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A mobile-web application for visualizing mortality and morbidity levels in Kenyan Counties and their attributing factors: a focus on Kenya health policies

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A Mobile-Web Application for Visualizing Mortality and Morbidity Levels in Kenyan Counties and their Attributing Factors: A Focus on Kenya Health Policies

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Declaration

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the dissertation contains no material previously published or written by any other person expect where due reference is made in the thesis itself.

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Abstract

The ability of people to enjoy a long, healthy life is critical to a developing nation. In Kenya, the mortality and morbidity levels are high, with the World Health Organization closely linking the wide-spread disparities to underlying social, economic, gender and geographical factors. These levels can be lower, especially for a country striving to achieve a middle-income economy status. Further, any meaningful health policy or health program needs to be informed of the statistics of illnesses and deaths occurring and their causes.

However, the main problem has been the lack of a clear association or connection between the illnesses and deaths reported and their attributing factors. Further, in Kenya, data on mortality and morbidity, published through various surveys, has mainly been presented in tabular form in spreadsheets and publications. This has proven to be hard to consume, let alone analyze, for purposes of informing health policy makers.

In view of the above shortcomings, this study sought to establish a link between the mortality and morbidity levels in Kenyan counties and their causative factors. To understand the current state of health mortality and morbidity levels, this study looked into existing literature on the state of India's and Kenya's mortality and morbidity levels, with a keen focus on health policies and government initiatives. First hand data was also collected through questionnaires.

Analysis of findings of the research conducted asserted the need of a visualization tool that provides dynamic, real-time manipulation of data on mortality, morbidity and their attributing factors. Consequently, a visualization tool was developed, allowing users to view the data in a more user-friendly format and further providing real-time manipulation of the data to produce user-defined visualizations, which can further be downloaded in various formats. This can, in turn, help policy makers and researchers make data-based decisions in their various studies.

Keywords: Health Data Visualization, Mortality, Morbidity, Health Policies, Mobile Technology.

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List of Abbreviations and Acronyms

BCS	–	British Computer Society
BZC	–	Beyond Zero Campaign
CHW	–	Community Health Workers
CSO	–	Civil Society Organizations
CRVS	–	Civil Registration and Vital Statistics Systems
DOH	–	Department of Health
FBO	–	Faith Based Organizations
GOI	–	Government of India
HIS	–	Health Information Systems
MOMS	–	Ministry of Medical Services
NACC	–	National AIDS Control Council
NFHS	–	National Family Health Survey
UML	–	Unified Modelling Language
UN	–	United Nations
UNEP	–	United Nations Environmental Program
USSD	–	Unstructured Supplementary Service Data
WHO	–	World Health Organization

Dedication

This dissertation is dedicated to Kenya's health workforce including Dr. Orangi Gavin and Dr. Orangi Geoffrey, who work tirelessly each day to cure ailing persons.

Acknowledgements

Profound appreciation and gratitude to my supervisor Dr. Joseph Sevilla for his continuous guidance throughout the duration of this dissertation. He has always provided me due and prompt direction on my research focus.

I further thank the almighty God, my parents, my three brothers and all my friends for their constant encouragement without which this research would not be possible.

Chapter 1: Introduction

1.1 Background of the Study

The ability of people to enjoy a long, healthy life is a critical part of a developing nation. It is also, according to the United Nations Population Division (UNPD), a fundamental aspect of human development (UN, Changing Levels and Trends in Mortality: the role of patterns of death by cause, 2012). In Kenya, morbidity levels can be lower especially for a country that was named a middle-income economy state.

The World Health Organization has closely linked the wide-spread disparities in the health status across the country to underlying social, economic, gender and geographical factors (WHO, Country Focus, 2014). Any meaningful health policy or health program needs to be informed of the illnesses and deaths occurring and their attributing causes. In Kenya, such information has been collected and published over the years through surveys, census reports and publications.

However, the main problem, that has been present over the years, is the lack of a clear and focused association or connection between the illnesses reported and the attributing factors. This has, consequently, made it hard for policy makers and other involved players to come up with clear, directed and informed policies and programs that can be a basis for countering the morbidity levels experienced for decades now.

This research, therefore, aims at establishing a link between morbidity levels in the Kenyan counties and their attributing factors with a keen focus on the trends which can help inform policy makers on what needs to be amended for the country to contain and also minimize morbidity levels in the Kenyan counties.

1.2 Problem Statement

Mortality and morbidity levels in Kenya have consistently been reported by the Kenya National Bureau of Statistics (KNBS, Kenya National Bureau of Statistics, 2015). The reporting format is usually in the form of publications either in .pdf format or tabular format in spreadsheets. Such formats are hard to analyze and manipulate. Moreover, seeing trends in a given dataset over the years or over a given geographical region, such as a county, has also been a tasking process. Consequently, researchers and decision makers in the health sector have had an uphill task of trying to consume this data so as to make useful inferences from the publications provided.

With this as the situation on the ground, the country has seen the inclusion of health policies that are not backed up by the data in the various official publications by the Kenya National Bureau of Statistics. As a result, such health policies are not directly focused on tackling the factors leading to the current mortality and morbidity levels in Kenya.

Existing solutions, some of which have been explored in Chapter 2 of this study, present similar data in a friendlier format, mostly through representing the data in visualizations. However, there is a downside to this; most of the visualizations cannot be dynamically manipulated. This means that the visualizations are presented in a static format thus not allowing the user to custom select what part they are interested in on the data being visualized

This is the niche the researcher aimed to fill, by providing a platform that visualizes health data and additionally allows the user to dynamically manipulate the indicators and see the resulting visualization of the data in real time.

1.3 Research Objectives

1.3.1 Broad Objectives

To design and develop a mobile application that will visualize the mortality and morbidity levels in Kenyan counties and their attributing factors and further show a trend of the same over the years.

1.3.2 Specific Objectives

(i.) To investigate health policies and the mortality and morbidity levels in developing countries.

(ii.) To analyze how health policies have influenced mortality and morbidity levels in Kenya over the past years.

(iii.) To identify the factors contributing to mortality and morbidity levels in Kenyan counties.

(iv.) To design and develop a mobile-web-based tool to visualize morbidity levels in Kenyan counties and the attributing factors.

(v.) To test the proposed mobile-web-based tool.

1.4 Research Questions

(i.) What are the health policies and morbidity levels in other developing and developed countries?

(ii.) How have the health policies influenced morbidity levels in Kenya over the past years?

(iii.) What are the factors contributing to morbidity levels in Kenyan counties?

(iv.) How can a web application be developed to visualize morbidity levels in Kenyan counties and the attributing factors?

(v.) How can the mobile-web application be tested?

1.5 Assumptions

Several assumptions have been made in the course of this study. First, that the current format of data released for consumption is not user-friendly, making it hard for users to analyze it, create trends and/or conclusions for their works. Second, that there is need for a visualization tool for purposes of presenting the data in a more user-friendly format and further allowing dynamic manipulation of the data as per user's needs.

1.6 Scope and Limitation of the Research

This research will draw its visualization data from publications and reports officially released by the Kenya National Bureau of Statistics (KNBS). Visualization will only cover geographical locations within the Kenyan boundaries.

1.7 Justification of the Research

Given the current presentation of health data officially released by the Kenya National Bureau of Statistics is mainly in pdf and spreadsheet format, then it becomes quite tasking, tedious and time-consuming going through the data for purposes of analysis and manipulation with a goal of making conclusive decisions and health policies from the data.

With the scope of this study limited to data from publications and reports officially released by the Kenya National Bureau of Statistics (KNBS) and visualizations only covering geographical locations within the Kenyan boundaries, the researcher herein aimed at providing a locally customized solution for the visualization of health data in Kenya. This research, consequently focused on providing a visual representation of mortality and morbidity levels in Kenyan counties, together with the attributing factors. As such, a meaningful analysis and conclusion of the data can be reached by the various experts consuming it, in a more user friendly manner.

1.8 Conclusion

Data produced by the Kenya National Bureau of Statistics is mostly in tabular form in publications and spreadsheets. This raises many challenges in regards to experts consuming the data in their research work and in advising policy making. Data in such a raw format makes it challenging to view trends, and/or make conclusions based on the numbers. Consequently, policies made on the health sector cannot be smoothly connected to the trends drawn from cross-platform analysis with other attributing factors, for example, health personnel, number of health centers, resource allocated to the health sector, etc.

This research is, therefore, crucial because it will visualize the data sets on health matters focusing on mortality and morbidity, and, in the process, present the data in a more user friendly manner. As a result, the various industry experts can simply and conclusively make inferences, which will correctly reflect on policies made on health by the relevant policy makers.

Chapter 2: Literature Review

2.1 Introduction

Mobile computing has exponentially evolved over the years. Your mobile phone has more computing power than what computers used to have during the Apollo era (NASA, 2009). The progress of mobile phone development has gone even as far as getting a "world's first" in terms of charging the cell phones, this being the use of urine according to scientists at the Bristol Robotics Laboratory (2013). With similar milestones being achieved each waking day, mobile is clearly the way to go when it comes to information dissemination especially when large masses of people are the target (Chen, Li & Liu, 2011).

Currently, the healthcare industry is contending with increased pressure to reduce costs while increasing the quality of services (Al-Hakim, 2007). As a result, in the recent years, trends have shown that healthcare organizations have increasingly embraced the use of quantitative methods for quality management (Carey & Lloyd, 1995). Presenting health statistics in a visual format can help identify areas in healthcare service delivery that require improvement thus ensuring quality and continuity of healthcare services (Olla & Tan, 2009). Furthermore, Osborn (2008), in his study of essential of statistics in health information technology, pointed out that statistics monitored over a specified time frame can be of importance to health-care decision makers (Osborn, 2008).

It has been noted that different categories of information are reported to those at the health managerial level for purposes of monitoring and evaluating the performance of public health services (Shao, Loconsole & Hajinasabrazlighi, 2012). These include population information, facilities information, health services activities, mortality and morbidity information, and medical personnel information. This ultimately increases accountability and gives a basis of an advised planning process.

This research will help inform the development of the proposed application on the need of leveraging on the increased usage of portable devices and increased availability of Internet amongst the larger masses. The proposed application is meant to visualize, in more user-friendly manner, data on mortality and morbidity levels in Kenya. This will further be accompanied by other factors attributing to the mortality and morbidity levels experienced such as; health facilities distribution and health workforce statistics.

2.2 Mortality and Morbidity

Mortality is a derivative from the Latin word, *mors,* meaning death (Partridge, 1966). Mortality rate refers to the ratio of deaths in a given geographical area to the total population of that area. Simply this is a measure of the number of deaths in a given population, proportioned to the size of that population and measured over a unit of time (Porta, 2014).

Morbidity is also derived from the Latin word, *morbidus*, meaning sick or unhealthy (Craig, 1858). Morbidity rate refers to the prevalence of a disease or the incidence rate of a disease (Porta, 2014). Morbidity can be taken to refer to illnesses, disabilities and injuries of a given population. Being aware of the distribution and frequency of an illness helps in controlling its spread and at times also helps identify its causes.

This research will focus on matters morbidity, in other developing countries then in Kenyan counties. Factors affecting and contributing to the said morbidity levels will also be focused on. The aim here will be to try and make a connection between morbidity levels in the country and the attributing factors.

2.2.1 Mortality Indicators

Some of the most critical mortality indicators and their brief definitions are highlighted below (UN, Indicators for Monitoring the Millennium Development Goals: Definitions, Rationale, Concepts and Sources, 2003):

a.) Life expectancy

This is the average number of years a person could expect to live in full health. (WHO, Cause-specific mortality and morbidity, 2009). This indicator also considers the years one lives in not so good health. This can either be because of a given disease or because of an injury. The life expectancy of any given country affects other parts of the economy too in terms of flow of income.

b.) Crude mortality rate

Crude mortality rate is the mortality rate across all the age groups and due to all causes. This indicator is usually used to explain or define a humanitarian crisis (WHO, Deaths in Darfur Exceed the Emergency Threshold, 2004). It looks at overall deaths and the causes of these deaths.

c.) Cause-specific mortality rate

This indicator refers to the mortality rate as a result of a specific disease such as cholera. Cause-specific mortality rate is usually measured within a given population during a specified period of time (Principles of Infectious Disease Epidemiology, n.d.). This indicator can be used on any disease to help reduce it.

d.) Age-specific mortality rate

This is the rate of death in a specific age or a specific age group. Age-specific mortality rate helps in comparing mortality at different ages, and mortality of the same age over time (WHO, Cause-specific mortality and morbidity, 2009).

e.) Infant mortality rate

Infant mortality rate refers to the number of children dying before one year of age or under one year of age divided by the number of live births. This is usually over a given period of time (WB, n.d.). This is an important and informative indicator of the health status of a given population.

f.) Neonatal mortality rate

Neonatal mortality rate refers to the death rate of infants during the first 28 days of life. (WHO, Mortality estimates by cause, age and sex for the year 2008, 2009).

g.) Maternal mortality rate

This indicator refers to the number of expectant mothers dying from childbearing related complications divided by the number of live births. Maternal mortality rate is measured within a given period of time.

2.2.2 Morbidity Indicators

Some of the most critical morbidity indicators and their brief definitions are highlighted below as defined by the United Nations (2003):

a.) Incidence rate

Incidence rate refers to the number of people contracting a disease in a given time period, usually calculated per 1,000 population at risk (UN, 2003). Only new cases are considered here. This indicator aids in informing someone's likelihood of being diagnosed with a given disease (DOH, 1999). The incidence rate is often measured over a given period of time.

b.) Prevalence rate

Prevalence rate is the total number of people having a particular disease or condition at a given time, also calculates per 1,000 population. Can be taken as a snapshot of the health situation in a given population (Porta, 2014).

2.3 Mortality and Morbidity Statistics

There is an increasing demand of better mortality and morbidity statistics in countries globally. This is important in setting public health priorities right and further track the countries' progress towards both national and international goals on health (WHO, Improving Mortality Statistics through Civil Registration and Vital Statistics Systems, 2014).

This demand has been met through the collection of data from various sources and activities, for example, census surveys, household surveys, health facility information systems, amongst others. According to the World Health Organization (2014), such surveys have significantly contributed to improved knowledge on mortality and morbidity patterns.

2.3.1 Why Focus on Mortality and Morbidity Statistics?

Information on what illnesses people are suffering from and factors contributing to the occurrence and/or reoccurrences of the said diseases is of utmost importance to public health decision making and policy making (UN, World Population Prospects: The 2010 Revision, 2010). This is because such information can be analyzed critically by various experts, within and without the health sector, with an aim of arriving at conclusive decisions based on the facts, figures, and trends extracted.

Statistics on morbidity levels can also be used in resource allocation (Kenya Ministry of State and Planning, National Development, and Vision 2030, 2007). Resource allocation can be in the form of medical personnel which include nurses, doctors, pharmacists, etc., or increasing the number of health facilities such as health units, dispensaries, clinics, and hospitals. Furthermore, planning of health information dissemination programs can also be enhanced and spread better through the consummation of statistics on morbidity levels.

2.3.2 Sources of Data for Mortality and Morbidity Statistics

Development partners such as the United Nations, World Health Organization, World Bank, etc. and countries such as the United States of America, United Kingdom, etc., undertake various

activities to meet the high demand of mortality and morbidity statistics (WHO, The global burden of disease: 2004 update, 2008). It should be noted that there is no one common repository of data for information from HIS (Amayo, Athman, Chiseka & Corea, 2008). The development partners and countries make use of a wide range of data sources on mortality and morbidity which can be generated from a number of sources. In Kenya, the main data sources, and their adequacy levels, have been highlighted in Figure 2.1. The scores in Figure 2.1 should be interpreted as outlined below:

0% - 19%: Non-functional

20% - 39%: Not adequate at all

40% - 59%: Present but not adequate

60% - 79%: Adequate

80% - 100%: Highly adequate

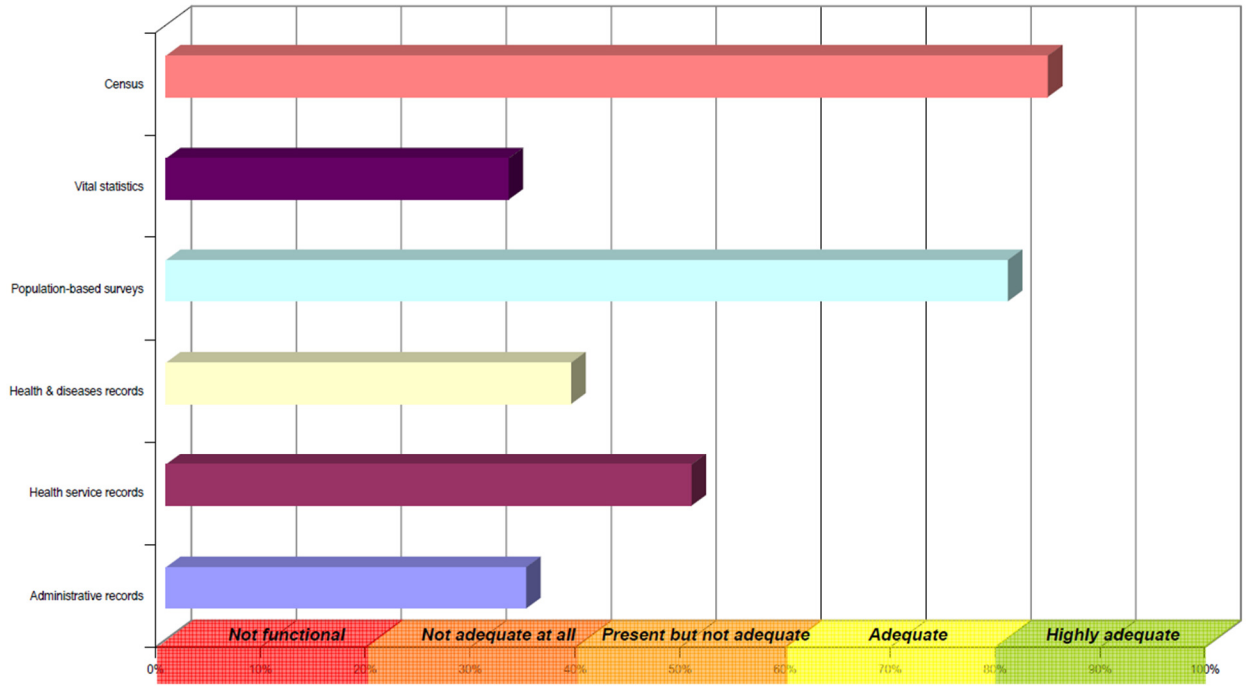

Figure 2.1: Scores for Data Sources Adequacy (Amayo, Athman, Chiseka & Corea, 2008)

A few of the data sources are as highlighted below:

a.) Censuses

During a census exercise, a health and demographic surveillance are usually collected with an aim of measuring and evaluating public health (KNBS, Population and Health Statistics, 2009). This is then aggregated to identify key mortality and morbidity indicators in the country.

b.) Civil registration and vital statistics systems (CRVS)

CRVS are systems that are used to register persons in various outlets. For example, in this study, health institutions are the holders of CRVS. Such data can then be harnessed by the various interested bodies for purposes of compilation and further usage of the derived information (KNBS, Kenya Facts and Figures 2014, 2014).

c.) Health care facilities

These are systems that are used to register persons in various health institutions. Such data can then be harnessed by the various interested bodies for purposes of compilation and further usage of the derived information. To collect data on mortality and morbidity, many sub-Saharan Africa countries have come up with a centralized Health management Information System (HMIS). Data generated from HMIS can be used to inform health policy making decisions and also inform on performance of the health sector (Emina, Sankoh, Wamukoya & Yazoume, 2012).

d.) Community-based reporting

In community-based reporting chiefs, assistant chiefs and Community Health Workers (CHW) in direct contact with the people are empowered to act as agents for birth and death registration of persons in their locality (Amayo, Athman, Chiseka & Corea, 2008). Civil Society Organizations (CSO) and Faith Based Organizations (FBO) are also used in community based reporting (GOK & UNICEF, Evaluation report of the community health strategy, 2010). These said persons are thoroughly taught to register their people and further trained on how to get the peoples' cooperation. It should be noted that after six months, the registration responsibility falls back to its lawful jurisdiction (Amayo, Athman, Chiseka & Corea, 2008).

e.) Vital registration (Institution for registration of births and deaths)

The Government of Kenya derives its mandate of registering all births and deaths from the Law of Kenya; Births and Deaths Registration Act (GOK, Laws of Kenya: Births and Deaths Registration Act, 2012). It should be noted that this act has not been comprehensively revised since its enactment in 1949. As such, data collected does not comprehensively meet the needs of its users such as statisticians and policy makers (WHO, Improving Mortality Statistics through Civil Registration and Vital Statistics Systems, 2014).

2.3.3 Factors to Consider in Selecting Data Sources for Mortality and Morbidity Statistics

Various methods exist for generating morbidity and mortality statistics data (Lancaster & Stanhope, 2013). However, these alternative methods tend to work in isolation from one another. Consequently, not a lot of value is leveraged from the data derived from these methods. There is, therefore, a need to create a strong synergy across the data sources while still maintaining the overall vision. Several factors need to be put into consideration to achieve such synergy when selecting the data sources to use to collect mortality and morbidity statistics, including:

2.3.3.1 Data Needs

The level of detail needed from the mortality and morbidity statistics will determine the data source choice and the data collection method employed (KNBS, Kenya National Bureau of Statistics, 2015). For example if the data is required in county level, the data sources will be different from those used to elicit data when it is required in national level; if needed in county form, the county or constituency health officers will be direct information sources, while if needed in national form national health officers will be direct sources of information.

The statistics and indicators commonly needed to track mortality in Kenya include (KNBS, Population and Health Statistics, 2009):

a.) Infant mortality rates by location.
b.) Distribution of deaths by cause.
c.) Age distribution of death causes.
d.) Crude death rates.
e.) Life expectancy at birth.

f.) Prevalence of diseases across cancer, diabetes, chronic diseases, amongst others.

2.3.3.2 Opportunities and Challenges

The main strengths and weaknesses of the various data sources also need to be put under consideration. Priority should be given depending on the purpose that should be achieved (WHO, The global burden of disease: 2004 update, 2008). Hence, if the strengths of a data source outweigh its weaknesses for a specified purpose, then priority is given to that source of data. Such strengths include (WHO, The global burden of disease: 2004 update, 2008):

a.) Accuracy of data collected.
b.) Periodicity of the data.
c.) Sustainability of the data in terms of time it will remain viable.
d.) Representativeness of the data.

2.3.3.3 Context and Capacity

A country's context in general needs to be taken into consideration when it comes to deciding which data sources should generate the much needed mortality and morbidity statistics (Leadbeter, 2000). This is of utmost importance since each data source places high demands on a country's resources, the three main ones being; human resources, financial resources and technical resources such as the academia, public health institutes, and national statistics offices to generate sufficient statistics on mortality and morbidity (UNDP, 2012).

Some countries face civil strife, war or other complex emergencies. All these make it quit strenuous to elicit data from the various data sources. As such, generating the most basic mortality and morbidity indicators becomes a major challenge.

2.4 Uses of Mortality and Morbidity Indicators

Data and statistics collected in various surveys can be applied in various sectors and programs in a country. This can then be used for varying purposes mainly research and informing policy making. Some of the applications put in place include:

a.) To measure important demographic indicators of life quality, for example, infant mortality rate, maternal mortality rate, amongst other indicators (KNBS, Kenya Facts and Figures 2014, 2014).

b.) As a measure and monitor of progress towards national and international health targets and health development programs such as the Millennium Development Goals (MDGs), the post 2015 development agenda, amongst other goals (UN, Millenium Development Goals and beyond 2015, 2015).

c.) To monitor the health status in a given population by directly measuring the mortality and morbidity levels. Timely reporting and recording of mortality and morbidity occurrences can be a priceless resource in providing early insight in prevalence of diseases (AbouZahr & Wardlaw, 2001). This, therefore, goes a long way in helping design prevention and intervention mechanisms.

d.) To establish a sound evidence base for public health policies and decision making. This will mainly be data-based decision making which is justifiable. (UN, Indicators for Monitoring the Millennium Development Goals: Definitions, Rationale, Concepts and Sources, 2003).

e.) For equitable resource allocation. This can either be in terms of health personnel or health facilities across the regions in the country (MPHS & MMS, 2009).

2.5 Mortality and Morbidity Statistics in Developing Countries

Mortality patterns in many developing countries point to high levels of infectious diseases and death risk during pregnancy and child birth (AbouZahr & Wardlaw, 2001). Majority of the developing countries have a low death registration rate and illness reporting rate. According to the World Health Organization (2014), this is mostly so in sub-Saharan Africa countries. This, therefore, makes it difficult to generate basic morbidity indicators, including crude morbidity rates.

The causes of the various illnesses are collected and compiled via 2 primary ways:

i.) Collection and compilation of medical records from health facilities.

ii.) Collecting samples verbally from a given sample space.

There is a considerable uncertainty in indicators reported due to limitations in data availability, timeliness and quality (WHO, Cause-specific mortality and morbidity, 2009). It has been noted that up to 80% of deaths in low income countries and middle income countries occur outside health facilities. This is mostly as a result of lack of sufficient health workforce, including doctors, nurses, pharmacists, etc., to register the morbidity events accurately.

According to the United Nations (2012), the life expectancy at birth of the entire world's population has seen an increase from 48 years, between the years 1950 and 1955, to 68 years, between the years 2005 and 2010. It should be noted, however, that the survival disparities, when analyzed for all the regions of the world, clearly show the difference in progress in the various geographic regions (WHO, The global burden of disease: 2004 update, 2008). Many developing countries began their transitions later than the developed countries (UN, Changing Levels and Trends in Mortality: the role of patterns of death by cause, 2012). Some have however made faster progress compared to others. These include Latin America, Caribbean, North Africa and Asia (UN, World Population Prospects: The 2010 Revision, 2010).

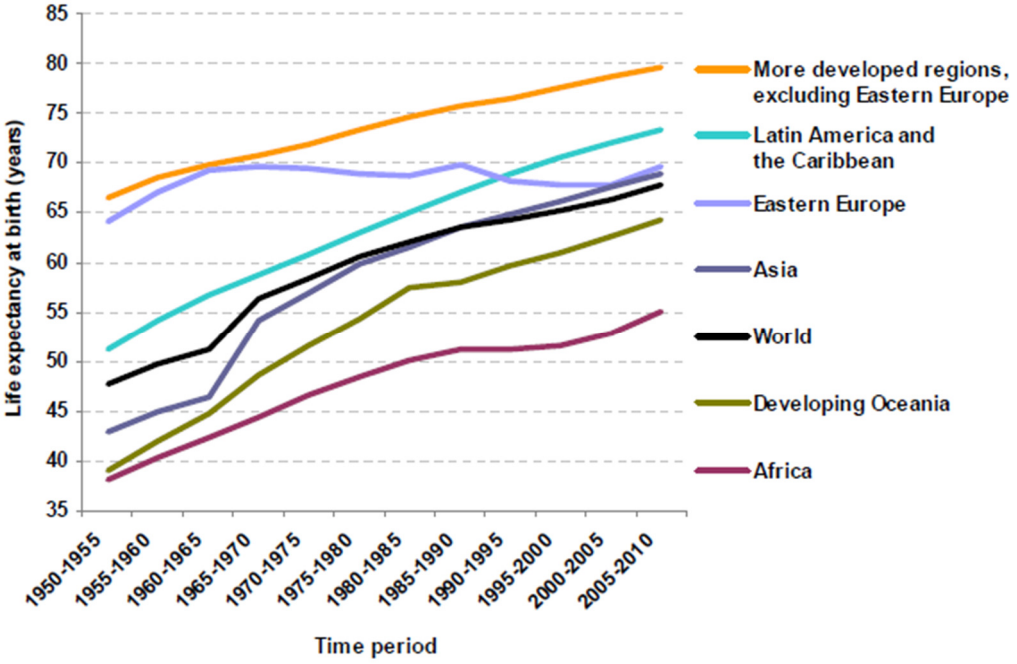

Figure 2.2: Life Expectancy at Birth for the World and Other Selected Regions, 1950-1955 to 2015-2010 ***(KNBS, Kenya Facts and Figures 2014, 2014)***

According to a study done by the World Health Organization (WHO) on estimates of mortality levels by sex, cause, and age (WHO, Mortality estimates by cause, age and sex for the year 2008, 2009), both southern and eastern Africa ha HIV/AIDS as the leading cause of death. Mortality levels in these two regions was also influenced by pneumonia, perinatal conditions and diarrheal diseases, which were amongst the top five contributors of death causes. These diseases are categorized by the World Health Organization under Group 1 death-causing diseases.

