Data, its sources and characteristics

Data	Source	Characteristics
Spatial Data		
Point Data (x,y)	Data Collection – Garmin GPS receiver	UTM WGS84 zone 37 south. X,Y,H coordinates, Year of acquisition 2010.
Attribute Data		
Digital images	Data collection – Sony Cyber Shot Digital camera	Date of acquisition: 17 May 2010, Spatial Resolution: 6.0 Mega Pixel
Health facility service data (see appendix I)	Data Collection – Interview	Date of acquisition: 8 May 2010

b. Secondary Data

This was the data that already existed from various outlined sources.

Table 3.2: Secondary data, its sources and characteristics

Data	Source	Characteristics
Spatial Data		
Population data (Total no. of housing units)	Lalji Meghji and Co. Ltd	Inferred data (No. of housing units x No. of persons per household)
Satellite imagery of study area	Google maps	Spatial resolution:20 Meters Date of acquisition:22 nd March 2009 Scale: 1:2500 for Nairobi

Digital maps of study area	i) Google maps ii) ILRI	i) Date of acquisition: March 2009 Spatial Resolution: 20 Meters Scale: 1:2500 for Nairobi ii) Year of acquisition 2006 Scale: 1:2500 for Nairobi
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3.2.2 Tools

Hardware

The Garmin 60CSx, update rate 1/second, acquisition times 1 second – warm start and 38 seconds cold start, overall accuracy was <10 meters (95% typical) and DGPS 3-5 meter. The handheld GPS was employed to capture and store the X and Y coordinate points for all the health facilities in the study area.

Sony Cybershot 6.0 Mega pixels. The digital camera was used to capture static digital photographs of each of the 19 health facilities in the study area.

4GB Sahara edrive flash disk; used to store a copy of the project files.

IBM ThinkPad Xseries Laptop; Intel duo core L7500 @ 1.65GHZ, 74.5 GB HDD, 0.95 GB RAM and a 13.5" screen display; used to prepare the project.

CD-R sony, 700MB; used to store the finalized project files.

HP LaserJet P4015n Printer and HP Color LaserJet 4700 dn; used to produce a hardcopy version of the final project for bidding then submission.

Software

Microsoft Office Visio 2007; was used for designing the project diagrams e.g. methodology flow chart, database external model, ERD.

Macromedia Dreamweaver 9.0; was used as an html/javascript editor that is an Integrated Developer Environment (IDE)

Microsoft Office suite 2007 – this combination of softwares were used to produce the final project report write up.

MySQL; Is an open source database that was used to design tables and store data.

PHP Application (Hypertext Preprocessor); A scripting language that was used to read data from MySQL database to the web browser. It was used to manipulate information held in the database and generate web pages dynamically each time content is requested by a browser.

Google Maps API (Application Programming Interface); Platform built by google for geolocating purposes, used for data representation and to customize the platform to suit the HMIS required results.

XAMP (Apache HTTP Server, MySQL, PHP and Perl); used as the Web development platform. It was used to define the Operating System (Windows), Web Server (Apache), database (MySQL), and scripting language (PHP). It also contained phpMyAdmin which provided a graphical user interface for the MySQL database manager.

3.3 Web-GIS in Health Care Management Information System

3.3.1 Data Collection

Primary data on health facility location, that is, point data was collected using handheld GPS. Services provided by health facility were collected through interviews and images of the health facilities were collected using a digital camera.

a. User Needs Assessment

User needs assessment was carried out to determine the various types of potential users of the HMIS and their information needs and the data that was required to satisfy those needs. Methods used to carry out the user needs assessment were as below.

i. Interviews

Patients at various health care facilities were interviewed including healthcare facility owners and or their staff to find out their information needs and what data was to be collected and to fulfill their needs. After the interviews were done it was established that majority of the patients required information on; healthcare facility operational hours, types of services offered, contact information for inquiry and emergency situations, location. For the healthcare facility owners and or their staff it was noted that they were keen to have information on facility location so that potential patients can know where to find the facility, clear outline of types services, who the owner of the facility is especially for recognized reputable names like Aga khan and metropolitan, name of the facility for ease of identification and facility type.

b. Definition of Healthcare Services and Health Facilities Indicators

The identification and definition of health facility indicators was carried out to make sure that from the primary data that was collected; health facilities types were correctly classified, health facility ownership was rightly recorded and the various numerous services were categorized according the health standards of the Kenya health system stipulated in the Kenya Essential Package for Health (KEPH).

i. Types of Health Facilities

Dispensaries are classified under level 2 of Kenya Essential Package for Health (KEPH). It is a specialized ambulatory facility which can be assigned to a hospital or serve as an independent institution.^[9] Dispensaries can also be defined as medical facility that dispenses free or low cost medicine and offer curative, rehabilitative, preventive, and promotive services and coordinates information flow from facilities in catchment area, serving no more that a population of 10,000 people.^[41]

Clinics are also classified under level two of KEPH is the clinic, which is for short term, non life threatening care. The clinic is a small private or public health facility that is devoted to the care of outpatients, often in a community, in contrast to larger hospitals, which also treat inpatients. It offers primary health care services, rehabilitative, curative, preventive, and promotive services and coordinates information flow from facilities in catchment area^[41], and opens at least 8 hours a day at least 4 days a week.^[29]

Health Centres are classified under level three of KEPH, the network of health centres in Kenya provides many of the ambulatory health services serve no more than 30,000 persons.^[41] In addition to level 2 activities health centres generally offer a wider range of services, such as basic preventive services for adults and children, curative services, mostly adapted to local needs, minor surgical services such as incision and drainage, limited emergency inpatient services, limited oral health services, maternity for normal delivery, laboratory, reproductive health services. They are staffed by midwives or nurses, clinical officers, and occasionally by doctors and augment their service coverage with outreach services, referring severe and complicated conditions to the appropriate level, such as the district hospital.^[9]

The Hospital existing in the study area is categorized under level four of KEPH. Hospitals in this level concentrate on the delivery of health care services. They

serve no more than 1,000,000^[41] persons, for long term, emergency and non emergency care with beds.

Hospitals are the facilities for clinical care at the district level. They are the first referral hospital. Hospital should provide the following: Curative and preventive care, quality clinical care by a more skilled and competent staff than those of the health centres and dispensaries, laboratory and other diagnostic techniques, surgical, outpatient activities, inpatient care until the patient can go home or back to the health centre, twenty-four hour services.

ii. Types of Ownership

Public: A unit delivering health services where the service provider is a government department.

Private: A unit delivering health services where the staff delivering the service is employed by any organization that is not a part of government for profit or not-for-profit.

Institutional: A unit delivering health services where the service provider is an institution e.g. school. [42]

iii. Definitions of Health Service

These definitions apply to health services in all cases. That is services that involve patient contact for diagnosis and treatment provided by health professional.

General: A unit delivering a range of services, usually related to an expected package, and within the scope of service of the health practitioners providing the services.

Specialized: A unit delivering a particular type of service relating to a particular patient group, disease or treatment.

iv. Levels of care

Outpatient Care: This is a non-admitted care where consultations, interventions, tests are done.

Primary Health Care: A set of prescribed services, generally falling within the skill base of a professional nurse, technician, mid level worker, counselor, community health worker, midwife and emergency medical practitioner. These services may be first point of contact or for follow-up care.

Referred Outpatient Care: Services provided by and requiring the skills of a general medical practitioner, a medical specialist or an allied health professional to which patients are referred, usually by appointment, for more specialized opinions or care. These will include referrals to general medical or surgical etc outpatients as well as referrals to specialist clinics.

Day Care: Treatment, observation or assessment that requires an extended stay, usually beyond the treatment or consultation as an outpatient, but of less than 1 day. Day case patients do not get counted in the midnight bed count.

Inpatient Care: Patients are admitted to hospital for at least one night for diagnosis, investigation or treatment.

3.3.2 Data Preparation

This phase involved data editing. Data editing was done to remove of errors in the spatial data collected using the hand held GPS and attribute data collected thorough interviews. The editing task included;

- Cleaning and quality control
- Checking and correcting the integrity of the captured data.
- Check on co-ordinate projection and transformation, and adjustments where necessary

- Conversion of data format to Google Earth's KML and/or xml. Others involve, removal of dangles, overshoot, undershoot and spelling mistakes.

3.3.3 GIS Database Development

The procedure below was used to create the database.

Data requirement of the database was done using external modeling to find out what data was required in each field of a table. Out of the external models identified an external model diagram was designed.

Entity relationship diagrams were designed in the conceptual model showing all the entities involved their relationships and attribute.

A list of the entities, their relationships and respective primary keys, foreign keys and attributes were defined in the logical model of database design.

Database tables were created by defining the fields in each table in the physical model of database design. The properties of each field were defined by specifying the data type, field size, validation rule, requirement constraint, format and indexes.

a. External Modeling

This was the determination of potential users of the database, their information needs and the data required to be housed in the database to meet those requirements. External modeling ensured a common understanding between the database developer and those who have a vested interest in the set up of the database; the patients, facility owners and the Government. This was critical to the success of the database development. In the definition of the requirements it was made sure that the requirements were actionable, measurable, testable, related to identified needs, and defined to a level of detail sufficient for database design. Requirements were determined by collecting information from a sample

of patients through interviews and from the health facility owners/staff. External modeling was the first step in database design of the HMIS database.

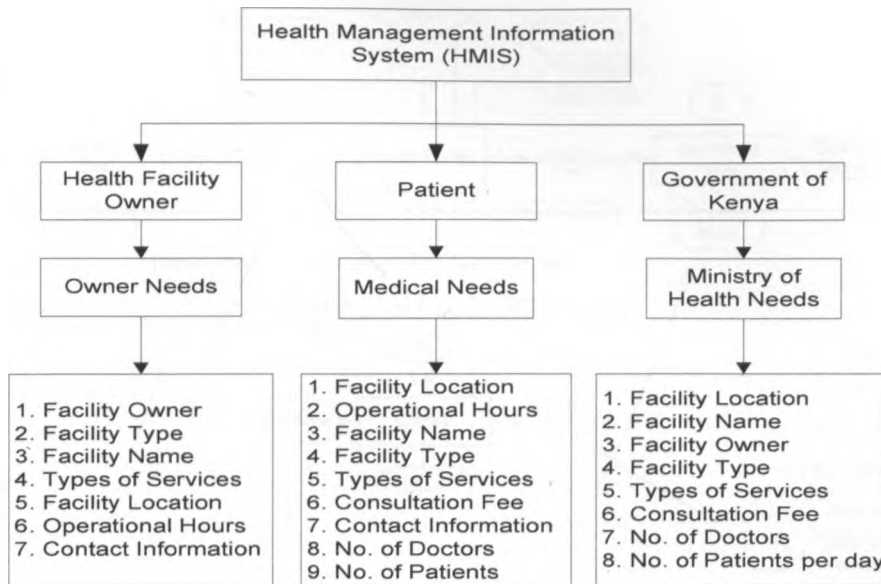


Fig. 3.3: Web-GIS HMIS External Model of the Database

b. Conceptual Modeling

In this type of modeling all external models were constructed and converted into an entity relationship diagram (see fig. 3.4) showing all the entities involved their relationships and attribute. Features of conceptual data model included:

- Identification and definition of all entities and the relationships among them.
- No specification of attributes.
- No specification of primary keys.

Conceptual modeling was the second step of the database design. It entailed the creation of a conceptual data model diagram popularly referred to as the Entity Relationship Diagram (ER-D) for the web-GIS HMIS database. This data model was built using the information obtained from conducting the user needs assessment.

