Assessing the adequacy of Public Health Facilities in a Devolved System of Government by use of GIS. Case study: Nairobi County, Kenya

BY

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A Project submitted in partial fulfillment for the Degree of Master of Science in GIS, in the Department of Geospatial and Space Technology of the University of Nairobi

June 2017
Declaration

I, Omalla Savio Ochieng, hereby declare that this project is my original work. To the best of my knowledge, the work presented here has not been presented for a project in any other university.

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Name of student ...........................................

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Date

This project report has been submitted for review with our approval as university supervisor(s).

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Name of supervisor ...........................................

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Date
Dedication

I dedicate this work to all my family and friends with whom we have formed a lasting bond that has stood the test of time. May the Lord walk with us through this life journey.
Acknowledgement

I would like to thank the following people for all their help and input that went into this work:

1. The Almighty God for having kept me in good health, enabling me to get to this point of studying and for all his mercies through and through.

2. My family for the patience and understanding they showed me during the long hours I spent working on this project.

3. My colleagues and classmates with whom I shared different concepts and ideas with.

4. My supervisor, Dr. Ing. Faith N Karanja for her valuable input as well as her tirelessness in ensuring the project was completed in good time.

5. The entire staff of the Department of Geospatial and Space Technology at the University of Nairobi for their dedication and professionalism during my time of study at the university.
Abstract

It has been a never ending battle for Kenya as the country attempts to build an effective health system that can effectively deliver quality health services to its population. After promulgation of the new constitution in 2010, the health function was devolved to the county governments. Devolving of the health functions resulted in the organization of the service delivery into six levels of care which was intended to efficiently use the existing resources through a referral system. The World Health Organization recommends an average of 23 doctors, nurses and midwives per 10,000 people for optimal service delivery. Kenya has one doctor, 12 nurses and midwives per 10,000 people as at the year 2014. The shortage of health care workers as well as poor distribution of both personnel and health facilities in a devolved system of government seriously compromises and undermines the health development of the country.

The main objective of this study was to assess the adequacy of public health facilities in a devolved system of government using GIS in Kenya more specifically Nairobi County. This was done by identifying the factors that determine the adequacy of health facilities in a devolved system of government from review of existing literature and publications. Spatial aspects of public health facilities in Nairobi county were established and analyzed through mapping of the existing health facilities and collecting of their attributes such as number of doctors and nurses as well as persons served per day. A Geodatabase for assessing their adequacy was developed after which an assessment of adequacy was done. It emerged that the county was hugely understaffed and lacked vital infrastructure such as ambulatory services. Only one facility had an ambulance even though there was no ambulance driver. The recommended doctor to patient ratio by the World Health Organization is 23 doctors and nurses in a population of 10,000. The ratio of doctors to nurses should be 1:4. Out of a population of 380,000 persons, only one doctor was found in the thirteen public health facilities that were interviewed. It also emerged that some facilities lacked fundamental facilities and services such as maternity services, toilets for both staff and patients as well as clean running water. In conclusion the information generated can help both levels of government to identify the areas in the health sector that require intervention as well as the kind of intervention. There is still a lot to be done in the health sector so as to bridge the existing gaps as well as sealing of existing loop holes.
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CHAPTER 1: INTRODUCTION

1.1 Background

According to World Bank (2000), Kenya is among the African countries that are generally held to be in crisis when it comes to health and healthcare. With the current population being well over 40 million citizens, Kenya has strived over the years to develop a health system that can adequately deliver quality and effective health services to its populace. Access to health care varies widely throughout the country. Major divides exist between rural and urban communities, and between the moneyed elite and the poorer masses (Turin, 2010).

A good cross section of the Citizens is having a declining quality of life. This can be attributed to poor health services and infrastructure, cost constraints in accessing required medical services from the facilities that provide them as well as other factors such as environmental degradation. In addition, the country also faces a significant burden of disease from communicable and non-communicable conditions as well as from injuries including those that result from violence. (GoK, 2010).

Estimates reveal that 82% of human well-being is lost to communicable diseases every year (WHO, 2007). Kenya’s infant mortality rate is at 48% with the life expectancy at birth being 58%. This is essentially lower than the worldwide normal of 68% mainly due to the influence of communicable diseases to the health of most individuals after the age of 42 (Kenyanya, 2015).

The Kenya Government, various healthcare agencies such as Insurance companies, National Hospital Insurance Fund (NHIF) and non-governmental organizations such as World Health Organization have made tremendous efforts to address and improve the quality of healthcare. However, Kenya is still plagued with issues that have traded off the provision of quality health care service. Some of the problems affecting healthcare in the Sub-Saharan Africa includes lack of infrastructure, poor management and administration of health facilities, lack of essential equipment, deficiencies in supply of medical drugs, affordability, accessibility and quacks or unqualified.

The review of the Kenya constitution proposed a devolved system of government where health was one of the devolved functions. After promulgation of the new constitution, county governments took effect after the general election in 2013 in Kenya. This resulted into restructuring of the health care system where only national referral hospitals remained under the jurisdiction of the national government. The former Sub district, district and provincial hospitals
as well as the health center’s and dispensaries were moved under the jurisdiction of the county governments.

Devolving of the health functions resulted in the organization of the service delivery into six levels of care which was intended to efficiently use the existing resources through a referral system. The categorization does not guarantee that direct access to health services meant adequate management of health needs in terms of staffing, management of available facilities as well as patient management (Ministry of Health, 2014).

According to article 43 of the Kenya Constitution (2010), ‘every person has a right to the highest attainable standard of health, which includes reproductive health rights’. It further states that ‘a person shall not be denied emergency medical treatment and that ‘the State shall provide appropriate social security to persons who are unable to support themselves and their dependants.’ 56.8% of the population in Kenya live below the national poverty line population meaning they are not able to afford or pay for health services (UNDP, 2015). Since every citizen is guaranteed the highest attainable standard of health, the government is tasked to provide health services to all categories and levels of citizens be it at a cost, at a subsidized fee or for free. The required expertise in terms of personnel and equipment should also be provided for on stand-by basis. It is important therefore for the government and planning agencies involved in health matters to know where the various health facilities are located or set up, the kind of health services that are offered as well as the personnel and staff in the various health facilities. It is also important to know what challenges are specific to the various health facilities in a particular jurisdiction.

According to (Burrough, 1986), Geographic Information Systems (GIS) can be defined as ‘the science and technology associated with the collecting, storage, manipulation, analysis and visualization of geo-referenced data’. GIS focuses on merging computer mapping competencies with database management and analysis tools. Systems used in GIS include numerous applications such as environmental sciences, city planning and agricultural applications. Among the key topics on the increase in GIS application is Public health.

If the potential for GIS to add value to health research and planning in Africa is to be legitimately assessed, then the technology must be relevantly applied aid in addressing pressing health issues in the Africa as a whole and especially Kenya (Frank & David, 2002).

GIS has been applied in the health sector in the comprehension, management and administration of malaria in Africa. GIS has been used to create models of occurrence of malaria disease (Craig,
et al., 1999), (Adjuik, et al., 1998), using climatic and remotely sensed data. The outputs of such models have been combined with population data to assess exposure levels, mortality and morbidity (Snow, et al., 1999) as additionally assessing and projecting the impacts of environmental changes on malaria.

GIS has been applied in examining imbalances in population per bed ratios and the ramifications of open access to the private and the formerly white hospital services in the province of KwaZulu-Natal, South Africa (Zwarenstein, et al., 1991).

GIS has been used to enhance informed health decision-making in developing countries such as Kenya as well as understanding accessibility of health services in Kenya (Noor, et al., 2009). A health facilities map of Kenya was first developed in 1959 but it was not until 2003 that this map was up-dated. This was followed by rapid expansion and funding of the health sector which included building of health centres and dispensaries.

In this project, the focus will be on assessing the adequacy of public health facilities in a devolved system of government in relation to their availability and location, the population they serve as well as the level of services offered in relation to Non communicable diseases such as cardiovascular diseases, cancers, chronic respiratory diseases and diabetes (WHO, 2015). GIS is the most appropriate tool for assessing the adequacy of the public health care facilities due to its analytical capabilities as well as visual interpretation.

1.2 Problem Statement

The World Health Organization recommends an average of 23 doctors, nurses and midwives per 10,000 people for optimal service delivery. Kenya has one doctor, 12 nurses and midwives per 10,000 people as at the year 2014 (Ministry of Health, 2014). The shortage of health care workers in a devolved system of government seriously compromises and undermines the health development of the country. Moreover, there exists a disparity in the distribution of health facilities and existing health personnel where the hard to reach regions receive less staff as well as health infrastructure.

