UNIVERSITY OF NAIROBI

COLLEGE OF BIOLOGICAL & PHYSICAL SCIENCES

SCHOOL OF COMPUTING & INFORMATICS

AWEB-BASED DISTRIBUTED HEALTH INFORMATION SYSTEM TO CATER FOR PATIENTS WITH CHRONIC AILMENTS

BY

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A project report submitted in partial fulfillment of the requirements for the award of Masters of Science in Computer Science of the University of Nairobi.

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DECLARATION

This project is my original work and, to the best of my knowledge, this research work has not been submitted for any other award in any university.

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(P58/73336/2009)

This project report has been submitted in partial fulfillment of the requirements for the Master of Science Degree in Computer Science of the University of Nairobi with my approval as the University supervisor.

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DEDICATION

I specifically dedicate this work to all medical practioners who devote their lives in helping patients with chronic ailments in Kenya, and across the world in general. Your effort in this noble course is definitely a determination towards making the world a better place to live!

ABSTRACT

Distributed Systems today are rising dynamically in terms of new applications, hardware and network components, users, workload changes and in various research applications. A distributed dataset is having its importance to provide the data from various sources. This research study aims at giving an overview in this area, evaluating the current status of field and envisioning possible future trends in this field with specific focus of developing a distributed system that will provide support for physicians, nurses, pharmacists and other healthcare professionals, as well as for patients and medical devices used to continuously monitor patients with chronic ailments.

A distributed web-system prototype was developed in this research study, with three peer databases and a main database, communicating through web services. Dummy patients were created at peer databases and through aunthticated mobile sms service, patients' data was made accessible from any of the other peer databases. From the results obtained it was evident that sharing of patients' previous medical history has a positive impact on the quality of healthcare patients receive whenever they visit medical facilities for treatment especially those suffering from chronic ailments. The use of web based distributed system to facilitate the access of this data was demonstrated in Chapters 4. Research on the use of web-based distributed systems in healthcare was done through indepth study of similar platform like the use of openMRS, mostly in the western world, and reviewed papers that underscored the importance of sharing medical data, especially for patients with chronic ailments, who may move from place to place.

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ABBREVIATIONS

EHealth – Electronic Health

ERecord –Electronic Record

QoS - Quality of Service

SMS – Short Message Service

USSD - Unstructured Supplementary Service Data

NGO – Non-Governmental Organization

USP – Unique Selling Point

HIV - Human Immunodeficiency Virus

AIDS – Acquired Immune Deficiency Syndrome

TB – Tuberculosis

MDR-TB – Multidrug Resistance Tuberculosis

XML - EXtensible Markup Language

SOAP - Simple Object Access Protocol

WSDL - Web Services Description Language

USSD - Unstructured Supplementary Service Data

UDDI - Universal Description, Discovery, and Integration

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CHAPTER 1: INTRODUCTION

1.1 Background

Health related systems in Kenya are hambered by inadquate financial resources coupled with a shortage and uneven distribution of healthcare specialists, information systems and mismanagement and lack of technical expertise (Freeman and Hughes, September 2013). In close relation to electronic medical records are personal health records that have emerged as an alternative means of enabling patients control access to their healthcare information while empowering them to make appropriate health associated decisions. With the personal heath records patients are able to maintain updated records and communicate their personal health information in a manner that enhances control of their health and in general lifestyles in better way. Giant technology vendors like Google and Microsoft have already released their personal health records products into the market. The most worrying observation is the the fact that the uptake of these technology remains dismal especially in developed countries with minimal research information available to substancially explain this low adoption trend (Helmer, et al., 2011).

This project culminated in the research and development of a distributed web based electronic medical record system platform and SMS information system meant for patient tracking, management, monitoring and programme management for patients suffering from chronic diseases mainly HIV/AIDS and TB, especially in resource poor areas. The aim is to improve health care service delivery in resource constrained geographical zones by coordinating a medical community to create and creating a collaborative environment through this software. The system will enable a constant relationship between a doctor(s) or clinical officer and his or her patient, throughout the medication period. This distributed healthcare information system will consist an amalgamation of independent computers connected through a wired or wireless network and distribution middleware, which enables computers to coordinate their activities and share the systems resources in a manner that will create a perception of a single system integrated computing facility. With extremely increasing demand, standalone systems cannot adequately serve needs especially those that are geographically distributed in nature.

1.2 Problem Statement

The scale-up of treatment for chronic ailments in developing countries requires a long-term relationship with the patient, accurate and accessible records of each patient's history and methods to track his/her progress. Chronic diseases such as cancers, diabetes, cardiovascular diseases, and asthma represent a rising and worrying health burden in emerging and third world countries. World health organization statistics reveal that out of 36 million annual chronic disease deaths a whooping 80 percent occur in low-and middle-income countries (WHO, May 2014). Prevention and multidisciplinary teams in primary care and public health best perform management of chronic disease. To manage the fast growing chronic disease burden an interdisciplinary basic care personnel is required (Bodenheimer, et al., 2009). Studies have shown that there is greater percentage of loss of follow-up of HIV patients in Africa especially Kenya during treatment and many patients not being started on treatment at all. Some programs for prevention of maternal–child transmission have more than 80% loss to follow-up of babies born to HIV-positive mothers. These patients are at great risk of developing drug resistance if their antiretroviral therapy is interrupted or even dying. Comparable complications have been found in the scale-up of MDR-TB management.

1.3 The Research Objectives

This research study aims at developing a distributed web-based system that will create a platform for sharing information among the different stakeholders that are tasked with managing patients with chronic ailments. The following are the specific objectives for this study:

i. To carry out research on the use of web-based distributed systems in healthcare.
ii. To develop a web-based distributed health information system.
iii. To test and evaluate the system.
iv. To analyse the results and interpret the findings.