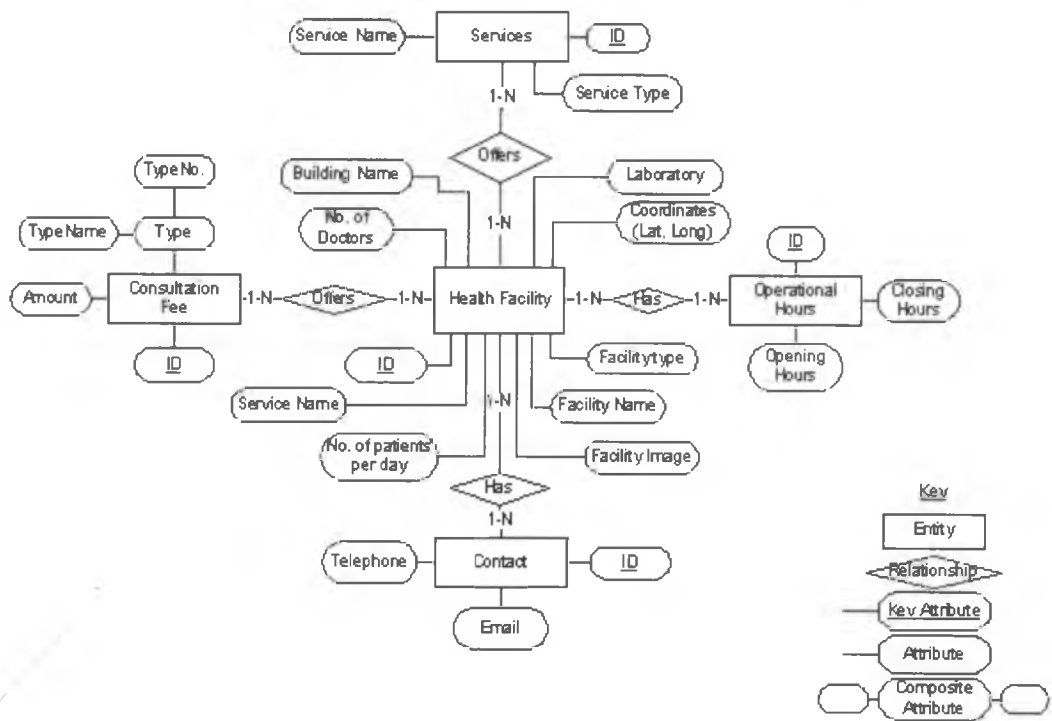


Fig. 3.4: Entity Relationship Diagram

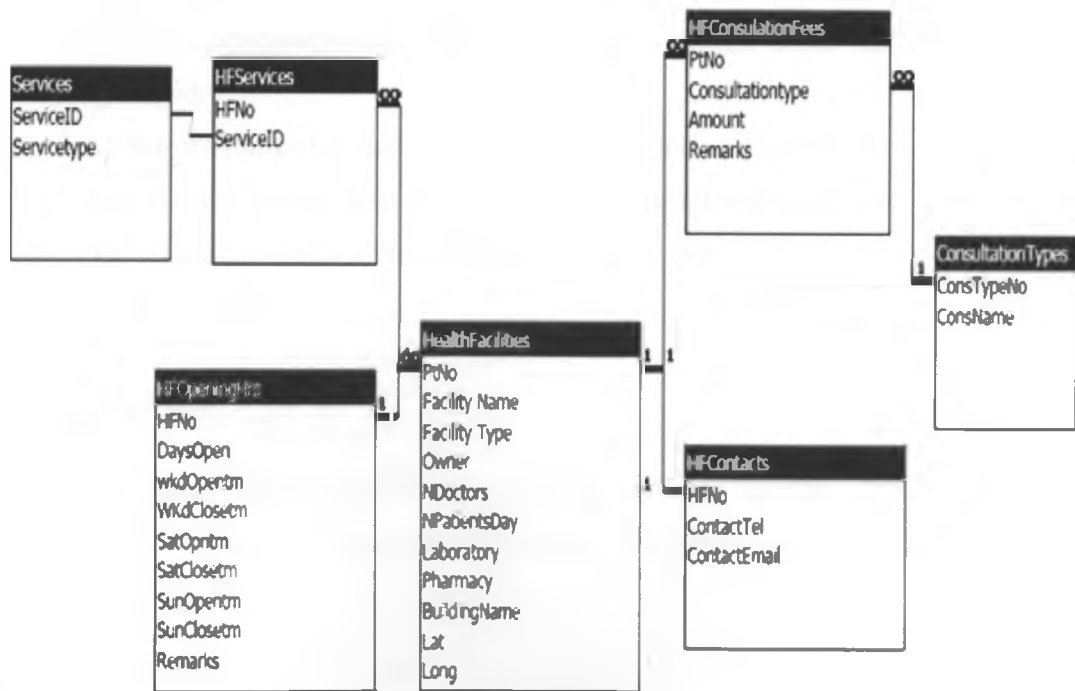


Fig. 3.5: Tables & Relationships

c. Logical Modeling

The logical data model was employed to describe the data much detail as possible, without regard to how that data was to be physically implemented in the database. This was the third step of the database design. Features of a logical data model included:

- Description of all entities and relationships among them.
- All attributes for each entity are specified.
- The primary key for each entity were specified.
- Foreign keys (keys identifying the relationship between different entities) were specified.
- Normalization was then carried out on each database table to make sure they complied with the 1 normalization, 2nd normalization and 3rd normalization.

The steps for designing the logical data model was as follows:

- Primary keys for all entities were specified
- All the relationships between different entities were identified and specified.
- All the attributes for each entity were identified and specified.
- Any many-to-many relationships were identified and resolved.
- Normalization of database tables was carried out.

Table Relations:

Health Facility (HFNo(pk),PtNo(fk), Facility Name, Facility Type, Owner, NDoctors, NPatientsDay, Laboratory, Pharmacy, BuildingName, FacilityImage,Lat, Long).

HFOperationalHrs (HFNo(pk), DaysOpen, WkdOpentm, WkdClosetm, SatOpentm, SatClosetm, SunOpentm, SunClosetm).

Services (ServiceID(pk), FacilityID(fk), ServiceName, ServiceType).

HFService (HFNo(pk), ServiceID (fk)).

HFContacts (ContactID(pk),HFNo(fk), ContactTel, ContactEmail).

HFConsultationFees (PtNo(fk), CounstationType(fk), Amount).

HFConsultationTypes (ConsTypeNo(pk), ConsName).

Normalization Procedure: The design of the database was based on the data that was collected and was initially stored in one table both spatial and non spatial. But because of existing repeating field like consultation fee, that initial consolidated table violated the first rule and therefore 1st normal form was carried out to eliminate the repeating group. The resultant tables from the first normal form were then checked for attributes that depended on only part of the multi-valued key, those that were found to be violating the second normalization rule were removed to separate table(s) to eliminate redundant data. Another check was done on the resultant tables of the second normal form. Attributes in these tables that did not form the description of the primary key were also removed to form separate table(s) to eliminate all the columns that did not depend on the primary key through third normalization.

d. Physical Modeling

Physical data model was the fourth and final step in database design and it represented how the model will be built in the database. The physical database model showed all table structures, including column name, column data type, column constraints, primary key, foreign key, and relationships between tables. The steps for physical data model design were as follows:

- Entities were converted into tables.

- Relationships were converted into foreign keys.
- Attributes were converted into columns.
- The physical data model based on physical constraints or requirements were modified.

3.3.4 Web-GIS HMIS Representation

a. Procedure for Web-GIS HMIS Representation:

A PHP script was written that was to output the created data tables in XML file (see fig. 3.6 & 3.7) because Google map API only reads XML files. The final output after running the PHP script was as below;

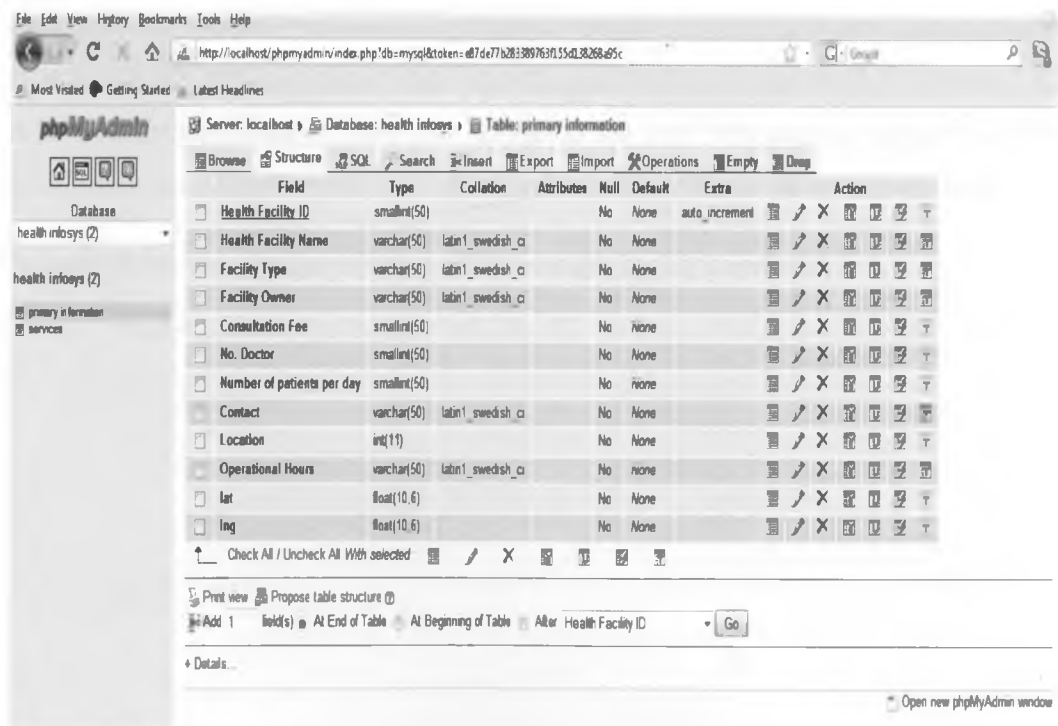


Fig. 3.6: XML Table Design after running PHP script

Server: localhost Database: health infoays Table: primary information

Showing rows 0 - 2 (3 total. Query took 0.0006 sec)

SELECT * FROM primary_information LIMIT 1, 30

Show: 30 row(s) starting from record # 0

in horizontal mode and repeat headers after 100 cells

Sort by key: None

+ Options

	Health Facility ID	Health Facility Name	Facility Type	Facility Owner	Consultation Fee	No. Doctor	Number of patients per day	Contact	Location	Operational Hours	lat	lng
<input type="checkbox"/>	0	Agha Khan	Hospital		1500	10	100				1.000000	34.000000
<input type="checkbox"/>	2	Buru buru clinic	Clinic	Private	300	2	9		0	8am to 8pm	1.345670	2.345660
<input type="checkbox"/>	3	Angels medical clinic	Clinic	Public	500	5	9		0	8am to 8pm	1.345543	2.343456

Check All / Uncheck All With selected

Show: 30 row(s) starting from record # 0

in horizontal mode and repeat headers after 100 cells

Query results operations

Print view Print view (with full texts) Export CREATE VIEW

Fig. 3.7: XML Table with data

A Java script was then written (see Appendix III) in HTML page to output the XML data about the facilities on the study area spatially referenced on Google maps.

A query form was designed using HTML script (see Appendix III.).

b. Application of Web-GIS for HMIS

Scenarios: Search Outcome for Health Facility Details

Search Option 1: General Search Procedure for facility details



Fig. 3.8: Search textbox appearing on L.H.S menu; search option 1

To perform a search using option 1, go to the search textbox on the Left Hand Side (L.H.S) menu.

Type the name of the facility service name of interest in the search textbox then click on the search command.

Search results show a list of health facility names that meet the stipulated search criteria.

Click on the facility name of interest from the outcome of the search result to view more details on the facility of choice, image of the facility and a map showing the location of the facility.