There was a Doctor’s strike in the year 2017 lasting for 100 days where the doctors who work under both the county and national governments country wide were demanding that both levels of government implement the Collective Bargaining Agreement signed in 2013. The agreement contains clauses touching on increasing the number of doctors to curb the current doctor shortage
as well as providing adequate medical equipment to doctors (Ministry of Health, 2013). This clearly indicates that the number of medical practitioners in public health institutions is inadequate in the country in general as well as lack of adequate facilities to support the sick with various ailments.

There is need to establish the adequacy of public health facilities in the current devolved system of government and if devolving the health function has in turn resulted to access of public health facilities trickling down to the lowest level of society. There is need to establish if indeed Kenya has attained the recommended ratio of doctor and nurses to patient ratio. There is need to establish the level at which public health facilities are serving the masses when it comes to non-communicable diseases as well as mapping out the location of the medical facilities.

1.3 Objectives
The main objective of this study was to assess the adequacy of public health facilities in a devolved system of government using GIS in Kenya more specifically Nairobi County through application of GIS. The specific objectives included:

1. Identify factors that determine the adequacy of public health facilities in a devolved system of government.
2. Determine the spatial aspects of public health facilities in Nairobi county
3. Design a GIS database on devolved health system
4. Analyze the adequacy of public health facilities in a devolved system of government

1.4 Justification for the Study
For Kenya to achieve the SDGs when it comes to health, then it is extremely important to evaluate the level and adequacy of public health facilities in terms of location as well as the actual services they offer. This study comes at a time where the Kenya Medical Practitioners, Pharmacists and Dentists union are pushing that both levels of government should increase uptake of medical practitioners into the health service as well as provide the much needed medical equipment to enhance their level of service delivery. The Practitioners are also agitating for better pay; justifying it with the long working hour shifts they have to put up with. As a result, this project will go a long way in helping both medical practitioners as well as the Nairobi County Government establish gaps in the staffing and equipping of medical facilities as well as verify if indeed the ideologies
fronted by the medical practitioners are justified. This project can also aid the medical practitioners put into perspective their demands to the relevant government offices as they continue to push for reforms in the health sector.

This study will therefore help answer questions like where the health services are offered and also establish if the facility offering the health service is over-burdened.

1.5 Scope of work
This research intends to map out the current public health facilities that are under the jurisdiction of either the National or Nairobi County governments. Attribute data to be collected include types of services offered, number of doctors employed in the facility and their specialty as well as bed capacity where applicable.

This study will assume that all kinds of treatment including specialized diagnosis and treatment should be offered in public health institutions.

1.6 ORGANIZATION OF THE REPORT
This report is organized into five parts. Chapter one contains the introduction to this study and its background, the problem statement, objectives of the study, scope of the study, its justification, and assumptions or hypotheses made. Chapter two contains the literature review which entails an overview of work that had been previously done in this field in a chronological manner. Chapter three contains the materials and methodologies used to accomplish the project. Chapter four entails the results and analysis of the findings as well as the discussion about the same while Chapter five contains the conclusions and the recommendations.
CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter outlines the concepts that have been studied and researched on when it comes to GIS and public health, previous work that had been done in relation to this study, the developments that have so far been achieved as far as this study is concerned and the definitions that are crucial in the understanding of the assessment of adequacy public health facilities.

2.2 Global Health Status

As 2015 drew to a close, the United Nations officially launched a set of 17 Sustainable Development Goals (SDGs) to replace the eight anti-poverty Millennium Development Goals (MDGs). The SDGs are supposed to aid in getting rid of social ills by the year 2030 (United Nations, 2015).

Matters relating to health are addressed in Sustainable Development goal number 3. It relates to good health and well-being and generally has the following goals :-

- By the year 2030, the global maternity ratio should have reduced to less than 70 per 100,000 live births.
- Preventable deaths of newborns and children under 5 years should cease with all the countries of the world aiming at reducing the neonatal mortality to as low as 12 per 1000 live births and under 5-year old mortality to as low as 25 per 1000 live births by the year 2030.
- The epidemics of HIV/AIDS, tuberculosis, malaria, combat hepatitis and neglected tropical diseases as well as water borne and other communicable diseases should cease by the year 2030.
- Premature mortality from non-communicable diseases should reduce by one third through prevention and treatment and promote mental health and well-being by the year 2030.
- Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.
- Strengthen the prevention and treatment of substance abuse, narcotic drugs as well as abuse and harmful use of alcohol.
- The number of deaths and injuries from road and traffic accidents to be halved by the year 2020.
• There should be universal access to sexual and reproductive health-care services-those for family planning included-information and education, and the integration of reproductive health into national strategies and programs for all countries by the year 2030.

• The world as a whole should achieve universal health coverage that knows no borders that includes financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable medicines and vaccines for all.

• The number of deaths and ailments from hazardous chemicals and air, water, soil pollution and contamination should be reduced substantially by 2030.

Sustainable Development Goal number 3 additionally underpins the research and development of vaccines and medicines for the communicable and non-communicable diseases that mainly affect developing countries, provide access to fundamental medicines and immunizations as per the Doha Declaration on the TRIPS Agreement and Public Health. This treaty affirms the right of developing countries to use to the full the provisions in the Agreement on Trade-Related Aspects of Intellectual Property Rights with respect to flexibilities to protect public health and, in particular, provide access to medicines for all. The various countries of the world should also work to substantially increase health funding, training, recruitment, development and retention of a healthy and workforce especially in developing countries as well as enhance the capacity for early warning systems, reducing risk as well as management of risks at a national and global level.

The World Health Organization recommends an average of 23 doctors, nurses and midwives per 10,000 people for optimal service delivery. The recommended ratio of doctors to nurses is 1:4. (Ministry of Health, 2014) (WHO, 2017). Countries that do not attain this ratio struggle to provide skilled health care to especially a huge number of pregnant women as well as emergency and specialized services. As a result, this has a direct consequence to the number of deaths in a given population. Community- based health workers, can be considered as non-skilled medical practitioners, often provide life-saving interventions to the communities in which they work in such as giving of immunizations to infants yet they are not included in the ratio of 23 doctors to 100,00 persons. The WHO requires as a policy that citizens should live with a 5km radius of a health facility (WHO, 2007).

For an effective workforce, there has to be a balance between the skilled, semi-skilled as well as the community workers. A poor mix of these categories of people impedes access to life-saving interventions and services (WHO, 2017). An integrated approach coupled with government
goodwill and well developed information systems is needed to ensure a skilled and motivated health workforce at the right place and time.

2.3 Regional Health Status
Healthcare in Africa generally differs, depending on the country. Populations residing in urban areas and towns are more likely to have access to better healthcare services than populations residing in the rural countryside and remote regions. Communities in rural areas have a challenge in accessing clean water as well as sanitation facilities. Such areas are plagued with illnesses as a result of poor hygiene such as diarrhea (WHO, 2008).

In 1978, The Alma Ata Conference declared primary health care as the key strategy for implementation by all countries of the world so as to improve the health status of the people and promote achievement of good health by all by the year 2000. This has remained a challenge especially in Africa though efforts are being made both at regional and global levels to improve the situation (WHO, 2008).

The principles associated with the primary health care implementation strategy of the Alma Ata Conference (WHO, 1978) are:

- Universal accessibility and coverage in relation to need. This means that there has to be a continuous and organized supply of the much needed health services to all people while defying geographical and financial barriers and boundaries.
- Community, individual involvement and self-reliance. This has the implication that individuals, communities and organizations have the right and responsibility to work together in decision making when it comes to health matters involving them.
- Appropriate and cost effective technology. Health care as well as service delivery procedures and equipment must be affordable and socially acceptable.
- Commitment from all sectors of people i.e. government, community and health practitioners is essential for the success of provision of primary health care.

African heads of state met in Abuja, Nigeria and agreed to collectively allocate 15% of their countries annual budgets towards improving the health sector in Africa as a whole (WHO, 2011). Since then, many of the African countries have missed their targets with the main reason being the level of resources needed against the population needs is way below what is needed. Some have made considerable efforts in regards to implementing the primary health care strategy. Many
countries have implemented the burden of disease and availability of evidence-based cost-effective interventions to provide universal access to health services. This means that the health services are designed to provide a set of minimum health activities that can be undertaken at various levels of health care thus having a decentralized system of healthcare (WHO, 2008). Decentralization of health care in Africa has resulted in more responsive and a more equitable distribution of the health facilities. Lower levels of health care are usually under the jurisdiction of local governments while the higher levels of care have varying levels of autonomy with some being either under the national government, faith based organizations, Non-Governmental Organizations and private institutions.