A report by the World Health Organization indicates that out of every 10 deaths in the whole world, 6 are caused by non-communicable diseases, 3 by communicable, nutritional or reproductive conditions, and 1 by injuries (WHO, Cause-specific mortality and morbidity, 2009). Figure 2.3 shows the broad categorization done by WHO on causes of death (WHO, The global burden of disease: 2004 update, 2008) together with the main diseases under each group.

Group I causes	*Deaths ('000s)*	*Group II causes*	*Deaths ('000s)*	*Group III causes*	*Deaths ('000s)*
Total	**15 637**	**Total**	**36 122**	**Total**	**5 129**
Lower respiratory infections	3 463	Ischaemic heart disease	7 254	Road traffic accidents	1 209
Perinatal conditions	2 603	Cerebrovascular disease	6 152	Self-inflicted	782
Diarrhoeal diseases	2 464	Chronic obstructive pulmonary disease	3 278	Violence	535
HIV/AIDS	1 776	Trachea/bronchus/lung cancers	1 387	Falls	510
Tuberculosis	1 342	Diabetes mellitus	1 256	Drowning	306
Malaria	827	Hypertensive heart disease	1 153	Poisoning	252
Maternal conditions	361	Cirrhosis of the liver	849	Fires	195
Meningitis	340	Nephritis/nephrosis	775	War and conflict	182

Figure 2.3: Leading Causes of Death by Group of Causes *(WHO, International Conference on Primary Health Care, Alma-Ata, USSR, 6-12, 1978)*

Group 1 mainly comprises of communicable diseases, nutritional conditions, maternal and perinatal conditions. Group 2 mainly consists of non-communicable diseases, while group 3 is made up of external sources of death which include both intentional and non-intentional injuries inflicted on self.

The political declaration of the high-level meeting of the general assembly on the prevention and control of non-communicable diseases that prevention is the footing behind the global response to non-communicable diseases. Countries that have reduced the risk of infant and childhood mortality from diseases like diarrhea and pneumonia, have seen a rapid increase in life expectancy. Through the Millennium Development Goals (MDGs), unprecedented attention has been given to infectious diseases causing death and thus impeding progress in the less developed regions. Such diseases include malaria, HIV/AIDS, and tuberculosis (WHO, Summary Country Profile for HIV/AIDS Treatment Scale-Up, 2005).

The same study by the World Health Organization (WHO, 2005) shows that heart diseases were the leading cause of death under Group 2 death-causing diseases. 2.2 years of lost life expectancy

were pinned to heart diseases in Southern Africa, and 4.3 years of lost life expectancy in North Africa. Figure 2.3 shows the five top leading causes of death in regions in Africa, and the number of years in terms of life expectancy lost due to the disease.

Rank	Cause of death	Survival gap (years
	Africa	
	Middle Africa	
1	Pneumonia	4.7
2	Perinatal cond.	4.1
3	Heart diseases	3.4
4	Diarrhoeal disease	3.1
5	HIV/AIDS	2.8
	Southern Africa	
1	HIV/AIDS	14.2
2	Pneumonia	2.8
3	Heart diseases	2.2
4	Perinatal cond.	2.0
5	Diarrhoeal disease	1.9
	Western Africa	
1	Perinatal cond.	3.7
2	Pneumonia	3.7
3	HIV/AIDS	3.3
4	Heart diseases	3.2
5	Diarrhoeal disease	2.7
	Eastern Africa	
1	HIV/AIDS	5.3
2	Perinatal cond.	3.2
3	Pneumonia	3.0
4	Heart diseases	2.9
5	Diarrhoeal disease	2.2
	Northern Africa	
1	Heart diseases	4.3
2	Perinatal cond.	1.7
3	Stroke	1.4
4	Pneumonia	1.1
5	Diarrhoeal disease	0.6

Figure 2.4: Leading Causes of Death by Region *(UN, Changing Levels and Trends in Mortality: the role of patterns of death by cause, 2012)*

2.6 A Focus on Mortality and Morbidity Statistics in India

It is often said that India is not a country, but a continent. India is the second most populous country in the world, with a population of over a billion people (GOI, 2011) distributed over the 28 massive states. 32% of the population is urban with the median age in India being 26.6 years (Worldometers, 2014). The United Nations estimates that India will be the most populous country in the world from 2028 (BBC, UN: India to be world's most populous country by 2028, 2013).

In 1950-1955, China and India had the same crude death rate and life expectancy at birth, but since China progressed more rapidly than India, China's infant mortality rate declined by more than 6

times, whereas that of India reduced by only 3 times (NIMS, ICMR & UNICEF, 2012) as shown in Figure 2.5.

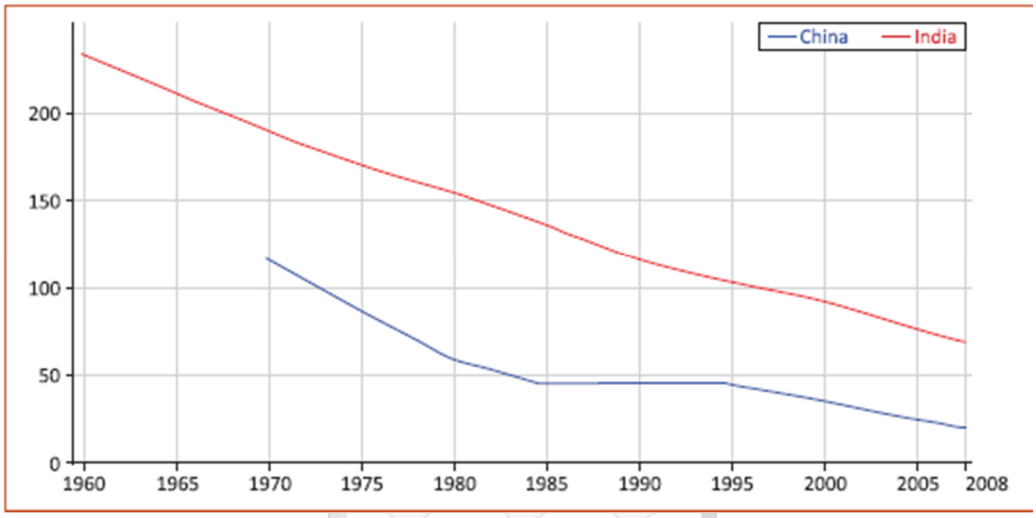

Figure 2.5: Trends: Under-five Mortality Rate in China and India (World Development Indicators) ***(Patel, et al., 2011)***

India is experiencing a fast changing social, political and demographic pattern, with an infant mortality rate of 56 per every 1,000 live births and a life expectancy of 64 years. In a series of studies focusing on a universal health coverage in India, it is seen that the entire Indian population faces a risk of chronic diseases, infectious diseases and injuries; with chronic diseases and injuries being the leading cause of disability and death in the country (Patel, et al., 2011). The same study reveals that much of the treatment and care provided for the said diseases and injuries happens in the private sector which proves to be expensive for a section of the population in India.

Calls for the Government of India to provide the same treatment at affordable costs in public institutions is high with a plea to strengthen both the social and economic framework so as to facilitate the same. Cost-effective prevention strategies are present, but have a low implementation rate (Patel, et al., 2011) especially amongst the poor population living in the rural areas.

The Global Burden of Disease (GBD) provides a framework that quantifies the contribution of diseases and injuries to mortality and loss of health. Loss of health is quantified by use of disability adjusted life years (DALYs). 2004 GBD estimates for India gives information on the distribution of the various diseases and injuries amongst the Indian population as shown in Figure 2.6.

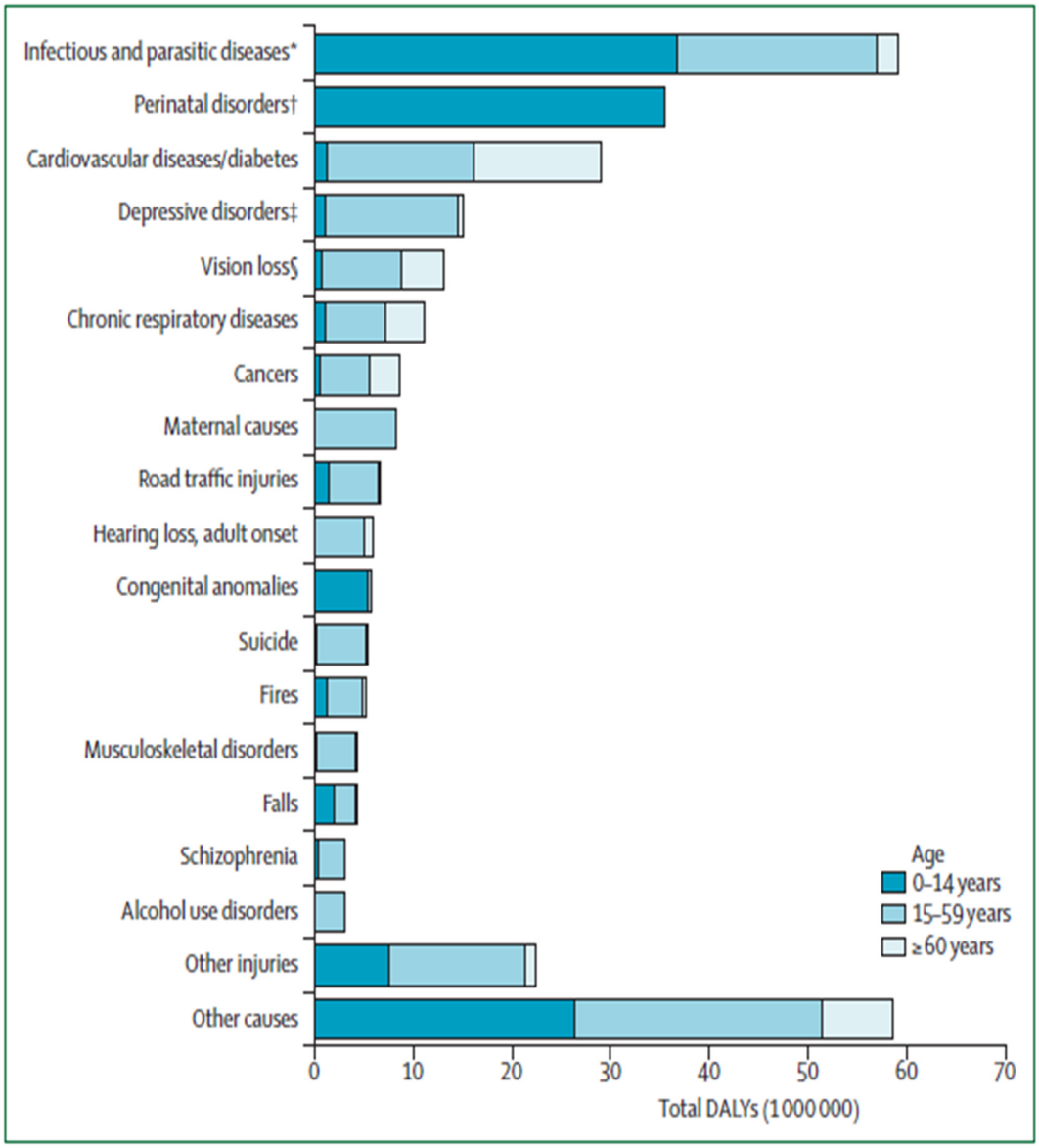

Figure 2.6: Estimated Burden of Selected Diseases and Injury in India in 2004 ***(Patel, et al., 2011)***

The projected burden of disease by cause in India is projected to decrease by about 16% (UN, Changing Levels and Trends in Mortality: the role of patterns of death by cause, 2012) as shown in Figure 2.6. The trend of the burden of disease from 2004 to date has also been highlighted in Figure 2.6. From the trend and projections provided, it is clear that the burden of disease in India has been decreasing and is projected to be on the downward curve in coming years up to the year 2030.

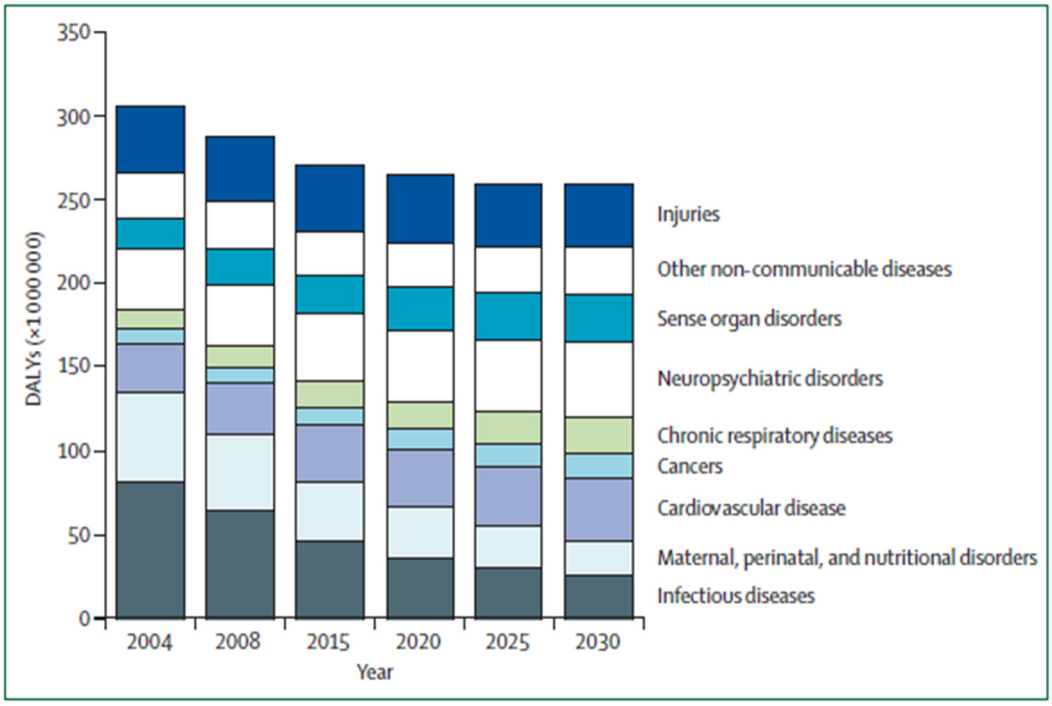

Figure 2.7: Projected Burden of Disease by Cause in India ***(UN, Changing Levels and Trends in Mortality: the role of patterns of death by cause, 2012)***

The social standing of India's population has seen more than 20% of the people getting at least one chronic disease, more so in the poorer population and in persons under 45 years. The improving socioeconomic status in India has been linked to reduced physical activity which in turn increases diseases such as obesity and diabetes.

2.6.1 Initiatives by the Government of India to Reduce Child Mortality Rates

The first global forum that considered how child mortality could be reduced by the development of the healthcare system was the International Conference on Primary Health Care, held in Alma Ata in 1978 (WHO, International Conference on Primary Health Care, Alma-Ata, USSR, 6-12, 1978). Following this declaration, the Government of India visualized a national goal to reduce its child mortality rates.

Since then, resources have been put in child survival programs. A Family Planning program was put into place in 1977, then the Expanded Program of Immunization (EPI) was established, followed by a Safe Motherhood Program in 1985 (NIMS, ICMR & UNICEF, 2012). These were later followed by other programs which carried larger baskets of services and focused more on reproductive rights for women.

The Government of India in 2005 launched a mission by the name National Rural Health Mission (NRHM) which focused on increasing the availability and accessibility of health care to, more so, the rural population, with a keen focus on children, women and the poor (AbouZahr & Wardlaw, 2001). Most notably, three rounds of the National Family Health Surveys (NFHS) were conducted in India, under the Ministry of Health and Family Welfare so as to provide information on the infant, maternal and mortality levels, the nutritional state of children and women, and the quality of health services. The main aims of the mission were to reduce Infant Mortality Rates (IMR) and improve access to universal health services (NIMS, ICMR & UNICEF, 2012).

Over the years, India has impressively improved its health status. There are, however, inequalities between the high socio-economic sectors and the low socio-economic sectors. This, therefore, means that not all populations have access to the health services provided, particularly the poor. In his study, Gwatkin (2000) makes an observation that for reduction of child mortality as in MDG-4, there is need for progress amongst those who are socio-economically disadvantaged. This can be achieved through policies which are directed towards fulfilling the Millennium Development Goals (Gwatkin, Ruststein, Johnson, Pande & Wagsaff, 2000).

2.7 Mortality and Morbidity Statistics in Kenyan Counties

Data is the cornerstone of firm policy decisions (CRA, 2011). The County Revenue Authority (CRA) thus ensures that decisions made, especially under the devolved county government, are evidence-based, authentic and objective. This is the same reason as to why Kenyan Health Policies need to be based on facts emanating from data collected from the population.

Kenya being a populous country, with approximately 44 million persons in 2012 (KNBS, Population and Housing Census: 2009, 2014), and further, squarely lying on the Equator, makes it an easy settle for tropical diseases. Malaria and tuberculosis are the more common tropical diseases and have been a long-time recurring problem in the Kenyan Public Health scenery (LC, 2007). Figure 2. 8 shows the leading causes of outpatient morbidity as at the year 2007 (MOMS, 2008). From Figure 2.6, it is clear that malaria, as at the year 2007 was the leading cause of outpatient morbidity in Kenya. Respiratory diseases follow as the second independent disease causing outpatient morbidity.

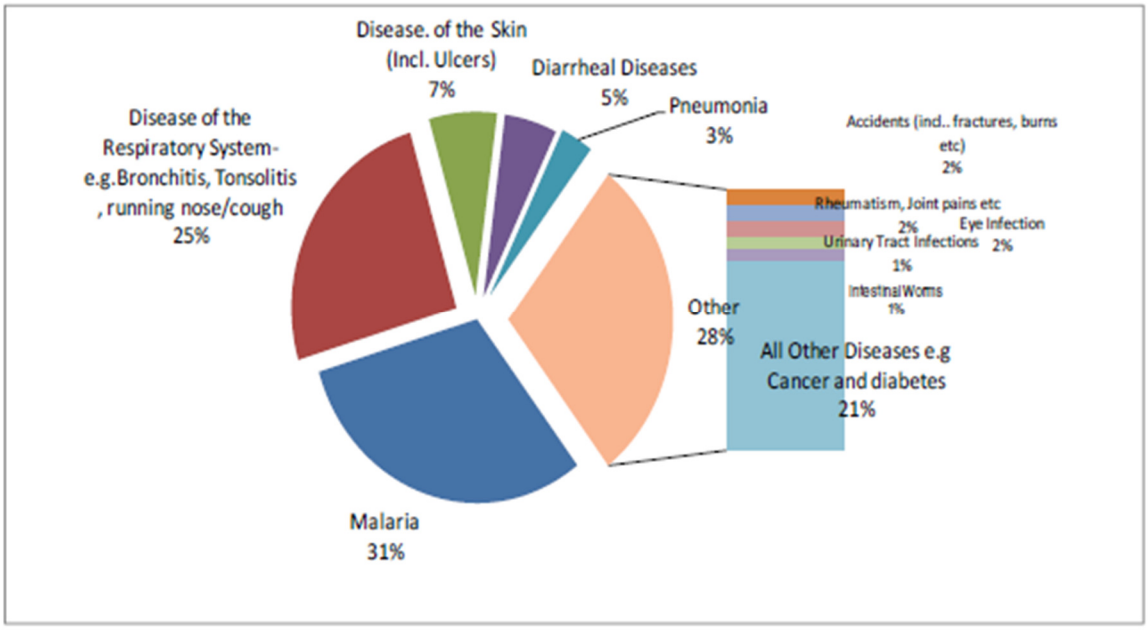

Figure 2.8: Leading Causes of Outpatient Morbidity, 2011*(MOPHS, 2011)*

HIV/AIDS has, however, also become a severe health concern in the country. The Ministry of Health (2004) announced that HIV/AIDS has surpassed malaria and tuberculosis statistics, making it the number one killer disease in the country. This has consequently caused a drop in the life expectancy in Kenya. At least 180,000 people die annually from HIV/AIDS in the country making it to be declared a public health emergency and a national disaster in 1999 (WHO, Summary Country Profile for HIV/AIDS Treatment Scale-Up, 2005).

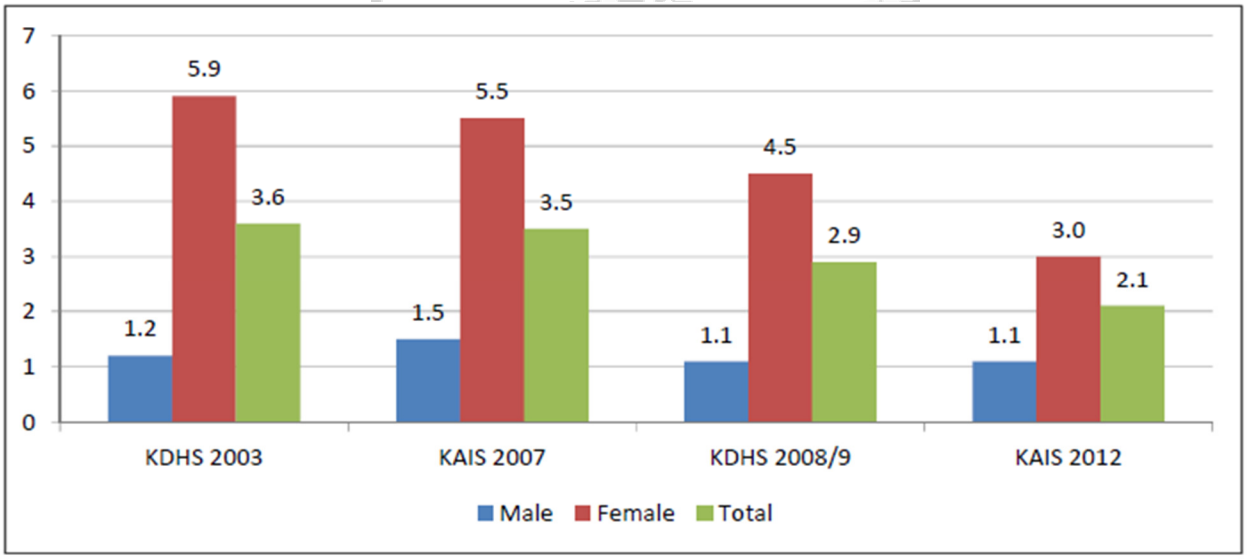

Figure 2.9: HIV Prevalence in Kenya *(MOMS, 2014)*

Aside from the diseases, accidents have also been on the rise. This is more so by motor vehicles, whose numbers on the roads has steadily risen over the years. Kenya is said to have the highest rate of road accidents globally, with 510 fatal accidents per every 10,000 vehicles, according to estimates in 2004. This can be compared to 260 fatalities in South Africa and 20 in the United Kingdom (WHO, International Conference on Primary Health Care, Alma-Ata, USSR, 6-12, 1978).

2.7.1 Health Infrastructure in Kenya

Kenya's health infrastructure suffers from inequities brought about by rural-urban imbalances. Further, a lack of adequate investment has also been a huge blow on the health infrastructure in Kenya.

According to the Ministry of Medical Services (2008), the healthcare system in Kenya has been built in hierarchical manner as outlined in Figure 2.10. The community forms the base of the healthcare system whereby families, households and villages act as the units that directly disseminate healthcare. This is then followed by dispensaries and clinics which act as interface between formal and informal healthcare system (WHO, International Conference on Primary Health Care, Alma-Ata, USSR, 6-12, 1978). Health centers, maternities and nursing care homes come next. Specialized healthcare is disseminated at this level which is still at close reach to most of the villages and homesteads. Primary hospitals come fourth. Primary hospitals mainly comprise of sub-district and district hospitals. At tier six, we have secondary hospitals which are mainly made up of provincial hospitals. Finally, tertiary hospitals come top, mainly made up of national hospitals, some of which are also regional referral hospitals. Complicated health cases are escalated to higher units (GOK & UNICEF, Evaluation report of the community health strategy, 2010). This is mostly if specialized care is needed as well as bringing attention to more complicated medical referrals.

Data from the Kenya National Bureau of Statistics (2014) indicates that tier one of health facilities as shown on Figure 2.10 are the majority in numbers. This goes on decreasing with the number of health facilities at level 6 in Figure 2.10 being the least.

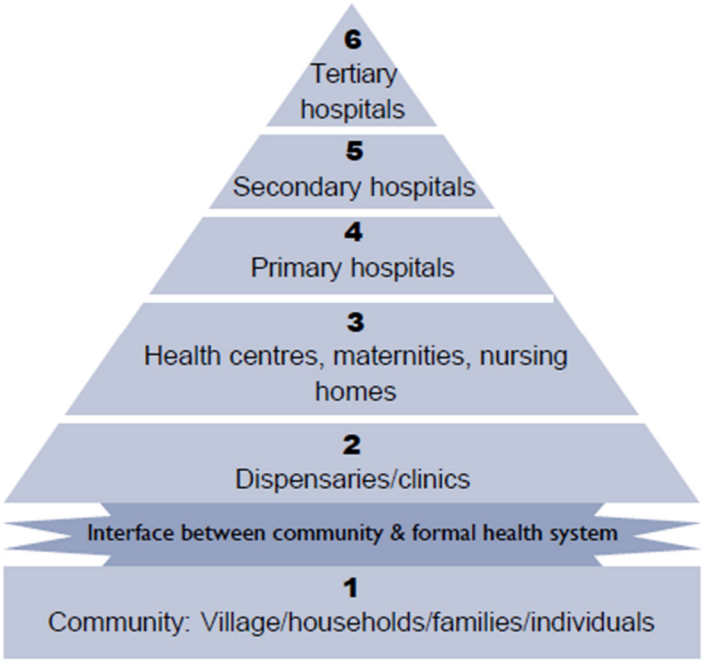

Figure 2.10: Health Facilities Levels *(MOMS, 2014)*

2.7.2 Health Personnel in Kenya

Health personnel are also not sufficient for the existing population. As at the year 2000, there was an estimated one doctor for over 10,150 people. The trend on the number of personnel over the years and the ratio per 100,000 population can be seen on Figure 2.11 and Figure 2.12. Data from the Kenya National Bureau of Statistics indicates that the number of registered nurses is the highest over the years amongst the registered medical personnel (KNBS, Kenya Facts and Figures 2014, 2014).