Search Option 2 & 3



Fig. 3.9: Directory of Services Search; search option 1 & 2

Procedure:

To perform a search for a particular service click on the 'Directory of Services' tab.

Search Option 2 (see fig. 3.9): Using the uncontrolled search, type a service name of choice e.g. 'Antenatal'.

Choose the criteria of search, whether 'any words' for a partial or non-certain input, 'all words' and 'exact phrase' for an input that is certain. Then click on the 'search button'.

Search results (see fig. 4.8) show a list of facilities with 'Antenatal' displayed as thumb nails.

Click on the *'Map of Facility'* link facility name of interest from the list of the search result to view detailed information about the facility of interest, its image and a map showing the location of the facility (see fig. 4.9).

Click on 'Clear selections' to return the search criteria's to 'null' if you want to perform another search.

Search Outcome for Other Health Facility Related Details

The General Search Procedure:

To perform a search based on other facility details other than health facility services, go to the *'Directory of Services'* tab.

Search Option 1 (see fig. 3.9): Using the uncontrolled search, type the facility detail of interest you want to query the system on. Choose the criteria of search, whether *'any words'* for a partial or non-certain input, *'all words'* and *'exact phrase'* for an input that is certain, then click on the *'search button'*.

or

Search Option 2 (see fig. 3.9): Click on the *'extended search'*, and choose from the drop down list on the category of choice. Then click on the *'search button'*.

The search results (see fig. 3.9) show a list of facilities that meet the search criteria specified displayed as thumb nails.

Click on the *'Map of Facility'* link on the facility name of interest from the list of the search results to view more details on the chosen facility, facility image and a map showing the location of that specific facility of interest.

Click on 'Clear selections' to return the search criteria's to 'null' if you want to perform another search.

3.4 Web-GIS Quality Control

3.4.1 Quality Control Checks for Data

The first quality control method that was employed on the data sets was used to measure the minimum requirements for the dataset. This type of quality control was typically a manual assessment of the data. It entailed comparing the schema also known as data structure and properties of a pre-existing similar master database structure. The output showed how the datasets were organized and named, and identified attribute relationships.

Once the dataset passed the initial check it was then subjected to a secondary quality check which was visual inspection of the features and the attributes. This was done by first creating a checklist of quick quality control inspections which involved comparing the feature counts between the source dataset and the converted or loaded data, looking for missing attribute values, confirming fields containing unique value don't have duplicate values. Comparing feature count helped identify missing features when data was loaded from source dataset into the new dataset.

KML file was created containing point data that had been collected initially during primary data collection using a Garmin handheld GPS to perform ground truthing. Some of the data that was collected during primary data collection already existed for instance point data, and facility services for a few health facilities. Therefore a comparison was done between data existing from different secondary sources and the primary collected data, interviewing, observation of health facility adverts.

3.4.2 Validation of search results

Validation mostly pertains to ensuring that the data is strongly typed by the user, it's in the correct syntax, it's within length boundaries, it contains only permitted characters, or that numbers are correctly signed and within range boundaries.

Validation in this Web Mapping HMIS system was ensured by defining the data types of the various table fields e.g. text for facility names at the database level and error messages were put e.g. "invalid input" where users will input numbers in a text defined field like health facility name.

It was imperative to implement in the Web-GIS HMIS for patients a web service validation mechanism web service was used in this system to provide patient related information on health through the internet. Security requirements for the health service provider and the users of the system is of paramount importance. Due to the message based architecture of the Web-GIS HMIS web services and the different environments that span trust boundaries in which they are increasingly being used to pose new challenges on a daily basis. Therefore these scenarios require security to be addressed at the message level to support cross-platform interoperability and routing through multiple intermediary nodes. Efforts have been made and security standards been designed to address web service security threats the most common being unauthorized access, parameter manipulation, network eavesdropping, disclosure of configuration data and message. Microsoft has released Web Services Enhancements (WSE) 2.0 for Microsoft .NET 1.1 and WSE 3.0 for .NET 2.0, which supports WS-Security and a related family of emerging standards. WSE allows you to implement message level security solutions including authentication, encryption and digital signatures.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Results

4.1.1 Web-GIS HMIS Representation

The final output result of the developed system was a dynamic Web-GIS map, mapping the location points of the health facilities in the study area with the database running at the back end, and a user interface in the form of a website like user interface with three pages presenting the information on various categories.

The Home page: This is the first page that the user will see when they load the Web-GIS HMIS. It displays a brief description of the system and its purpose. From this page, a user aware of what they are looking for can use the search function on this page and still get their required results.

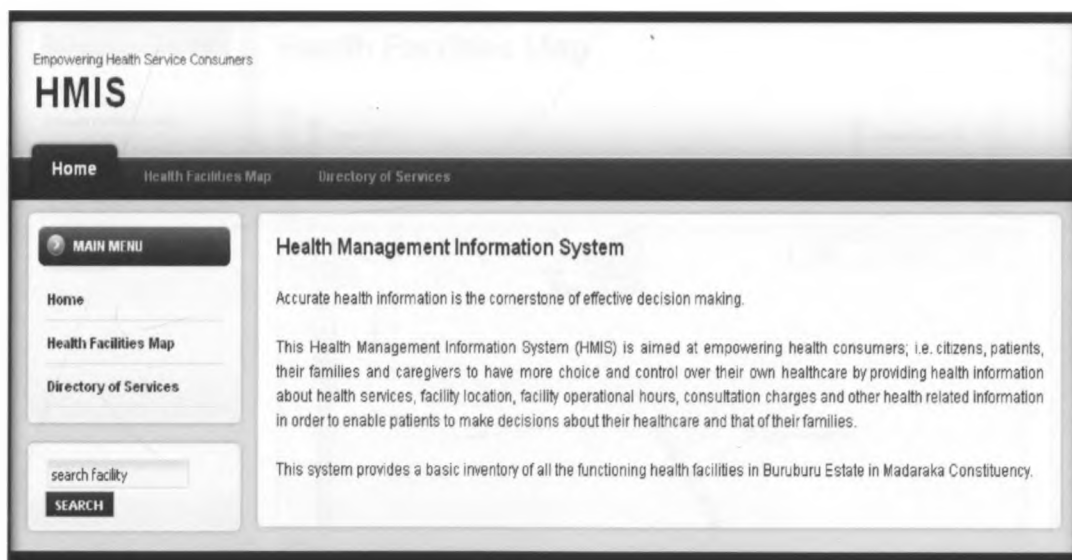


Fig. 4.1: Web page: 'Home'

The Health Facilities Map page: This is the second menu on the Web-GIS HMIS. It displays information on the various types of health facilities showing the different types of health facilities with the number of that facility type against the facility type name e.g. 'Dispensary(2)', 'Hospital(1)' e.t.c. Each facility type has an icon color therefore all facilities under that facility type are displayed on the map using

that icon color. Also on that page a dynamic web map with zoom and pan functions is displayed. When a facility type is selected e.g. clinic, all the clinics in the study area are displayed on the map showing their location using icons. When any of the icons showing location of a health facility is clicked, information on that health facility is displayed at the bottom of the map and included in that information is a link named 'more..' that takes the user to a page displaying that facility's image, services and other information about the facilities and also a replicated map showing the location of that clinic.

The map: The map used in the Web-GIS HMIS is tailored from Google maps and it was a populated with additional information to meet project objectives like health facility point data with was categories in terms of facility types, facility names and facility owner. It has a zoom in and zoom out tool and a pan function to allow the user to navigate the map to view information of interest.

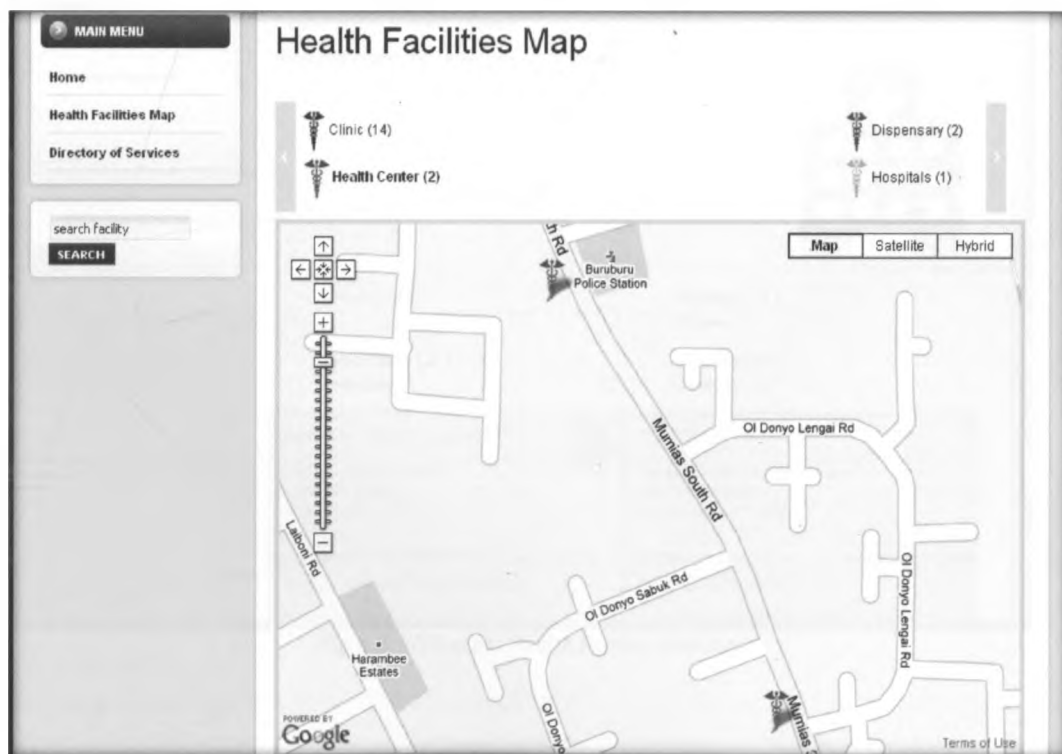


Fig. 4.2: Web page: 'Health Facilities Map'

The Directory of Services page: This is the third menu on the Web-GIS HMIS. When it loads it displays information on the various types of health facilities showing the different types of health facilities with the number of that facility type against the facility type name e.g. 'Dispensary(2)', 'Hospital(1)' e.t.c. Each facility type is displayed in different thumb nail color and is therefore all facilities are listed on this page in there thumb nail color. When a user selects a facility type is selected e.g. 'dispensary', all the dispensary in the study area captured in the system are the only ones displayed as thumb nails. This page also implements a strong search function to enable the user to find specific information based on a controlled search through use of drop downs and uncontrolled or open search through use of a textbox to allow the user to type in the information they would like to search.