The main problem with Africa when it comes to health is financing and transfer of labour. There are few trained medical personnel to handle the vast number of people who need medical care. Moreover, there are countries which educate and train their own professionals, even overseas, only for them not to come back home after completing their studies. They find better opportunities and working conditions as well as are offered higher attractive salaries than in their home countries. The medical facilities lack basic medical equipment and reagents for day to day use as well as inadequate supply of medicines. Not only do the medical facilities lack essentials, they are also few in number hence more often than not overcrowded. Some of these deficiencies are being addressed through private public partnership where the government offers an insurance scheme where people can access the medical services in private institutions and the government through the insurance scheme foots a certain percentage of the medical bill.

The doctor to patient ratio is Africa varies between countries with the common factor being that the ratio is too low. South Africa’s doctor to patient ratio is 0.8 doctors to 1000 people while in Uganda the ratio was 1 doctor to 24,725 patients (WHO, 2017).
2.4 The Kenyan Health Situation

2.4.1 Background

Before 2012, the Kenyan health system was structured in such a way that all health care facilities were classified into six levels as shown in the table below:

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>TYPE</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Community units</td>
<td>Community level</td>
</tr>
<tr>
<td>2</td>
<td>Dispensary</td>
<td>Village level</td>
</tr>
<tr>
<td>3</td>
<td>Health Centre</td>
<td>Location level</td>
</tr>
<tr>
<td>4</td>
<td>District Hospital</td>
<td>District Headquarters</td>
</tr>
<tr>
<td>5</td>
<td>Provincial Hospital</td>
<td>Provincial Headquarters</td>
</tr>
<tr>
<td>6</td>
<td>National Hospital</td>
<td>Capital City</td>
</tr>
</tbody>
</table>

Table 2.1 Classification of Health Facilities

Primary health care was provided at the community, dispensary and healthcare centers’ level. Dispensaries were run by registered nurses who were supervised by a nursing officer at the respective health centre (Kavuwa, 2010). Dispensaries provided outpatient services for simple non-complicated cases such as common cold, minor cuts and burns. Patients who could not be managed at the dispensary level were referred to the health centres.

District and provincial hospitals provided integrated curative and rehabilitative care. District hospitals were similar to health centres but had the capacity to handle surgical cases while provincial hospitals were able to provide specialized care including intensive care, life support and specialist consultations. The best quality of health care in Kenya was found at the National Referral hospitals such as Kenyatta Teaching and Referral Hospital and Moi Teaching and Referral Hospital. Gaps in the health care system were and are still filled by private and Institution ran facilities (Kavuwa, 2010).

In the year 2003, following the election of a new government, the Constituency Development Fund (CDF) was created so as to fund development projects at the constituency level which included but not limited to building of new health facilities as well as equipping the existing ones (Noor, et al., 2009).

In the year 2007, The Regional Centre for Mapping of Resources and Development, one of the leading mapping agencies in Kenya, conducted a study on the Situation Analysis of Health Service Providers in Kenya (Regional Centre for Mapping of Resources for Development, 2007).
In their study, the agency visited among other agencies the Health Management Information System unit situated at the Ministry of Health Headquarters, International Livestock Research Institute, Central Bureau of Statistics, Kenya Medical Research Institute as well as faith based organisations secretariats with the aim of examining available data and information in terms of relevance, completeness and use in the mapping of health service providers. They also identified existing GIS databases in the country that attempt to capture health care systems and data.

The key findings were that the health database at the national scale was incomplete because most mapping exercises that had been conducted previously concentrated at the sub-national levels being either pilot projects or focused on regional problems e.g. the Health Management Information System which was based at the then Coast province. Previous mapping exercises which had been carried out by Health Programmes had focused on specific health issues such as Malaria mapping. This lead to omitting of some important health information at the time resulting in incomplete mapping of e.g. health indicators.

The study also noted that some health services had been sporadically mapped either by health agencies of individuals during field visits thus resulting in irregular and incomplete datasets such as the statistical data that was collected from Kenya National Bureau of Statistics (KNBS) during field survey. Some health facilities had incorrect geographic coordinates such as those in the KEMRI database whilst some had never been updated since they were developed, perhaps due to cost implications of the exercise.

Duplication of efforts among data collecting agencies was noted whereby several similar health related databases exist within various ministries and organisations. This resulted from uncoordinated mapping exercises where data is generated to meet particular organisational needs. Information generated from the mapping exercises is not shared between partners in the health sector leading to duplication of efforts in the health sector.

The centralized system of government was plagued by political interference and nepotism where those in government favoured their regions as opposed to others as well as unequal distribution of resources.
2.4.2 Current Trends

After promulgation of the new Kenya constitution 2010 and its enactment in the year 2012, the health function was devolved to the county governments. It was widely believed that devolving the health function to the county government would lead to a more efficient health system with improved access to public health facilities as well as equitable distribution of the same. The devolved system according to (Ministry of Health, 2014) is categorized into four levels.

**Level 1** is the community level and is composed of community based demand creation activities. A level one facility should be designed to serve 5,000 people and requires 50 volunteer community owned resource persons as well as 2 community health extension workers. Each community health extension worker is expected to supervise and support 25 community owned resource persons (CORP) who are each expected to serve 20 households or 100 people.

**Level 2 and 3** are the primary care level whose focus is on responding to the demand generated and is composed of dispensaries, health centres and nursing homes. These facilities should be able to at least carry out a normal delivery, should exist on average for every 10,000 people and an average of 30 outpatient visits per day for any of the services offered if everyone in the catchment area is to visit the health facility once a year.

**Level 4 and 5** are the county referral services level consists of county referral hospitals which are expected to provide specialised services. They consist of former district hospitals in the counties. These facilities should be available for every 30,000 persons with a capacity to handle at least 4 deliveries per day with a befitting workload that is fair on the system and staff.

The counties are responsible for level 1, 2, 3, 4 and 5 health facilities. Referrals within the counties are received from primary care facilities within the county, other county referral facilities within the county as well as community units within the county.

The Ministry of Health headquarters is responsible for level 6 health facilities which consist of the four National referral hospitals namely Mathari Hospital, Kenyatta National Hospital, National Spinal Injury Hospital and Moi Teaching and Referral Hospital (Ministry of Health, 2014). Level 6 facilities provide national referral services that are specialised, including blood banks and research institutions.

All medical cases through the public health services in Kenya go through a referral process that starts from the lowest facilities to the highest tertiary facilities.
2.4.3 Requirements for Effective Referral Services

According to (Ministry of Health, 2014), for a smooth running and effective referral system, the health system must have the following basic provisions organised in such a manner that they respond adequately to referral needs. These are:

- **Quality health services**: The framework of the health system must provide effective, safe and high quality personal and non-personal health interventions and management as of where and when needed.

- **A well-performing health workforce**: In addition to attracting skilled personnel in sufficient numbers, the health system should also be able to maintain a responsive and productive health workforce.

- **A well-functioning health information system**: The health management information system, currently situated at the Ministry of Health headquarters, should be able to produce, analyse, disseminate and generate reliable and timely information.

- **An efficient system of access**: The health system should guarantee availability of essential medical products such as vaccines. The technologies applied in the health system should be safe and cost effective as well as assure quality.

- **A good health financing system**: The financing system should avail adequate funds for health. The financing system should ensure that people can use the needed services without being exploited and impoverished from the need to pay for them.

- **Leadership and governance**: There should be clear and comprehensive guidance for effective service delivery coupled with proactive oversight, capacity building, regulation and accountability.