Numbers

	2010	2011	2012	2013*
Doctors	7,129	7,549	8,092	8,682
Dentists	898	930	985	1,045
Pharmacists	2,337	2,432	2,076	2,202
Registered nurses	29,678	31,719	35,148	37,907

Figure 2.11: Number of Registered Medical Personnel, 2010 – 2013 *(KNBS, Kenya Facts and Figures 2014, 2014)*

Numbers

	2010	2011	2012	2013*
Doctors	18	19	20	21
Dentists	2	2	2	3
Pharmacists	8	8	6	5
Bsc Nursing	2	3	4	4
Registered Nurses	75	83	86	91
Enrolled Nurses	86	87	65	64

Figure 2.12: Registered Healthcare Personnel per 100,000 Population, 2010 – 2013 ***(KNBS, Kenya Facts and Figures 2014, 2014)***

The Government of Kenya recognizes that human resource is key in the health planning sector and has thus embarked on a strategy to address this constraint in a plan dubbed 'Human Resources for Health Strategic Plan' (MPHS & MMS, 2009). This plan analyses the current situation, factors, influences, and constraints of health personnel in the country. It then proposes a plan to remedy the situation so as to improve the health sector status.

2.7.3 Health Policies in Kenya

Provision of high quality healthcare services for all Kenyans is still a huge challenge due to the imbalance in the demand and supply of health services and limited human resources for health. The Kenyan Government is determined to increase the access to essential health services and thus ensure the health sector hits its goals in Vision 2030, MDGs, and the Economic Recovery Strategy.

The ambition of Vision 2030 on the Kenya health sector is directed at providing equitable and affordable healthcare at the highest standards (Kenya Ministry of State and Planning, National Development, and Vision 2030, 2007). To achieve this, the healthcare system needs to be restructured. This will be made possible by addressing some key projects such as:

i.) Creation of a national health insurance scheme to promote equity in the financing aspect.
ii.) Funds channeled directly to health centers, as opposed to via district/county headquarters.
iii.) Scaling access of healthcare to the disadvantaged, especially the poor and the orphans.

Maternal and child health care have received wide attention in the Kenya health policies due to the alarming maternal and neo-natal mortalities recorded in the country, with recent reports by the United Nations ranking Kenya amongst the top 10 countries on maternal deaths (AbouZahr & Wardlaw, 2001). This is more so in the light of wanting to achieve the Millennium Development

Goals, particularly the 4th Goal – Reduce child mortality, and the 5th Goal – Improve maternal health. Further, the number of midwives aiding in delivery of new born babies is unavailable, posing an increased danger of death amongst pregnant women (UNFPA, 2014).

As a result, free maternal services have been introduced by the Government of Kenya for the women. This may be the light for the reduction in maternal death rate. Expenditure on health by government has had a change over the years as in the Figure 2.13.

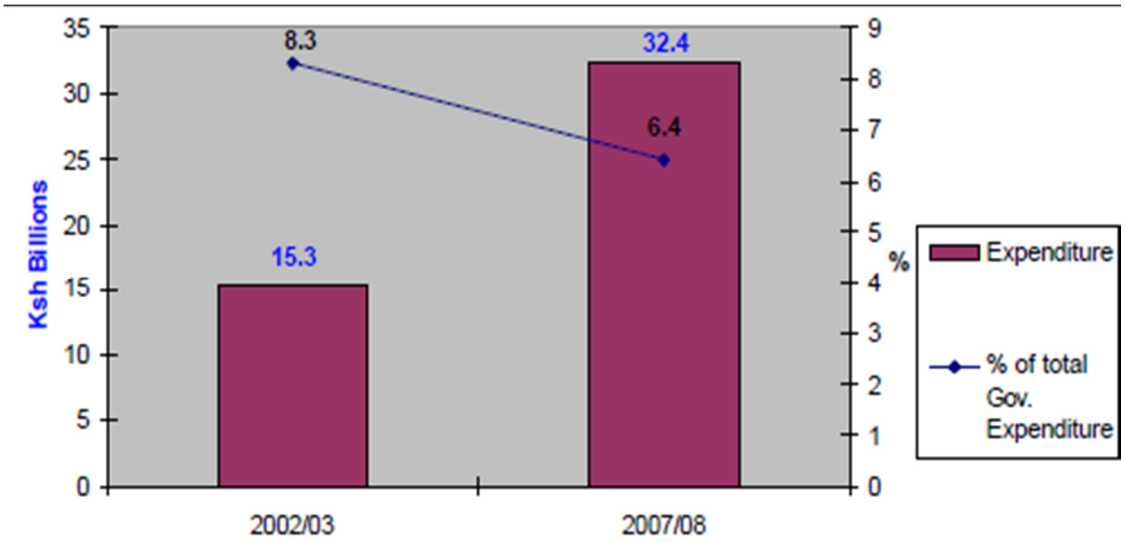

Figure 2.13: Level of Government Health Expenditure ***(MOMS, 2008)***

2.7.4 Initiatives by the Government of Kenya to Tackle Mortality and Morbidity Rates

2.7.4.1 A 10-year Kenya National Malaria Strategy (KNMS)

The Kenya Medical Research Institute (2010) put a 10-year national strategy focused on malaria. The main goal of this strategy was to reduce the mortality and morbidity associated with malaria by a target 30% by 2009 and maintain it all the way to the year 2017. Several strategic approaches were taken to accomplish this initiative (KEMRI, 2000). They include:

i.) Information Education Communication – this was meant to provide the public with knowledge on preventing and treating malaria

ii.) Vector control – in this approach, communities at risk of malaria were steered towards the use of insecticide-treated nets

iii.) Monitoring and evaluation – this strategy was used to provide reliable information on the progress made in the control of malaria

2.7.4.2 Beyond Zero Campaign (Free Maternal Services)

The beyond zero campaign is an initiative championed by the First Lady of Kenya, Margaret Kenyatta (BZC, 2014). This initiative was aimed at spearheading free maternal services. The Beyond Zero Campaign is focused on reducing maternal mortalities because Kenya's progress on maternal healthcare was at a slow. With Kenya having a goal of attaining the Millennium Development Goals, the 4th and 5th MDGs stand out in this campaign which are; to reduce child mortality, and improve maternal health, respectively (Wagstaff, 2004).

Its aim was to raise awareness on the link between good health, more so on maternal, newborn and children's health, and a strong nation. Funds for this campaign are raised through charity marathons, which have been graced by the presence of the first lady (UNAIDS, 2014).

2.7.4.3 Kenya National AIDS Strategic Plan 2009/10 – 2012/13(KNASP 3)

This is a plan developed in 2009 as a result of the study on modes of transmission of HIV/AIDS. This study identified the key sources of new infections and further pointed out the groups of people most vulnerable to HIV transmission (AVERT, 2014). This initiative, spear-headed by the National AIDS Control Council (AVERT, 2014), had 4 main targets:

i.) Reduce, by 50%, the number of the new infections caused by HIV.
ii.) Reduce, by 25%, the number of AIDS related deaths.
iii.) Reduce morbidity levels due to HIV.
iv.) Reduce the socioeconomic impact of HIV and AIDS.

NACC is currently preparing for KNASP 4, while reviewing the ground work for KNASP 3. The 4th cycle aims at shifting from crisis management to sustainable management.

2.7.4.4 Kenya Vision 2030

The ambition of Vision 2030 on the Kenya health sector is directed at providing equitable and affordable healthcare at the highest standards (Kenya Ministry of State and Planning, National Development, and Vision 2030, 2007). To achieve this, the healthcare system needs to be restructured. This will be made possible by addressing some key projects such as:

i.) Creation of a national health insurance scheme to promote equity in the financing aspect.
ii.) Funds channeled directly to health centers, as opposed to via district/county headquarters.

iii.) Scaling access of healthcare to the disadvantaged, especially the poor and the orphans.

2.7.5 Sources of Health Data in Kenya

There are various data sources which provide information on health and disease occurrence in Kenya (Kibet, Wanjala, & Gikunda, 2008). A report published by the Ministry of Medical Services indicated the main sources of health data (MOMS, 2008) which include:

i.) National Hospital Insurance Fund (NHIF) – NHIF is a state corporation set up to provide a medical insurance cover to all its members and their declared dependents (NHIF Mandate, n.d.).

ii.) Office of Vital Registration (VR) – These are institutions charged with the registration of births, deaths and marriages (Kibet, Wanjala, & Gikunda, 2008).

iii.) Kenya Medical Research Institute (KEMRI) – KEMRI as an institution has been given the mandate to conduct health research in Kenya (KEMRI Mandate, n.d.). KEMRI is a state corporation.

iv.) Ministry of Health (MoH) – The Ministry of Health has been mandated with the duty of regulating the health policy in Kenya, regulating health matters, overseeing the health facilities in the country and further managing the health personnel (About the Ministry of Health, n.d.).

v.) Integrated Disease Surveillance and Response (IDSR) – this gives weekly reports which show the trend (increase or decrease) of diseases in the country.

Some of the above data sources are primary while others are secondary. However the aggregated data is usually released by the Kenya National Bureau of Statistics (KNBS, Kenya Facts and Figures 2014, 2014). Furthermore, KNBS is the official holder, and provider of all information emanating from the government of Kenya. This is the reason why the scope of this study was limited to data coming from the Kenya National Bureau of Statistics.

2.8 Visualization

Visualization is the process through which data, knowledge and information is transformed into graphical representations (Zhang, 2007) such as charts, graphs, maps, etc. Through the use of pictures, also known as visuals herein, people can more easily comprehend data as opposed to when they are directly reading numbers organized in a spreadsheet as rows and columns (Tableau

Software, 2012). Visualization is a relatively new concept (Chen, Hardle, & Unwin, 2007) that can be a companion to policy makers, researchers, decision makers, etc. which can allow them to effectively ask important questions on matters of growth, trends, history, and so on.

Visualization has been classified as a computing method that facilitates the seeing of the unseen. It has been proven to be faster for users to grasp data when displayed in a visual format such as graphs and charts, as opposed to going through data in spreadsheets or reports (SAS, 2011). Visualizations help explain complex phenomena by leveraging existing computing methods (Hansen & Johnson, 2011).

2.8.1 Data Visualization

Data visualization is a technique used to represent a given data set in graphical or pictorial form (SAS, 2011). It is a relatively modern way of representing and analyzing statistics (Chen, Hardle, & Unwin, 2007). With the increased collection of data in various sectors of the economy, there arises a need to simplify the process of manipulating and analyzing the data therein. Consequently, researchers and decision makers at all levels need a data visualization tool that allows for the analysis of results presented visually (SAS, 2011).

The data is usually organized into various indicators which are then used to plot out the graphical representations. Tools facilitating data visualization allow users to intuitively present information (Tableau Software, 2012). If data is not organized and presented innately, then all the data we collect will be meaningless. The main purpose of designing a data visualization tool is to create a platform that will be easily understood by all users; novice and experts alike (Murray, 2013). At its utmost best, data visualization is viewed as expert storytelling.

2.8.1.1 Why Data Visualization?

The current information age has been characterized by information overload most of which is unprecedented (Levitin, 2014). Such information overload has sprouted from all avenues including people, technology such as social media, organizations such as company polls, processes such as registration of persons and general surveys (Ruff, 2002). Widespread access to the web and ease of sending e-mail messages to a large group of people at a very low cost is also another reason for information overload (Understanding Information Overload, 2014).

At the same time, there is an increased need for us to make more and better decisions and at a faster pace than previously required. A report done by the Harvard Business Review found that 80% of the people rely on data in their day-to-day activities while another 73% of the people say they rely on data to make decisions (HBS, 2010). The Harvard Business Review, on a different study (Harvard Business Review Analytic Services, 2011), reported that 88% of people believe that it is increasingly important to make decisions quickly based on data and in real time. With the amount of data on an exponential growth, there arises a need for faster, smarter data-based decision making.

Information overload is often overwhelming, consequently, raw data only becomes useful to us when we apply methods of deriving useful insight from it (Murray, 2013). Data visualization has been proven to be faster and easier for users to grasp data when displayed in a visual format such as graphs and charts, as opposed to going through data in spreadsheets or reports (SAS, 2011). With business analytics needs on the high, data visualization is thus paramount. Furthermore, we humans are intensely visual creatures (Murray, 2013) hence can more easily interpret visuals like charts and graphs as opposed to detecting patterns in rows and columns of numbers. Users need to be given the power to display and comprehend their data in real time and in completely new forms, which is where data visualization comes in (Izenda, 2015).

2.8.1.2 Interactive and Dynamic Data Visualization

Data visualizations can either be static or dynamic and interactive. Static data visualization provide pre-composed views of the data. Consequently, to represent several perspectives of the same data, several static views will be needed to accomplish this (Murray, 2013). More often, static data visualizations are mostly employed when being published on a static medium such as a printer report. Static visualizations, however, limit the number of dimensions of the data that can be represented.

On the other hand, dynamic and interactive data visualization give power to the users to explore the data at hand by themselves. Avenues for manipulating the data in real time and seeing the visualizations change there and then are a major part of interactive, dynamic data visualizations. In a nutshell, interactive and dynamic visualizations provide an overview of the data in a visual format, alongside additional tools for dynamically manipulating the data in order to drill down into the various indicators required by the user.

Dynamic, interactive data visualizations can be utilized by a wide array of persons from those new to the subject matter all the way to the experts who are well vast with the data and the subject. When compared to static visualizations, dynamic and interactive data visualizations encourage the user to engage more with the data. Depending on the transitions and the animations used in the dynamic visualization, exploration of the data by the user through dynamic manipulation can feel more like playing a game (Murray, 2013). Audiences, who might otherwise not care about the data, are thus more engaged to the topic and or data at hand when presented with dynamic visualizations as opposed to static visualizations.

2.8.2 Benefits of Data Visualization

Data visualization needs to be flexible enough to allow the user an opportunity to tell and informed story. Visualization of data has brought about multiple advantages to the users of such visualizations. To begin with, data visualization is a really good technique for highlighting trends of the data being visualized and accentuating outliers for purposes of research, policy advisory and decision making.

Further, through data visualization, the user is able to search for and discover interesting data points or specific data points tailored to their need (Telea, 2014). Before the era of computers, it was an uphill task to analyze data that comprised of many variables (Chen, Hardle, & Unwin, 2007). This has now been made possible through the provision of selection options which the user can dynamically manipulate to achieve their needs.

Moreover, data visualization is important in inspiring and eliciting new questions for further exploration based on the data being visualized (Cairo, 2012). This is most relevance to researchers and decision makers as they are exposed to new aspects of the data which can be paramount focal points in their interaction with the data.

Additionally, data visualization leverages the implausible visual system of the human brain to move large amounts of information into the brain very quickly. Consequently, the retention of the data and information being analyzed will be higher (Murray, 2013). This is quite important especially for decision makers who are bombarded with large amounts of data which they more often need to remember for their sound judgement on a given situation. The ability of the human

brain to identify patterns and further communicate relationships has also benefited from the visualization of data (Yau, 2011).

2.9 Previous Research

A report by Stanley Morgan reported that more people are expected to connect to the Internet via mobile devices than desktop computers in the coming years (Morgan, 2009). Stanley further underpinned the dramatic growth in mobile Internet usage to the massive adoption of 3G services, VoIP, video and social networking. No other technology has reached so many people in such a short time like mobile technology has (Greene & Mamic, 2015). Mobile devices, tablets amongst other mobile technologies are now crucial channels through which solutions are being delivered.

In sections 2.8.1, 2.8.2 and 2.8.3, the author reviewed three applications that visualize varying data on matters health with an aim of drawing a comparison between various indicators. Further the gaps and limitations of the approaches therein have been highlighted with an aim of motivating the study.

2.9.1 Quality Care Navigator

Figure 2.14: Quality Care Navigator - Location Selection Screenshot (QCN, 2010)

Quality Care Navigator is a mobile-web tool that allows the user to do a comparison of health facilities between two or more locations. Medical care offered by the selected location is then manipulated using the provided health indicators to enable the user make an informed decision on whether or not to visit the health facility. The measures of comparison have been wisely selected

by healthcare experts. These indicators are standard medical practice indicators that one expects in all health facilities.

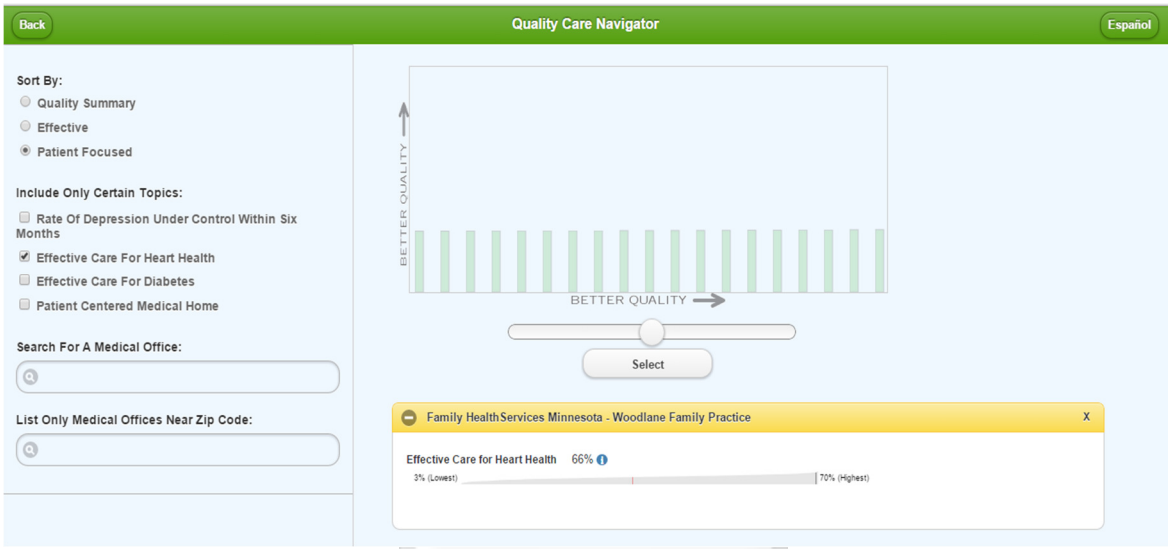

Figure 2.15: Quality Care Navigator – Health Indicator Selection Screenshot (QCN, 2010)

The user selects from a pre-populated facility list, with each item on the list having location-health facility pairs. This then loads a list of indicators that the user can select and use for comparison. A visual representation e.g. a bar graph then loads to give a graphical interpretation of the data. One can then drill down to get the actual data used to populate the visual.

The Quality Care Navigator mobile-web application can be accessed via www.qualitycarenavigator.com/index.html

2.9.1.1 Approaches in Quality Care Navigator

Quality Care Navigator uses locations of health facilities as their major approach to visualizing health data. The user thus has to first and foremost select a location such as Boston, Minnesota, etc., before they can narrow down to any other health indicator therein.

Data used in the application is derived from the Institute of Medicine (Balogh, et al., 2011), a branch of the National Academy of Science. The data is then put into a framework that is easy to understand. This framework helps in the derivation of comparisons in a quick and easy manner. The data is primarily for realigning health statistics which has a vast amount of useful information.

2.9.1.2 Gaps Identified in Quality Care Navigator

In Quality Care Navigator, not all aspects of medical care have been provided for the user to utilize when generating the comparison. The focus is mainly on the location of the various health facilities. This is not enough to make an informed decision when wanting to visit a given health facility. Further, to get a summary of a specific section of the visualization needs one to go through all previous sections using a slider. This is a tedious process and not as user-friendly.

Additionally, the health indicators and visualization options provided are limited to only one type for every health indicator selection made. As a result, the user is confined to only one visualization type, such as an incremental bar. This in most cases does not cater for the needs of all the users, who at different occasions, may require different visualization types.

2.9.2 Childbirth Risks

Childbirth Risks is a mobile-web application that uses open data on cesarean births, preterm births and low birth weight to map these disparities across states in the United States of America. Childbirth Risks is a project about "healthy people 2020" (Office of Population Affairs, 2010).

The user is allowed to select the age, race and state for which they want to visualize data on. This then populates in graphical form, with a brief explanation of the visualization. A module on mapping disparities shows the results in geo-data form. The user can then dynamically manipulate the data using the filter provided for race, for example Asian, Hispanic, Black-American, etc. and age brackets.

The application can be accessed via http://www.mappinghealth.com/childbirth/maps.html

2.9.2.1 Approaches in Childbirth Risks

Childbirth risks focuses on various aspects on births of children, specifically preterm births, births through cesarean and births that are below the normal birth weight. This data set is then visualized in graphical form for the users to interact with easily.

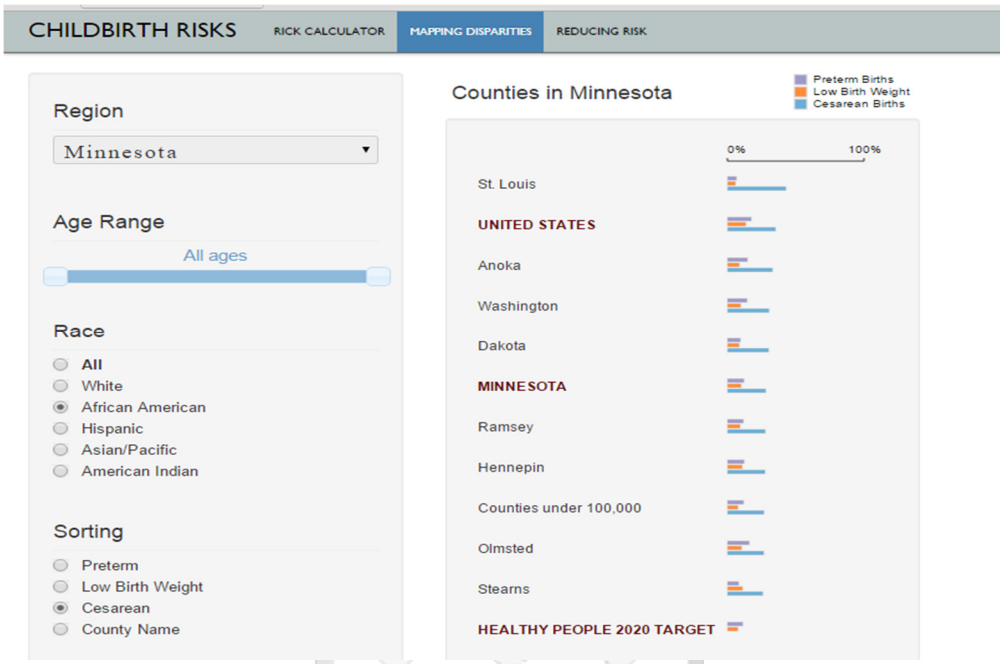

Figure 2.16: Childbirth Risks Visualization Tool Screenshot *(CBR, 2011)*

2.9.2.2 Gaps Identified in Childbirth Risks

Childbirth Risks is limiting in terms of the types and range of visualizations provided for a given data set and indicators chosen. This, therefore, limits the array of options for the users who want to see the visualizations in other forms. Further, this application misses a feedback form/module which is paramount in visualization applications since the indicators and data sets can be updated at any time, also, different users would like varying combinations of data sets for purposes of making data-directed conclusions.

Moreover, the user has no variety of options to choose from in terms of the visualization format. The visualization provided is fixed and cannot be manipulated in real time.

2.9.3 Maternity Care

Maternity Care is a web application that uses open data to highlight the levels of maternity care and factors around it such as paying rates for caesarian section procedures. It further shows a trend over the years for these data sets, which can then better inform health strategies in maternity care.

The indicators used by Maternity Care web application include; average labor delivery costs, caesarian sections, maternal death rate and infant death rate.

The application can be accessed via http://www.mappinghealth.com/maternitycare

2.9.3.1 Approaches in Maternity Care

Maternity Care has narrowed down its data sets and visualizations to factors revolving around maternity care. This includes but is not limited to payment rates for maternity related activities such as cesarean sections and the average child delivery costs.

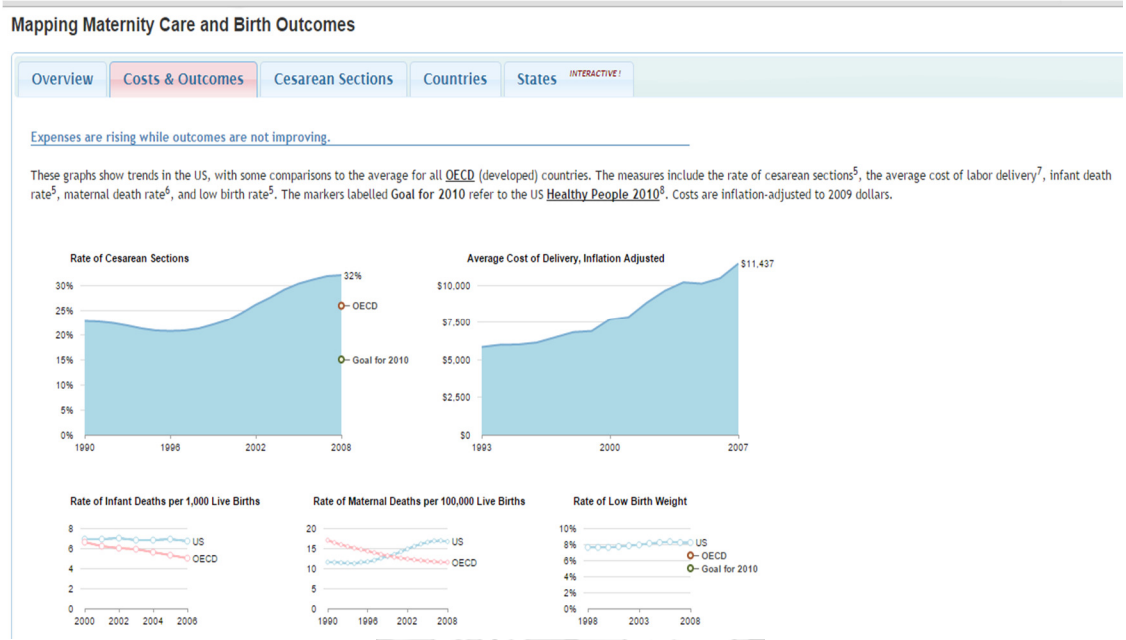

Figure 2.17: Maternity Care Visualization Tool Screenshot *(MC, 2011)*

2.9.3.2 Gaps Identified in Maternity Care

Maternity Care is not user friendly due to the amount of data presented to the user on one page when focusing on data on the various States. Furthermore, dynamic manipulation of data being represented is not possible. The user, therefore, has to make use of the visualizations as they have been provided. This is a limiting factor to the user as it does not allow them the freedom to interact with the data through real time, dynamic manipulation for analysis purposes.

2.10 Analysis and Conclusion

The proposed solution has the same basic objectives as the projects highlighted in Section 2.8 which provide data visualization on matters health and the attributing factors for purposes of advising researchers, policy makers and advisers. However, these systems have limitations such as not providing room for the user to dynamically manipulate data so that they generate visuals on only what they need. Consequently, the proposed solution will have advantages which address these short-comings. Some of the merits include:

i.) A solution that allows the users to dynamically manipulate the data sets so that the visuals generated are within the time periods and indicators they want.

ii.) A solution with a friendly and intuitive user-interface which can be utilized by any user without requiring a long explanatory guide.

iii.) A solution that allows for interaction between the user and the developer in terms of a feedback module where users can request for a cross-indicator visualization related to mortality and morbidity.

iv.) An open-source solution which can be utilized without restriction by any individual wishing to get a visual representation of the mortality and morbidity levels in Kenya together with the attributing factors.

v.) A solution that provides an option of downloading a user-tailored visual in various formats such as an image or spreadsheet of in pdf format.

The perspective of policy formulation has increasingly changed from theory-based decisions to data-based decisions. Statistics and its dynamic interpretation is, therefore, becoming the center of basing decisions and advising on policy. Availing these statistics in a more user-friendly manner, as opposed to the traditional tabular and publications form, is consequently becoming an increasing need in policy making.

Matters health, especially on mortality and morbidity, are crucial in helping a developing country, such as Kenya, attain the Millennium Development Goals. Therefore, analyzing statistics on mortality and morbidity and the attributing factors is paramount if the country wishes to formulate data-advised policies, based on facts from actual data from the ground.