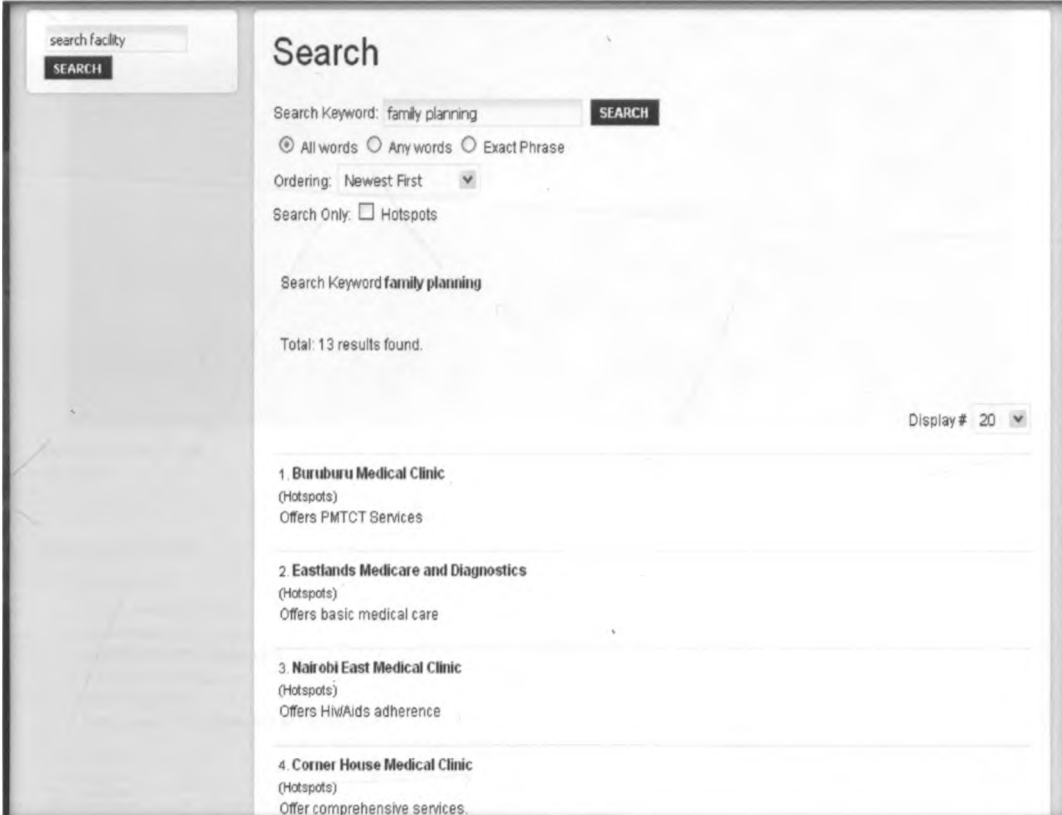


Fig. 4.3: Web page: 'Health Facility Directory'

4.1.2 Scenario Outcomes using L.H.S. Search Function

Search Option 1: Outcome for Health Facility Services

Type Facility service on the L.H.S search textbox e.g. *'Family Planning'*.



The screenshot displays a search interface with a search bar on the left containing the text 'search facility' and a 'SEARCH' button. The main search area on the right has a 'Search' heading, a search keyword input field with 'family planning' entered, and a 'SEARCH' button. Below the search bar are radio buttons for 'All words' (selected), 'Any words', and 'Exact Phrase'. There is also an 'Ordering' dropdown menu set to 'Newest First' and a 'Search Only' checkbox for 'Hotspots' which is unchecked. The search results section shows 'Search Keyword family planning' and 'Total: 13 results found.' A 'Display #' dropdown menu is set to '20'. The results list includes:

- 1 **Buruburu Medical Clinic**
(Hotspots)
Offers PMTCT Services
- 2 **Eastlands Medicare and Diagnostics**
(Hotspots)
Offers basic medical care
- 3 **Nairobi East Medical Clinic**
(Hotspots)
Offers HIV/AIDS adherence
- 4 **Corner House Medical Clinic**
(Hotspots)
Offer comprehensive services.

Fig. 4.4: List of search results for facilities offering *'Family Planning'*

Click on a facility of choice displayed in the search results e.g. Corner House Medical Clinic. The outcome is as below.

Mumias South Road
- Nairobi

Services offered are:

- Outpatient
- Basic Medical Care
- Antenatal Care
- Anti-Retroviral Treatment
- Family Planning
- Immunization
- Integrated Management of Child Illness

Map Satellite Hybrid

Corner House Medical Clinic

Mumias South Road
- Nairobi

Offer comprehensive services.

nglican
richo

u Buru
spire

Blessed
Sacrament
Catholic Church

Mumias South Rd

Anisya Crescent

Ouering Rd

POWERED BY
Google

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Fig. 4.5: Facility details, image & map showing the location of 'Corner House Medical Clinic' in Buruburu

Health Facility Location (building name)

Type building name on the L.H.S search textbox e.g. 'Petosam House'. Results show.

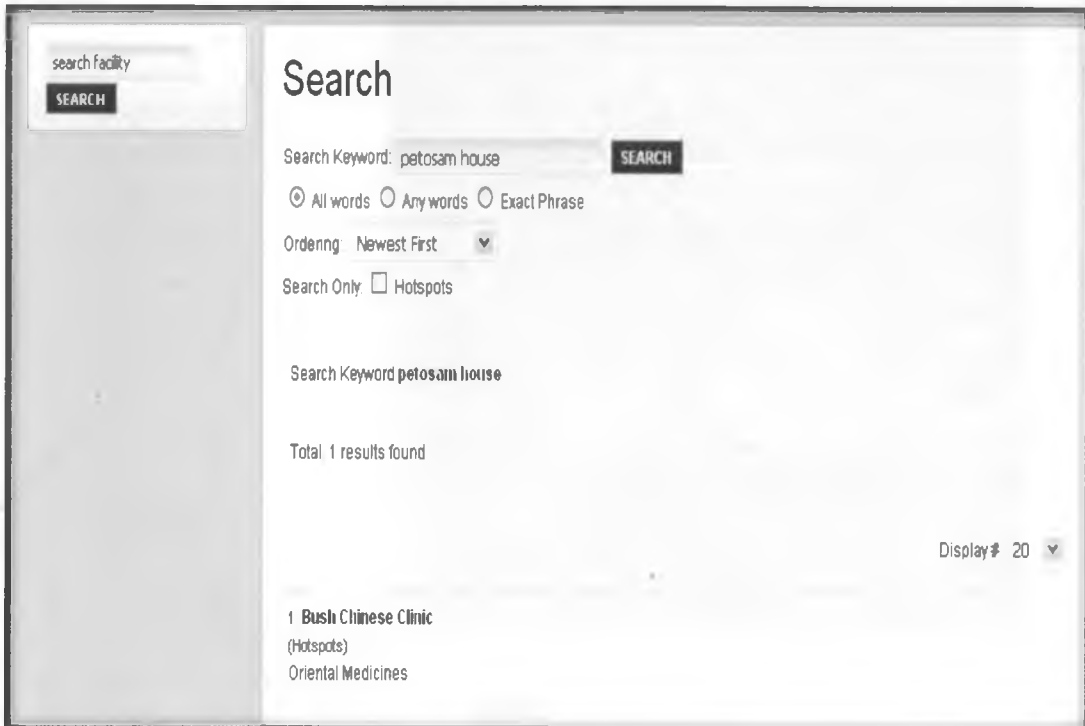


Fig. 4.6: Results for facilities located in the 'Petosam House'

Click on 'Bush Chinese Clinic' displayed in the search results. See outcome below


Bush Chinese Clinic

Petosam House, 1st floor
- Nairobi

Services offered are:

- Outpatient
- Basic Medical Care
- Antenatal Care
- HIV/AIDS
- Lumbago
- Bronchitis
- Diabetes
- Enterogastritis
- Fibroids
- Heart Disease
- Infertility
- Hypertension
- Obesity
- Skin Ailments
- STIs/STDs
- Allergy
- Arthritis
- Epilepsy
- Anaemia
- Gout
- Neurosis
- Family Planning
- TB Treatment
- Pharmacy

Open: Monday-Saturday 9am
Closing: Everyday 7pm

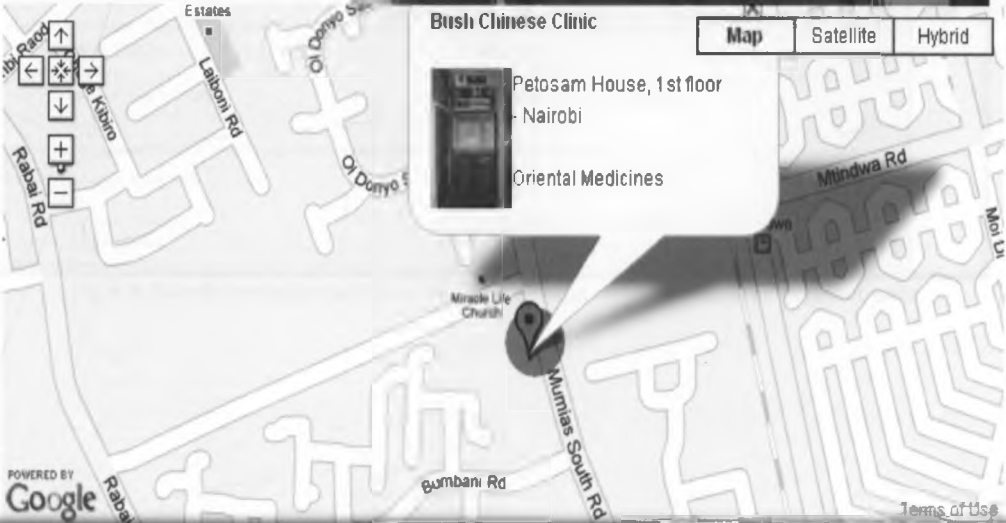


Bush Chinese Clinic

Petosam House, 1st floor
- Nairobi

Oriental Medicines

Map Satellite Hybrid



POWERED BY Google

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Fig. 4.7: Facility details, image & map showing the location of 'Chinese Clinic' in Buruburu

4.1.3 Scenario Outcomes using 'Directory Services' search function

Search Outcome for Health Facility Services using search option 2 & 3

Carry out the search from the Directory of Services page (see procedure in 3.3.4.1.2)

Health Facilities Directory Search

Online Health Facility and Services Directory for Buruburu area

Search for: antenatal **SEARCH**

Any words All words Exact phrase

EXTENDED SEARCH OPTIONS **CLEAR SELECTIONS**

Search Results

Found 11 results while searching for **antenatal**

Buruburu Medical Clinic Elyson House, 1st floor Nairobi Makadara Kenya Map of Facility Facility Ownership: Private Images: 0	Agah Khan University Hospital Fair Lane Center Nairobi Makadara Kenya Map of Facility Facility Ownership: Private Images: 1
Metropolitan Hospital Rabai Road Nairobi Makadara Kenya Map of Facility	Buruburu Health Center Buruburu Complex Building, 1st Floor Nairobi Makadara Kenya Map of Facility

Fig. 4.8: Search results for facilities offering 'antenatal care' are displayed as thumb nails

Choose the facility of interest from the search results and click on 'Map of facility' link in its thumb nail e.g. Metropolitan Hospital and the outcome is as below;

Metropolitan Hospital

Rabai Road, Buruburu
Nairobi

Outpatient
Consultation, Outpatient-500, inpatient-1500, Consultancies-1000
Doctor, 20
Patients per day, 110
Inpatient
Basic Medical Care
Casualty
Antenatal Care
Post natal care
Well Baby Clinic
Anti-Retroviral Therapy
C-Section
Family Planning
Immunization & Vaccination
Integrated Management of Childhood Illness
Prevention of Mother to Child Transmission
Laboratory
Maternity
Pediatric
X-Ray
Pharmacy
Breast Cancer clinic
Chronic Care Clinic
Dental Clinic
Nutrition Clinic





Fig. 4.9: Details, Image & map of Metropolitan Hospital showing facility location in Buruburu

Health Facility Operational Hours

Carry out the search on the Directory of Services page (see procedure in 3.3.4).
The search outcome is as below.