- **Health infrastructure**: Both levels of government should develop infrastructure, transport and technology needed for effective access of health services at each level of care.
Table 2.2.: Key requirements needed to manage the movement of expertise at different levels of care

<table>
<thead>
<tr>
<th>Service Provider</th>
<th>Support to Facilities and Equipment</th>
<th>Human Resources</th>
<th>Commodities and Supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Care Units</strong></td>
<td>Community units</td>
<td>Motorized transport</td>
<td>Clinical officers, nurses and other Health cadres as necessary</td>
</tr>
<tr>
<td><strong>County Hospital</strong></td>
<td>Primary Care units</td>
<td>Screening equipment, diagnostic kits</td>
<td>Specialists, medical officers, nurses, medical laboratory technologists, rehabilitation team</td>
</tr>
<tr>
<td><strong>County Hospital</strong></td>
<td>Sub-county hospital</td>
<td>Utility Vehicle, communication gadgets, physiological monitors, diagnostic kits</td>
<td>Surgical specialists, medical specialists, pathologists, radiologists, medical laboratory technologists, nurses and others</td>
</tr>
<tr>
<td><strong>County Referral Hospital</strong></td>
<td>County hospitals</td>
<td>Utility vehicle, communication gadgets, fully equipped theatre with anaesthetic</td>
<td>Medical and surgical specialists, physiotherapists, medical laboratory technologists, nurse specialist, bio-medical</td>
</tr>
<tr>
<td>National Referral Hospital</td>
<td>machine, vacuum machine, surgical sets, physiological monitors, theatre tables, diagnostic kits</td>
<td>engineering personnel, drivers, diagnostic imaging personnel, dentists, clinical officer specialists</td>
<td>surgical blades, sutures, chemicals, and laboratory reagents</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>National Referral Hospital</strong></td>
<td>Utility vehicle, communication gadgets, fully equipped theatre with anaesthetic machine, vacuum machine, surgical sets, physiological monitors, theatre tables, specialised sets, diagnostic kits</td>
<td>Surgical specialists, obstetricians, gynaecologists, neurosurgeons, orthopaedic surgeons, plastic surgeons, cardiothoracic surgeons, paediatric surgeons, oral maxillofacial surgeons, uro-surgical specialists, ophthalmologists, ENT specialists, anaesthetists, medical specialists, diabetic specialists, neurophysicians, cardiology specialist, psychiatrists, urologists, dermatologists, respiratory and infectious disease specialists, paediatric specialists</td>
<td>Pharmaceutical supplies (anaesthetic drugs, analgesics, antibiotics, etc.), nonpharmaceuticals (e.g., syringes, surgical blades, and sutures), chemicals, and laboratory reagents</td>
</tr>
</tbody>
</table>
2.5 Adequacy of Health Facilities

2.5.1 Indicators for assessing adequacy of public health facilities

This research is centred on application of GIS in assessing the adequacy of public health facilities in Nairobi county. The failure of health systems in developing countries like Kenya to provide appropriate preventive and curative interventions unless checked will continue to be a hindrance to the achievement of this sustainable goal. An assessment of the adequacy of the public health systems can provide valuable insight to the current situation of the public health facilities as well as provide plausible recommendations and solutions to improve the general situation. One indicator of the level of adequacy of the public health facilities is the level of the population’s access to the facility as well as the successful provision of services at the health facility (Kavuwa, 2010).

This assessment of adequacy can be done by measuring accessibility levels as well as the equitable distribution of facilities (Raghdaa, 2017). According to (Obrist, et al., 2007), who developed a framework for analysis and action, the aspects that influence the health-seeking process are accessibility, adequacy, acceptability, availability, affordability and equity.

1. In a particular jurisdiction such as a locality or even city, the ability of the locals to access essential services such as health services is directly related to the quality of life that such people lead (Pred, 1977). High accessibility means that a given facility is easily reachable. This means that accessibility is a measurable variable which relates to the level of opportunity given for interaction with an object/event/person (Johnston, et al., 1986a). Accessibility in geographical terms hence refers to the physical proximity of a health
facility that can be assessed through use of GIS methods. A high distribution of public health facilities as well as a well-developed road network enhances accessibility. Presence of health facilities and a road network does not automatically translate to high accessibility levels because the facilities may be poorly equipped, expensive to pay for or transport may be an issue. Accessibility problems include long distances that a patient has to travel to the nearest health facility, unreliable or poor public transport system, lack of personal transport interventions such as motorcycles and private vehicles. Accessibility also relates to the amount of time that is required to reach a given health facility (Obrist, et al., 2007).

Several models have been employed to calculate geographical accessibility. The least cost path analysis has been previously used to estimate the distance and time taken to travel between settlement areas and various facilities by use of an existing road network (Lovett, et al., 2000). Ratio models were developed and used to estimate the number of facilities needed in a given population for varying geographical zones (Stimson, 1981). Currently, the WHO requires as a policy that citizens should live with a 5km radius of a health facility (WHO, 2007). This policy is however debatable in the sparsely populated areas as it can lead to over-establishment of public health facilities which may result in stretching and depletion of health budgets as well as facilities that are not well equipped.

2. Adequacy relates to how the organization of public health facilities meet patient expectations (Obrist, et al., 2007). It relates to how the services in a health facility are organized and to what degree the set up meets the patient’s expectations. This can be aspects like operating times of the facility, social factors such as aesthetics and quality of the facility (Obrist, et al., 2007). Such information can be collected through customer surveys.

3. Acceptability relates to cultural and religious aspects. It also relates to aspects such as the patients feeling cared for in a health facility. It also involves procedures, information and explanations as well as treatment being given in a competent manner such that patients have confidence in the health care provider, be it the personnel or the facility itself. Socio-cultural factors also affect societies acceptence of health facilities. This can be religion, culture and education (Obrist, et al., 2007). When people are educated, they become enlightened and are more receptive to health interventions for preventive Measures as well as curative health services. Some religions are known to discourage their members from
accessing health services deeming it as an infiltration of Western values into their way of life and instead rely on prayer alone. Some people may not accept services from a health practitioner who is either male or female (Mwasi, 2010).

4. Availability in this context relates to the actual existing of the health facility and services such that they meet the needs of the population. It also refers to the number of health facilities that a population can choose from. According to (Mwasi, 2010), it involves the types of services that can be offered, what health facilities can offer the required services, enough personnel to offer the actual required service as well as are the services sufficient to meet the demand of the population that the health facility is meant to serve. The World Health Organization recommended an average of 23 doctors, nurses and midwives per 10,000 people for optimal service delivery (Ministry of Health, 2014).

5. For affordability, the population must be able to pay for the services offered at the prices they are being offered at. The affordability encompasses the direct costs of services e.g. consultation fee or price of medication that has been prescribed, cost of transportation to the health facility as well as other charges such as parking fees. Affordability thus is influenced by economic barriers. (Mwasi, 2010) alludes to the fact in some areas, people have to sell their critical assets so as to pay for access to drugs, obtain ambulance services as well as raise the fees needed to access or travel to the relevant health facility.

6. Equity in health care relates to the distribution of resources and is different from equality which in most jurisdictions means that everyone in a given population has equal access to say health facilities. Equity refers to the fairness of a distribution and has the implication that the population with the higher need should have more or a higher access to facilities, in this case health facilities. The need can be derived from economic classification of a population. It is largely assumed that low income groups have higher need for access to public facilities (Besler, 2011). Equity also means that the whole population has access to the same range of health services according to their needs and preferences despite their income levels, area of residency or social status.

Besler (2011) studied equity in terms of categories of people in the community who are need in Kansas City when it came to accessing neighbourhood parks. She incorporated the socio economic status of the population and three components of accessibility i.e. travel cost, gravity potential and minimum distance to study equity. Her study concluded that even though most of the high need
population had equitable access to neighbourhood parks, there still existed groups that did not have access to the same.

2.6 Geographic Information Systems and public health

Public health and personal health have in the recent past been thought to mean the same thing. The difference between the two terms is that public health refers to the health of a population as opposed to the health of an individual or individuals to which personal health refers to. Public health operates in the domain of governments and other national as well as international bodies as opposed to private or individual context (O'carroll, et al., 2003)

In 1854, John Snow, an English doctor, provided the exemplary case of how mapping can be applied in public health. He was of the supposition that cholera was a water borne disease and proceeded to map the locations of those afflicted by cholera in relation to public water supplies in London. In doing so, he identified the water source responsible for the flare up of cholera disease. The removal of the pump handle of the offending water source led to a decline of the incidence of cholera thereby helping the medical community of the time to agree with his theory of cholera being a water borne disease. GIS has continued to be used in public health for epidemiological studies. (Kathleen, 2017) (Fradelos, et al., 2014)
The use of GIS and spatial representation of various health issues has aided professionals arrive at conclusions faster and in informed ways when it comes to decision making in the field of public health (Hanchette, 2003). Risk assessment models for monitoring and mitigating contamination of drinking water in the city of London are based on GIS (Taylor, et al., 2013). Moreover, other research and works touching on Hepatitis c as well as intravenous drug use have been done and modelled on GIS platforms (Trooskin, et al., 2005).

GIS can contribute to public health in many ways such as providing information regarding the distribution of health services. Health experts can easily identify challenges and inconsistencies with respect to the accessibility to health services and as a result provide mitigation measures to handle the situation (Fradelos, et al., 2014; Foley, 2002).