With the dynamic game-changing environment brought about by mobile technology, information dissemination, in terms of availing data at the hands of the user as and at when he or she needs it, is now the rising trend. Using the proposed mobile application will thus enable researchers, policy makers, and other health open data consumers to effectively, efficiently and factually, interpret and apply the data in an easier, friendlier and user tailored format.

Chapter 3: Research Methodology

3.1 Introduction

In Section 1.5 of this study, two major assumptions were made by the researcher; first that the current format of data released for consumption was not user-friendly, making it hard for users to consume it and second, that there is need for a visualization tool for purposes of presenting the data in a more user-friendly format and further allowing dynamic manipulation of the data as per user's needs. A survey was thus obligatory for purposes of verifying the said assumptions. This chapter, thus, sought to highlight the dynamics and approaches undertaken in carrying out the survey and how the data collected was analyzed to affirm the assumptions of the researcher. The design and development approaches of the proposed system are also highlighted in this chapter.

3.2 System Analysis and Design

Analysis and design of the system illustrates the various components of the system, with an aim of showing an end to end, seamless flow and interaction of the different modules. Through system analysis and design, the behaviors and components of the modules were highlighted more clearly in system analysis and design. Unified Modelling Language (UML) was used to document the analysis and design process.

3.2.1 UML (Unified Modelling Language)

UML is much more comprehensive and hence why it was chosen for system analysis and design (Halpin, 2000). It also has a wide selection of system analysis and design diagrams (Gandharba, 2010) for the system analyst to choose from. UML further facilitated the use of object oriented notation which enabled the successful modelling of the system objects and process flows (Rozanski & Woods, 2011).

3.2.1.1 Use Case Diagrams

Each use case in the system as well as all actors interacting with the system are highlighted in a use case diagram (Bittner & Ian , 2003). This diagram further shows the interaction of the actors with the use cases, as well as interaction of use cases with other use cases in the system.

Actors, in use case diagrams, denote the users of the system, while the use cases symbolize the various functionalities of the system.

3.2.1.2 Design Class Diagram

A design class diagram shows the definition of classes during analysis and design of the system (Satzinger & Jackson, 2008). The classes of the proposed application were defined using their attributes and methods.

3.2.1.3 Activity Diagram

An activity diagram shows the transition in state of an activity and is represented by transitions and states of the activity (Jalloul, 2004). Each activity diagram has a start state and an end state. Activity diagrams representing the various activities of the proposed system were included in Appendix F of this study.

3.2.1.4 SSD (System Sequence Diagram)

System sequence diagrams show the chronological order in which events are executed by actors in the system (Satzinger & Jackson, 2008). This helps give a clear picture of the various actions an actor can take to complete a process.

3.2.1.5 ERD (Entity Relationship Diagram)

An entity relationship diagram shows how data is organized, in terms of the attributes of the data, visibility of these attributes by other entities, and the association between the various entities (Coronel & Steven , 2014).

3.2.1.6 DFD (Data Flow Diagram)

DFDs illustrate the flow of data between two or more processes (Bittner & Ian , 2003). They further indicate the various data stores in a system, and further shows what data flows in and out of the data stores. DFDs go an extra mile to indicate the external entities of the system, i.e. systems, persons or organizations that are external to the system but interact with it. DFDs can be represented in more than one level, with each lower level expounding on major processes illustrated in the method above it.

3.2.2 Data Analysis Procedures

Data analysis can either be done through a quantitative approach or a qualitative approach (Creswell, 2013). Both approaches were employed in this study. Mean, standard variation and variance were used in the calculation of the data during analysis. Other visualization tools such as

bar charts were also used to show the frequency of data received from the respondents of the research of this study.

3.2.3 Research Instruments

3.2.3.1 Online Questionnaires

An online questionnaire was selected as a data collection method in this study because it is a fast method of collecting data from a large group of people who are geographically apart, thus cutting off the geographical divide (Allen & Earl, 2009). Online questionnaires are further filled at the once own pace and privacy hence the respondents were not under undue pressure when providing the information in terms of being afraid of their identity being known. In this research, online questionnaires were created using Google Docs and distributed to the respondents via email.

3.2.3.2 Document Review

Existing documents addressing the issue of mortality and morbidity levels and their attributing factors were reviewed by the researcher. Document reviews were of importance as this helped the researcher understand aspects on visualization of data, and how to present it in the easiest way possible for the user to dynamically manipulate and consume it. The researcher was also able to get appropriate information on the most appropriate architecture of the system. Document review served as a good benchmark for the system developed on this study as the researcher was able to identify what exists and gaps that need to be filled in existing applications.

3.2.4 Research Design

The business dictionary describes research design as a detailed outline of how an investigation will be undertaken (BusinessDictionary, 2015). It entails several processes which include; how data collection will be done, what instruments will be used in data collection, how the said instruments will be used and the means that will be used to analyze the collected data (Creswell, 2013).

This study employed the use of quantitative, qualitative research and exploratory research to describe the study objectives, explain how the objectives were met, and further, how implementation and testing of the system was done to meet the user requirements. Exploratory research helped the researcher determine the best research design to be followed. The researcher here wanted to determine the best approach to gather data for the study. Both quantitative and qualitative research methods were chosen. In this study, quantitative research entailed gathering

hard facts and statistics that are quantifiable which would guide the study. Structured online questionnaires were used here and complimented with telephone and face-to-face interviews. This was achieved through surveying a fairly large number of people, who, the researcher ensured were a true representative of the targeted users.

This was then followed by a qualitative research which tried to elicit a deeper understanding of the facts, figures and statistics collected in the quantitative research. Semi-structured and unstructured group discussions and interviews were undertaken by the researcher. The qualitative research helped uncover the trends in the people's thoughts and opinions. A smaller number of respondents, compared to the quantitative research, was targeted.

3.3 System Development and Implementation

The proposed system was designed and implemented following the Agile Methodology (Jim, 2009). The four main project phases were followed; planning (determining why the system should be built), analysis (determining who will use the system, what it will do, where and when it will be used), design (how the system will work), and implementation (which includes deployment and maintenance).

Since agile development was the chosen methodology to implement the system, then this gave room for progress assessment and reiteration throughout the process, seeing outputs in each cycle in an incremental manner. A program log was kept to monitor any program changes. Scrum meetings, also known as sprints (Schwaber, 2004), were utilized too, where the team periodically met, gave updates of the development status and what was expected as output upon the next sprint.

Agile was advantageous to the development of this system since it provided faster results. Agile is also the better implementation methodology for projects with changing requirements like this project, since users would request to visualize different data sets at a given point in time.

3.4 System Testing

Testing is paramount as it ensures that the performance of the system is as defined in the user specifications (Gordon & Wiseman, 2003). The testing areas of the system were defined beforehand to ensure it was done systematically, further, the results needed to be well documented. Various testing phases were applied on the system, each carried out using a clearly outlined test plan. Stub tests were done to ensure basic control structures, such as printing or deleting or

searching work well before any modules were programmed. Unit tests were conducted to ensure each module performed its expected functions. Integration testing was done to ensure different modules worked together as expected. System testing ensured the entire system worked as expected. Finally, acceptance tests were done to ensure the system served the needs of the users.

3.4.1 Location of Study

The population targeted by this study was the various consumers of open data provided by the government of Kenya through the Kenya National Bureau of Statistics (KNBS, Kenya National Bureau of Statistics, 2015). These include an array of researchers from various sectors including journalists, lawyers, students, etc., and policy makers in the various institutions both in the public and private sector.

This research was carried out in Kenya with a focus on Nairobi County. Nairobi County was selected as the target location of the study because it is home to the central government of the country (Bienen, 2015); this thus makes it resident to a majority of the policy makers based in the Ministry of Health and the County Government. Further, the largest referral and teaching hospital, Kenyatta National Hospital, is found in Nairobi (Eilers & Gruber, 2014). Consequently a majority of diverse health practitioners can be found here in the city. As a result, research being done in this study would benefit much in terms of information gathering as many of the respondents' groups, who are our target population, are found in Nairobi County.

3.4.2 Target Population

Selection of the target population for this study was opened to any individual wanting to dynamically manipulate open data from the Government of Kenya in a fast, easy and efficient manner, and further be able to visualize the same in a graphic manner for varying consumption modes. This group was selected because they are direct users of the data visualized, which they can incorporate in their research and/or health policy making and advisory. A breakdown of the various targeted populations include:

3.4.2.1 Healthcare Practitioners

These comprises of all healthcare personnel working at dispensaries, hospitals, pharmacies, healthcare research laboratories amongst others. This target population could use the visualization tool to correctly refer and/or suggest optional facilities for their patients.

3.4.2.2 County Government

The country government, which is the new geographical territory in Kenya, were selected as a target population due to the devolution of health activities to the county level. They can thus use the visualization tool to well inform their decisions at the county level on matters health.

3.4.2.3 Ministry of Health

The Ministry of Health is the official body of the government in charge of health matters in the entire country. For a fair and informed execution of its duties, the Health Ministry utilizes the visualization tool to be informed of the various health indicators and trends in all the counties.

3.4.2.4 Policy Makers

Policy makers need to base their decisions and policies on facts, which can be done by analyzing statistics on data released over the years. For a more user friendly and easier task of analyzing and manipulating this data, the visualization tool developed herein targets policy makers, by providing real time manipulation and visualization of health data indicators in the country.

3.4.3 Sampling Strategies

Random sampling was used in this research. This gave each unit in the total population an equal chance of being selected as part of the sample (Yu, 2007). Chow, (2008) derived the formulae that we will use to get the sample size.

$$\mathrm{n} = z * z[p(1-p)/d^2]$$

Where:

n = required sample size

z = confidence level = 95%

d = marginal error (5%)

p = 10% estimation of the need of sharing tool

n = 0.95×0.95[0.1(1-0.1) ÷ 0.0025]

The population in Kenya is approximated at 44 million people (KNBS, Population and Housing Census: 2009, 2014). According to the World Bank, approximately 7 million Kenyans have at

least achieved secondary school education. Past secondary school education, one can confidently undertake an in-depth research for various purposes such as school assignments, news creation or policy making. Mobile phone usage has been approximated at 70% of the total population of Kenya (CCK, 2012). This therefore shows that 4.9 million Kenyans have gone through secondary school education and have mobile phones. Internet usage is approximately 35% within the Kenyan population (CCK, 2012). This puts the number of literate, Internet enabled mobile phone users at approximately 1,715,000 people.

Table 3:1: Sample Population Size of Literate, Internet Enabled Mobile Phone Users in Kenya

Population	Confidence level of 95%		
Confidence Interval	5%	7%	10%
1,715,000	385	196	97

A sampling size of 97 was used.

3.4.4 Ethical Measures

Protecting the privacy and confidentiality agreement of the respondents is key in research. This is where ethics comes in which is a key area of data gathering. For participants to comfortably and honestly provide data to your research, then the highest level of trust needs to be put in place.

In this study, the respondents were not obliged to write their names to the questionnaires, or reveal the same during oral interviews. However, each of these data sources had a special code for reference purposes.

3.4.5 Piloting

Piloting is a small experimental exercise done to test the working of the system (BCS & Ould, 1986). A pilot is normally done on a smaller group compared to the actual intended population of users. From a pilot study, system flaws and challenges can be easily identified and rectified before releasing to the larger mass of users. Pilot testers were selected through a first come first picked basis where the first 10 people to download the application from the application store were approached to be included in the pilot run.

3.5 Conclusion

This chapter describes the methods and processes that were used in data collection for answering the research questions. In general this research investigated the need for visualizing mortality levels, morbidity levels and their attributing factors, further having a keen focus on health policies in Kenya. The chapter covered sections on research design, study variables, location of study, target population, sampling strategies, research instruments, validity, reliability, piloting, data collection procedures, ethical measures and data analysis procedures.

Chapter 4: System Design and Architecture

4.1 Introduction

This chapter sought to highlight the system design and architecture of the proposed system. A detailed description of the system structure was given to deepen the understanding of the system. Data flow within the various system modules and their triggers was also laid out. A greater part of the design and architecture of the proposed system was informed by findings from the survey conducted in this study. The questions asked in the survey brought out various aspects in terms of design and architecture of the proposed system. Through the findings, the researcher was able to incorporate the user requirements elicited from the survey. A comprehensive pre-data analysis and findings from the survey has been expounded upon in section 4.2.

4.2 Pre-data Analysis and Findings

4.2.1 Introduction

In section 1.5 of this study, the researcher made two main assumptions; first, that the current format of data released for consumption is not user-friendly, making it hard for users to consume the data and second, that there is need for a visualization tool for purposes of presenting the data in a more user-friendly format and further allowing dynamic manipulation of the data as per user's needs.

In view of the above, a pre-survey was carried out for purposes of verifying these assumptions, thus justifying the need for the proposed system. The questionnaire respondents selected in this research included health policy advisors, health sector decision makers and researchers in various disciplines. The pre-data analysis questionnaire was developed using Google Forms and distributed via email to the respondents. The questionnaire used can be found in Appendix D.

4.2.2 Questionnaire Design

The aim of this research was to get information on the use and importance of data visualization to aid in research, decision making, and policy and advising on matters concerning health in the areas of mortality and morbidity in Kenyan counties.

To achieve this goal, the questionnaire used in the research was subdivided into three sections:

i.) Health open data information
ii.) Data-based decision making

iii.) Research dynamics on mortality and morbidity levels

4.2.3 Discussion on Findings

An online survey was carried out by the researcher as a way of eliciting data from the respondents. This required that both the interviewer and the respondents have connection to the Internet. Further, the online questionnaire used was discrete in that it did not require an identity from the respondent; only an input on the respondent's occupation/job title; whether the respondent was a researcher, health policy maker, health policy advisor or medical personnel. The rest of the questions were optional. Participants were emailed with a link to the online questionnaire, which they were to submit after completing within a given time frame.

The online questionnaire was designed to collect data around issues on health open data information, data-based decision making and research dynamics on mortality and morbidity levels, with a keen focus on visualization of data on health. A copy of the questionnaire is attached in the Appendix A.

Out of the 97 targeted respondents, 90 responded to the questionnaire. This is a 92.78% response rate of the targeted group of respondents.

4.3 Sampled Questions Response

Intricate results obtained from the research questionnaire can be found in Appendix A. A sample of responses from a few of the questions has been analyzed in Sections 4.3.1, 4.3.2 and 4.3.3.

4.3.1 General Information Questions

These are questions neither related to mortality and morbidity levels nor data visualization. General questions were asked to get a feel of the array of those partaking in the survey.

a) Gender Distribution

All the respondents were requested to indicate their gender. The distribution of the males and females in the respondents cluster is as shown in Figure 4.1. The number is braces shows the percentage of respondents' genders.

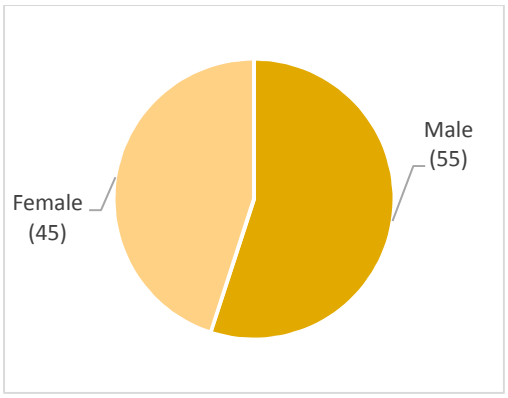

Figure 4.1: Respondents Gender Distribution

It is clear that majority of the respondents were male with a percentage of 55%. The difference in number is not large enough to conclude that the overall male respondents were more than the females.

b) Mobile Devices Type Distribution

Respondents were asked a question on what type of mobile device they used for Internet based research. Figure 4.2 shows the responses received from the respondents to this question.

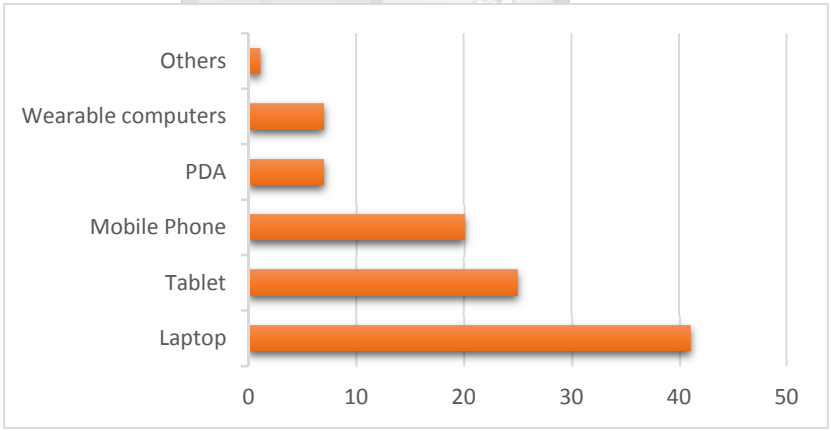

Figure 4.2: Respondents Mobile Devices Type Distribution

From Figure 4.2, laptops are the leading mobile device type used for purposes of utilizing the proposed visualization tool followed by tablets and mobile phones. This shows that there is a need for the proposed system to scale relevantly across the different mobile device types.

4.3.2 Health Open Data Questions

a) Health Open Data Awareness

Respondents were asked if they were aware of the availability of open data on health factors provided by the Government of Kenya. The responses received are as shown on Figure 4.3. 89% of them acknowledged that they were aware of the existence of health open data. The number is braces shows the percentage of respondents that chose the given option.

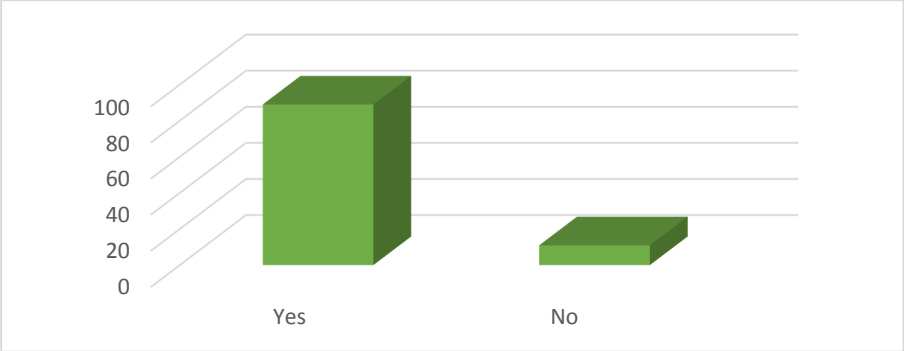

Figure 4.3: Health Open Data Awareness Distribution

This was definitely a positive response since this study and the proposed system are both pegged on availability and usage of health open data.

b) Current Format of Open Data on Health

All respondents were asked a question on whether they agree that the current format of health open data is user-friendly. Table 4.1 shows the responses received. Of all the responses received, 69% disagree on the fact that the current format of open data on health is user-friendly. Those who agreed to this question were 21%, while 10% were neutral.

Table 4:1: User-friendliness of Current Format of Open Data on Health

Current Format of Open Data on Health is User-friendly	Number of Respondents	Percentage
Agree	20	21%
Disagree	67	69%
Neutral	10	10%

From the responses received, there is need to provide the data in a friendlier manner in terms of user experience when it comes to using, analyzing and manipulating the data,

4.3.3 Research Dynamics on Mortality and Morbidity Levels in Kenya

a) Ease of gathering data on mortality and morbidity

The study sought to know how easy it currently is to gather data on mortality and morbidity. Table 4.2 shows 44% of the respondents said it is very difficult to do so, closely followed by 40% of the respondents who said it was difficult to do so. Actual numbers of respondents who selected the various options as answers can also be found on Table 4.2.

Table 4:2: Ease of Gathering Data on Mortality and Morbidity

Ease of Gathering Data on Mortality and Morbidity	Number of Respondents	Percentage
Very Difficult	42	44%
Difficult	38	40%
Neutral	10	11%
Easy	5	5%
Very Easy	0	0%

The respondents who selected very difficult and difficult as their answer imply that it is not easy to gather mortality and morbidity data currently. This is a positive response for this study as it indicates a need to consolidate the said data onto one platform.

b) Ease of analyzing data on mortality and morbidity

Respondents were asked how easy it currently is to gather data on mortality and morbidity. Figure 4.4 shows 44% of the respondents said it is very difficult to do so, closely followed

by 40% of the respondents who said it was difficult to do so. Actual numbers of respondents who selected the various options as answers can be found on Table A.7.

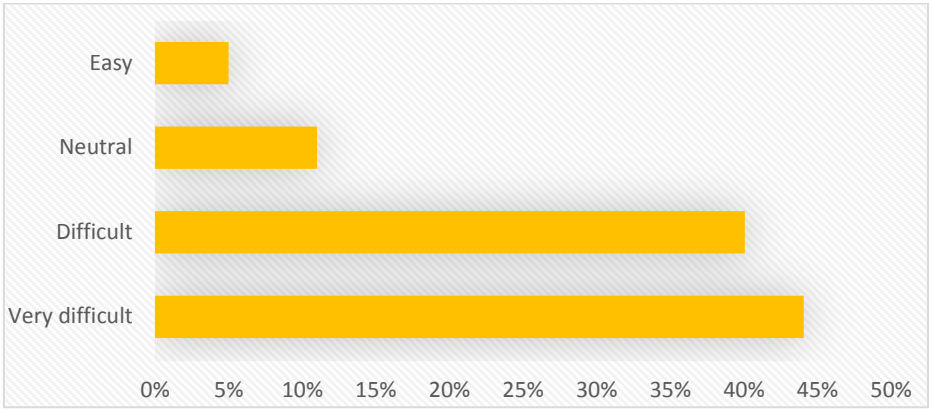

Figure 4.4: Ease of Analyzing Data on Mortality and Morbidity

The respondents who selected very difficult and difficult as their answer imply that it is not easy to analyze mortality and morbidity data currently. This can be attributed to the current data format presented. It is a positive response for this study as it indicates a need to convert the said data into a more fathomable format for purposes of analysis for a research or policy making.

4.3.3 Visualizing and Dynamically Manipulating Health Data

a) Platform for visualizing and dynamically manipulating health data

This study sought to identify if the respondents would use a platform that provided for dynamic manipulation and visualization of health open data to the health policy making process and research. 90% of the respondents, 88 in count, agreed that they would use such a tool as shown on Figure 4.5.

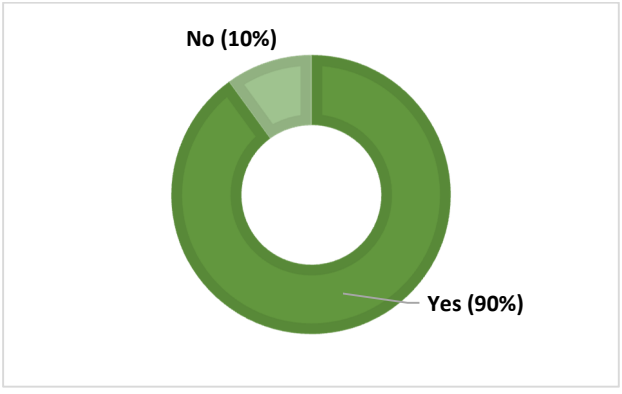

Figure 4.5: Need of a Platform for Visualizing and Dynamically Manipulating Health Data

b) Benefits a platform for visualizing and dynamically manipulating health data

The same 99 respondents from section 4.3.3 a) went ahead and gave some benefits the visualization platform could bring. Some of the benefits highlighted include:

i.) A more user-friendly format of presenting data through the use of various visualization diagrams.

ii.) Presenting the ability to dynamically manipulate the data sets and see the outcome in real time.

iii.) Policy makers and researchers can easily cross-analyze the data sets to form valid, data-based conclusions.

iv.) Saves time getting the necessary data consolidated for use.

v.) Providing the ability to download manipulated datasets in several available formats.

4.4 Summary of Responses from Sampled Questions

From the sampled responses, 89% of the respondents acknowledged that they were aware of the existence of health open data. This question was significant in informing the design and architecture of this study since all the data used in designing the proposed system was open data from KNBS. 69% of the respondents said no to the current format of health open data being user-friendly. These two questions helped justify that there is a need for providing the open data in a more user-friendly manner, hence justifying the assumption that the current data is not user-friendly.

84% of the respondents said it was very difficult to analyze the data in its current form. This confirmed that a niche exists in the format of data presentation hence why the researcher decided to present the data in a visual format which is easier to analyze. 90% of the respondents resoundingly agreed that there is therefore a need for a visualization platform for purposes of decision making and research. This response further affirmed the researchers second assumption made in section 1.5 that there is need for a visualization tool for purposes of presenting the data in a more user-friendly format and further allowing dynamic manipulation of the data as per user's needs.

Distribution of the mobile device type used was fairly distributed, with 41% of the respondents agreeing to using laptops while 25% tablets, followed by 20% who agreed to using mobile phones

in doing an Internet-based research. This ultimately informed the researcher's decision to base the design and architecture of the proposed system on a mobile-web platform which could scale across several platforms without implementing it on every mobile operating system independently. It is thus clear that all the questions asked in the pre-questionnaire survey were significant in informing the design and architecture of the proposed system as highlighted in section 4.5 and 4.6.

4.5 System Architecture

System architecture is a conceptual model which outlines the structural design of the system (Rozanski & Woods, 2011). The proposed visualization application comprises of two ends; the front end and the backend. The front end is a mobile-web platform that can be accessed by the users of the system. The users are free to use any device that supports a mobile-web application and one that has access to the Internet. This can either be a laptop, a desktop, a tablet or a mobile phone.

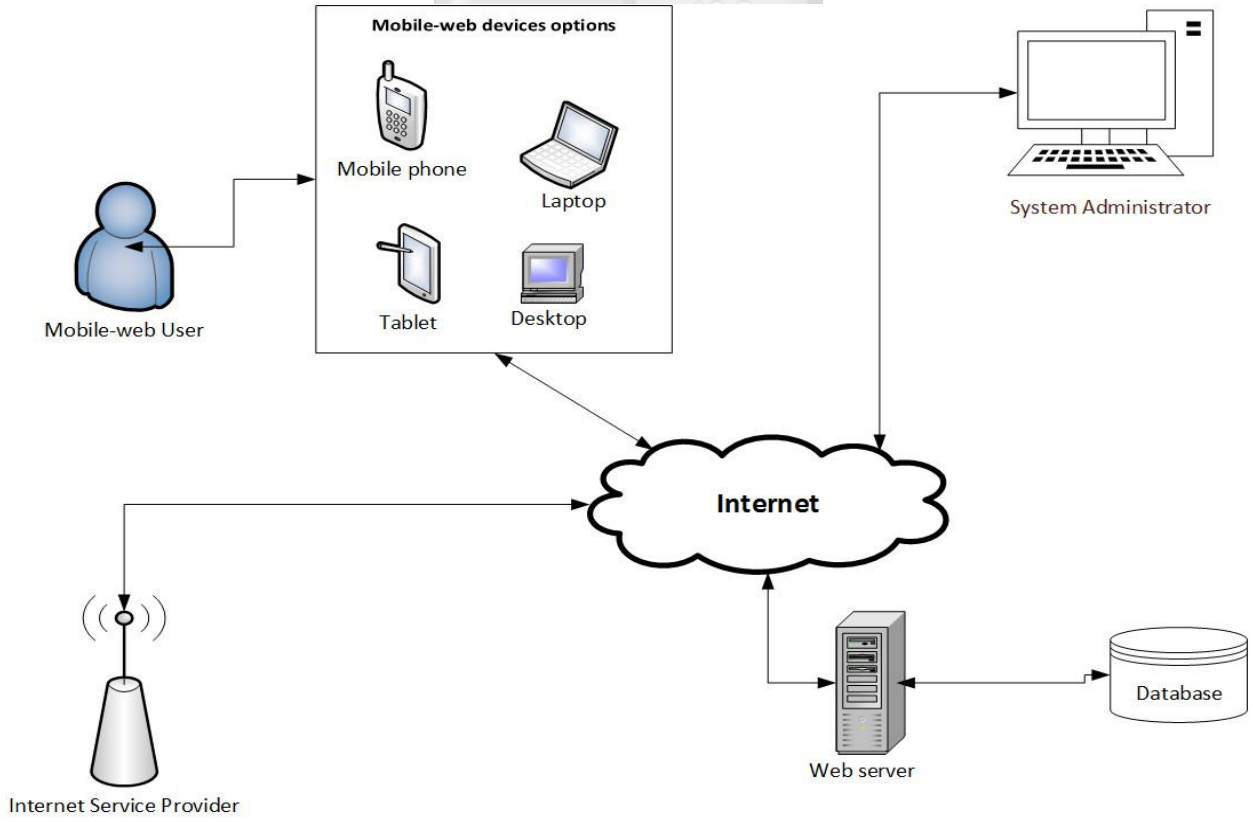

Figure 4.6: System Architecture for the visualization platform

The backend is a web portal accessible only by the system administrators. The backend runs purely on a web browser. It also requires access to the Internet to be able to access data from the database. The database is hosted on a web server. One common database feeds both the front end and the backend of the visualization tool. To access the database, both the backend and the front end need to be connected to the Internet. Queries to the database are directed to the webserver which then processes and responds to the queries. To successfully read from and write to the database Internet access is essential in all the devices in use. Figure 4.6 shows the overall architecture of the proposed visualization application.