Health Facilities Directory Search

Online Health Facility and Services Directory for Buruburu area

Search for: **SEARCH**

Any words All words Exact phrase

EXTENDED SEARCH OPTIONS **CLEAR SELECTIONS**

Search Results

Found 2 results while searching for **Any entry**

Baus Optical Fair Lane Center, 1st floor Nairobi Makadara Kenya Map of Facility Facility Ownership: Private Images: 0	Jobee Herbal Clinic Buruburu Nairobi Makadara Kenya Map of Facility Facility Ownership: Private Images: 0
---	---

<< Start < Prev 1 Next > End >>

Fig. 4.10: List of search results for facilities operating between 9a.m and 6p.m

Click on the 'Map of Facility' link from the thumb nail of the facility name of interest on the search results e.g. Baus Optical and the outcome is as below;

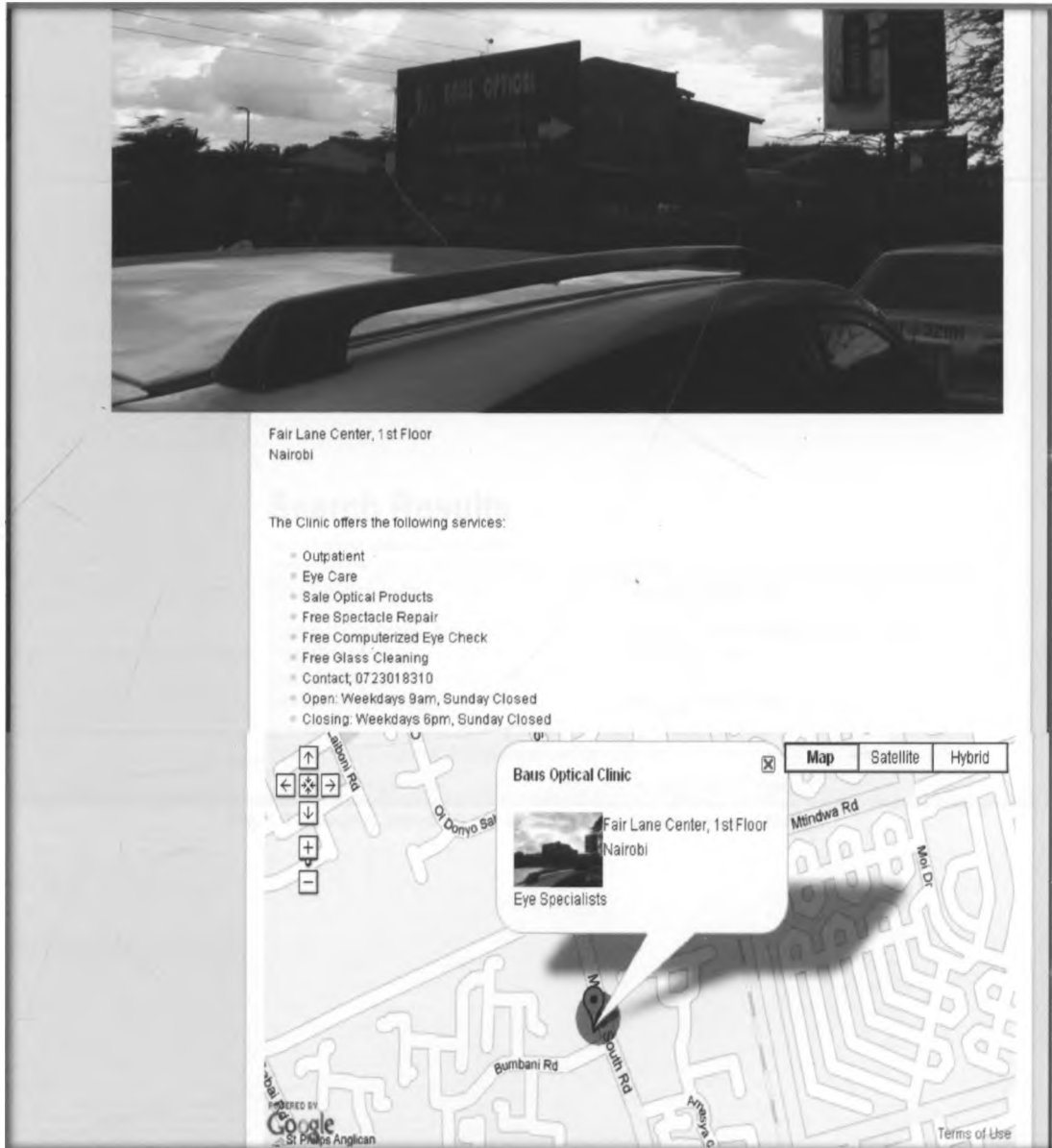


Fig. 4.11: Image of Baus Optical & Map Showing the location of Baus Optical Clinic in Buruburu

Health Facility Consultation fee

Carry out the search on the Directory of Services page (see procedure in 3.3.4)

Search for: ← Search Option 1

Any words All words Exact phrase

Consultancy Fees: ↓ Search Option 2

Facility Ownership: ↓

Number of Doctors: ↓

Patients per day: ↓

Opening Time: ↓

Closing Time: ↓

Select Category: ↓

Search Results

Found 7 results while searching for 500

Buruburu Medical Clinic Elyson House, 1st floor Nairobi Makadara Kenya Map of Facility Facility Ownership: Private Images: 0	Buruburu Health Center Buruburu Complex Building, 1st Floor Nairobi Makadara Kenya Map of Facility Facility Ownership: Private Images: 0
Eastlands Medical Center	Meridian Medical Center

Fig. 4.12: Search based on the amount of 500 consultation fee

Click on the 'Map of Facility' link in the thumb nail of facility name of interest from the search results e.g. 'Meridian Medical Center' and the outcome is as below;

The screenshot displays a search result for the Meridian Medical Center. At the top is a photograph of the building, which is a two-story structure with a sign that reads "MERIDIAN MEDICAL CENTRE" and a "BARCLAYS" logo. Below the photo, the text identifies the location as "Buruburu Business Complex, 1st floor, Nairobi".

Underneath, a section titled "Services provided are:" lists the following services:

- Outpatient
- Basic Medical Care
- X-Ray
- Ante natal care
- Post natal Care
- Health Education
- Anti-retroviral
- STD diagnosis & treatment
- Prevention of Mother-child Transmission
- Treatment of Chronic Ailments
- Pharmacy
- Counseling

Operating hours are listed as: "Open: Monday-Friday 8:30am, Saturday-Sunday & Holidays 9am" and "Closing: Monday-Friday 8pm, Saturday-Sunday & Holidays 6pm".

At the bottom, a map shows the location of the center. A callout box over the map provides the name "Meridian Medical Center", a small thumbnail image of the building, the address "Buruburu Business Complex, 1st floor, Nairobi", and the note "Offers basic medicare." The map includes street names such as Mumbi Ln, Harambee Estates, O'Donyo Sabuk Rd, and Mtindwa Rd. Navigation controls and map style options (Map, Satellite, Hybrid) are also visible.

Fig. 4.13: Detail Information, Image & Map Showing the location of Meridian Medical Center in Buruburu

4.1.4 Analysis of Results

Out of the 19 health facilities covered in this study, 14 of the health facilities were found to be of facility type clinic, 2 were dispensaries, 2 were health centers and 1 a hospital. Also 17 facilities out of the 19 health facilities were privately owned and 2 were institutionally owned.

Inpatient services were found only at Metropolitan hospital. 10 health facilities offered antenatal care, 12 facilities offered family planning services, 5 health facilities had both immunization and vaccination services with 5 health facilities having only immunization without the vaccination service. Gynecological services were offered in 5 health facilities, 2 health facilities offered minor surgery. Well baby clinic were offered in 2 health facilities, 13 health facilities had laboratories, 8 health facilities had pharmacies or chemist, 10 health facilities had TB diagnosis and or TB treatment. And two facilities offered specialized services that is dental and optical services.

The health facilities that opened the earliest did so at 7.30 a.m. and those that opened the latest did so at around 10 a.m. but majority opened at around 8 a.m. The latest facilities to close did so at 9 p.m. and the majority of those that closed early closed at 6 p.m. and only 6 facilities remain closed on Sunday.



Fig. 4.14: Distribution of the 19 health facilities in Buruburu Estate

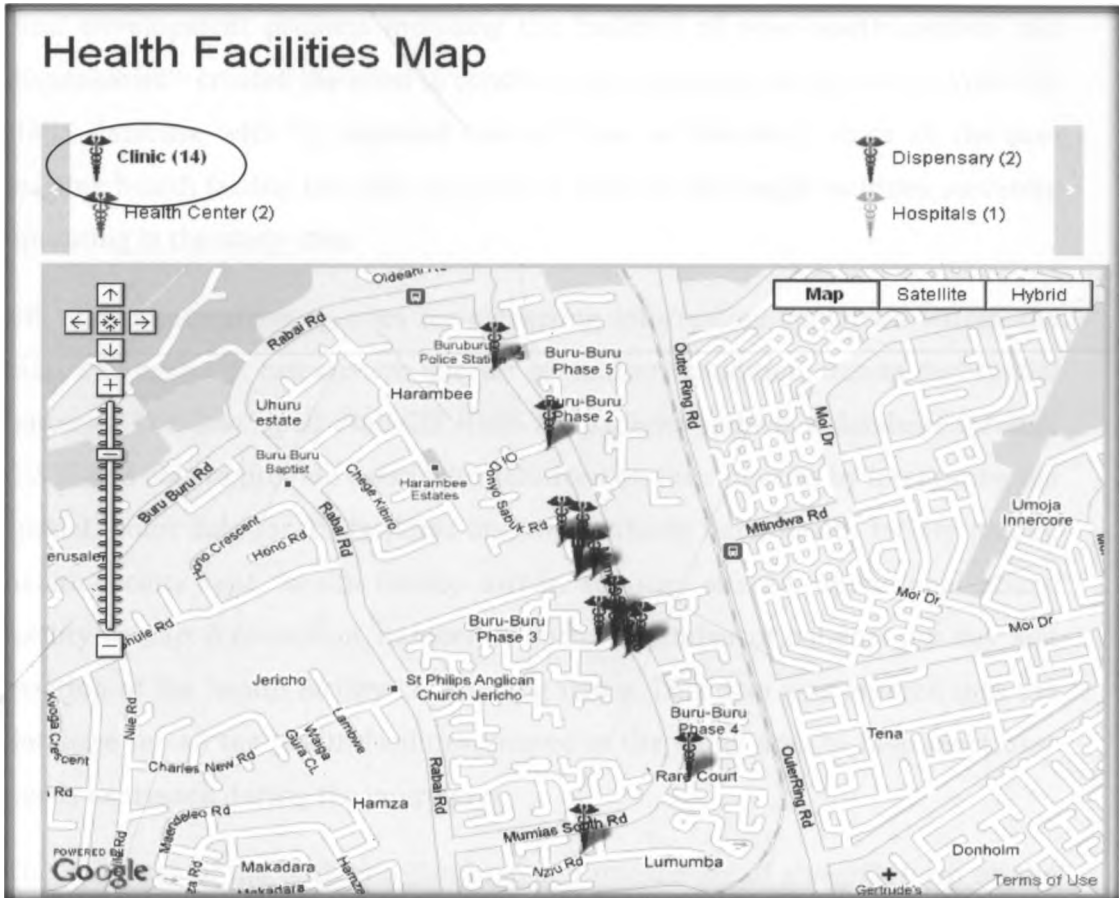


Fig. 4.15: Distribution of Health Facility Clinic in Buruburu

4.2 Discussion

A national database of GOK, NGO, local authority, mission and the private sector health service providers was completed in 2003. All other available health facility listings were brought together to form a single, comprehensive list and each facility provided with a unique code based on its location, the level of service provision that is from the hospital level which is the highest level all through to dispensary level which is the lowest level and finally by sector; MoH, Mission, NGO or private. Unfortunately by 2007 there had been no effort made to update a single list of health service providers across Kenya with a single unique spatial identifier. This therefore, and establishment of a new government in 2002 that promoted the establishment of a constituency development fund (CDF) to fund

local development projects including the building of new health centers and dispensaries⁽¹⁾ created the need to conduct data collection and develop a Web-GIS HMIS database with the updated current data in this study since all the pre-existing health facility lists did not capture most of the health facilities currently operating in the study area.