The desire for spatial information distribution of phenomena as well as the demand for thematic maps for registering themes on the earth’s surface fast tracked the development of GIS. According to (Crampton, 2001), through the infusion of aerial photos from photogrammetry, satellite images
from remote sensing, detailed mapping with significant increase in accuracy was realized. These maps thus created were the first form of GIS.

Howard T. Fisher, in 1963, created SYMAP (Synagraghic Mapping System). This was an attempt at introducing the concept of geographic / cartographic data. The program had the ability to make, reproduce as well as print maps. Tremendous progress in the field of information technology has promoted the creation of programs which are able to combine, analyze and present information from various geographical sources and areas (Cooke & Foresman, 1998) (Crampton, 2001).
CHAPTER 3: MATERIALS AND METHODS

3.1 Study Area

Nairobi City County is not only one of the 47 counties but also the Capital city of the Republic of Kenya. The county has a total area of 696.1 Km² and is located between longitudes 36°45’ East and latitudes 1°18’ South. It lies at an altitude of 1,798 metres above sea level. It borders Kiambu County to the North and West, Kajiado to the South and Machakos to the East. The population of Nairobi county in 2017 is estimated at 4,253,330 persons (Nairobi City County, 2016). The county is divided into 17 sub-counties as shown in figure 3.1.

![Nairobi County Map](image)

Fig 3.1: Nairobi County map

Nairobi City County contributes 60% of Kenya’s GDP. It is also the major gateway to East and Central Africa hosting the Jomo Kenyatta International Airport, the largest airport in the region. Nairobi City County is an attractive County for residents, workers and investors due its strategic
location in the region. It has attractive physical, social and economic features that offer promising opportunities for socio-economic development for all.

The county faces major challenges which hamper the realization of its full development potential. High population growth rate, fueled by rural-urban migration, stands at 9.8% per year (Nairobi City County, 2016). The bulging numbers coupled with high unemployment rates especially among the youth has led to stretching of the already inadequate city resources. Informal settlements in the county are ranked amongst the largest urban slums in Africa, characterized by poor housing, health, security as well as social services continue to expand. Lack of infrastructure development, maintenance and expansion has led to stretching of social facilities as well as inadequate health and recreation facilities and other social amenities.

Nairobi county is well served by public transport with almost all corners of the county being covered by road network. The city centre as well as major roads experience traffic jams during rush hour which start from 6am – 9pm for morning hours and 4pm – 8pm for evening hours.

There are 762 registered health facilities in Nairobi as per the Ministry of Health Facility list (2017) with those that are ran by the County government being 78 and the National government having 4 namely Kenyatta National Teaching and Referral Hospital, Mathari Mental Hospital, Pumwani Maternity Hospital as well as the National Spinal Injury Hospital. (See figure 3.2)

Makadara sub-county has a population of 160,434 persons with an area of 13km². It is a key centre in the eastlands region of Nairobi county in that it houses amenities such as the infamous Makadara Law Courts as well as the Makadara Train Station. The sub-county housing sector consists mainly of housing units which were built a few years after Kenya attained its independence. Most of these houses are ran down and families live as many as 6 persons in a 2 roomed unit. (See figure 3.2)
Scarcity of water supply is common in this sub-county with water vendors pulling handcarts being a common site. The sub-county has 4 health facilities operated by the county government out of 41 registered health facilities (Ministry of Health Kenya, 2017). This accounts for only 9.76% of the total number of health facilities in the sub-county.

Kibera sub-county on the other hand with an area of 12.10km² has a population of 178,284 people according to the Kenya population census of 2009. This figure is projected to have risen to between 230,000 – 270,000 people (Nairobi City County, 2016). The sub-county is host to the largest slum in Africa characterized by mud- houses of about 4metres by 4metres with corrugated iron sheet roofing as shown in figure 3.3. These structures house upto 8 people.
Fig 3.3: Kibera slum
3.2 Data and Data Sources

a) Primary Data

This is data that was collected first hand from the study area.

Table 3.1: Primary data

<table>
<thead>
<tr>
<th>DATA</th>
<th>CHARACTERISTICS</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point data (x,y)</td>
<td>UTM Coordinates – WGS84 zone 37S, Acquired in 2017</td>
<td>Ground visit using Garmin GPS 76CSx</td>
</tr>
<tr>
<td>Health Facility Data</td>
<td>Acquired in May 2017</td>
<td>Interviews</td>
</tr>
</tbody>
</table>

b) Secondary Data

This is data that was collected from already existing sources.

Table 3.2: Secondary data

<table>
<thead>
<tr>
<th>DATA</th>
<th>CHARACTERISTICS</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Facility Data</td>
<td>Previous data collected</td>
<td>Ministry of Health website Public reports and documents Facility websites</td>
</tr>
<tr>
<td>Population Data</td>
<td>2017 projections</td>
<td>Nairobi county development plan 2017 - 2018</td>
</tr>
<tr>
<td>Roads data</td>
<td>Existing shape files</td>
<td>Survey of Kenya (2017)</td>
</tr>
<tr>
<td>Boundary data</td>
<td>Existing shape files as per IEBC</td>
<td>Survey of Kenya (2017)</td>
</tr>
<tr>
<td>Devolved Functions data</td>
<td>Data from publications and reports</td>
<td>Desk study of Nairobi County Health policy documents and Ministry of Health</td>
</tr>
</tbody>
</table>
3.3 Materials and Equipment

Table 3.3: Summary of equipment and their specifications

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Computer</td>
<td>DELL Vostro 3500 (2.53 GHz, 3GB RAM, 320GB HDD)</td>
</tr>
<tr>
<td>Printer</td>
<td>HP laser-jet printer</td>
</tr>
<tr>
<td>Garmin hand-held GPS</td>
<td>Series 76Csx</td>
</tr>
<tr>
<td>Samsung Mobile Phone Camera</td>
<td>16MP, 32x optical zoom</td>
</tr>
</tbody>
</table>

Table 3.4: Summary of software and their respective versions

<table>
<thead>
<tr>
<th>Software</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows 10</td>
<td>Professional (64-bit)</td>
</tr>
<tr>
<td>ArcGIS</td>
<td>10.4</td>
</tr>
<tr>
<td>Global Mapper</td>
<td>v10</td>
</tr>
<tr>
<td>Microsoft Office</td>
<td>2016</td>
</tr>
<tr>
<td>DNR Garmin</td>
<td>v5.4.1</td>
</tr>
</tbody>
</table>

3.4 METHODOLOGY

In this report, GIS data collection tools and geo-statistical data analysis methods were used. Figure 3.4 is a flow-chart gives a summarizing the methodology employed in realizing the objectives of this study.
Fig3.4: Flow chart showing an overview of the methodology

1. **Data Identification** (Sources)
2. **Data Collection**
3. **Data Editing** (Georeferencing, projection transformations)
   - **Data Correct?**
     - NO
     - **Review factors that determine adequacy of public health facilities**
     - **Determine spatial aspects of public health facilities in Nairobi**
     - **Design a Geodatabase for a devolved health system**
     - **Analyze adequacy of public health facilities**
   - YES
     - **Conclusions and Recommendations**
     - **Output** (Visualization and interpretation)
3.5 Data Collection

a) Desk Study of Existing Data

A review was done on existing reports and publications both from the Ministry of Health as well as Nairobi City County. Data in relation to the various health facilities in the county was collected and recorded. The data available from the Ministry of Health website in relation to the public health facilities in Nairobi was also obtained. Such data included the services offered at the health facilities as well the list of all the health facilities in the county that are operated by either the County government or the National Government, operating times of the facilities as well as inpatient bed capacities. The desk study was mainly used to acquire data that was to be used for benchmarking the public health facility situation on the ground. Services provided by various health facilities was also obtained for some of the health facilities.

b) Field Data Collection

Field data collection was narrowed down to two sub-counties in Nairobi county i.e. Kibera and Makadara Sub-counties for the sake of completing this study in the stipulated time. This exercise was necessary for collecting data on the spatial location of the health facilities and also for verification of the existence of the health facilities. Field data collection was done through observations e.g. observation of queues in the health facilities, carrying out interviews and filling in questionnaires (appendix 1) by relevant staff at the health facilities. The coordinates of the health facilities were collected using a hand held GPS device initialized to Arc1960 datum with an accuracy of ±3 meters. The field data collection was done so as to verify the data obtained during the desk study as well as add attributes and data that were not obtained during the desk study. Photographs of some of the health facilities were collected using mobile phone cameras.