They interact with the system through any mobile web device, including but not limited to laptops, tablets and personal computers. The users of the system include policy makers from the government and the Ministry of health, researchers looking into mortality and morbidity levels in Kenya and the attributing factors, patients looking to make informed decisions on health matters and the private sector like insurance companies. Figure 4.6 classifies all these users as the mobile-web users.

4.6 System Design

The proposed mobile application was designed to provide a visualization solution that would represent data on mortality and morbidity levels using graphical representations. The main aim here was to provide platform where mortality and morbidity trends can be easily traced, with a connection with the attributing factors. From this, policy makers can be better placed to make policy based on solid facts and statistics.

This section will expound upon the analysis and presentation of the data collected by the researcher. Further, the design structure of the proposed solution will be illustrated using various design diagrams. User requirements in the form of data and statistics collected from the requirements elicitation stage will be portrayed in different visual formats. Unified Modelling Language (UML) was used to design and elaborate the requirements and components of the proposed system (Pilone & Pitman, 2005). UML enabled the researcher to visualize, model and document the proposed system (Satzinger & Jackson, 2008).

4.6.1 Use Case

The interaction of the users of the system with the various functionalities of the visualization platform is illustrated in the use case diagram in Figure 4.7. This use case highlights all the major functionalities that the proposed system offers. All the external systems and users interacting with the proposed solution have also been highlighted.

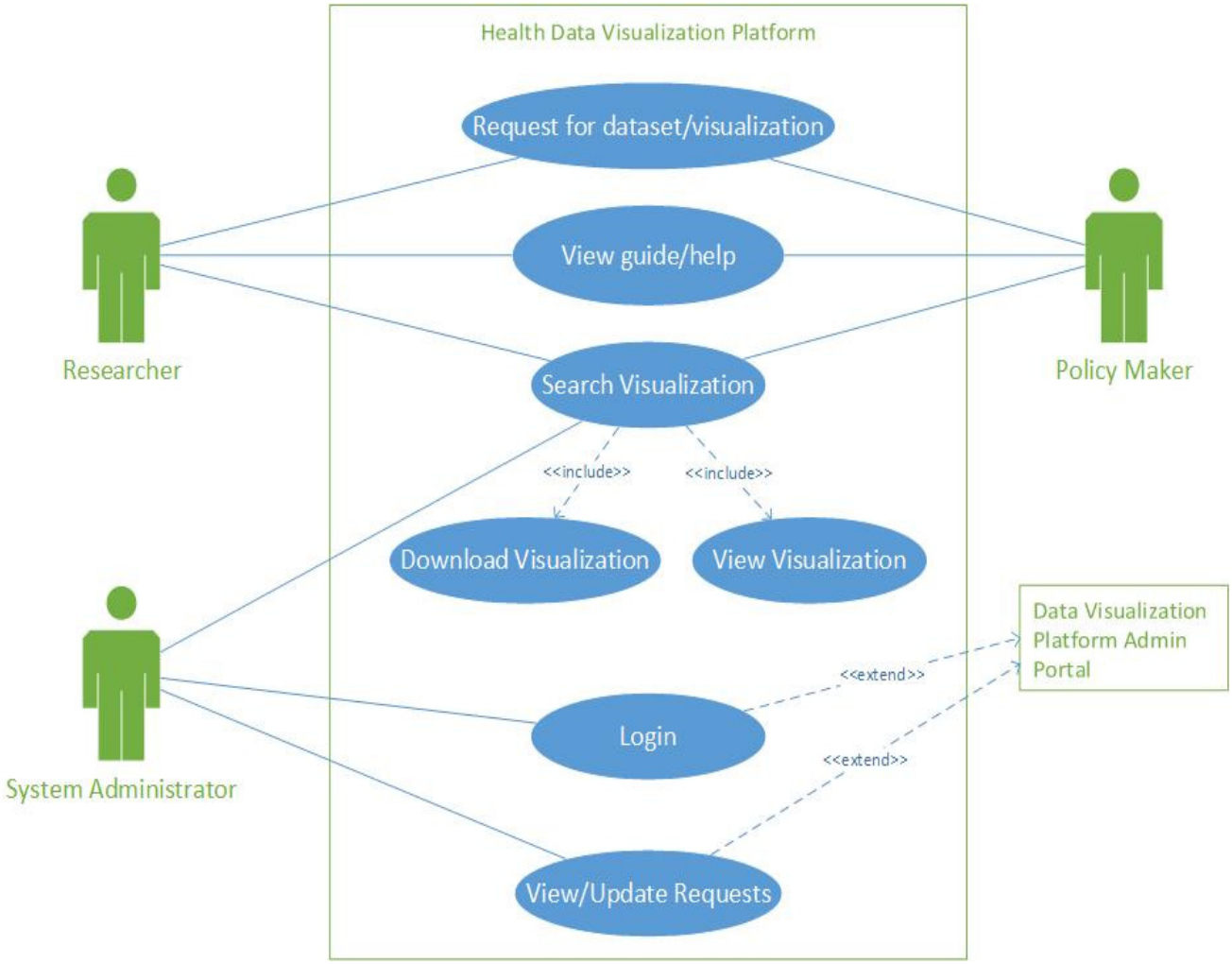

Figure 4.7: Health Data Visualization Use Case Diagram

4.6.1.1 View Visualization Use Case Description

Table 4.3 shows the use case description for viewing and downloading a visualization and further highlights the primary actors and triggers of the use case.

Table 4:3: View/Download Visualization Use Case Description

View/Download Visualization Use Case Description	
System: Health Data Visualization Platform	**Group ID:** group A
Use Case Name: View visualization	**UC ID:** 1
Primary Actor: Researcher, Policy Maker	
Goal: View a visualization with specific visualization indicators	
Trigger: Researcher/policy maker access health data visualization platform	
Relationships • Includes	
Input: health indicator, period in years, county name	
Normal/Basic Flow of events	
Actor	**System**
2. Researcher selects health indicator, period in years and county name	1. System provides available visualizations 3. System refreshes view as per manipulation
Output: visualization with the specified health indicators	
Test Cases: • Unit testing: UT1	

4.6.1.2 Request for Data/Visualization Use Case Description

Table 4.4 shows the use case description for requesting for data and related visualizations and further highlights the primary actors and triggers of the use case.

Table 4:4: Request for Data/Visualization Use Case Description

Request for Data/Visualization Use Case Description	
System: Health Data Visualization Platform	**Group ID:** group A
Use Case Name: Request visualization	**UC ID:** 3
Primary Actor: Researcher, Policy Maker	
Goal: Request for a dataset/visualization with specific visualization indicators	
Trigger: Researcher/policy maker access feedback module in health data visualization platform	
Input: user's name, title of item request, detailed description of request	
Normal/Basic Flow of events	
Actor	**System**
1. Researcher selects requests module 2. Researcher provides name, title of item request and a detailed description of request	3. System records request and sends shows a confirmation to user
Post-condition on success: Database updated with user request and request information	
Post-condition on failure: User alerted of failure and requested to try again.	
Test Cases: • Unit testing: UT3	

4.6.2 System Sequence Diagram

Searching for a visualization, manipulating a visualization and downloading a visualization, in a format of the user's choice, are amongst the main features of the visualization tool. Figure 4.8 shows the major flow of events and data therein for major functionalities of the proposed system.

Figure 4.8: Health Data Visualization System Sequence Diagram

4.6.3 Class Diagram

Figure 4.9 shows a class diagram of the proposed system. It comprises the main classes of the system. It is made up of the Requests class, the Datasets class and the Users class. The class diagram highlights the main attributes of each class together with their respective data types. Further, the functions used in each class are also highlighted as shown in Figure 4.9.

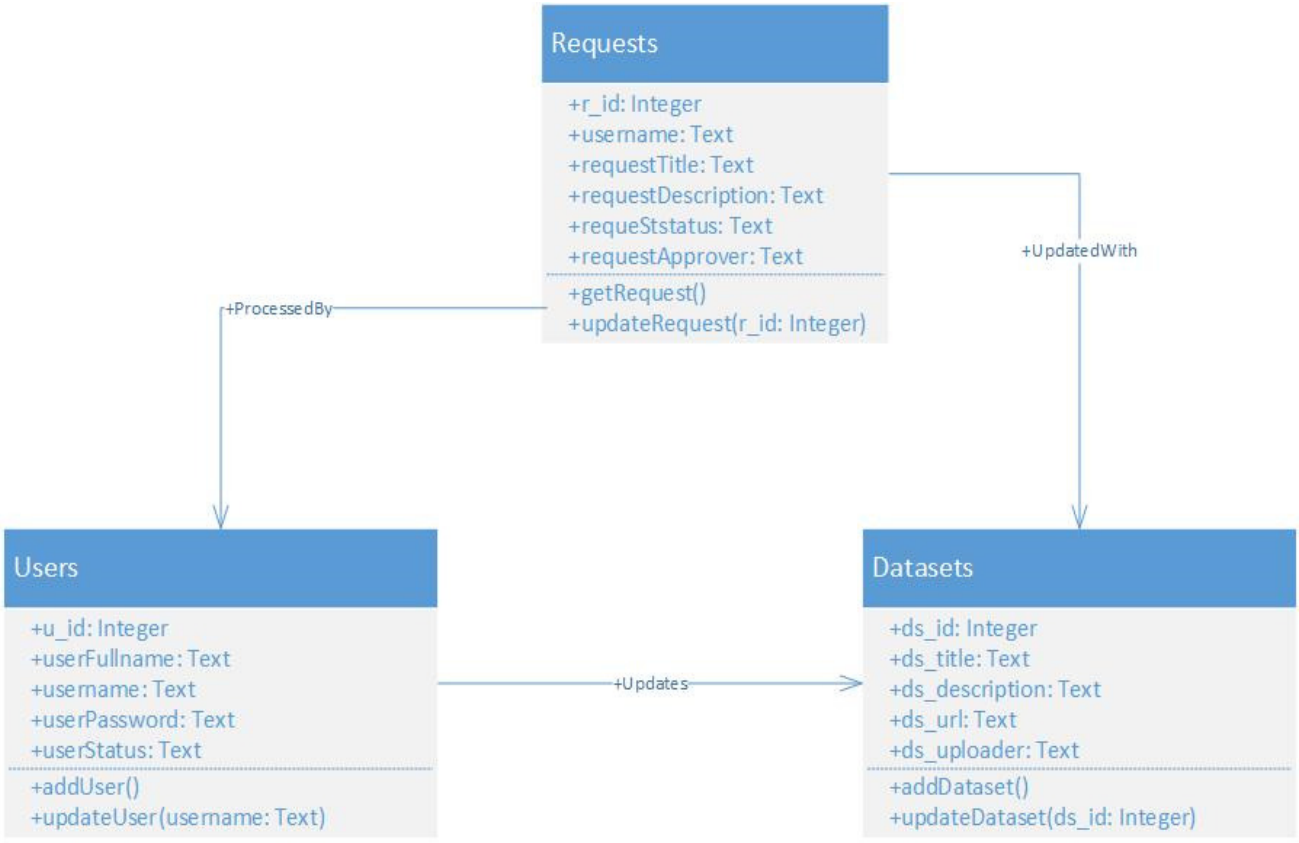

Figure 4.9: Health Data Visualization Class Diagram

4.6.4 Schema for Logs Stored

The data being visualized is maintained in spreadsheets. However, logs of requests made by the users using the client-side of the application are maintained in tables in a database for purposes of maintaining an authentic audit trail. Figure 4.10 shows the schema of the table that maintains request logs in the database.

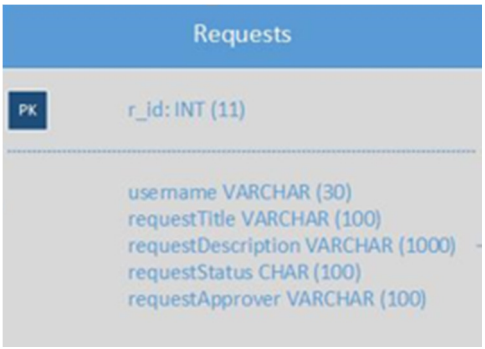

Figure 4.10: Table Schema - Requests Logs

Further, a log of all datasets used to create the visualizations presented in the client-side part of the system is also maintained in a table. Figure 4.11 shows the schema of the table that maintains dataset logs in the database.

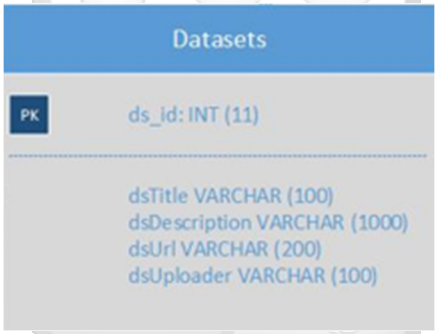

Figure 4.11: Table Schema - Datasets Logs

A log of the users processing the requests received and updating the datasets used to create the visualizations is also maintained. Figure 4.12 shows the schema of the table that maintains users' logs in the database.

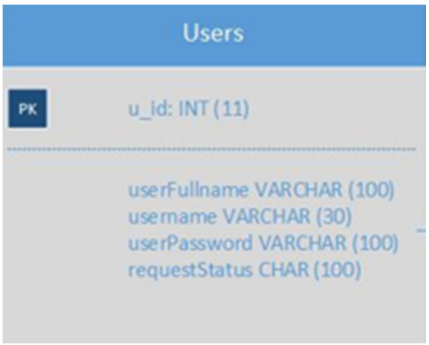

Figure 4.12: Table Schema – Users Logs

Chapter 5: System Implementation and Testing

5.1 System Implementation

Designing of the proposed application was followed by its development and implementation as per system designs done in Chapter 4 of this study. The proposed system was implemented in two major parts; the client side, which is a mobile-web application installed on any device supporting mobile –web platforms and which is Internet enabled, and the system administrator backend which runs on the web and is hosted online. The backend and the front end communicate via restful services using POST, DELETE, PUT and GET in HTTP. In this system, the mobile-web client side application sends a request to the backend which receives and processes the requests, returning the response to the client side application. Web scripting tools were used; PHP, HTML, JQuery Mobile, CSS. Mobile-web visualization plugins were also used; Tableau and D3.

5.1.1 Client Side Mobile-Web Application

The client side of the application runs on a mobile-web platform. This allows the users to access it on any Internet enabled device which supports the mobile-web platform. The main use of the client side is to visualize the health data sets highlighted therein. It further allows the user to dynamically manipulate or query the data therein so as to come up with their desired data sets to visualize. The generated visualizations can be in many varying formats such as pie charts, line graphs, bar graphs, etc. depending on what data set is being visualized. News on Kenya health policies is also provided on the client-side to keep the user up to date and well informed on matters mortality and morbidity in Kenya. The client-side of the application has three major functionalities which include:

i.) Kenya health policy news
ii.) Health data visualization
iii.) User requests

5.1.1.1 Kenya Health Policy News

The Kenya health policy news page provides for a one-stop shop for news on matters health. Focus is given to mortality and morbidity news. This page helps the users be up to date and well informed about information on health mortality and morbidity. As such, they are able to get the bigger picture of the visualizations provided one of the other modules of the client-side application.

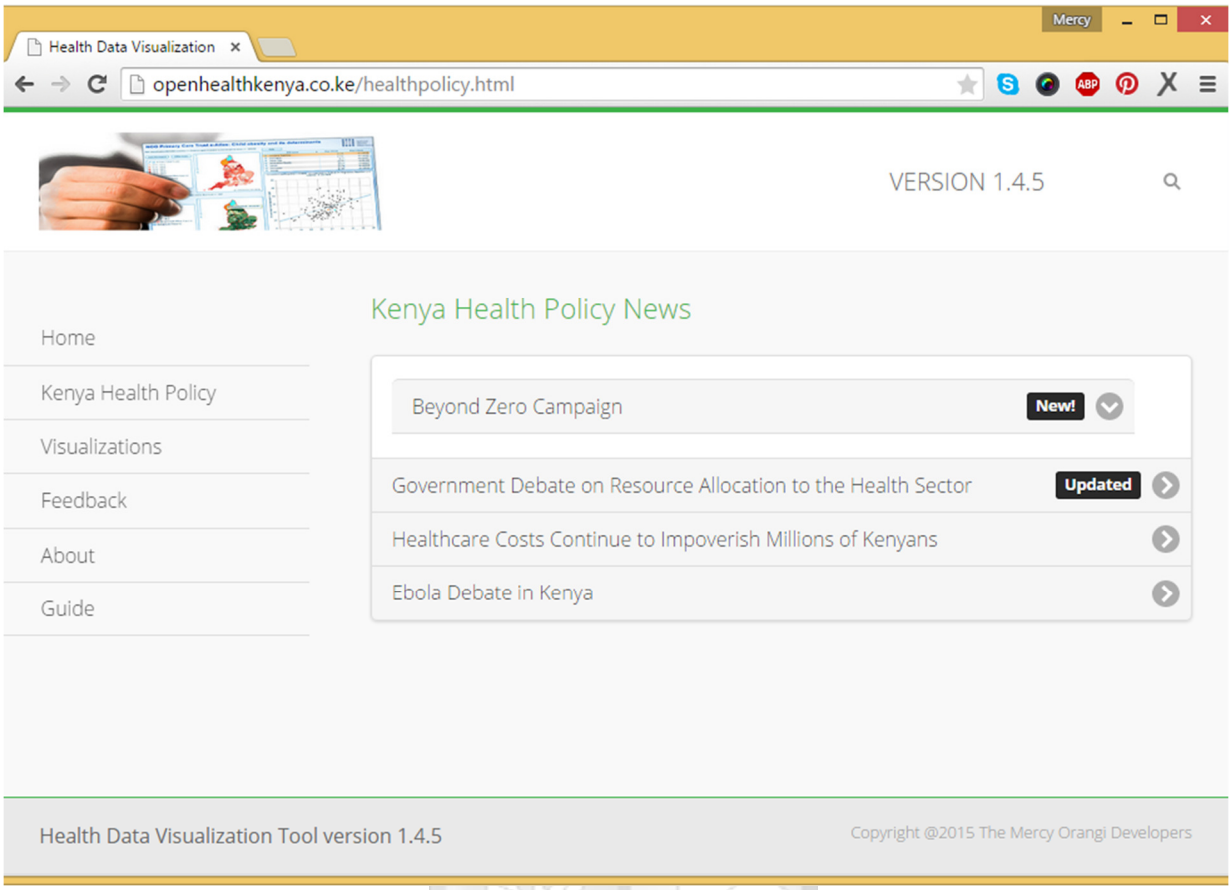

Figure 5.1: Health Policy News Screenshot

5.1.1.2 Health Data Visualization

The visualizations page presents various data sets on varying health indicators in a visual form. This can either be in the form of pie charts, bar graphs, line graphs, etc. which give the user ability to visually analyze the data for purposes of research or informing health policy making. In this module, the user is further provided with a functionality that allows dynamic manipulation of data which will then update the visualization in real time as shown in Figure 5.2.

A functionality for downloading the visualization has also been provided. The user can download a visualization he/she has tailored to fit their needs. Various options of downloading the required visualizations are also provided as shown in Figure 5.3. This makes it flexible, direct and easy to use the visualizations in a research, report or publication. Further visualization screenshots have been highlighted under Appendix G.

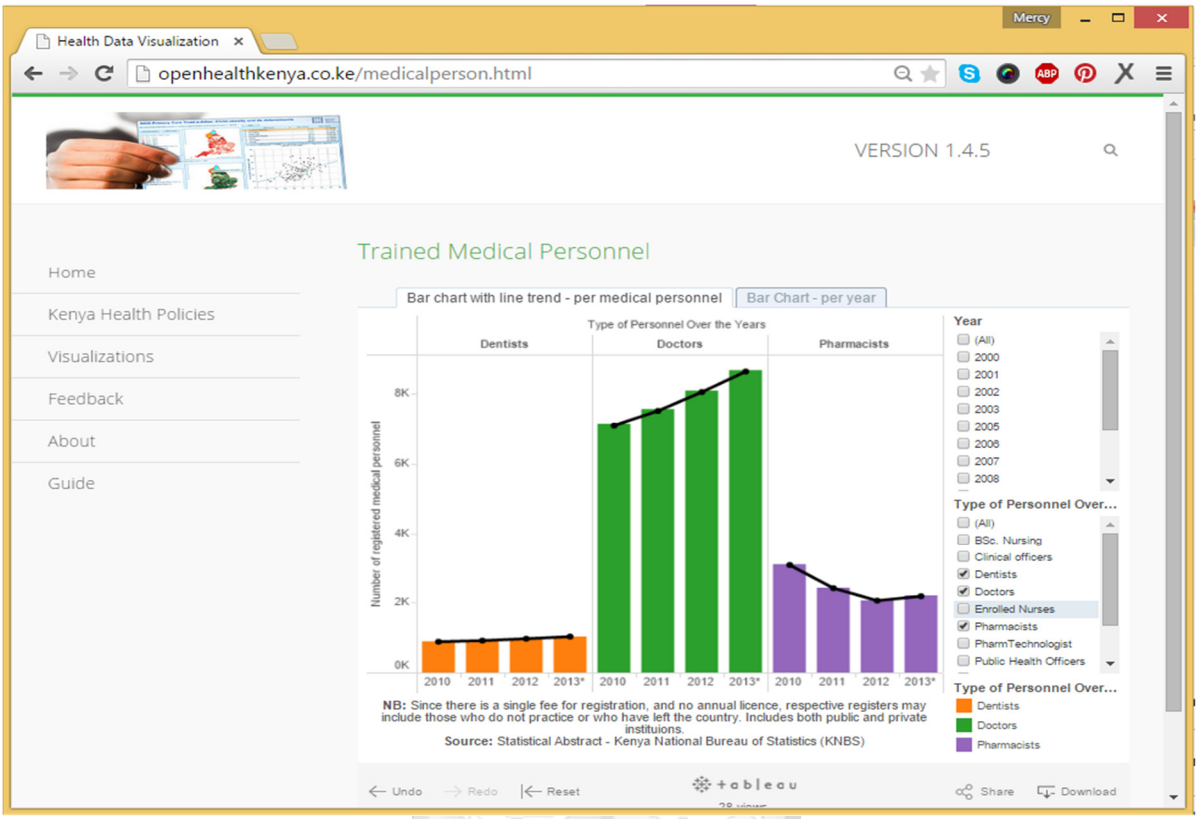

Figure 5.2: Health Data Visualization Screenshot for Trained Medical Personnel

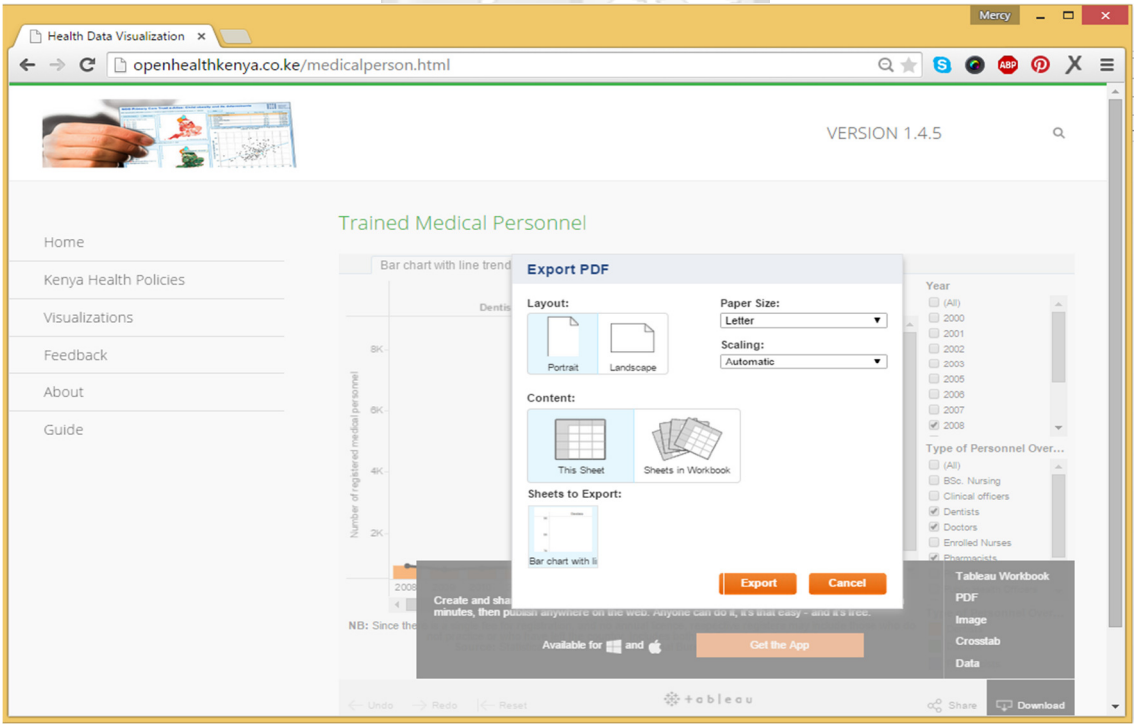

Figure 5.3: Download Option for Visualization

5.1.1.3 User Requests

This user requests module provides a communication platform between the system administrator and the client-side, front-end users. Through this module, the users are able to log a request to the system administrator for a dataset and its visualization to be provided or added onto the platform. This functionality provides continuity of the system and its utilization since new data sets will be requested for periodically following various surveys conducted.