GIS allows interactive queries for extracting information contained within the map, and tables. It can answer queries of location, condition, trends and spatial patterns. The developed Web-GIS HMIS for patients embeds a database through GIS that is able to provide users with solutions on their queries by integrating the spatial; point data for 19 facilities and the attribute data; health facility names, health facility type, health facility owner, services offered, operational hours, facility contact information, number of doctors, number of patients per day and location of the health facility i.e. building name. This data was entered into the database for all the health facilities located in the study area to help meet user needs expressed during the interviews.

The existence of the back end database and integration of a search form on the user interface signified that users of the system were able query the database to obtain specific information of interest. Using the search procedures outlined in 3.3.4 users therefore are equipped with the ability to extract information from the database even to a point of being able not just to gain meaningful and desirable information.

The Web-GIS HMIS enabled users to identify location of the health facilities after the carrying out a search by including map results through displaying health facility results on the map. The zoom and pan tools on the displayed map enabled users of the system to interact with the dynamic map to obtain desired information from more detailed through zooming out to specific scanty details by zooming in as much as they desired. The map therefore served a vital role in equipping the user with direction information and orientation once they are on

the ground trying to locate the facility especially through relating existing features close to the facility of interest as shown on the map.

Recent advancements in GIS technology have moved towards web-based GIS where by health data is stored in a central server which can be accessed from various terminals at remote locations connected to the server through internet or intranet.^[43] Authorization and authentication methods need to be applied to protect individual confidentiality while accessing data. Dynamic maps published on the web allow patients to locate the most convenient services to their home, neighborhood or work easily. The ability to visualize the look of the facility in the Web-GIS HMIS was made possible by incorporating facility image to enable users to easily identify the facility on the ground.

During data collection it was evident that patients and other residents of the area needing medical services indirectly that is on behalf of a relative or friend or for any other reason were not able to get such information to for them to make an informed choice. For instance, in a situation where the a resident patient needs to visit a facility for a particular medical service the patient is reluctant to pay high consultation fee therefore such a patient has no way to find out which facility has the lowest consultation fee except may be thorough word of mouth from others who may or may not give that patient the correct information. This is therefore where the Web-GIS HMIS came in and such needs were able to be met by queering the database.

It was noted that on most facilities were crowded in the same area, which was the Buruburu shopping center area and worse still some facilities even where located in the same building. This made it challenging to perform some analysis like determination of catchment population for each facility since the buffers would overlap considerably making the analysis results lacked meaning.

The launch of Google Earth in June 2005^[37] has lead to the drastic improvement of Kenya's' imagery, therefore enabling the visualization of buildings and roads when streamed at high resolutions. This technology of being capable to locate and

identify structures in space has been used to triangulate coordinates to visualize building structures likely to be health facilities. In this regard therefore, facility owners found the Web-GIS HMIS a necessary system to have since they realized that it will be a form of advertisement for their facilities because of incorporation of Google maps; which is an internet based GIS technology enabling health facility location to be instantly available across the globe hence anyone, anywhere with access to the internet can view their facility information and act on that knowledge.

Despite the exceptional advantage of having designed a user friendly web site pages where information is presented clearly and vast benefits of this Web-GIS HMIS patients system, users are expected to have a basic computer skills in web access to enable them to be able to search for the web address on search engines for those who don't know the web address, typing for inputting required query. information in the search text box and also zooming and panning when navigating through a map.

CHAPTER 5: CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusions

The developed web-GIS HMIS met the stipulated objectives of empowering the patient with health facility related information and also went further to also meet health manager's needs.

Despite the fact that this system has been designed with the patient as the user in mind it also contains information that could help health manager in health management matters for instance, it shows facility inventory and distribution which can help in the determination of equity resource allocation when evaluating health system performance. It also provides information like distribution of health facilities, number of doctors in each facility and patients attended per facility per day.

GIS was a vital tool in providing health facility location information through embedded Google maps. The map served a vital role in equipping the user with directional information. The web based technology employed also enabled the Web-GIS HMIS to be accessed by many users despite their location.

5.2 Recommendations

The outcome of this study has shown that the use of the Web-GIS HMIS for patients was a necessary and beneficial tool to the population of the study area. Therefore it is in the best interest of the Government of Kenya through Ministry of Health to scale up the project to a national wide coverage so as to meet the needs of entire Kenyan population.

Kenya is mobile phone market is growing very fast since its introduction in the country. The boom of mobile phones in Kenya has been increased economic growth. A large part of this boost comes from the innovative use of mobile phone technology by local entrepreneurs. Mobile phones in Kenya are used for a wide variety of tasks. Small and Medium Enterprises, Non-governmental Organizations

and Mobile Companies and are finding new uses for mobile phones and the mobile technology by coming up with original methods for solving their own problems. In the case of the developed Web-GIS HMIS, it would be ideal to tailor the system to incorporate the mobile technology in order to make it easier to the vast majority of Kenyans having handheld cell phones to access the HMIS information website at a click of the button on their mobile handsets thereby giving them flexibility of access anytime and everywhere.

Short Message Service (SMS) is another component that can come with the adoption of mobile technology in the Web-GIS HMIS. This would be an effective component to incorporate into the HMIS system so that instead of patients having to visit cyber shops or purchasing wireless internet connection modems as is the current trend in Kenya, users can be able to send structured short messages to the Web-GIS HMIS hosted by a server and the web system, due to its design and configuration in supporting the Short Message Service would then also be able to send back to the user a structured Short Message containing results of the inquiry.

Challenges

Some variables were not incorporated due to the scope and limitations of the study, these variables could have added more value to the system:

- Patient Records; diagnosis & treatment information
- Doctor details; Names, specialization and availability

REFERENCES

1. Noor A.M., Alegana V.A., Gething P.W., Snow R.W (2008). 'A spatial national health facility database for public health sector planning in Kenya'.
2. Noor A.M, Zurovac D, Hay S.I, Ochola S.A, Snow R.W (2003). 'Defining equity in physical access to clinical services using geographical information systems as part of malaria planning and monitoring in Kenya'.
3. Noor A.M, Amin A.A, Gething P.W, Atkinson P.M, Hay S.I, et al. (2006). 'Modeling distances travelled to government health services in Kenya'.
4. Noor A.M, Gikandi P.W, Hay S.I, Muga R.O, Snow R.W (2004). 'Creating spatially defined databases for equitable health service planning in low-income countries: The example of Kenya'.
5. Lippeveld T. (2001). 'Routine Health Information Systems: the glue of a unified health system'.
6. Detmer D. (2003). 'Building the national health information infrastructure for personal health, health care services, public health, and research'.
7. WHO. 60th World Health Assembly, Resolution 60.27 'Strengthening of health information systems'.
8. Ministry of Health (MOH) Kenya (2010). 'The Kenya Health Facility List'.
9. Muga R., Kizito P., Mbayah M., Gakuruh T. (2005). 'Overview of the Health System in Kenya'.
10. McLaffery S.L. (2003). 'GIS and health care', Annual Reviews of Public Health Vol. 24 pp.25-42.
11. Bullen N., Moon G., Jones K. (1997). 'Defining localities for health planning: a GIS approach'.
12. Hewitt A., Tinline R. (2004). 'GIS and health care: spatial accessibility of cancer clinics in Hamilton, Ontario'.
13. Allianz International Health Care Insurance (2009).
14. Briggs D.J, P.Elliott (1995). 'The use of geographical information systems in studies on environment and health', World Health Statistics Quarterly Vol. 48, No.2, pp. 85-94.

15. Republic of Kenya (2006). 'Service Charter for Health Service Delivery'.
16. WHO (2004). 'Review of health information systems (HIS) in selected countries: South Africa' World Health Organization.
17. UN (2000). 'United Nations Millennium Declaration'. United Nations General Assembly, A/RES/55/2 (<http://www.un.org>).
18. Sachs J.D, McArthur J.W (2005). 'The Millennium Project: a plan for meeting the Millennium Development Goals'.
19. WHO (2001). 'Macroeconomics and Health: Investing in Health for Economic Development'. World Health Organization, Geneva, Switzerland, p. 202.
20. WHO (2000). World Health Report: 'Health Systems: Improving Performance'. World Health Organization, Geneva, Switzerland, p. 206.
21. Misra A., Kishore H., Barot K. (2009). 'A GIS analysis of health care services in the city of Pune'.
22. Tanser F. (2006). 'Geographical information systems (GIS) innovations for primary health care in developing countries'.
23. Longley P., et al (2005) 'Geographic Information Systems and Science'.
24. <http://www.gisind.com/web-gis.html> (2007)
25. Cindy C., DFID Health Resource Centre. ELDIS Key Health Issues 'Management Information Systems'
26. Wikipedia Encyclopedea. (March 2010)
27. Tanser F., (2006). 'Modeling and understanding primary health care accessibility and utilization'.
28. Thaddeus S., Maine D. (1994). 'Too far to walk: maternal mortality in context'.
29. WHO (1996). 'Investing in Health Research and Development: A Report of the adhoc Committee in Health Research Relating to Future Intervention Options'. World Health Organization, Geneva, pp. 278.
30. WHO (1999). World Health Report: 'Making a difference'. World Health Organization, Geneva, pp. 122.

31. Division of Statistics, United Nations (1997) Accessibility Indicators in GIS. UN Department for Economic and Social Information and Policy Analysis, New York, pp. 1 to 24.
32. Ingram D.R, Clarke D.R & Murdie R.A (1978). 'Distance and the decision to visit the accident and emergency department'.
33. Igun U.A (1979). 'Stages in health-seeking: a descriptive model'.
34. Garner P., Giddings P. (1985). 'Rural health centre use: variations with distance and disease'.
35. Habib O.S, Vaughan J.P (1986). 'The determinants of health services utilization in southern Iraq: a household interview survey'.
36. Muller I, Smith T, Mellor S et al. (1998). 'The effects of distance from home on attendance at a small health centre in rural Papua New Guinea'.
37. Google Earth. <http://earth.google.com/>(2007)
38. www.unhcr.org, UNHCR (2001-2010). Accessed June 16th 2010.
39. Luis J.M, Moreno O.(2005), 'Towards the Establishment of a European Research AREA', Research Area of Telemedicine and Information Society, Institute of Health Carlos III, Spain.
40. Williamson L., Stoops N., Heywood A. (2006). 'Developing a District Health Information System in South Africa: A Social Process or Technical Solution?'
41. Ministry of Health (MOH) Kenya (2007). 'Norms and standards for health service delivery' MOH: Nairobi, Kenya.
42. Ministry of Health (MOH) South Africa (2006). National Department of Health, 'Health facility definition' South Africa.
43. Najafabadi A.T (2009). 'Applications of GIS in Health Sciences'.

Appendix: I

Interview Schedule for Patients

1. How do you decide which facility to visit any time you need medical attention?
2. Where do you get medical information about existing facilities in this neighborhood?
3. If you have a medical emergency at night how do you determine which facility to visit?
4. If you want to visit a facility and you don't know where it is located how do you go about finding it?
5. When you need a specific medical service how do you determine which facility to visit?

Interview Schedule for Facility Owner/Staff

1. What is the registered name of this facility?
2. What type of facility do you consider this facility to be?
3. What is the ownership of this facility?
4. How much is the consultation fee?
5. Is the fee you have mentioned apply to all services or are there some services that have different consultation fee that stated (in 4 above)?
6. What medical services does this facility offer to the public?
7. What are your hours of operation?
8. Do the hours you have stated include weekends and public holidays?
9. Are there any services that are offered on different operational hours?
10. How many number of Doctors offer medical care in this facility?
11. How many patients do you receive in a day?
12. What telephone number(s) whether cell phone or land line do you use in this facility?
13. Do advertise this facility? How about Google maps?