Various staff at the health facilities were interviewed in a bid to find out how the facilities operate with respect to the referral system that is now used in the Kenyan public health sector. The interviews were also done to verify whether the services and facilities listed in the documents obtained during the desk study were a true reflection of the services offered at the various health facilities as well as to identify any challenges being experienced in the day to day running of the health facilities.
The devices were initialized to Arc1960 datum and UTM projection. The GPS devices had an accuracy of ±3 meters which was sufficient enough for GIS analysis. After collecting point data, the coordinates were downloaded in Dbase IV format using the DNR Garmin software. Arc1960 and UTM were set as the datum and projection respectively, before downloading from the GPS device into the software. The Dbase IV file was opened using Microsoft Excel spread sheets, edited and exported to ArcGIS.

Data collected from the various health facilities in Kibera and Makadara sub-counties was cleaned and validated before being entered in Excel tables. These dataset was then imported into the GIS platform to form part of a file geo-database. Other spatial datasets in this database included the 2009 Census population and housing data for Nairobi County, and private and community run health facilities in the county. Key identifiers (codes) for each of the facilities were generated in order to provide linkages and relations between various spatial and non-spatial data.

Using ArcGIS 10.2 software, the geo-processing tools, especially Spatial Analyst, the geographical coverage of reach of the various public health facilities in targeted sub-counties was projected. Using the geo-processing tools, a distance buffer was created around the identified public health facilities in a bid to depict the geographical spread of the medical services to the population living in the neighborhood as well as the estimated size of the population that are unlikely to be served by the public health system.

The fraction of the population that visits the public health facilities in each of the sub-counties was established and the number of patients expected to be served by a given member of each health category.

3.6 GIS Database Development

The top-down design method was used. This approach starts with a generalized idea of what is needed for the system and then works down to the more specific details of how the system will interact. This process involves the identification of different entity types, their relationships and the definition of each entity’s attributes.

Relational and Object Oriented are the most common types of databases. In this case, Relational database model was used. It uses common fields which are attributes that appear in more than one table/relation to establish the relation between the tables and form an overall data structure.
The processes involved in modelling a relational database are data collection and analysis, External model design, Conceptual design, Logical design and Physical database design.

The data specifications and requirements of the database was done through external modelling so as to establish the kind of data that was required for each field in the tables after which an external model diagram was developed. The requirements were determined by collecting relevant information from the public health facilities by administering questionnaires and carrying out interviews.

3.6.1 External Modelling

External modelling involves determination of users as well as potential information needs as well as the data requirements for the database being developed. It is done by interviewing the various potential users of the database and establishing their data needs in relation to the database. In this project, a number of people in the county were interviewed so as to establish the kind of data that would be useful to them, as patients, in such a kind of database. Staff at the county offices as well as the health facilities were also interviewed so as to establish their data needs in relation to the current health structure employed in the Kenyan jurisdiction.

External modelling establishes a common understanding between interested parties in the database as well as the database developer. Figure 3.5 shows the external model diagram that was arrived at.
Fig 3.5: External Model of Assessing Adequacy

**Real World of public health facilities**

**Health Facility Model**
- Facility code
- Facility name
- Level
- Type
- Services offered
- Bed capacity
- Facility location
- Operational hours
- No of Doctors
- No of Clinical officers
- No of community health workers
- No of community owned resource persons
- Nurses
- Ambulances available
- No of interns
- Average number of patients served daily

**Referral needs model**
- Facility code
- Facility name
- Facility level
- Facility equipment
- Human resource available
- Ambulance available

**Patient Model**
- Facility location
- Waiting time
- Facility type
- Doctors available
- Services available
- Operating hours
- Fees charged

**Government model**
- Facility code
- Facility name
- Facility type
- Services offered
- No. of health workers
- Infrastructure available
- Consultation fee
- Inpatient capacity
- Functional labs
- Radiology services
- Dialysis Equipment
- CT scan
- Maternity
- County
- Sub-county
3.6.2 Conceptual Modelling

A conceptual model describes the information needs of the institution developing a database. Conceptual modelling entails defining the main concepts and objects in a proposed database and determining the relationships between them. Conceptual modelling involves construction of the external models and converting the models as an entity relationship diagram showing the entities with their attributes.

In the domain of assessing adequacy of public health institutions, the concept of the county government, referral system, personnel and services offered. In these domains the various objects or entities that are defined. For example, in the domain of personnel in the public health facilities, the various categories of personnel that exist in public health facilities are defined. Figure 3.6 shows the conceptual model that was developed. In the domain of referral the objects related with referral such as equipment, ambulance, location of the nearest referral facility, facility level and name are defined.

The relationships between the health facilities and the different domains are also defined and are interpreted as follows:

1. One or many public health facilities can offer one or many services and many services can be offered by one or many public health facilities.
2. A public health facility can only be facilitated by one county or national government but one county government or national government can facilitate many public health facilities.
3. One or many public health facilities can provide one or many referral cases and one or many referral cases can be handled at one or many public health facilities.
4. A public health facility can contain at least one or many health personnel while many personnel can work in one or many public health facilities.
Fig 3.6: ENTITY – RELATIONSHIP DIAGRAM
3.6.3 Logical Model Schemas

This process involved construction of a model of the information to be used by this study. It is based on data extracted from the conceptual model. The Logical data model is independent of any particular Data Base Management System. The following relations were set up:

1. **Referral needs** (Facility code, Name, Level, Equipment, Human resource available, Ambulance)
2. **Health facility** (Name, Level, Services offered, Location, Bed capacity, Operating hours, No of personnel, Rank of personnel, Average patients per day)
3. **County Government** (Facility code, Name, Type, Sub county, No of health workers, Infrastructure available, Inpatient capacity, Consultation fee, Operational laboratory, Radiology, Dialysis equipment, CT scan, Maternity)
4. **Patient** (Facility location, Name, Average waiting time, Services available, Medical personnel available, Operating hours, Fees charged)

There already existed a database by the Ministry of Health known as the master facility list. Part of this database relevant for this study was captured and incorporated with the data that was collected during the field study. For the purposes of this study the attributes that were collected from primary sources include common ailments treated at the various facilities, average number of patients treated, the number of various medical personnel, inadequacies experienced and challenges as well as availability of selected services. This data was used to form another data base for assessing the adequacy of the public health facilities. Its relation was given as:

5. **Adequacy** (Facility name, Code, Coordinates, Common ailments treated, Average daily patients, Medical officer, Clinical officer, Community health worker, community owned resource person, Nurses, Ambulance, Interns, Inadequacy, Availability of Radiology Services, Availability of CT scan, Availability of Maternity, Availability of wards, TB diagnosis and treatment, Availability of Functional Labs, Availability of Dialysis equipment)
3.7 Analyzing Adequacy of Health Facilities

3.7.1 Database management

In ArcGIS 10.4 software environment, the methods that were used to associate the spatial and attribute stored in tables were join and relate. For both of these functions to work, the tables being joined need to have common fields not necessarily of the same field name but the data types have to be one and the same. This implies that a user can only join a field with string data type to another of string data type but not for instance, string data type to number data type. Table 3.7 shows the alphanumeric identifier for the various public health facilities in Nairobi.

Fig 3.7: A sample showing the alphanumeric common identifiers (P-Codes) for the various health facilities in Nairobi.

In performing of the join operation, the attributes on one table were appended onto the other based on a common field. P-codes, unique alpha-numeric identifiers, provided the basis of carrying out the join operation.
Fig 3.8: The join function between P_CODE in GIS_IN-ASSESSING-ADEQUACY_OF_PUBLIC_HEALTH_FACILITIES table and CODE in Nairobi Health Facilities table.

A relate function defines the relationship between two tables. It depends on the existence of common fields but it does not append attributes of one table to the other. This function allows for easy access of related data when needed as shown in figure 3.8.

From the data collected in field, a spatial database describing the situation in 12 public hospitals in Makadara (5) and Kibera (7) sub-counties was developed. To derive new information and further interrogate the database, a number of SQL queries were run. Applying SQL queries to a database provides specific results. These results are represented in a layer or table view. The query can be used to join several tables or return a subset of columns or rows from the original data in the database.
CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Introduction
This chapter outlines the major findings of the study, the analysis that was done and further discussions on the results obtained.