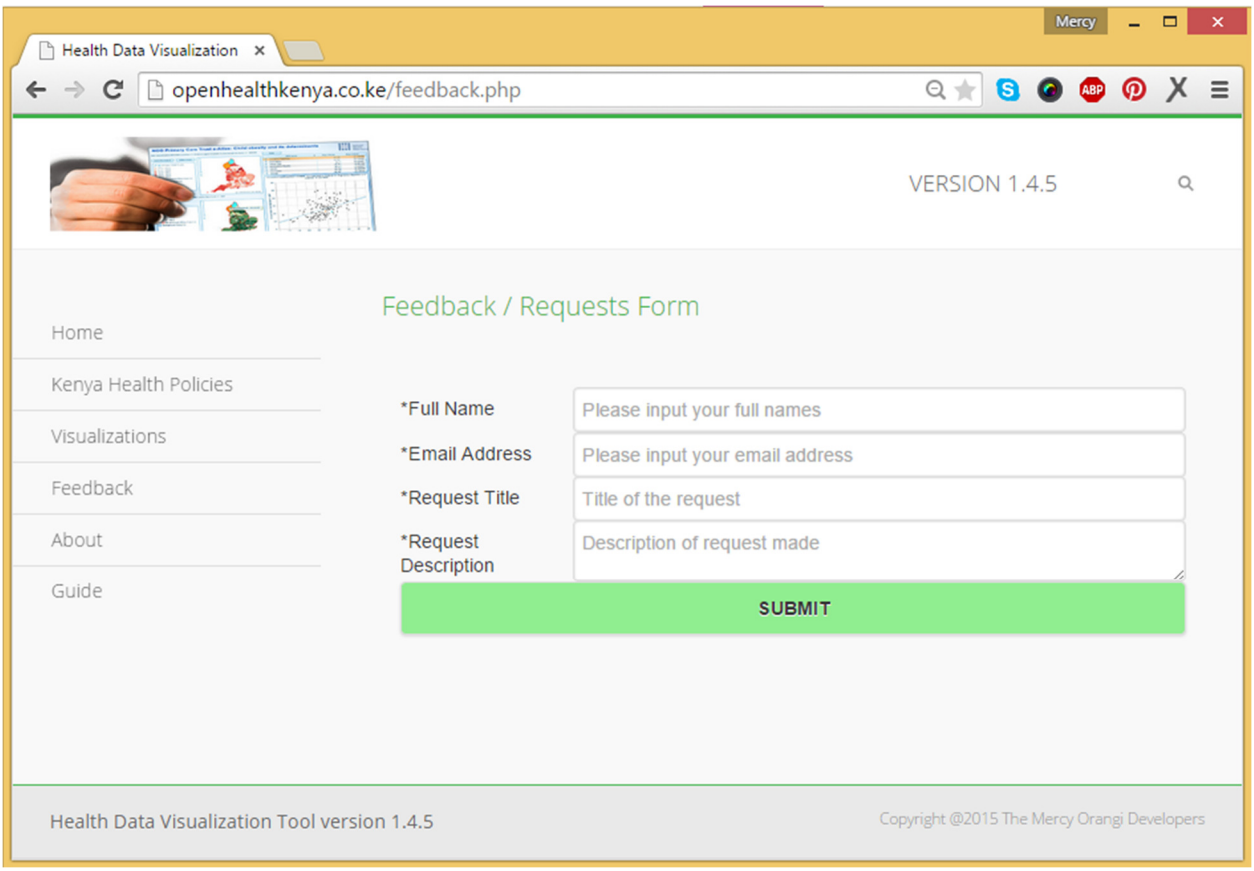

Figure 5.4: Requests/Feedback Page Screenshot

5.1.2 Back-End System Administration Web Portal

The backend application is a full web platform hosted online. As such, it can be accessed via any web browser with Internet access. The backend web portal is independent off the client-side system and is only accessible by the system administrators. Through the backend web portal, the system administrator is able to view a detailed list of all the requests made by users who need further visualizations and matching data sets added to the platform. Moreover, one is able to manage the list of data sets and links to their respective visualizations and further, the administrator is able to

manage users of the backend system. The three major functionalities of the backend are as listed below:

i.) Requests dashboard
ii.) Visualization administration
iii.) User administration

5.1.2.1 Requests Dashboard

The requests dashboard page provides a dynamic view of a list of all the requests made by the users via the client-side portal. One can search the requests list and further query it using dynamic characters. Further, this dashboard allows for updating of the requests, whereby, the administrator can update who attending to the query, and further allow for adding of the link to the visualization serving the particular requests.

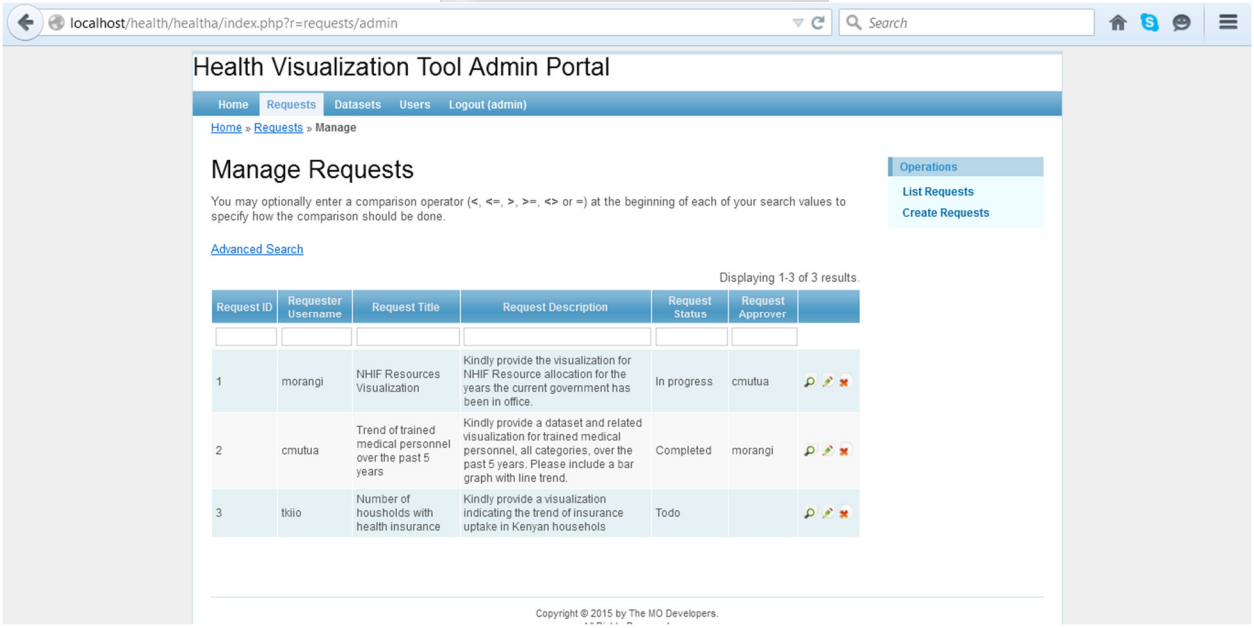

Figure 5.5: Requests Dashboard Screenshot

5.1.2.2 Visualizations Administration

Any visualization on the system is stored on the cloud. The same applies for any visualization requests that have been approved and attended to. It is therefore important to maintain and update the links to the various visualizations generated for consumption by the end users. This page will therefore allow the system administrator to add and update the links that redirect to the

visualizations. This in essence provides a reference point for all visualizations added to the system. A visualization record may or may not be pegged to a request depending on whether or not the administrator had it before it was requested for.

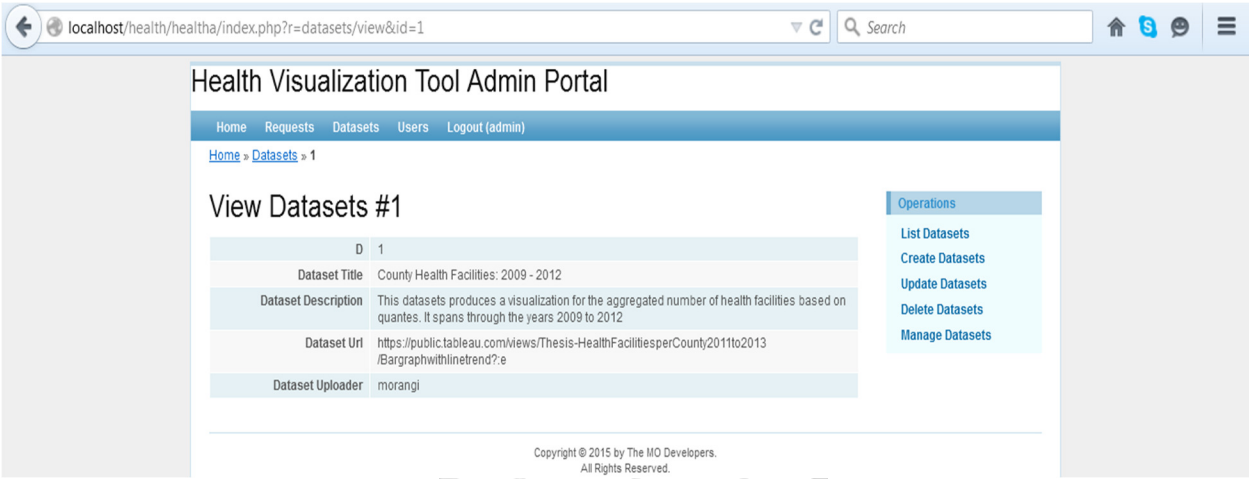

Figure 5.6: Visualization Datasets Administration Screenshot

5.1.2.3 User Administration

New system administrators, herein also referred to users of the backend system administration web portal might need to be created. Further, existing users of the system may, at one point or another, want to update their user details. This page provides for adding, and updating of user details. It provides a search and specific querying functionality in order to quickly identify a record. Adding a new user record and updating existing ones is also provided for in the system. Figure 5.7 shows the backend user administration dashboard.

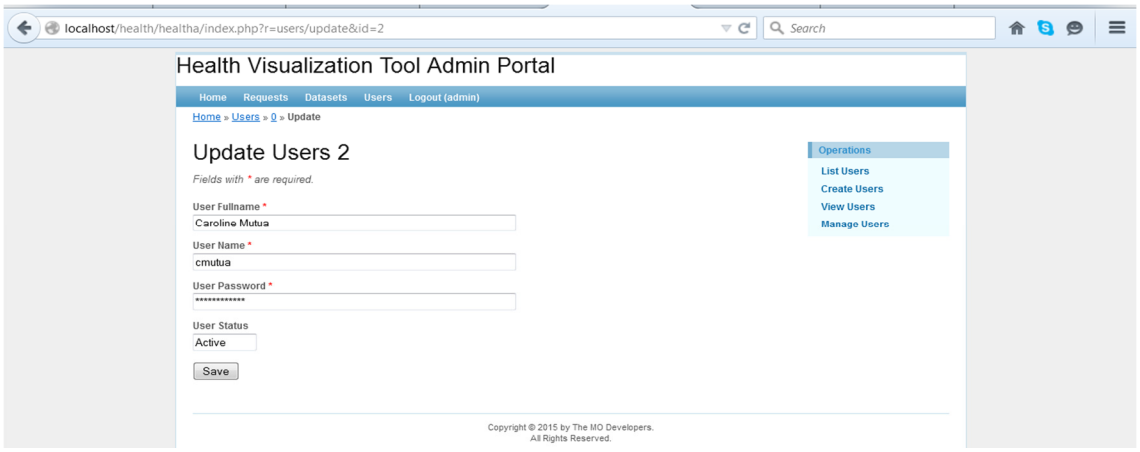

Figure 5.7: Backend User Administration Screenshot

5.2 System Testing

5.2.1 Introduction

Testing of the system was done extensively in all the modules; both on the front-end mobile-web client module and on the backend system administration web portal. Testing was a critical part of the system's lifecycle because it aided the researcher in identifying whether or not the research objectives were achieved. Through testing, the researcher was also able to identify what improvements would be needed in subsequent versions of the system. Lastly, but definitely not least, testing helped in verifying the functionality of the various modules and their inter-functionality thus confirming whether or not the entire system worked seamlessly. Testing was carried out in three broad areas: system functionality, system usability and system security.

Table 5:1: Respondents Demographics

PERSONAL ATTRIBUTE	RESPONSE	TOTAL NUMBER
Gender	Male	38
	Female	29
Age	16 – 18	7
	19 – 25	14
	26 – 40	27
	40 and above	19
Occupation/Place of work	Nairobi County Government	16
	Ministry of Health - Health Practitioner	17
	Ministry of Health - Managerial	16
	Other (e.g. Insurance Company)	18
Have you used a data visualization tool before?	Yes	30
	No	37

A total of 77 respondents participated in testing the system. However, the responses got were from 67 respondents. This gives the testing survey a response rate of 87%. The respondents were drawn randomly from Nairobi County. They comprised of policy makers from the County Government of Nairobi, health practitioners from hospitals in Nairobi County, representatives from the Ministry of Health and policy makers in other private companies such as insurance companies. 30 of the respondents used in testing the system were drawn from the initial data collection process.

5.2.2 Functionality Testing

Functionality testing was done to ensure that the system met all the specifications and requirements defined earlier. In this section, a detailed description of all the functions of the system is done. All the tests were carried out using browser applications that support mobile-web applications and also have Internet access.

a.) Test Case on Application Launch

Table 5:2: Application Launch Test

Test Case Name: Application Launch **Date Tested:** 1st March 2015 **Tested By:** Mercy Orangi **Test Description:** Step by step test for launching the application				
TEST STEPS				
Pre-Condition: The mobile device in use must have a web browser, for supporting both the front end and the backend applications. Further, the mobile device in use must have connection to the Internet.				
Post-Condition: User is taken to the home page of the application so as to access the system.				
Step	**Action**	**Expected Response**	**Pass/Fail**	**Comments**
I	Start application by putting the web address of the application on the web browser, then hit enter to load the application.	Home page screen is now visible to the user.	Pass	None

The user should easily be able to open and close the application by providing the application's link on a browser which should redirect them to the homepage. Table 5.2 shows the test that was done, together with relevant expected behavior, to confirm the application launched successfully.

b.) Test Case on Visualization Manipulation

The main functionality of the application was visualization of health data. Manipulation of the visualizations provided was a key functionality which provided maximum freedom to the user in terms of giving them the ability to provide the specific indicators they need which then updates and loads the respective visualization. Table 5.3 shows the visualization manipulation tests that were done.

Table 5:3: Visualization Manipulation Test

Test Case Name: Visualization Manipulation **Date Tested:** 2nd March 2015 **Tested By:** Mercy Orangi **Test Description:** Step by step test for dynamic manipulation of the visualizations				
TEST STEPS				
Pre-Condition: User needs to have successfully loaded the visualization page he/she wants to manipulate.				
Post-Condition: The visualization selected by the user is updated in real-time to reflect the changes he/she has made on the indicators to show.				
Step	**Action**	**Expected Response**	**Pass/Fail**	**Comments**
I	Select desired indicators on the right panel of the visualization currently loaded.	The visualization updates in real time to reflect the selected visualization indicators.	Pass	None

c.) Test Case on Downloading Visualizations

Since the data used to generate the visualizations was open data, the user was given the freedom to download the visualizations and/or data used for reuse any their research or works. Several download formats were provided to ensure the user is not limited. Table 5.4 shows the steps performed in testing the downloading of visualizations.

Table 5:4: Visualization Manipulation Test

Test Case Name: Downloading Visualization **Date Tested:** 2nd March 2015 **Tested By:** Mercy Orangi **Test Description:** Step by step test for downloading visualizations				
TEST STEPS				
Pre-Condition: User needs to have successfully loaded the visualization page he/she wants to download.				
Post-Condition: The user gets a downloaded file on his device's local storage. The format is as he/she selected to download.				
Step	**Action**	**Expected Response**	**Pass/Fail**	**Comment**
I	Click on download option at the bottom right corner of the visualization.	A popup of the various file formats to download is seen.	Pass	None
II	Click on the file format you wish to download.	Page settings for the format to download are presented.	Pass	None
III	Click on 'Export' button to generate file with the format and settings set.	A popup confirmation that the file has been exported.	Pass	None
IV	Click on 'Download' button to download the file to your local device memory.	A file on your local device memory having the selected visualization with the specified format.	Pass	None

5.2.3 Usability Testing

Usability testing was conducted to ensure that the application met the required aesthetic values. This was an important test since application users always like applications that are appealing to the eye. Table 5.5 describes the tests that were done to ensure the application developed from this study met the intended visual appeal.

Table 5:5: Usability Testing

Test Case Name: Application Usability **Date Tested:** 5th March 2015 **Tested By:** Mercy Orangi **Test Description:** Step to step tests for application usability				
TEST STEPS				
Pre-Condition: Application must have loaded successfully.				
Post-Condition: User can seamlessly navigate through the application.				
Step	**Action**	**Expected Response**	**Pass/Fail**	**Comments**
I	User can see all the menus.	All the menus are visible and make sense.	Pass	None
II	User can press/click to select on any of the menu items	All the menu items are clickable and redirect to expected page	Pass	None
III	Overall appearance and color mix and balance	Colors well mixed and balance in all pages	Pass	None

5.3 Conclusion

Both the front end mobile web application and the backend system administration web portal passed the security tests, functionality tests and usability tests conducted on them. The positive tests were a clear indication that the system was fit for use by the public without any negative effects or user dissatisfaction. From the tests, the user experience proved to be better than the current systems.

Chapter 6: Discussions

6.1 Discussion of Post Data Analysis and Users Tests Results

To get feedback from users after they interacted with the system, this study distributed a review/feedback questionnaire to a selected population of the initial users of the system. The link to the application was distributed to the respondents which was then followed by instructions on how to access and use the system. The post-data analysis questionnaire was developed using Google Forms and distributed via email to the respondents. The questionnaire used can be found in Appendix D.

6.1.1 Usability Testing Results

The post questionnaire survey sought to understand the ease of use of the system. From loading to navigating to navigating to posting a request.

a.) Launching Application

Users were asked to navigate to the provided web address to access the application on their web browsers. Here, the researchers wanted to know how easy it was to launch the application on the browser. Figure 6.1 shows the responses provided by the respondents. 85% of them agreed that launching the application was easy.

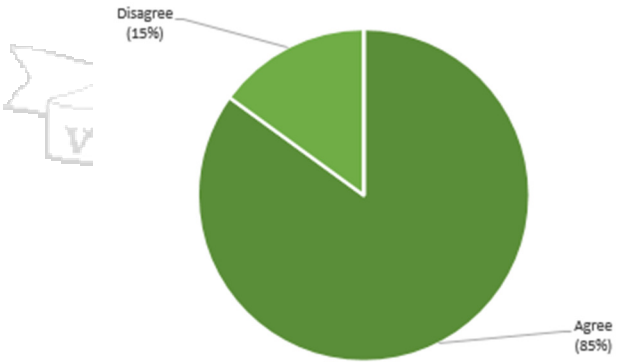

Figure 6.1: Ease of Launching the Application

b.) Aesthetic Value of Application

The responses received on the aesthetic value of the system indicated that users did like the look and feel of the application. The post-questionnaire asked the users if they felt that the application was generally appealing to the eye or not. Figure 6.2 shows the distribution of responses received. 95% of the respondents said yes to this question.

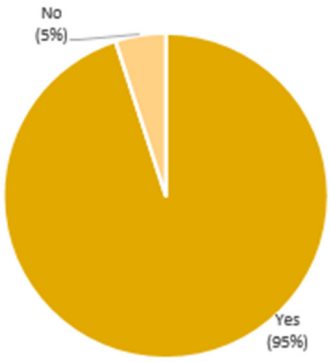

Figure 6.2: Aesthetic Value of Application

c.) Device Used to Access Application

Since the client side application is optimized for access on all platforms supporting web applications, the researcher here sought to identify the most used mobile device type. This would later inform some of the future works in terms of optimizing for the platform with many users. Figure 6.3 show that 40% of the people most preferred accessing the application via a tablet, 55% via a laptop, while 5% preferred using a mobile phone.

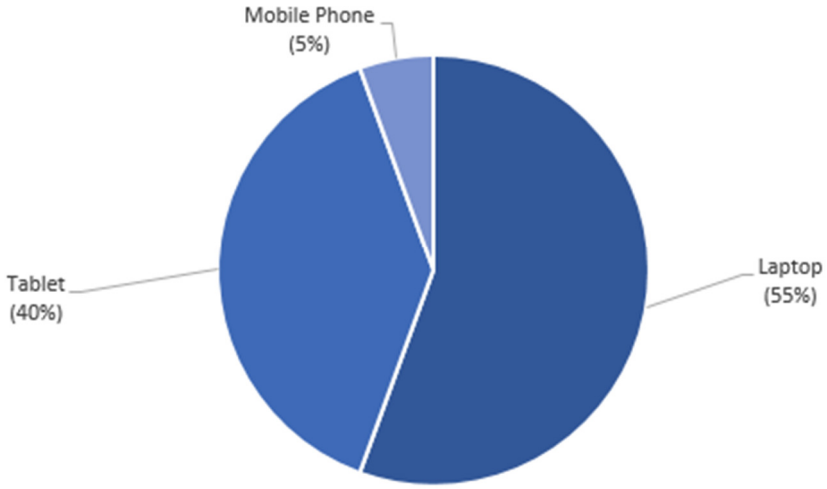

Figure 6.3: Device Used to Access Application

d.) Locating Menu Items in the Application

The various menu options of the applications were located strategically on various panels within the web page. To confirm this, the users were asked if they found locating

of the menu items hard or easy. Figure 6.4 shows that 90% of the respondents said yes, i.e. found it easy to locate the menu items without difficulty.

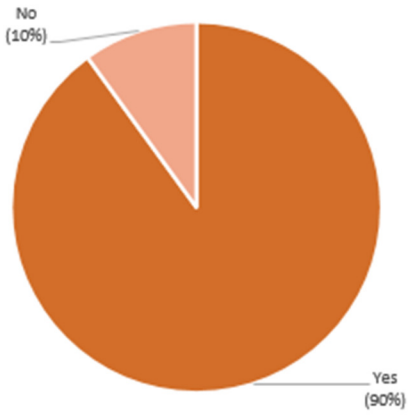

Figure 6.4: Locating Menu Items in the Application

e.) Responsiveness of Application

This study sough to know the responsiveness of the application when being used. Users were asked whether they found the application non-sluggish and seamless during navigation. 95% of them agreed that the system was responsive. Figure 6.5 shows the number, in brackets, of those who said yes (agreed it was responsive), and those who said no.

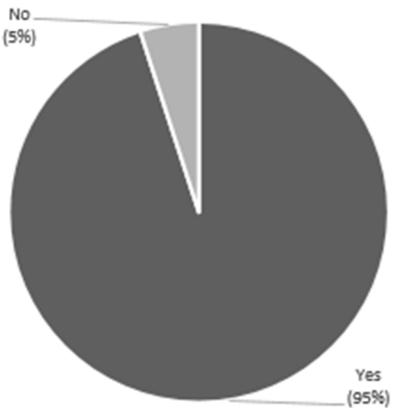

Figure 6.5: Responsiveness of Application

6.1.2 Functionality Testing Results

This study, through the post-questionnaire distributed, sought to find out if the functionality of the system was seamless and behaved as expected.

a.) Searching for Visualization in Application

The users were asked if they found it easy to search through the application either through the search button or through the menu hierarchy of the application. Table 6.6 shows that all the 100% of respondents agreed to this question.

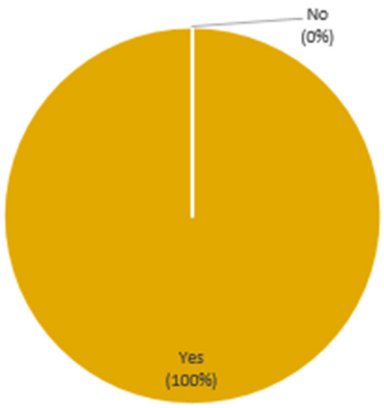

Figure 6.6: Ease of Searching in Application

b.) Posting a Request via the Application

Because this study wanted to make the platform provided interactive, the researcher here sought to identify the ease and quickness of posting a request via the front end mobile web application. Figure 6.7 shows that 88% of the respondents responded with a yes.

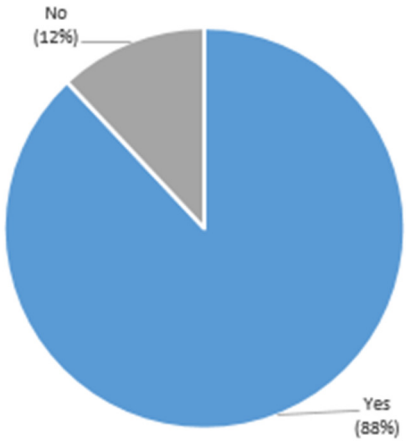

Figure 6.7: Ease of Posting Request via Application

6.1.3 General Workability Results

Users were asked to rate the overall experience while using the features in the application. Through this question, this study sought to know if the application met its purpose and if the users were comfortable using it and coming back again to the platform. In general, the respondents were asked if they had any challenges while using the system. Figure 6.8 shows 89% answered no, meaning they had no challenges. While 11% answered yes they encountered challenges along the way. This mainly attribute to poor Internet connection.

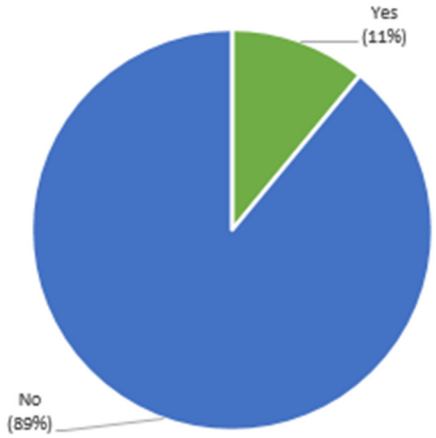

Figure 6.8: General Workability of the Application

6.2 Discussion of Research Objectives

The research objectives were stated in Section 1.3 of this study. The corresponding research questions were outlined in Section 1.4 of this study. Each of these study objectives, and corresponding questions, have been progressively answered throughout previous sections of this study.

The first objective sought to investigate the health policies and mortality and morbidity levels in developing countries. This objective was majorly met in Chapter 2, Literature Review, where the researcher opted to focus on India, as a developing country, and look at its health policies. Here, the trends in mortality rates in India were highlighted. Further, the morbidity levels were also looked into in terms of the estimates on the burden of diseases and injury in India. This study also highlighted the health policies in India by spotlighting a few of the initiatives by the Government of India to reduce child mortality rates.

The second objective sought to analyze how health policies have influenced the mortality and morbidity levels in Kenya over the past years. Section 2.7.4 of this study helped achieve this objective. This section highlighted the policies put in place and initiatives undertaken by the Kenya Government with an aim of lowering the mortality and morbidity levels by focusing on improving the factors which affect these two critical health indicators. This helped inform the study of the various plans and strategies, by the Government of Kenya, in consciously aiming at lowering mortality and morbidity factors.

Objective three, as outlined in Section 1.3.2 of this study, looked at factors contributing to mortality and morbidity level in Kenyan counties. This objective was met through various sections in Section 2.7. First the study looked at the health infrastructure in Kenya, then the health personnel in Kenya and its counties, and finally the health policies in Kenya, with a key focus on various initiatives, by the Government of Kenya, aimed at lowering the mortality and morbidity levels in the country. Spotlighting these factors helped this study defragment the third objective so as to highlight the various factors and how they affect the health statistics being focused on.

The fourth objective from Section 1.3.2 of this study looked at designing and developing a mobile-web-based tool that would visualize morbidity levels in Kenyan counties and their attributing factors. This objective was met partly in Chapter 4 of this study, which helped the researcher come up with the design, flow and structure of the proposed system. Objective four was also partly met under Section 5.1: System Implementation, where the application was develop and implemented to meet the desired requirements of this study. The pre-data questionnaire further helped in meeting this objective where questions on the ease of currently gathering and analyzing data on mortality and morbidity levels in Kenya were asked. Only 5% of the respondent agreed it was easy/very easy to do so. This study, therefore, had a good justification for designing and developing a tool for visualization purposes.

The fifth, and final objective of this study was to test the viability of the proposed mobile-web-based tool. Testing was extensively done under Section 6.2 of this study. Functionality, usability and security testing were all done extensively on both the client-side application and the back-end side too. Test findings indicated that 83% of the respondents had no challenges with the general workability of the system. Through the tests, it was also noted that a majority of the users preferred accessing the system through laptops (56%) and through tablets (39%). This, and the entire testing

process as a whole, helped the researcher identify future work that could be added onto the system as discussed in Section 7.3.