Appendix II

Healthcare Facility Attribute Data

Health Facility Name	Health Facility Data
Aga Khan University Hospital	Owner: Private
	Type: Clinic
	Consultation Fee; 600 Normal, 1000 Corporate
	Outpatient
	Basic Medical Care
	Doctors; GP 6
	Number of patients per day; 100
	Antenatal Care Clinic; 1:30pm-3pm
	Family Planning Clinic; 1:30pm-3pm
	Vaccination
	Immunization
	Gynecological Clinic; Tuesdays 9am-12pm, Wednesday 2pm-4pm
	Minor Surgeries
	Well Baby Clinic; Thursdays 8:45am-11:45am
	Laboratory
	TB Diagnosis
	Pharmacy
	Contact; 020-788 320
	Open: Weekdays 8 am, Sundays Closed
	Closing: Weekdays 8pm, Sundays Closed
	Building Name; Fair Lane Center, 1 st floor
Baus Optical	Type: Clinic
	Owner: Private
	Consultation Fee; Free
	Outpatient
	Doctor; 1
	Patients per day; 10
	Eye Care
	Sale Optical Products
	Free Spectacle Repair
	Free Computerized Eye Check
	Free Glass Cleaning
	Contact; 0723018310
	Location; Fair Lane Center, 1 st floor

Health Facility Name	Health Facility Data
	Open: Weekdays 9am, Sunday Closed
	Closing: Weekdays 6pm, Sunday Closed
Buruburu Health Centre	Type: Health Center
	Owner: Private
	Consultation 500
	Doctor; 2
	Patients per day; 10
	Outpatient
	Basic Medical Care
	Antenatal Care
	Laboratory
	Pharmacy
	Eye Care
	Family Planning
	Immunization
	Vaccination
	Dental Care
	Counseling
	Contact; (020)2343172/0720797790
	Location: Buruburu Complex Building 1 st Floor
	Opening: Weekdays & Saturdays 8am, Sundays 9am
	Closing: Weekdays 8pm, Saturdays 6pm, Sundays 5pm
Buruburu Medical Clinic	Type: Clinic
	Owner: Private
	Consultation: 500
	Outpatient
	Doctors: 2
	Patients per day; 15
	Basic Medical Care
	Antenatal Care
	Postnatal Care
	Eye Care
	Family Planning
	Pediatric
	Immunization
	Vaccination
	Gynecological
	PMTCT
	TB Diagnosis

Health Facility Name	Health Facility Data
	Laboratory
	Counseling
	TB Treatment
	Contact; (020) 7808380/ 0723660737/ 0722720003
	Location; Elyson House, 1 st floor
	Open: Monday-Saturday 7:30am
	Closing: Monday-Saturday 7:30 pm. Sunday Closed
Bush Chinese Clinic	Type: Clinic
	Owner: Private
	Consultation Fee; 300, Free Fridays & Saturdays
	Outpatient
	Doctor; 2
	Patients per day; 20
	Basic Medical Care
	Antenatal Care
	HIV/AIDS
	Lumbago
	Bronchitis
	Diabetes
	Enterogastritis
	Fibroids
	Heart Disease
	Infertility
	Hypertension
	Obesity
	Skin Ailments
	STIs/STDs
	Allergy
	Arthritis
	Epilepsy
	Anemia
	Gout
	Neurosis
	Family Planning
	TB Treatment
	Pharmacy
	Contact; 0717159816/ 0733556612
	Petosam House, 1 st floor
	Open: Monday-Saturday 9am
	Closing: Everyday 7pm

Health Facility Name	Health Facility Data
Charolyn Specialist Clinic	Type: Clinic
	Owner: Private
	Consultation Fee; 500
	Out Patient
	Doctor; 1
	Patients per day; 13
	Basic Medical Care
	Family Planning
	Laboratory
	Obstetrician
	Gynecologist
	Elyson House, 1 st floor
	Open: Weekdays 8 am, Sundays Closed
	Closing: Weekdays 8pm, Sundays Closed
CliniX Health Care	Type: Clinic
	Owner: Private
	Consultation Fee; 350
	Outpatient
	Doctors; 1
	Patients per day; 70
	Basic Medical Care
	Casualty
	Antenatal
	Postnatal
	Family Planning
	Immunization
	Integrated Management of Child illness
	Prevention of Mother to Child Transmission
	TB Diagnosis
	Laboratory
	Operating Theatre
	TB Treatment
	Accident Services
	Pharmacy
	Psychiatric
	Pediatric
	Dental Care
	Ambulance
	X-Ray
	Ambulance
	Corporate Accounts
	Contact; (020) 2019230/7, 8078541

Health Facility Name	Health Facility Data
	Location; Clinix Healthcare Buruburu Branch
	Open: Everyday 8am
	Closing: Everyday 7pm
Corner House Medical Clinic	Type: Clinic
	Owner: Private
	Consultation Fee; 500
	Outpatient
	Doctors; 2
	Patients per day; 10
	Basic Medical Care
	Antenatal Care
	Anti-Retroviral Treatment
	Family Planning
	Immunization
	Integrated Management of Child Illness
	Laboratory
	Pharmacy
	X-Ray
	Counseling
	Well Baby Care
	Minor Surgeries
	Contact; 0721260978
	Location;
	Open: Daily 10am-2pm then 6pm-8pm
Eastlands Medical Centre	Type: Clinic
	Owner: Private
	Consultation; General-500, Pediatrician-1000, Obstgynecologist-800
	Outpatient
	Doctors; 4
	Patients per day; 15
	Basic Medical Care
	Antenatal Care
	Physiotherapy
	Family Planning
	Immunization
	Prevention of Mother to Child Transmission
	TB Diagnosis & Treatment
	Laboratory
	Pediatric

Health Facility Name	Health Facility Data
	Counseling
	Contact; (020)782103/ 0722240623
	Location;
	Open: Monday-Saturday 9am, Sunday 11am
	Closing: Monday-Saturday 7pm, Sunday 4pm
Eastland Medicare & Diagnostic	Type: Clinic
	Owner: Private
	Consultation; 300
	Outpatient
	Doctors; 2 GPs
	Patients per day; 6
	Basic Medical Care
	Antenatal
	Laboratory
	Family Planning
	Counseling
	TB Treatment
	Contact;
	Location; Elyson House, 1 st floor
	Open: Sunday-Friday 9am, Saturday Closed
	Closing: Sunday-Friday 8pm
Healthwise Medical & Dental Clinic	Type: Clinic
	Owner: Private
	Consultation; Physiotherapist 1000, Dentist-300, GP-250
	Outpatient
	Doctors; 3
	Patients per day; 20
	Antenatal
	Anti-retroviral
	Immunization
	Laboratory
	Dental
	Physiotherapy
	Contact;
	Location; n/a
	Open: Monday-Friday 10am, Saturday-Sunday 10am, Holidays 10am

Health Facility Name	Health Facility Data
	Closing: Monday-Friday 8pm, Saturday-Sunday 6pm, Holidays 3pm
Jobee Herbal Clinic	Type: Clinic
	Owner: Private
	Consultation; 300
	Outpatient
	Doctor; 1
	Patients per day; 8
	Basic Medical Care
	Counseling
	Family Planning
	Nutrition
	HIV/AIDS
	Heart Disease
	Infertility
	Skin Diseases
	STDs/STIs
	Hypertension
	Ulcers
	Epilepsy
	TB Treatment
	Contact; 0722914667, jobee@yahoo.com
	Location; Epren Center 2 nd Floor Room 14.
	Open: Weekdays 9am, Sunday Closed
	Closing: Weekdays 6pm, Sunday Closed
Meridian Medical Centre	Type: Health Center
	Owner: Private
	Consultation; 500
	Outpatient
	Doctor; 2
	Patients per day; 35
	Basic Medical Care
	X-Ray
	Ante natal care
	Post natal Care
	Health Education
	Anti-retroviral
	STD diagnosis & treatment
	Prevention of Mother-child Transmission
	Treatment of Chronic Ailments
	Pharmacy

Health Facility Name	Health Facility Data
	Counseling
	Gynecological services
	Minor Surgeries
	Diagnostic Laboratory
	Cancer Diagnosis
	Immunization
	Vaccination
	Family Planning
	Therapeutic Nursing
	Diagnostic Radiology
	Travel Health
	Pre-employment Medical Examination
	Food handlers Medical examination
	Insurance Medical Examination
	Medical Legal Services
	Contact; (020) 2451654
	Location; Buruburu Business Complex, 1 st floor
	Open: Monday-Friday 8:30am, Saturday-Sunday & Holidays 9am
	Closing: Monday-Friday 8pm, Saturday-Sunday & Holidays 6pm
Metropolitan Hospital	Type: Hospital
	Owner: Private
	Consultation; Outpatient-500, Inpatient-1500, Consultancies-1000
	Doctor; 20
	Patients per day; 110
	Outpatient
	Inpatient
	Basic Medical Care
	Casualty
	Antenatal Care
	Post natal care
	Well Baby Clinic
	Anti-Retroviral Therapy
	C-Section
	Family Planning
	Vaccination
	Immunization
	Integrated Management of Childhood Illness
	Prevention of Mother to Child Transmission
	Laboratory

Health Facility Name	Health Facility Data
	Maternity
	Pediatric
	X-Ray
	Pharmacy
	Breast Cancer clinic
	Chronic Care Clinic
	Dental Clinic
	Nutrition Clinic
	Ambulance
	Hypertension
	Diabetes
	HIV/AIDs Counseling
	TB Diagnosis & Treatment
	ENT Clinic
	Pediatric
	Gynecologist
	Theater
	Referral Services
	Contact; (020) 2020263/ 0733602114/ 0722207665
	Location; Rabai Road, Buruburu
	Open: Monday-Sunday 8am
	Closing: Monday-Sunday 7:30pm
Millennium Dental Clinic	Type: Clinic
	Owner: Private
	Outpatient
	Consultation; 300
	Doctor; 1
	Patients per day; 5
	Dental care
	Contact; n/a
	Location; n/a
	Open: Weekdays 8am, Sunday 9am
	Closing: Weekdays 8pm, Sunday 5pm
Nairobi East Medical Clinic	Type: Clinic
	Owner: Private
	Outpatient
	Consultation; 500
	Doctor; 2
	Patients per day; 5

Health Facility Name	Health Facility Data
	Basic Medical Care
	Antenatal
	General Counseling
	Family Counseling
	Child Therapy
	HIV/AIDS Adherence Counseling
	Kenya Sign Language Special Counseling
	Family Planning
	Immunization
	Laboratory
	Chemist
	Contact; n/a
	Location; n/a
	Open: Monday-Saturday 9am, Sunday 10am
	Closing: Monday-saturday 9pm, Sunday 9pm
Women Clinic	Type: Clinic
	Owner: Private
	Outpatient
	Consultation Fee; 300
	Doctor; 1
	Patients per day; 4
	Laboratory
	Counseling
	Contact; 0722763795
	Location; n/a
	Open: Everyday 8am
	Closing: Everyday 7pm
Buruburu Girls High School Dispensary	Type: Dispensary
	Owner: Institutional
	Outpatient
	First aid
	Consultation Fee; free
	Counseling
	Location; Buruburu Girls High School
	Open: Weekdays 9am, Sunday Closed
	Closing: Weekdays 9pm, Sunday Closed
Buruburu High School Clinic (NPC)	Type: Dispensary
	Owner: Institutional

Health Facility Name	Health Facility Data
	Outpatient
	First aid
	Consultation Fee; free
	Counseling
	Location; NPC Church
	Open: Weekdays 9am, Sunday Closed
	Closing: Weekdays 9pm, Sunday Closed