4.2 Factors That Determine Adequacy of Public Health Facilities

4.2.1 Accessibility
Accessibility in geographical terms refers to the physical proximity of a health facility that can be assessed through use of GIS methods. Physical proximity can be enhanced by having a high distribution of public health facilities coupled with a well-developed road network. The number of public health facilities in both sub-counties visited was found to be less than 15% of the number of health facilities listed. The number of public health facilities, those ran by the National and County Governments, stands at 10.76% of the total number of health facilities registered by the Ministry of Health. If the population in the areas where these facilities are located were to depend on these facilities, then the health facilities would be inaccessible due to the long queues of people waiting to be served as a result of their low numbers. Other accessibility issues include long distances that patients have to travel to the nearest health facility. Currently, the WHO requires as a policy that citizens should live within a 5km radius of a health facility (WHO, 2007) especially in highly populated areas such as Nairobi county and by extension Makadara and Kibera Sub-counties.

4.2.2 Adequacy
This was found to relate to how the organization of public health facilities meet patient expectations. It includes aspects such as operating times of the health facilities, social factors and quality of the facilities. These all have an impact on patient expectations. There were facilities which lacked basic services such as availability of water and toilets for both patients and doctors. Most of the facilities also highlighted issues with availability of medicines, shortage of staff, detergents and medical reagents. Such shortages have an impact on patient expectation and satisfaction in the public health facilities.
4.2.3 Acceptability
This aspect of adequacy was found to relate to the cultural, religious beliefs as well as procedures, information, explanations and treatment being given in a competent manner such that patients have confidence in the health care provider. Community owned resource persons as well as Community Health workers are charged with educating the public in matters relating to health. With an enlightened population, people become more receptive to health interventions for preventive Measures as well as curative health services.

4.2.4 Availability
Availability relates to the actual existing of health facilities and services such that they meet the needs of the population. It also refers to the number of health facilities that a population can choose from. Personnel who offer the required services should also be present and in adequate numbers such that the demands of the population can be met. The World Health Organization recommended an average of 23 doctors, nurses and midwives per 10,000 people. For optimal service delivery the ratio of nurses to doctors ought to be at least 1:4. (Ministry of Health, 2014).

4.2.5 Affordability
For a service in a health facility to be deemed affordable, the population must be able to pay for it at the price it is being offered at. Affordability encompasses the direct costs of services e.g. consultation fee, price of prescribed medication, cost of transport.

4.2.6 Equity
Equity refers to the fairness of a distribution and has the implication that the population with the higher need should have more or a higher access to public health facilities. The need can be derived from economic classification of a population. It is largely assumed that low income groups have higher need for access to public health facilities. The higher the population the more need for the public health facilities.
4.3 Analyzing Adequacy of Public Health Facilities

Adequacy of public health facilities was analyzed by use of SQL statements. A sample of the SQL statements developed for assessing adequacy of public health facilities and the results are shown below.

1. Determining the number of health facilities that serve an average of less than 100 patients per day. [Query function: "patients_d" >=100]
Fig 4.1: A sample showing a query and the results

The query result indicates that 10 out of the 12 health facilities surveyed in the two sub-counties attend at least 100 patients every day.
2. Determining the facilities that treat diarrhoea but have no doctors and no fully functional labs. 

[Query function: ( "Diseas_2" = 'Diarrhoea' OR "Diseas_3" = 'Diarrhoea' ) AND "Medical_Of" = 0 AND "Labs" = Y ]

Fig 4.2: A sample showing a query and the results

The results indicate that Lindi and Karanja road community clinics (both located in Kibera sub-county) have no medical doctors to treat diarrhoea patients despite having working laboratory equipment.
Using GIS *identify* geo-processing tool, the attribute information associated with a given spatial feature (line, polygon or point) can be retrieved as a whole. For instance, for the second query above, the attribute data for Karanja Road and Lindi community clinic can be accessed using the tool. The data appears as shown in figure 4.3.

![Attribute data for query results](image)

**Fig 4.3: Attribute data for query results**

The attribute data contains the data that was captured during the field survey.
4.4 Spatial Aspects of Public Health Facilities in Nairobi County

There are 762 registered health facilities in Nairobi as per the Ministry of Health Facility list (2017) with those that are ran by the County government being 78 and the National government having 4 namely Kenyatta National Teaching and Referral Hospital, Mathari Mental Hospital, Pumwani Maternity Hospital as well as the National Spinal Injury Hospital. (See figure 3.2)

![Map showing distribution of public health facilities in Nairobi county](image)

This accounts for only 10.76% of the total health care facilities that are available in the county. The rest are operated by either private institutions, NGO’s or by church groups. With only 78 out of 762 being operated by the county government, the bulk of health care is provided by private institutions, NGO’s and church groups. This situation is depicted in the Ministry of Health facility list(Ministry of Health Kenya, 2017).
4.4.1 Makadara Sub-County

Makadara sub-county was found to have 6 health facilities under the jurisdiction of the Nairobi County Government out of the 41 registered health facilities in the sub-county (Ministry of Health Kenya, 2017). These are Bahati clinic, Hono clinic, Makadara Health Centre, Ofafa I clinic, Maringo clinic and Mbotela clinic. These account for 14.63 % of the total number of health facilities in the sub-county as shown in figure 4.5. Only one facility, Makadara health centre, did not respond to the questionnaire hence realizing a response rate of 83.33%.

![Pie chart showing coverage of public health facilities in Makadara county](image)

Fig 4.5: Pie chart showing coverage of public health facilities in Makadara county

Out of the 6 health facilities, five were of level 2 and one level 3 as shown in figure 4.6.
Fig 4.6: Map showing distribution of public health facilities in Makadara sub-county

According to the 2009 Population and Housing Census by the Ministry of Planning (Kenya), Makadara Sub-County had a population of approximately 184,000 distributed in ten sub-locations as shown in figure 4.7.
Fig 4.7: Graph showing population distribution in Makadara sub-county

Fig 4.8: Map showing distribution of public health facilities in Makadara sub-county against population density
From figure 4.8, it can be deduced that the public health facilities are mainly located in the wards with high population density. Six out of ten wards have no public health facilities.

4.4.1.1 Staffing

It was found that there was only 1 doctor, 4 clinical officers, 23 community health workers, 20 community owned resource persons and 29 nurses in the sub-county. Most of these staff also doubled up as receptionists and cleaners in the various health facilities.

4.4.2 Kibera Sub-County

Kibera sub-county was found to have 62 registered health facilities (Ministry of Health Kenya, 2017) with 8 being under the county government and 1 under the National government i.e. Kenyatta National Referral and Teaching Hospital. This accounts for 14.52 % of the number of health facilities in the sub-county as shown in figure 4.9. Only one facility, Mbagathi District Hospital, did not respond to the questionnaire whilst Kenyatta National Referral and Teaching Hospital was not included in the study.

![Fig 4.9: Pie chart showing coverage of public health facilities in Kibera county](image)
Out of the 9 health facilities, 7 were of level two status, 1 of level four status and 1 level 6 status as shown in figure 4.10.

Fig 4.10: Map showing distribution of public health facilities in Kibera sub-county

According to the 2009 Population and Housing Census by the Ministry of Planning (Kenya), Kibera Sub-County had a population of approximately 196,000 distributed in eight wards as shown below.
Fig. 4.11: Graph showing Distribution of population in Kibera sub-county

Population density is highest in Gatwikira and Laini Saba and lowest in Woodley and Kenyatta Golf Course wards. Six wards, i.e. Lindi, Olympic, Laini Saba, Makina and Silanga, have a total population of approximately 160,000 people. This population is served by six health facilities. Woodley ward is served by one clinic (Woodley clinic). No public health facility is located in Kenyatta Golf Course ward.
Fig 4.12: Map showing distribution of public health facilities against population density in Kibera sub-county

Most of the public health facilities are concentrated in the wards with higher population density. Kenyatta Golf Course however was found to have no public health facility.

4.4.2.1 Staffing

It was found that there were 10 clinical officers, 15 community health workers, 6 community owned resource persons, 23 nurses and no doctors or medical officers in the sub-county.
4.5 Discussions of the Results

The factors determining adequacy of public health facilities were found to be relevant especially in the current devolved system of government in play in Kenya. Accessibility not only refers to physical proximity but also number of facilities to choose from. Adequacy refers to the organization of the health facilities such that they meet customer expectation. Shortages and lack of essential staff, equipment and medicine have a direct impact on customer expectation and satisfaction with services that are offered. Acceptability is a function of public education on the need and benefits of utilizing the health facilities as well as competence of the various health care providers. Availability means that the health facilities actually exist and are offering services according to the needs of the population they serve while affordability has the implication of the general public being able to pay for the aforementioned services at the price they are being offered at. Equity relates to the fairness in which the public health facilities are distributed.