6.3 Conclusion

The objectives of the study sought to understand the current situation on matters around mortality and morbidity levels in Kenya and its counties. Consequently, the study sought to analyze and understand the various factors contributing to the current mortality and morbidity levels. Further, the policies around health in Kenya were explored with an aim of establishing their connection and contribution to the mortality and morbidity levels in the country. So as to put all these in perspective, this study explored the mortality and morbidity levels in other developing countries, with a key focus on India and the initiatives undertaken by the Government of India in trying to reduce the mortality and morbidity levels in India.

The extensive research done in the course of this study, coupled by information gathering through questionnaires, helped inform the need of the proposed health data visualization platform. This tool was built to inform policy makers and researchers on matters mortality and morbidity in Kenya by providing the ability to dynamically manipulate and visualize health data in real time. This generally was a leap ahead in terms of user-friendliness and the dynamism introduced to analyze the health data, which in the end aids in data-based decision making. Encouragingly, the proposed application received positive reviews all the way from the need of having it, to its functionality and usability.

Chapter 7: Conclusions, Recommendations and Future Work

7.1 Conclusions

Data visualization on matters mortality and morbidity is a relatively new concept when it comes to representation of open data. Official dissemination of health data by the government of Kenya, through the Kenya National Bureau of Statistics has, up until recently, been in the form of publications and spreadsheets which simply provide numbers on the various indicators. This has proven to be a difficult dataset to consume, hence the recent uptake to change the format of disseminated data. With this in consideration, this study took a relevant step by analyzing the current data dissemination formats which informed the need of a visualization tool in the current context in Kenya. Findings from the questionnaires used in data collection affirmed the importance and the need of a tool that could present data in a more user-friendly format and further provide a dynamism for the user to select their desired indicators and be able to see the results in real time. Respondents also provided helpful information on changes the system could refine on or add.

Consequently, the designed health data visualization tool was designed to allow the user to view data on mortality and morbidity levels in Kenya, and their attributing factors, in a visual format. Each visualization provided different relevant visual formats to represent the data. The added value to the visualizations was the provision to dynamically manipulate the dataset's indicators and be able to see the related visualizations in real time. Other benefits that came along with this visualization tool include; being able to download the visualizations, in different format, for external use, having a one-stop shop for getting news on health policies in Kenya, and being able to request for more visualizations to be added onto the portal.

Findings from the research conducted in this study indicated that health policy decision makers could benefit from the proposed solution, especially when their decisions need to be speedy and further backed up by data. Moreover, the findings also indicated that researchers from all avenues, be it journalists, students, medical personnel, etc., in need of information on mortality and morbidity levels in Kenya and their attributing factors, are in need of a platform that could allow easier interpretation of the data, and seamless manipulation of the data to reflect indicators they need in their study. The model of the proposed solution proved to be relevant to them.

7.2 Recommendations

The findings of this study were key in understanding the current environment of health data dissemination and its subsequent use by various consumers of the data. From this research, it was noted that the dynamics around releasing and utilizing the health data did not reach the satisfaction of the users. To make the users more receptive, this study recommends the following:

i.) A more frequent cycle in the release of data on mortality and morbidity levels and their attributing factors. This could be quarterly or so data releases as opposed to the current yearly cycle.

ii.) Provision of more refined data indicators on matters mortality and morbidity so as to make more informed conclusions and/or decisions from the data.

iii.) Having more health data based on county level geographical boundaries as opposed to provision since counties are the new administrative units in Kenya.

7.3 Future Work

Health mortality and morbidity in Kenya is a key area of discussion when it comes to elevating the social and economic status of the country. Therefore, there is a need to keep the conversation going based on the data provided and information from the experts. As such, some of the future work that could be implemented could be based on the provision of a more interactive platform which can be achieved in several ways, some of which are highlighted below:

i.) Adding a module for cross checking data from KNBS with similar data from other sources such as the World Bank. This will aid in asserting the accuracy levels of sources of data that are released by other sources besides the Kenya National Bureau of Statistics.

ii.) Subscription of users to allow them receive instant updates on new visualizations on the platform. This can be in the form of a USSD subscription provision, especially now that most mobile phones support USSD applications.

iii.) A question and answer module that allows experts in health interact with common users and enlighten them on matters around data on mortality levels, morbidity levels, and their attributing factors.

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Appendix A: Pre Questionnaire Responses

a.) Respondents Gender

In Table A.1, respondents were asked to give their gender; either Male, Female or Other. Of all the responses received, 55% were Male, with a count of 52, and 45% were Female, with a count of 42.

Table A.1: Respondents Gender

Gender	Number of Respondents	Percentage
Male	52	55%
Female	42	45%

b.) Mobile Device Types Distribution

Table A.2 shows the types of mobile devices used for research purposes amongst the respondents. Majority of the respondents used laptops followed by the other mobile device types shown in the table.

Table A.2: Mobile Device Types Distribution

Mobile Device Type	Number of Respondents	Percentage
Laptop	40	40%
Tablet	25	25%
Mobile phone	20	20%
PDA	7	7%
Wearable computer (e.g. Google Glass, Smart Watch, etc.)	7	7%
Others	1	1%

c.) Internet Access on Mobile Devices

Table A.3 shows the responses received on the question on whether or not the respondents' mobile devices have Internet access. Of all the responses received, 84% had Internet access on their mobile devices, with a count of 80, and 16% did not have Internet access on their mobile devices, this representing a count of 15.

Table A.3: Internet Access on Mobile Device

Internet Access on Mobile Device	Number of Respondents	Percentage
Yes	80	84%
No	15	16%

Figure A.1 shows a pie chart of the same data. The number is braces shows the percentage of respondents that chose the given option. This was a positive response to this study since the proposed system required Internet access to be functional.

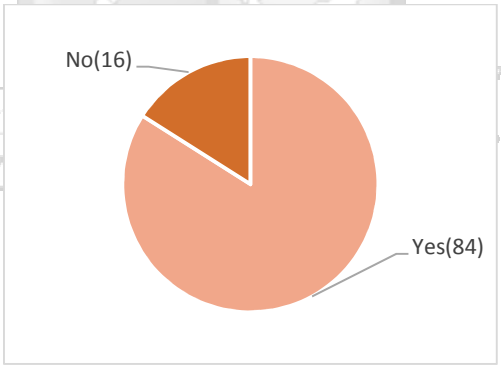


Figure A.1: Internet Access Distribution

d.) Open Data Awareness Distribution

Table A.4 shows the responses received on the question on whether or not the respondents were aware of the existence of open data on health. Of all the responses received, 89% were aware of the existence of open data, with a count of 78, while 11% were not aware of the existence of health open data, with a count of 10.

Table A.4: Open Data Awareness Distribution

Health Open Data Awareness	Number of Respondents	Percentage
Yes	78	89%
No	10	11%

e.) User-friendliness of Current Format of Open Data on Health

Figure A.2 shows the responses received on whether respondents agree that the current format of health open data is user-friendly. Of all the responses received, 69% disagree on the fact that the current format of open data on health is user-friendly, with a count of 67. 21% agree with this statement, while 10% were neutral on this.

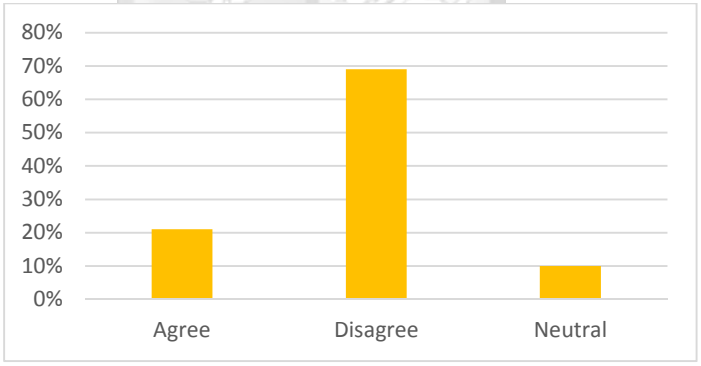


Figure A.2: User-friendliness of Current Format of Open Data on Health

f.) Ease of Gathering Data on Mortality and Morbidity

Figure A.3 shows the responses received on the ease of gathering data on mortality and morbidity levels. Of all the responses received, 44% said it was very difficult with a count of 42, while 40% said it was difficult with a count of 38.

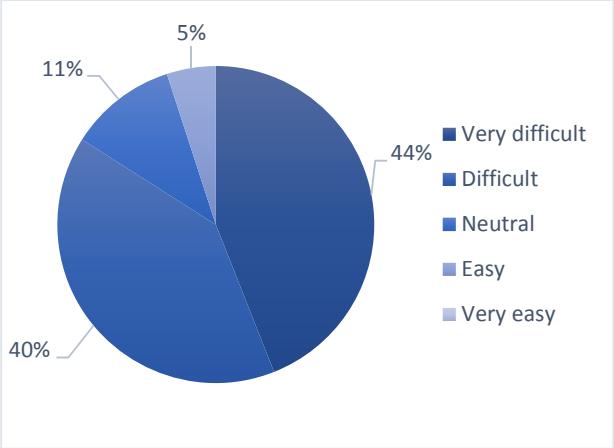


Figure A.3: Ease of Gathering Data on Mortality and Morbidity

g.) Ease of Analyzing Data on Mortality and Morbidity

Table A.7 shows the responses received on the ease of analyzing data on mortality and morbidity levels. Of all the responses received, 44% said it was very difficult with a count of 42, while 40% said it was difficult with a count of 38.

Table A.5: Ease of Analyzing Data on Mortality and Morbidity

Ease of Gathering Data on Mortality and Morbidity	Number of Respondents	Percentage
Very Difficult	42	44%
Difficult	38	40%
Neutral	10	11%
Easy	5	5%
Very Easy	0	0%

h.) Ease of Cross-Analyzing Data on Mortality and Morbidity

Table A.8 shows the responses received on the ease of cross-analyzing data on mortality and morbidity levels with other factors such as health facilities, finances on health, health personnel, etc. Of all the responses received, 63% said it was very difficult with a count of 60, while 25% said it was difficult with a count of 25. Figure A.4 shows the same data in a visual form.

Table A.6: Ease of Cross-analyzing Data on Mortality and Morbidity with Other Factors

Ease of Gathering Data on Mortality and Morbidity	Number of Respondents	Percentage
Very Difficult	60	63%
Difficult	25	25%
Neutral	10	10%
Easy	2	2%
Very Easy	0	0%

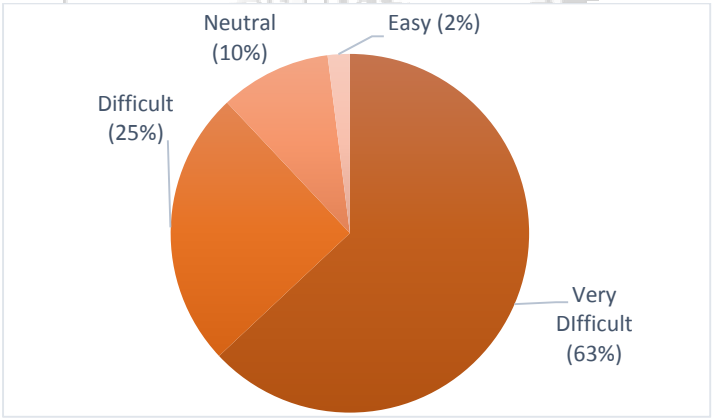


Figure A.4: Ease of Cross-analyzing Data on Mortality and Morbidity with Other Factors

i.) Need of a Platform that Provides for Dynamic Manipulation and Visualization of Health Open Data

Table A.9 shows the responses received on the question on whether or not the respondents would use a platform that provided for dynamic manipulation and visualization of health open data to the health policy making process and research. 90% of the respondents, 88 in count, agreed that they would use such a tool as shown on Table A.9.

Table A.7: Need of a Platform that Provides for Dynamic Manipulation and Visualization of Health Open Data

Need of a platform that provides for dynamic manipulation and visualization of health open data	**Number of Respondents**	**Percentage**
Yes	87	90%
No	10	10%

Appendix B: Application Test Results

a.) Application Navigation Test

Table B.1 shows tests that were done in the application to ensure that the user could seamlessly move from one page to another as expected.

Table B.1: Application Navigation Test

Test Case Name: Application Navigation **Date Tested:** 1st March 2015 **Tested By:** Mercy Orangi **Test Description:** Step by step test for navigating through the application				
TEST STEPS				
Pre-Condition: The mobile-web application must have loaded successfully implying there is Internet access and that the browser supports the mobile-web platform.				
Post-Condition: User is taken to the relevant page of the application when he/she selects it from the menu items on the current page.				
Step	**Action**	**Expected Response**	**Pass/Fail**	**Comments**
I	Click on any menu item on the left panel from the current page.	Page represented by the menu item clicked is now visible as the current active page of the system.	Pass	None

b.) System Administrator Login Test

Table B.2 shows the step by step administrator login tests that were done. The backend system administration platform required that the user logins in first. Tests were done to confirm that the expected login process was achieved.

Table B.2: System Administrator Login Test

Test Case Name: System Administrator Login **Date Tested:** 2nd March 2015 **Tested By:** Mercy Orangi **Test Description:** Step by step test for system administrator login				
TEST STEPS				
Pre-Condition: User needs to have successfully loaded the web address of the backend web portal. Further, user should have a username and password to use in login in.				
Post-Condition: User should successfully access the system's home page				
Step	**Action**	**Expected Response**	**Pass/Fail**	**Comments**
I	Start application by loading the web address on your web browser, tap the login option, then enter the login credentials provided.	Redirected to home page if correct credentials are provided or error message if wrong credentials are given.	Pass	None

c.) Updating User Requests Test

Table B.3 shows the step by step user requests updating tests that were done. Through the backend web portal, the system administrator was able to see all the requests made by the users. The requests, therefore, were assigned to a specific administrator to work on them. The administrator therefore needed to update the requests accordingly after providing the visualizations.

Table B.3: Updating User Requests Test

Test Case Name: Updating User Requests **Date Tested:** 2nd March 2015 **Tested By:** Mercy Orangi **Test Description:** Step by step test for updating requests from users.				
TEST STEPS				
Pre-Condition: User should have successfully logged in to the system.				
Post-Condition: Request updated successfully.				
Step	**Action**	**Expected Response**	**Pass/Fail**	**Comments**
I	On the requests dashboard, user taps the manage requests menu.	The application loads a list of all the requests in the system.	Pass	None
II	Under manager requests screen, user taps on the update icon on the record to be updated.	The application loads a new screen with the editable data for the selected record loaded.	Pass	None
III	User edits/updates required fields then clicks on Save button	The application loads a screen having a summary of the data updated.	Pass	None

d.) Adding New Users Test

Table B.4 shows step by step tests that were done to add new users. The system administrator was able to add new users to the backend administration portal whenever he or she was required to.

Table B.4: Test Case on Adding Users on Backend Portal

Test Case Name: Adding New Users **Date Tested:** 2nd March 2015 **Tested By:** Mercy Orangi **Test Description:** Step by step test for adding new users to the backend portal.				
TEST STEPS				
Pre-Condition: User should have successfully logged in to the system.				
Post-Condition: New user added successfully.				
Step	**Action**	**Expected Response**	**Pass/Fail**	**Comments**
I	On the users dashboard, user taps the create user menu.	The application loads a page with field entries for the new user to be added.	Pass	None
II	Under create user screen, user taps on the create button for the new user to be created on the system.	The application loads a screen having a summary of the user created.	Pass	None

e.) Application Security Test

The proposed solution had inbuilt security features. This was put in place to ensure the visualizations produced were protected. Mainly, the protection was from unauthorized updating. Login to the backend system administration also had inbuilt security features. These features restricted specific actions to be performed by specific users. Table B.5 shows the various system security tests that were carried. This tests were performed to ensure the system was well secured from unauthorized persons.

Table B.5: Test Case on Application Security

Test Case Name: Application Security **Date Tested:** 10th March 2015 **Tested By:** Mercy Orangi **Test Description:** Step by step test for the application's security features.				
TEST STEPS				
Step	**Action**	**Expected Response**	**Pass/Fail**	**Comments**
I	User authentication	Username password combination provided is compared with what has been stored.	Pass	None
II	Input validation	Input provided by user is checked to confirm it meets the specified requirements.	Pass	None

Appendix C: Pre Data Survey Questionnaire

a.) Figure C.1 shows the introduction page to the pre data survey questionnaire

The Use of a Visualization Tool to Access Health Open Data on Mortality and Morbidity Levels and Attributing Factors: A Focus on Kenya Health Policies

Pre-Questionnaire

REFERENCE NO: iLab/sno/079188

Researcher
I am a graduate student undertaking a Master's degree in Mobile Telecommunication and Innovation at the Strathmore University. I am currently carrying out a study on the use of a visualization tool to access health open data on mortality and morbidity levels and attributing factors with a focus on Kenya health policies.

Non-Disclosure Assurance
The information required is purely for academic purposes and will not be shared with any other third party, unless with prior agreement.

Research Objectives
(ii.) To analyze how health policies have influenced morbidity levels in Kenya over the past years.
(iii.) To identify the factors contributing to morbidity levels in Kenyan counties.
(iv.) To design and develop a mobile - web tool to visualize morbidity levels in Kenyan counties and the attributing factors.
(v.) To test the viability of the proposed web-based tool.

Directions in responding to the Questionnaire
Please check all boxes that apply in each question where references to "you" or "your" refer to yourself. Please feel free to inquire if you need any clarifications.

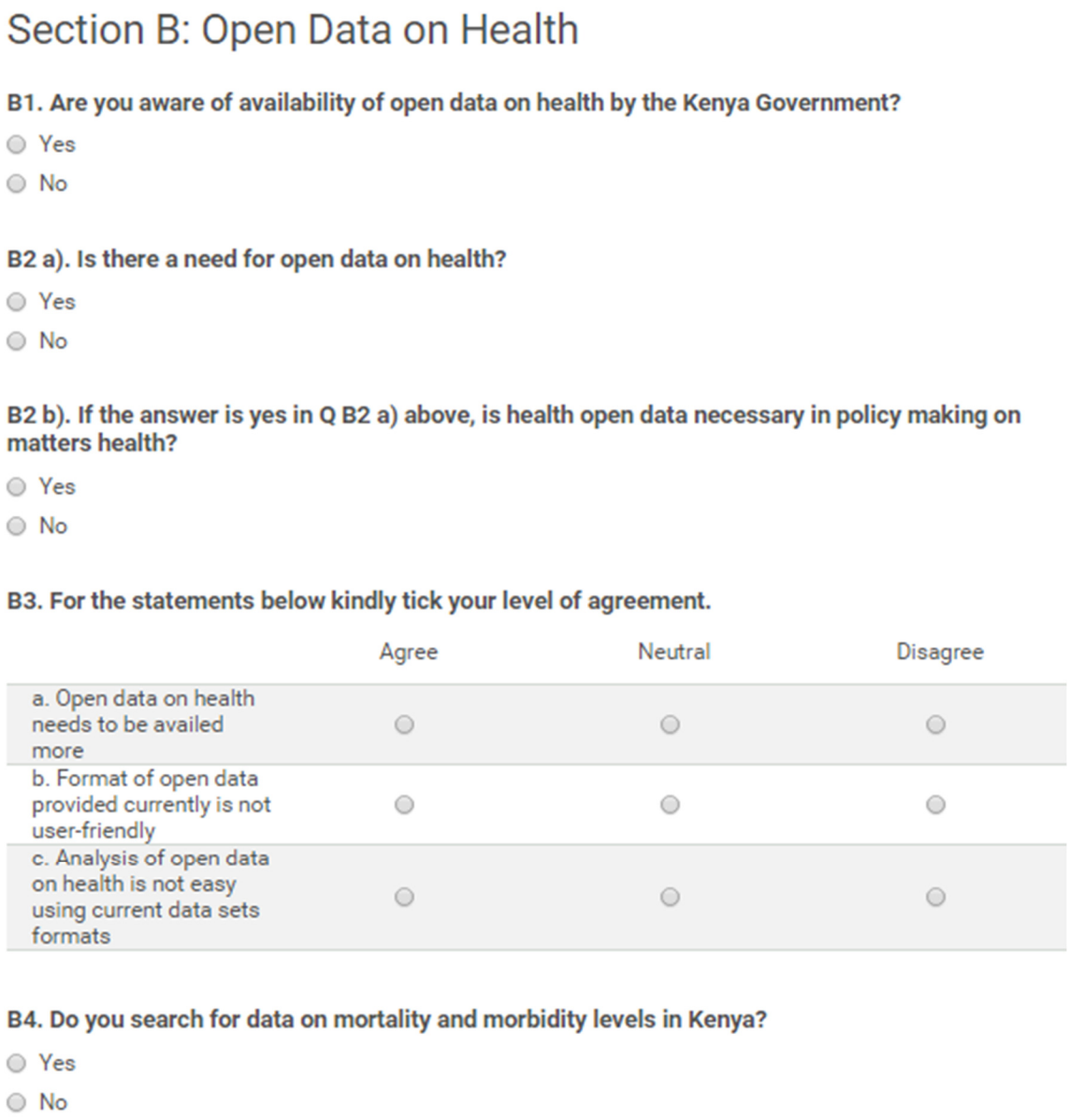
Correspondence/Inquiries
Mercy Orangi
Email: mercyorangi@gmail.com
Mobile Number: +254710377694
Skype: mercy.orangi

Figure C.1: Pre Data Survey - Introduction

b.) Figure C.2 shows the first section of the pre data survey questionnaire. Only general information was collected in this section to help understand the respondent's background

Figure C.2: Pre Data Survey - General Questions

c.) Figure C.3 shows the second section of the pre data survey where questions on health open data were asked.



Section B: Open Data on Health

B1. Are you aware of availability of open data on health by the Kenya Government?

- Yes
- No

B2 a). Is there a need for open data on health?

- Yes
- No

B2 b). If the answer is yes in Q B2 a) above, is health open data necessary in policy making on matters health?

- Yes
- No

B3. For the statements below kindly tick your level of agreement.

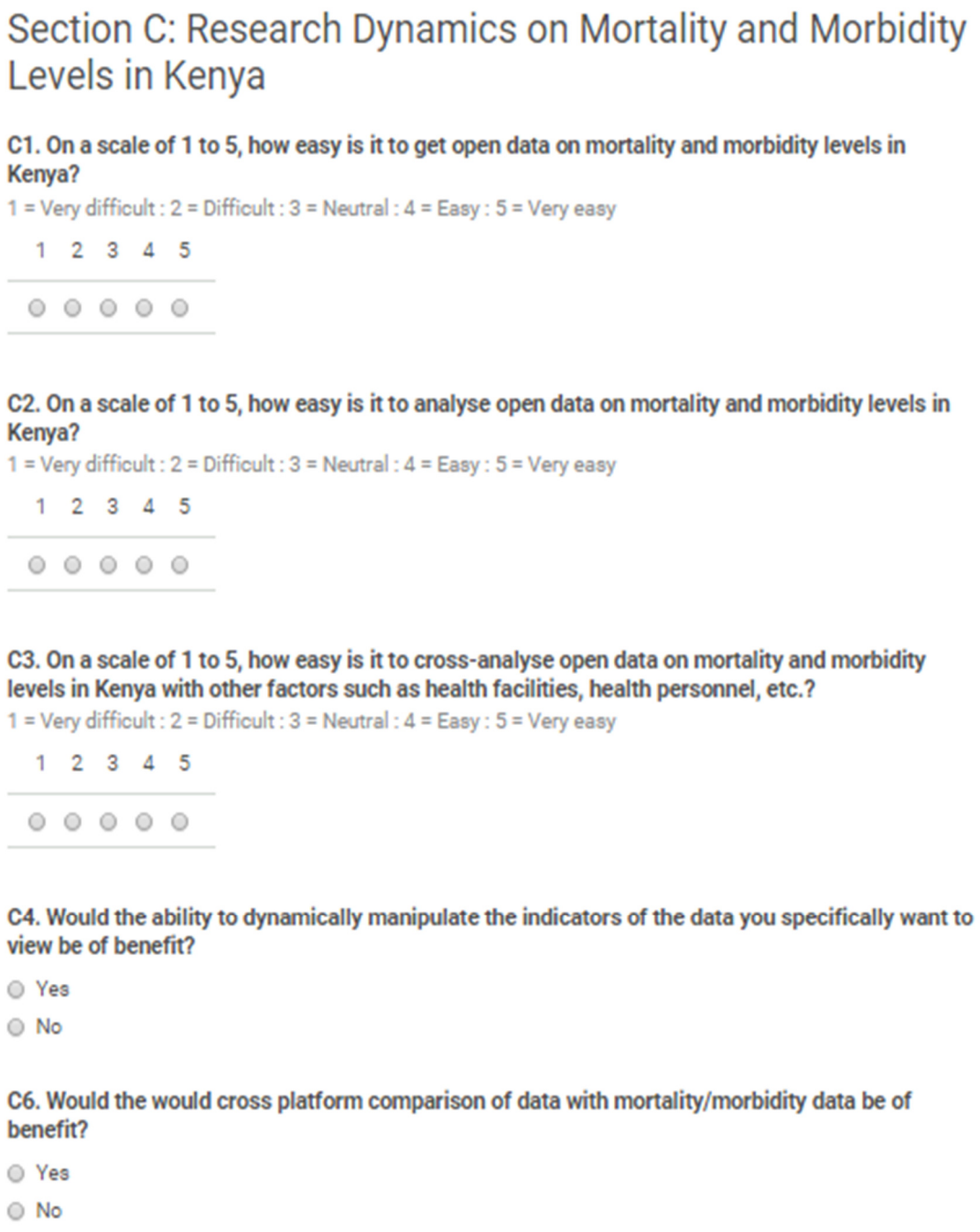
	Agree	Neutral	Disagree
a. Open data on health needs to be availed more			
b. Format of open data provided currently is not user-friendly			
c. Analysis of open data on health is not easy using current data sets formats			

B4. Do you search for data on mortality and morbidity levels in Kenya?

- Yes
- No

Figure C.3: Pre Data Survey – Health Open Data Questions

d.) Figure C.4 shows the third section of the survey where questions were asked concerning the current research dynamics.



Section C: Research Dynamics on Mortality and Morbidity Levels in Kenya

C1. On a scale of 1 to 5, how easy is it to get open data on mortality and morbidity levels in Kenya?

1 = Very difficult : 2 = Difficult : 3 = Neutral : 4 = Easy : 5 = Very easy

1 2 3 4 5

C2. On a scale of 1 to 5, how easy is it to analyse open data on mortality and morbidity levels in Kenya?

1 = Very difficult : 2 = Difficult : 3 = Neutral : 4 = Easy : 5 = Very easy

1 2 3 4 5

C3. On a scale of 1 to 5, how easy is it to cross-analyse open data on mortality and morbidity levels in Kenya with other factors such as health facilities, health personnel, etc.?

1 = Very difficult : 2 = Difficult : 3 = Neutral : 4 = Easy : 5 = Very easy

1 2 3 4 5

C4. Would the ability to dynamically manipulate the indicators of the data you specifically want to view be of benefit?

Yes

No

C6. Would the would cross platform comparison of data with mortality/morbidity data be of benefit?

Yes

No

Figure C.4: Pre Data Survey – Health Data Research Dynamics Questions

e.) The forth and final section of the pre data survey sought to understand if there is a need to abse policies in health on facts from data.