Healthcare Facility Spatial Data

Facility Name	Latitude (South)	Longitude (East)
Aga Khan University Hospital Buruburu Medical Center	1.28774	36.88083
Baus Optical	1.28796	36.88119
Buruburu Health center	1.27956	36.87779
Buruburu Medical Clinic	1.28555	36.87986
Bush Chinese Clinic	1.28695	36.88083
Charolyn Specialist Clinic	1.28546	36.87987
CliniX Health Care	1.28155	36.87910
Corner House Medical Clinic	1.29180	36.88281
Eastlands Medical Center	1.28469	36.87997
Eastland Medicare & diagnostic	1.28554	36.88027
Healthwise Medical & Dental Clinic	1.28450	36.87944
Jobee Herbal Clinic	1.27917	36.87761
Meridian Medical Center	1.28349	36.87992
Metropolitan Hospital	1.28800	36.87473
Millenium Dental Clinic	1.28777	36.88153
Nairobi East Medical Clinic	1.29404	36.88005
Women Clinic	1.28762	36.88040
Buruburu Girls High School Dispensary	1.28369	36.87328
Buruburu High School Clinic (NPC)	1.29252	36.87989

Appendix III

Web-GIS HMIS Representation:

PHP Script

```
<?php
$username="root"; $password=""; $database="mysql";$server="localhost";
|
$doc = domxml_new_doc("1.0");
$node = $doc->create_element("markers");
$parnode = $doc->append_child($node);
// Opens a connection to a MySQL server
$connection=mysql_connect (localhost, $username, $password);
if (!$connection) {
    die('Not connected : ' . mysql_error());}
// Set the active MySQL database
$db_selected = mysql_select_db($database, $connection);
if (!$db_selected) {
    die ('Can\'t use db : ' . mysql_error());}
// Select all the rows in the markers table
$query = "SELECT * FROM markers WHERE 1";
$result = mysql_query($query);
if (!$result) {
    die('Invalid query: ' . mysql_error());
}
header("Content-type: text/xml");
// Iterate through the rows, adding XML nodes for each
while ($row = @mysql_fetch_assoc($result)){
    // ADD TO XML DOCUMENT NODE
    $node = $doc->create_element("marker");
    $newnode = $parnode->append_child($node);
    $newnode->set_attribute("name", $row['name']);
    $newnode->set_attribute("address", $row['address']);
    $newnode->set_attribute("lat", $row['lat']);
    $newnode->set_attribute("lng", $row['lng']);
    $newnode->set_attribute("type", $row['type']);
}
$xmlfile = $doc->dump_mem();
echo $xmlfile;
?>
```

XML Script

```
<?xml version="1.0" encoding="utf-8" standalone="yes" ?>
- <markers>
- <marker lat="1.287155447749432" lng="34.5907287077521" label="Agha Khan Hospital" icon="red">
- <tab>
  <label>General Infor</label>
- <contents>
  <![CDATA[ Information <br />(Buru buru clinic) ]]>
</contents>
</tab>
- <tab>
  <label>Contacts</label>
- <contents>
  <![CDATA[ Contact information goes here.<br />(Marker One) ]]>
</contents>
</tab>
- <tab>
  <label>Images</label>
- <contents>
  <![CDATA[ <br> ]]>
</contents>
</tab>
</marker>
</markers>
```


Java Script

```
<script type="text/javascript">
  //
function load() {
  if (GBrowserIsCompatible()) {
    var iconBlue = new GIcon();
    iconBlue.image = 'http://labs.google.com/ridefinder/images/mm_20_blue.png';
    iconBlue.shadow = 'http://labs.google.com/ridefinder/images/mm_20_shadow.png';
    iconBlue.iconSize = new GSize(12, 20);
    iconBlue.shadowSize = new GSize(22, 20);
    iconBlue.iconAnchor = new GPoint(6, 20);
    iconBlue.infoWindowAnchor = new GPoint(5, 1);
    var iconRed = new GIcon();
    iconRed.image = 'http://labs.google.com/ridefinder/images/mm_20_red.png';
    iconRed.shadow = 'http://labs.google.com/ridefinder/images/mm_20_shadow.png';
    iconRed.iconSize = new GSize(12, 20);
    iconRed.shadowSize = new GSize(22, 20);
    iconRed.iconAnchor = new GPoint(6, 20);
    iconRed.infoWindowAnchor = new GPoint(5, 1);
    var customIcons = [];
    customIcons["hospitals"] = iconBlue;
    customIcons["clinics"] = iconRed;

    var map = new GMap2(document.getElementById("map"));
    map.addControl(new GSmallMapControl());
    map.addControl(new GMapTypeControl());
    map.setCenter(new GLatLng(47.614495, -122.341861), 13);

GDownloadUrl("phpsqlajax_genxml.php", function(data) {
  var xml = GXml.parse(data);
  var markers = xml.documentElement.getElementsByTagName("marker");
  for (var i = 0; i &lt; markers.length; i++) {
    var name = markers[i].getAttribute("name");
    var address = markers[i].getAttribute("address");
    var type = markers[i].getAttribute("type");
    var point = new GLatLng(parseFloat(markers[i].getAttribute("lat")),
      parseFloat(markers[i].getAttribute("lng")));
    var marker = createMarker(point, name, address, type);
    map.addOverlay(marker);
  }
});</pre></div><div data-bbox="445 949 533 967" data-label="Page-Footer"><p>Page | 77</p></div>
```

HTML Script for query

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
  "http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">

<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=UTF-8" />
  <title>BURUBURU GIS HEALTH INFORMATION SYSTEM</title>
<script src=
"http://maps.google.com/maps?file=api&v=2&sensor=false&key=ABQIAAAA2wMxKzbUnKCnJKYi5A1
g5Tb6oMHjyWRwypEq0w" type="text/javascript"></script>

  <link rel="stylesheet" href="travel.css" type="text/css" charset="utf-8" />

  <script type="text/javascript">

  // JAVASCRIPT CODES GO HERE!!

</head>

<body>
</body>
</html>
```

Module Search:

```
<div class="search">
<input name="searchword" id="mod_search_searchword" maxlength="20"
alt="Search" class="inputbox" type="text" size="20" value="search
facility" onblur="if(this.value==" this.value='search facility';"
onfocus="if(this.value=='search facility') this.value=";" /><br /><input
type="submit" value="Search" class="button"
onclick="this.form.searchword.focus();"/> </div>
<input type="hidden" name="task" value="search" />
<input type="hidden" name="option" value="com_search" />
</form> </div>
<script type="text/javascript">

  /*  */

  var 2FieldNames = new Array();</pre></div><div data-bbox="452 949 540 967" data-label="Page-Footer"><p>Page | 78</p></div>
```

```

2FieldNames[0] = "field_cost";
2FieldNames[1] = "field_ownership";
2FieldNames[2] = "field_patients";
function reset2SearchForm() {
var CookieRemove = " = 0; expires=0; path=/;";
$('2Search').value = "Search ... ";
document.cookie = "2SearchCookie[2Search]" + CookieRemove;
document.cookie = "2SearchCookie[searchphrase]" + CookieRemove;
$("searchphraseany").checked = true;
$("Cid").value = 0;
document.cookie = "2SearchCookie[cid]" + CookieRemove;
$("SearchPage").value = 0;
document.cookie = "2SearchCookie[SearchPage]" + CookieRemove;
for(i=0; i < 2FieldNames.length; i++) {
    $(2FieldNames[i]).selectedIndex = 0;
    document.cookie = "2SearchCookie[" + 2FieldNames[i] + "]" +
CookieRemove;}
    for(SearchFormComboBxCounter; SearchFormComboBxCounter > 0;
SearchFormComboBxCounter--) {
        if(SearchFormComboBxCounter > 0) {
            chBox = document.getElementById("sdrops_" +
SearchFormComboBxCounter);
            chBox.parentNode.removeChild(chBox); }}
        SearchFormComboBxCounter = 0;
        $("CatSelected_0").selectedIndex = 0;}
window.addEventListener('load', function() {
var SearchResponseContainer = new Fx.Slide('SearchResponseCont

```

```

ainer');

    var SearchFormExtOpt = new Fx.Slide('SearchFormExtOpt');
    SearchFormExtOpt.slideOut();
    $('SearchFormExtOptToggle').addEvent('click', function(e){
    e = new Event(e);
    SearchFormExtOpt.toggle();
    e.stop();});

    $('SearchFormContainer').addEvent('submit', function(e) {
    new Event(e).stop();

    var log = $('SearchResponseContainer').empty().addClass('ajax-loadin
g');

    var url = "http://localhost/healthGIS/index2.php?" +
$('SearchFormContainer').toQueryString();

    var query = new Ajax(url, {
    method: 'get',
    onComplete: function() {
    log.removeClass('ajax-loading');},
    update: log});

    query.request();

    SearchFormExtOpt.slideOut();});

    $('SearchSubmitBt').click();});

    var SearchFormComboBxCounter = 0;

    var SearchFormCatsChilds = new Array();
    var SearchFormCatsNames = new Array();

    function addSearchFormCatBox(cid, c) {
    if(cid == 0) {
    if(c == 0) {

```

```

$("Cid").value = cid;}

else {

    box = c - 1;

    $("Cid").value = $("CatSelected_" + box).options[$("CatSelected_" +
box).selectedIndex].value;}

    if(c < SearchFormComboBxCounter) {

        for(SearchFormComboBxCounter; SearchFormComboBxCounter > c;
SearchFormComboBxCounter--) {

            if(SearchFormComboBxCounter > 0) {

                chBox = document.getElementById("sdrops_" +
SearchFormComboBxCounter);

                chBox.parentNode.removeChild(chBox); }}

                SearchFormComboBxCounter = c; }}

                if(cid != 0) {

                    $("Cid").value = cid;

                    url =
"http://localhost/healthGIS/index2.php?option=com_2&no_html=1&2Task
=SigsiuTreeMenu&Itemid=98&catid=" + cid;

                    SearchFormComboSendRequest(url,c);}}

                    function SearchFormComboSendRequest(url,c) {

                        var SearchFormCatHttpRequest;

                        if (window.XMLHttpRequest) {

                            SearchFormCatHttpRequest = new XMLHttpRequest();

                            if (SearchFormCatHttpRequest.overrideMimeType) {

                                SearchFormCatHttpRequest.overrideMimeType('text/xml');}}

                                else if (window.ActiveXObject) {

                                    try { SearchFormCatHttpRequest = new
ActiveXObject("Msxml2.XMLHTTP"); }

```

```

    catch (e) {
        try {
            SearchFormCatHttpRequest = new
ActiveXObject("Microsoft.XMLHTTP");
        }
        catch (e) {}
    }
    if (!SearchFormCatHttpRequest) {
        alert('Sorry but I Cannot create an XMLHTTP instance');
        return false;
    }
    SearchFormCatHttpRequest.onreadystatechange = function() {
        if (SearchFormCatHttpRequest.readyState == 4 &&
SearchFormCatHttpRequest.status == 200)
        SearchFormCatGetSubcats(SearchFormCatHttpRequest,c);
        SearchFormCatHttpRequest.open('GET', url, true);
        SearchFormCatHttpRequest.send(null);
        function SearchFormCatGetSubcats(XMLDoc,c) {
            if(!XMLDoc.responseXML) {
                return null;
            }
            var r = XMLDoc.responseXML;
            var categories = r.getElementsByTagName("category");
            if(c < SearchFormComboBxCounter) {
                for(SearchFormComboBxCounter; SearchFormComboBxCounter > c;
SearchFormComboBxCounter--) {
                    if(SearchFormComboBxCounter > 0) {
                        chBox = document.getElementById("sdrops_"
SearchFormComboBxCounter);
                        chBox.parentNode.removeChild(chBox);
                    }
                    SearchFormComboBxCounter = c;
                }
                if(categories.length > 0) {
                    SearchFormComboBxCounter++;
                }
            }
        }
    }
}

```



```
(span}}
```

```
function SearchRes(page) {  
  $('SearchPage').value = page;  
  $('SearchSubmitBt').click(); }  
/* ]]> */  
</script>
```