The current distribution of public health facilities is such that some of the smallest administration units, wards, for example golf course ward in kibera sub-county, viwandani and uhuru wards in makadara sub-county do not have public health facilities. The wards have historically not had public health institutions. The public health facilities were inherited by the county government from the defunct Nairobi City Council where the administrative boundaries of the defunct council were largely assimilated. From figure 4.4, sub-counties such as kasarani and westlands only have 2 public health facilities under the county government’s jurisdiction, embakasi east has none while roysambu sub-county has only 1 public health facility.

Applying the health referral strategy in Makadara, with its population of 184,000 persons, for level one facilities in this sub-county, if each facility is to be availed for every 5,000 people requiring 50 volunteer community owned resource persons as well as 2 community health extension workers then there should be 37 level 1 facilities.

For level 2 and 3 facilities designed to exist for every 10,000 persons with the capacity of handling on average 30 patient visits, then 18 of these facilities should be available.

Level 4 and 5 facilities with each facility serving a catchment of 30,000 persons should be 6 in number for an effective referral health system.
Only one facility, bahati clinic, was found to have a maternity unit. It is also the only facility that could diagnose and treat Tuberculosis as well as having a fully functional laboratory

According to (Ministry of Health, 2014) for Makadara sub-county to have an effective referral health system for its population of 184,000 persons, then the government needs to have 369 doctors and nurses, 1,605 Community Owned Resource Persons, 64 Community Health Workers as shown in table 4.1.

<table>
<thead>
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<th>IDEAL SITUATION</th>
<th>CURRENT SITUATION</th>
<th>SHORTFALL</th>
</tr>
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</tr>
<tr>
<td>(MO/ CO)</td>
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</tr>
<tr>
<td>NURSES</td>
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<td>29</td>
<td>310</td>
</tr>
<tr>
<td>C.O.R.P</td>
<td>1840</td>
<td>20</td>
<td>1820</td>
</tr>
<tr>
<td>C.H.O</td>
<td>74</td>
<td>23</td>
<td>51</td>
</tr>
</tbody>
</table>

For level one facilities in Kibera sub-county, if each facility is to be availed for every 5,000 people requiring 50 volunteer community owned resource persons as well as 2 community health extension workers then there should be 39 level one facilities with 1800 community owned resource persons and 72 community health workers.

Level 2 and 3 facilities designed to exist for every 10,000 persons and having the capacity of handling an average of 30 patient visits per day on top of carrying out normal deliveries, there should be 20 of these facilities in this sub-county.

There should also be 7 level 4 and 5 facilities in the sub-county for an effective referral system.

None of the facilities visited had a maternity unit with despite two of the facilities handling maternity cases meaning they only help with the delivery of the new born and afterwards send the mother home to recover. The situation is crippled with lack of ambulatory services with the only ambulance available in the sub-county having no driver. All the facilities handled more than 30 patients per day.
According to (Ministry of Health, 2014) kibera sub-county to have an effective referral health system for its population of 196,000 persons, then the government needs to have 460 doctors and nurses, 1,950 Community Owned Resource Persons and 78 Community Health Workers as shown in table 4.2.

**Table 4.2: Disparities in Staff in Kibera Sub-County**

<table>
<thead>
<tr>
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<th>SHORTFALL</th>
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<tbody>
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<tr>
<td>NURSES</td>
<td>368</td>
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<td>345</td>
</tr>
<tr>
<td>C.O.R.P</td>
<td>1950</td>
<td>6</td>
<td>1944</td>
</tr>
<tr>
<td>C.H.O</td>
<td>78</td>
<td>15</td>
<td>63</td>
</tr>
</tbody>
</table>

It was also established that for the devolved health system to work, the health system must be able to provide effective and high quality health interventions where and when such interventions are needed. The health system should also be able to attract, train and retain sufficient, skilled, responsive and productive health staff. This is a problem in Kenya and Africa as a whole where governments train and educate personnel up to and including giving them scholarship opportunities to study overseas but the various governments cannot retain the staff due to poor enumeration or lack of equipment which gives them the opportunity to practice the newly acquired skills.

A health management information system such as the one currently being ran by the Ministry of Health (Kenya) should be able to produce, analyse, disseminate and generate reliable and timely information. The system was found to have gaps in that it did not contain information on the staffing at the various health facilities or contain services that are offered at the various health facilities whether private or public.

A devolved health system should ensure availability of essential medical products and technologies at the lowest level of access as viably possible. Good leadership and governance coupled with a good financing system should ensure that both levels of government develop
infrastructure, avail equipment, transport and technology required for effective access of health services at all levels of care.
CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions
The factors that determine the adequacy of public health facilities were found to be accessibility, adequacy, acceptability, availability, affordability and equity. These factors were found to be fundamental especially in the devolved system of government at play in Kenya whereby services are expected to trickle down to the lowest level of society. These factors should be considered especially when setting up new health facilities.

Spatial aspects of public health facilities in the sub-counties of Nairobi that were studied were analysed and was found to be wanting. While incorporating the factors determining adequacy of public health facilities, the number, spread and coverage of these health facilities can be improved significantly. Cases of sub-counties, the smallest administrative unit, missing health facilities will be a thing of the past.

The Geodatabase that was developed on devolved health system met the objective of assessing the adequacy of public health facilities. The geodatabase was based on relational database model which is easy to use though the users will be expected to have some GIS knowledge.

The information generated can help government institutions as well as both levels of government, national and county, identify what area of the health sector requires what kind of intervention e.g. it was found that there were health facilities that were offering maternity services and yet they had no personnel nor infrastructure for the same, lack of transport facilities i.e. ambulatory services within the county health system. The geodatabase can be used as a model in developing one for the whole county as a whole since it was based surveys from two sub-counties. Since the geodatabase provides information such as distribution of health facilities as well as facility inventory, it can help the county government distribute resources in an equitable manner since it shows number of personnel as well as average patient visits per day.

5.2 Recommendations
The results of this study identified the factors that come into play when it comes to adequacy of public health facilities. There is still a lot to be done so as to realise the benefits of a devolved system of government especially in the health sector. It is also in the interest of the public health sector that such a project can be extended to the national level as such analysis is beneficial to the whole country as a whole.
From this study, it would be prudent for the county health service to first develop the existing health facilities in such a way that they are fully functional and eradicate some of the problems that were identified such as unavailability of toilets or lack of clean running water. Once the existing facilities are fully functional then a suitability analysis of where to locate new facilities can be done in order to bridge the existing gaps.

It may not be possible for the county health services to develop capacity to handle the entire population of Nairobi county but they should at least make sure the health facilities that they operate are of world class standards and can serve as benchmark to health facilities that are not operated by them.

The National Health Insurance Fund, NHIF, has contributed in enabling citizens access the much needed health services in private institutions where such services are available. However, an investigation as to whether in promoting of the fund by the national government is hindering the development of the county health services in terms of infrastructure and human capacity building in that the government is sponsoring citizens to access health services in private institutions which may be owned by privileged people as opposed to building capacity to provide for these services in the county health facilities.
References


Lovett, A., Haynes, R. & Gale, S., 2000. *Accessibility of primary health care services in East Anglia*. Norwich: School of Medicine, Health Policy and Practice, University of East Anglia.


APPENDIX A

PROJECT: APPLICATION OF GIS IN ASSESSING ADEQUACY OF PUBLIC HEALTH FACILITIES IN A DEVOLVED SYSTEM OF GOVERNMENT. CASE STUDY: NAIROBI COUNTY

1. Name of Health Facility

CONTACTS DETAILS (optional)

2. Name of the respondent

   Designation

   Contact details

MEDICAL RESPONSE

3. Which are the common ailments treated in this facility?

   1. 
   2. 
   3. 

4. By way of estimating, how many patients does this facility serve every day?

   

STAFFING

5. How many of the following categories of medical staff do you have in this facility?

   Medical Officers / Doctors

   Clinical Officers

   Community Health Workers

   Community owned resource persons

   Nurses

   Number of Ambulances available

   Do you have medical/health interns? Yes  No

   If Yes, how many?
MEDICAL INADEQUANCY
6. Where would you say that this facility is experiencing shortage/inadequacy?
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
7. What challenges does this facility face in terms of staffing?
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

8. What challenges does this facility face in terms of service delivery?
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

AVAILABILITY OF SELECT SERVICES
(Circle appropriately)
Radiology Services  Y  N
CT scan  Y  N
Maternity  Y  N
Wards & in-patient bed capacity  Y  N
How many wards?  [ ] Beds?  [ ]
TB diagnosis and Treatment  Y  N
Fully stocked and functional labs  Y  N
Dialysis  Y  N