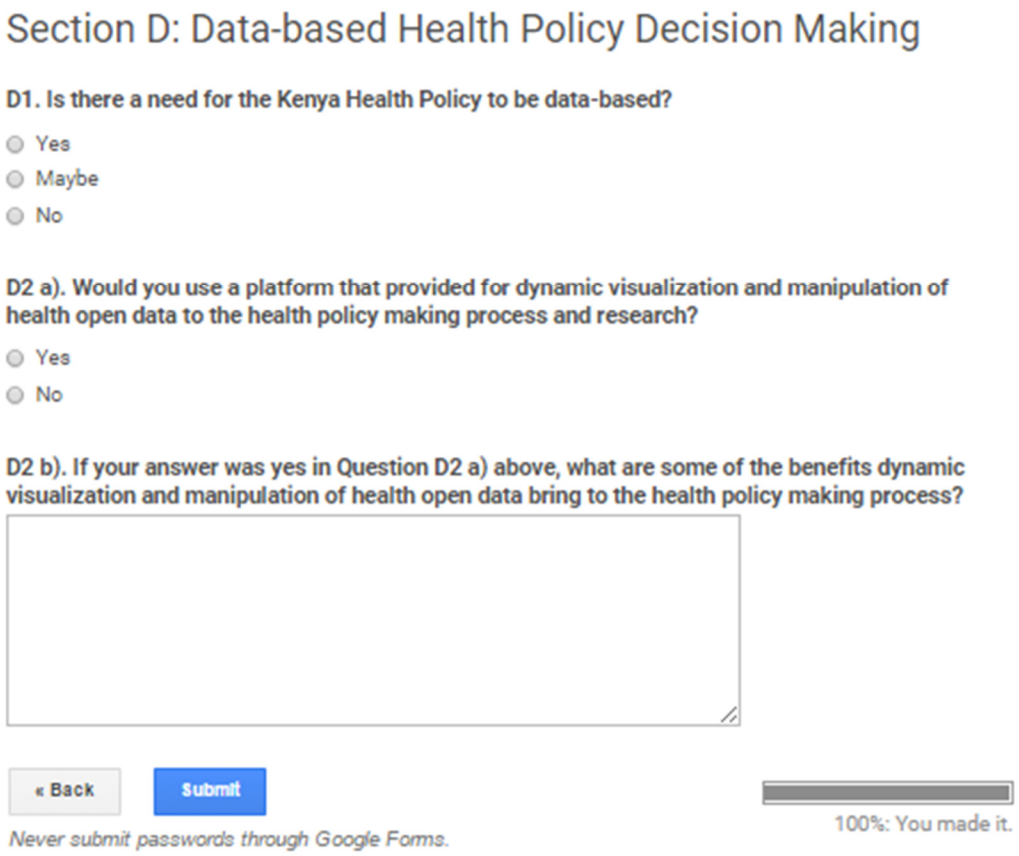


Figure C.5: Pre Data Survey - Use of Health Data in Policy Making Questions

Appendix D: Post Data Survey Questionnaire

The Use of a Visualization Tool to Access Health Open Data on Mortality and Morbidity Levels and Attributing Factors: A Focus on Kenya Health Policies

Post-Questionnaire

REFERENCE NO: iLab/sno/079188

Researcher:
I am a graduate student undertaking a Master's degree in Mobile Telecommunication and Innovation at the Strathmore University. I am currently carrying out a study on the use of a visualization tool to access health open data on mortality and morbidity levels and attributing factors with a focus on Kenya health policies.

Non-Disclosure Assurance:
The information required is purely for academic purposes and will not be shared with any other third party, unless with prior agreement.

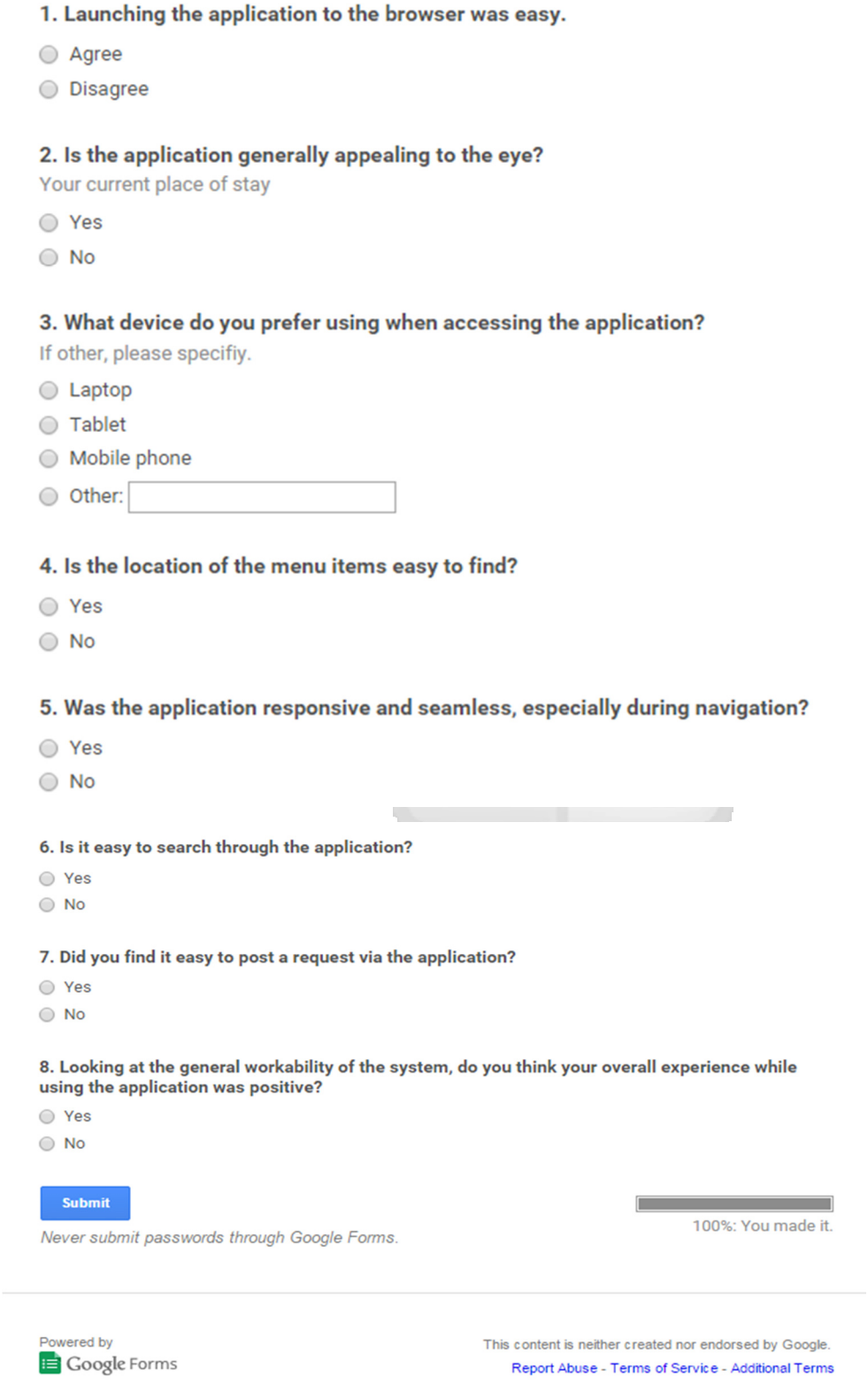
Research Objectives:
(ii.) To analyze how health policies have influenced morbidity levels in Kenya over the past years.
(iii.) To identify the factors contributing to morbidity levels in Kenyan counties.
(iv.) To design and develop a mobile - web tool to visualize morbidity levels in Kenyan counties and the attributing factors.
(v.) To test the viability of the proposed web-based tool.

Directions in responding to the Questionnaire
Please check all boxes that apply in each question where references to "you" or "your" refer to yourself. Please feel free to inquire if you need any clarifications.

Correspondence/Inquiries
Mercy Orangi
Email: mercyorangi@gmail.com
Mobile Number: +254710377694
Skype: mercy.orangi

Figure D.1: Post Data Survey Questionnaire - Introduction

a.) Figure D.1 shows the post questionnaire used to collect feedback on the application



1. Launching the application to the browser was easy.

- Agree
- Disagree

2. Is the application generally appealing to the eye?

Your current place of stay

- Yes
- No

3. What device do you prefer using when accessing the application?

If other, please specifiy.

- Laptop
- Tablet
- Mobile phone
- Other:

4. Is the location of the menu items easy to find?

- Yes
- No

5. Was the application responsive and seamless, especially during navigation?

- Yes
- No

6. Is it easy to search through the application?

- Yes
- No

7. Did you find it easy to post a request via the application?

- Yes
- No

8. Looking at the general workability of the system, do you think your overall experience while using the application was positive?

- Yes
- No

Submit

100%: You made it.

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Figure D.2: Post Data Survey Questionnaire

Appendix E: Use Case Descriptions

a.) View/Download Visualization Use Case Description

Table E.1 shows the use case description for downloading a visualization and further highlights the primary actors and triggers of the use case.

Table E.1: Use Case Description for Downloading a Visualization

<table>
<tr><th colspan="2">View/Download Visualization Use Case Description</th></tr>
<tr><td>System: Health Data Visualization Platform</td><td>Group ID: group A</td></tr>
<tr><td>Use Case Name: Download visualization</td><td>UC ID: 2</td></tr>
<tr><td>Primary Actor: Researcher, Policy Maker</td><td></td></tr>
<tr><td colspan="2">Goal: Download a visualization with specific visualization indicators</td></tr>
<tr><td colspan="2">Trigger: Researcher/policy maker access health data visualization platform</td></tr>
<tr><td colspan="2">Relationships
• Includes</td></tr>
<tr><td colspan="2">Input: health indicator, period in years, county name</td></tr>
<tr><td colspan="2">Normal/Basic Flow of events</td></tr>
<tr><td>Actor</td><td>System</td></tr>
<tr><td>2. Researcher selects health indicator, period in years and county name

4. Researcher selects download format</td><td>1. System provides available visualizations

3. System refreshes view as per manipulation

5. System presents downloaded file</td></tr>
<tr><td colspan="2">Test Cases:
• Unit testing: UT2</td></tr>
</table>

b.) Approve Request for Data/Visualization Use Case Description

Table E.2: Use Case Description for Approve Request for Visualization

<table>
<tr><th colspan="2">Approve Request for Data/Visualization Use Case Description</th></tr>
<tr><td>System: Health Data Visualization Platform</td><td>Group ID: group A</td></tr>
<tr><td>Use Case Name: Grant visualization request</td><td>UC ID: 4</td></tr>
<tr><td>Primary Actor: System administrator</td><td></td></tr>
<tr><td colspan="2">Goal: Approve request for a dataset/visualization</td></tr>
<tr><td colspan="2">Trigger: System administrator access requests module in administrator health data visualization platform</td></tr>
<tr><td colspan="2">Input: status, dataset name, link to data store</td></tr>
<tr><td colspan="2">Precondition: Administrator is logged in and has access to requests module</td></tr>
<tr><td colspan="2">Normal/Basic Flow of events:</td></tr>
<tr><td>Actor</td><td>System</td></tr>
<tr><td>1. System administrator selects requests module

3. System administrator selects a request from available requests to view details

4. System administrator generates visualization as requested

5. System administrator updates user portal with visualization

6. System administrator provides link to data store, and updates status of request</td><td>2. System provides available requests

7.System updates request details</td></tr>
<tr><td colspan="2">Post-condition on success: Database updated with request details and status information</td></tr>
<tr><td colspan="2">Test Cases:
• Unit testing: UT4</td></tr>
</table>

Table E.2 shows the use case description for approving a visualization request and further highlights the primary actors and triggers of the use case.

Appendix F: Design Diagrams

a.) Download Visualization Activity Diagram

Figure F.1 shows the activity diagram in the process of downloading a visualization. It represents the step by step actions of both the system and the user of the system. The start state and the new end state are also indicated.

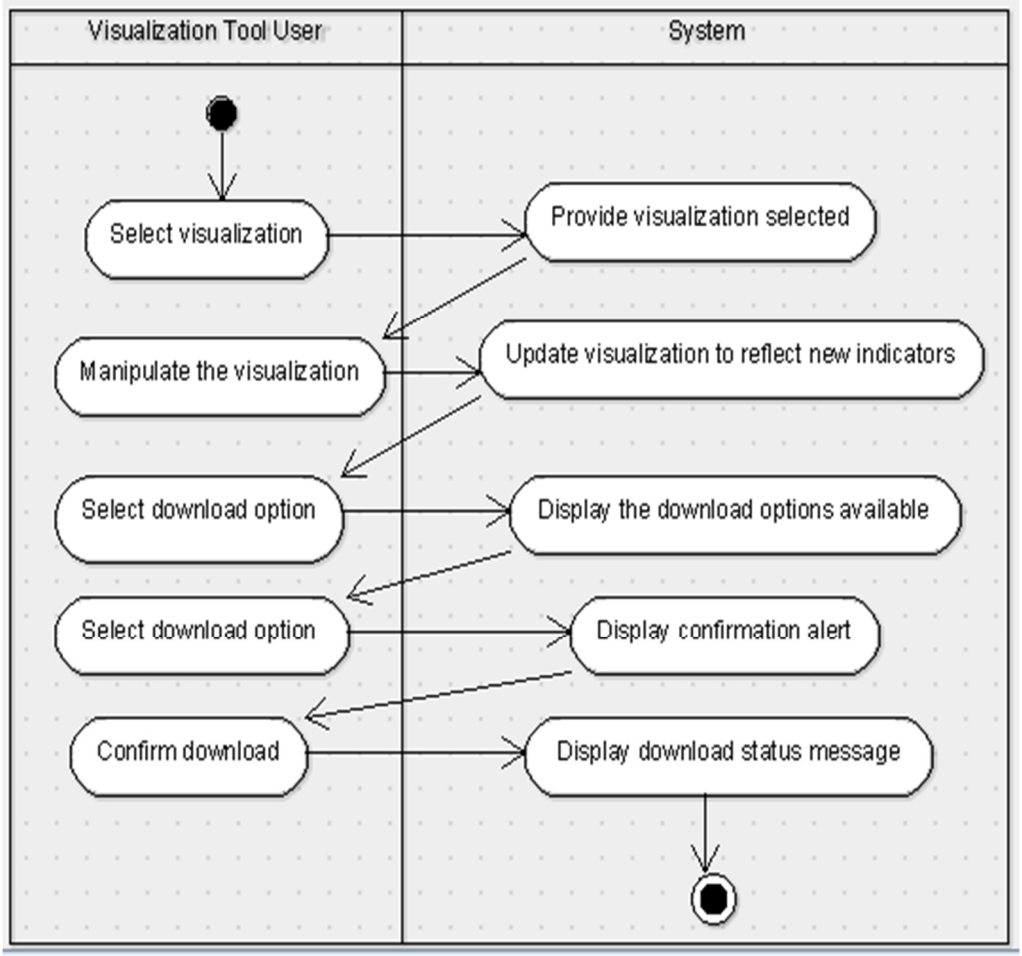

Figure F.1: Download Visualization Activity Diagram

The steps to follow in downloading the desired visualization are straight forward and simplified for any user to perform.

b.) Post Feedback Activity Diagram

Figure F.2 shows the activity diagram of posting feedback via the front end system.

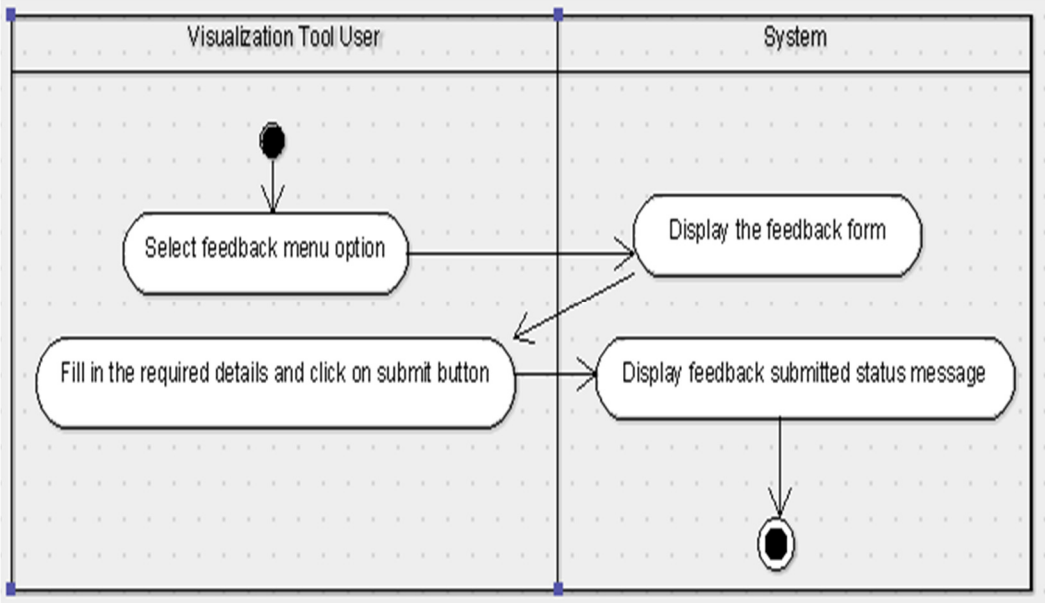

Figure F.2: Post Feedback Activity Diagram

Appendix G: Application Screenshots

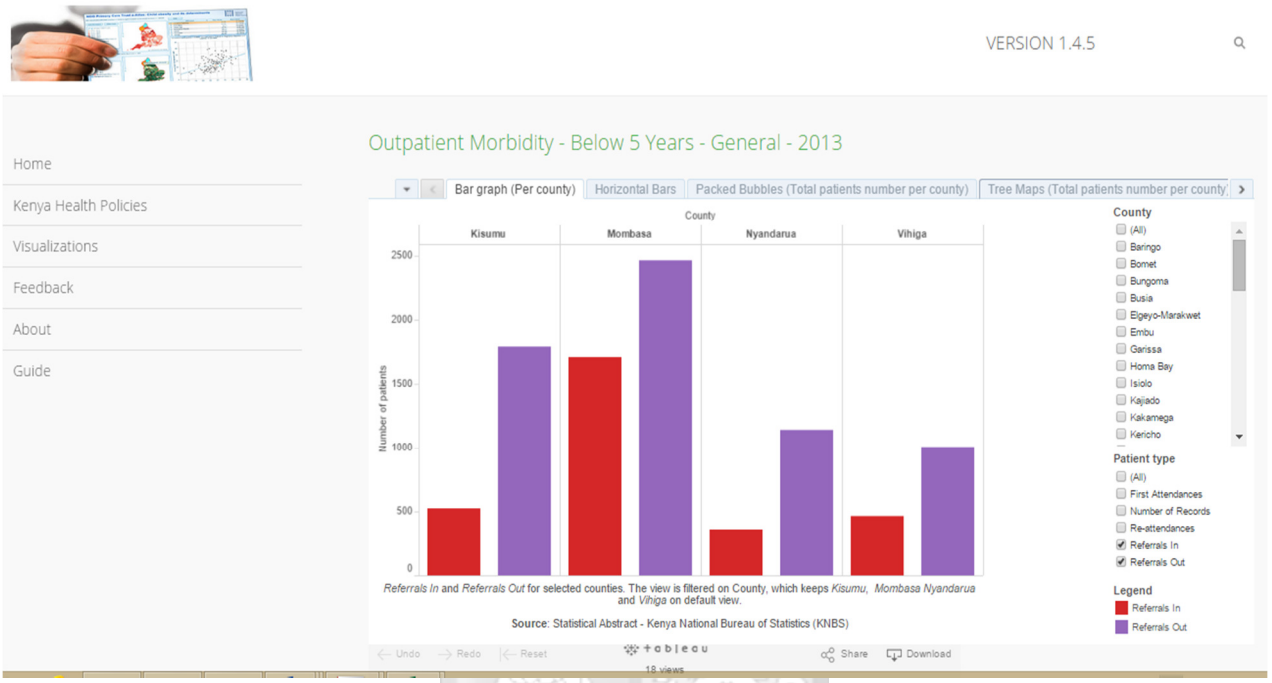

Figure G.1: Application Screenshot - Bar Graph Visualization

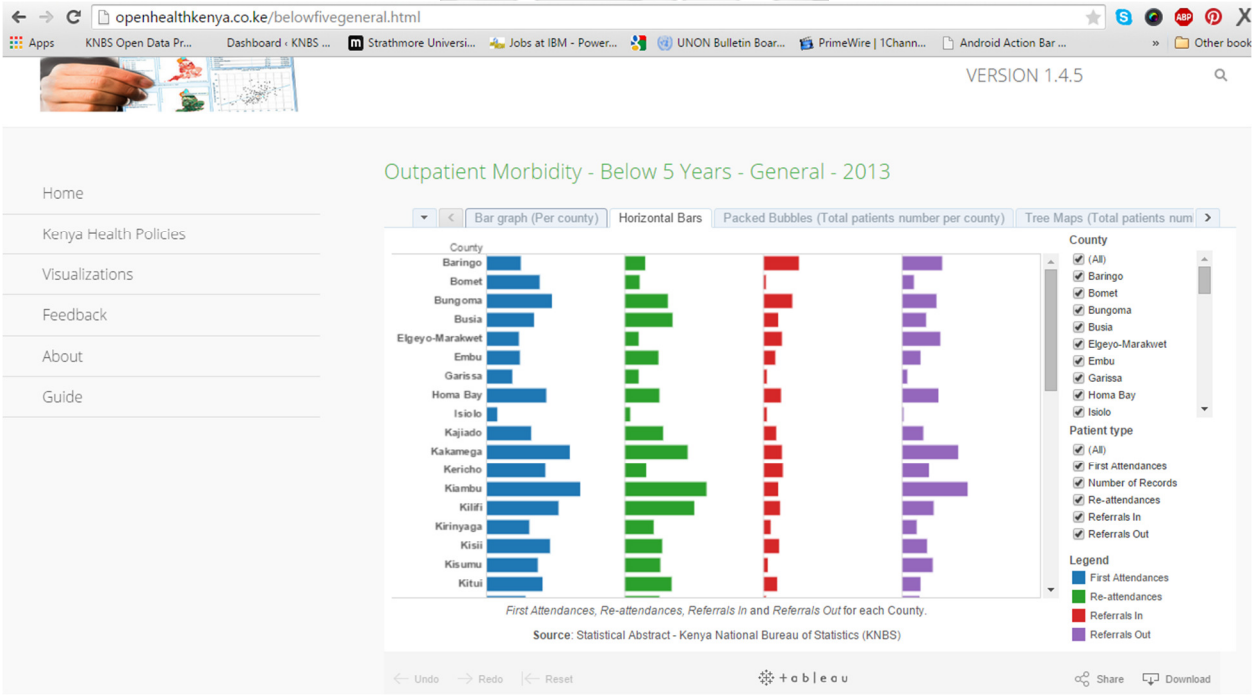

Figure G.2: Application Screenshot – Horizontal Bars Visualization

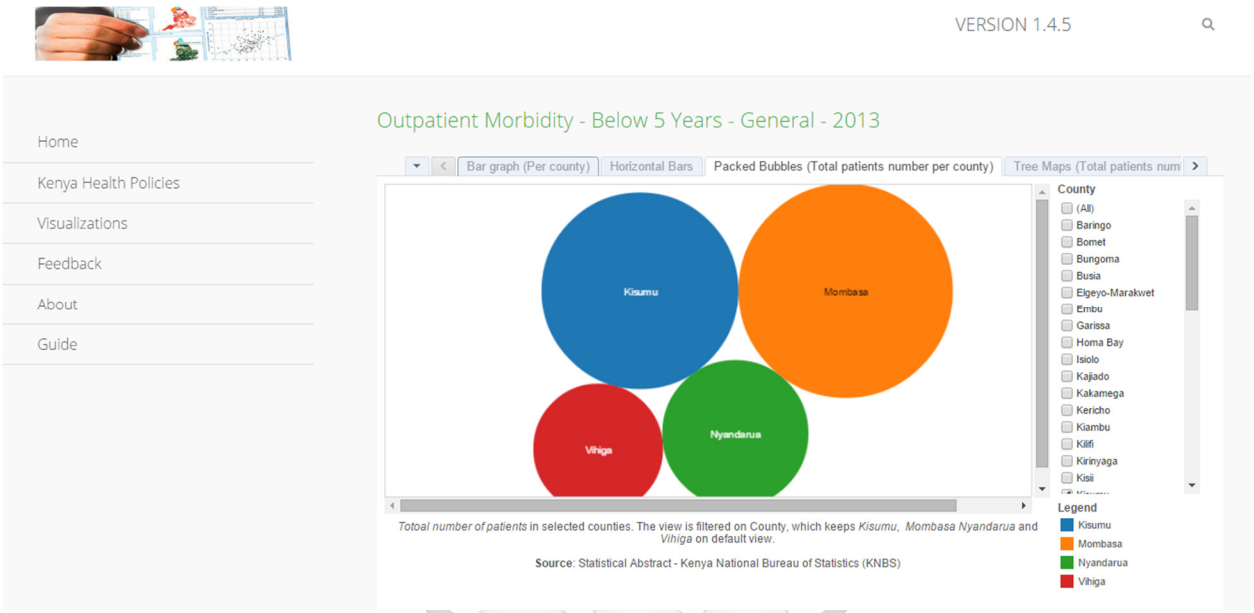

Figure G.3: Application Screenshot – Parked Bubbles Visualization

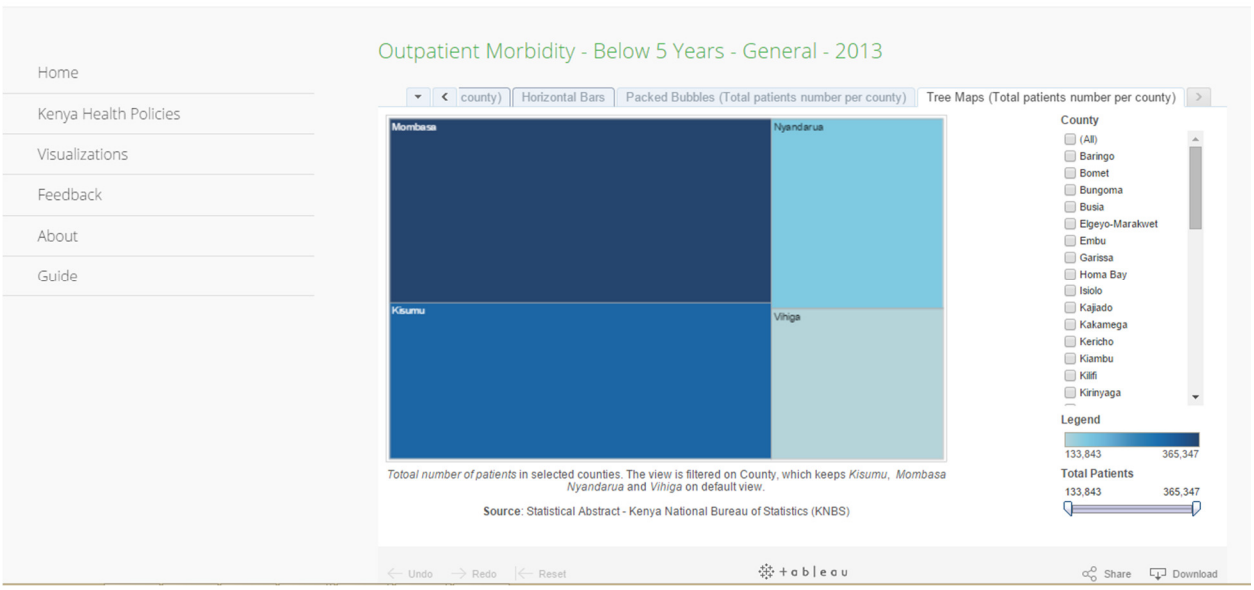

Figure G.4: Application Screenshot – Tree Maps Visualization