The system will help track patients by way of keeping records of critical data such as laboratory tests and medication while providing continual updates of their treatment regimes status. If the system is a generic systems that could easily be replicated to help combat AIDS and other chronic diseases in Kenya and even extended to Africa. The solution will help to plan and coordinate the health care of patients with chronic or terminal medical conditions, including patients with these conditions who require multidisciplinary, team-based care from at least two or more other health or care providers.

1.4 Justification

Distributed Systems being web-based applications supported by the Internet allow for sharing of resources locally as well as globally leveraging on the fast growing Internet technology aiding efficieny and fast data transfer operations. In comparison to the traditional information systems, distributed systems perform tasks better based on the following merits attributed to distribution; openness coupled with sharing of resources and concurrency, robustness and scalability. The major alternative of the distributed system to be developed in this project might be openMRS, an open source medical system that can be used to do similar purposes. This project's competitive edge is based on the fact that success stories for openMRS are unavailable in Kenya. This means that most hospitals use manual systems or standalone information systems to record data. Unlike the openMRS, the proposed solution will be accessed uniformly from the distributed databases infrastructure. Through sharing the databases, data from all medical institutions will be synchronized making it easier to track and monitor patients even when patients change the medical facilities.

1.5 Research Questions

Findings from a number of studies indicate standalone health systems do not make it possible to share patients' medical information especially for patients with terminal or chronic. This state, not only leaves physicians attend to such patients without consideration of their medical history but also subject these patients to poor healthcare. This research project provides solutions to fundamental questions regarding the effective use of distributed systems in healthcare such as;

i. Do the current health systems adequately serve the needs of patients with chronic ailments?
ii. Does the use of distributed systems in healthcare significantly address the challenges associated with managing patients with chronic ailments?
iii. Which other addional services do distributed systems contribute in the management of patients with chronic ailments?
iv. Is it feasible to develop a web-based distributed health infomation system?

1.6 The Proposed Solution

This cloud based web system that will be used by physicians to keep track of patients who suffer from chronic diseases and who need a long-term relationship with them. The product is unique in such a way that, all patient data is kept in a central database and thus makes it easier to avoid duplicate data incase patients visit different health centers for medication. It will be easier to know the medical history of a patient in an event he/she changes location due to social/natural factors. The only thing needed to access the system is a computer connected to Internet in case of the web interface and a mobile phone in case of the SMS interface/system.

1.7 The Scope

This study will be limited to developing a distributed web based system that will have an interface for capturing patients' medical data and a database to store the data. The system will be integrated with a mobile platform for short messaging service interactions. The government and other institutions (NGOs) will have easier time to track the trend and effectiveness of the care given to patients. It will help reduce data duplications of patients across various institutions. The system will improve the quality of care and reduce loss of follow up on patients with chronic ailments in Kenya.

1.8 The Research Outcome and Significance

The system will go a great mile in ensuring that institutions that deal with chronic ailments have got an easy and convenient way to keep track of their patients and to monitor their medication with minimal or no data loss. Chronic disease, inclusive but not limited to diabetes, is a fast-growing problem in sub-Saharan Africa. Within AMPATH's geographic area of western Kenya, there are already an estimated 60,000 persons living with diabetes, and that number is expected to double over the next two decades. Unfortunately, as the threat of early death and disability from chronic disease like diabetes grows in sub-Saharan Africa, it is clear that countries like Kenya have almost nothing in place to meet this challenge (Ampath, 2010)

1.8.1 The Social Purpose

The most beneficial people are those affected by HIV/AIDS and other chronic ailments like TB. These people and or government embracing the importance of the system will measure the social impact. The system has a higher potential of being adopted by health institutions in Kenya due to its immense value. Other than HIV/AIDS and TB, the system can also be used to keep track of patients with malaria, typhoid and other diseases. When successful, the system can be expanded to other African countries in resource poor areas.

1.9 Challenges and Limitations

Distributed systems design is obviously a challenging endeavor. How do we do it when we are not allowed to assume anything, and there are so many complexities? We start by limiting the scope. We will focus on a distributed systems design that uses a client-server model with mostly standard protocols. It turns out that these standard protocols provide considerable help with the low-level details of reliable network communications, which will make our work easier.

1.10 Application in Society

A chronic medical or health condition is one that has been (or has capacity to be) present for a period of six months or longer. These conditions include, but not limited to Asthma, Cancer, Cardiovascular disease, Diabetes, Musculoskeletal conditions and Stroke. There is no list of eligible conditions. However, affected patients require a structured approach, including requirement for continous care from a multidisciplinary team (Autrarian department of Heath, 2014). The major users of the system will include public and private institutions who offer medical care to patients with chronic or terminal ailments (HIV/AIDS, Cancer, etc.). This will include government and private hospitals, clinics and health centers. Major NGO institutions whose mandate is to fight AIDS will also find the system useful. Such institutions include Kenya Red Cross, United Nations, World Health Organization, and The World Bank. Rates of reporting in the health information system are high inspite of the challenges of accuracy and completeness. This project will make it possible for the Government of Kenya and affiliated stakeholders access health information that is complete and accurate for community centric programs (Freeman and Hughes, September 2013). The Unique Selling Point (USP) here is that, the system will store data across all health institutions in a central database hence making it easier to know when a patient switches services from one institution to another.

1.11 Conceptual Model of the proposed healthcare distributed system

An SMS gateway will be installed which will utilize bulk SMS to send automated SMS to patient’s phones to remind them of their next visit to hospital or remind them to take their drugs.

Patients will also be able to apply and track, through SMS, their medical history: the drugs they have taken, the physicians they have visited, and their progress on drug usage. The patients will also receive through SMS, health living tips and information on how effectively manage their diseases.

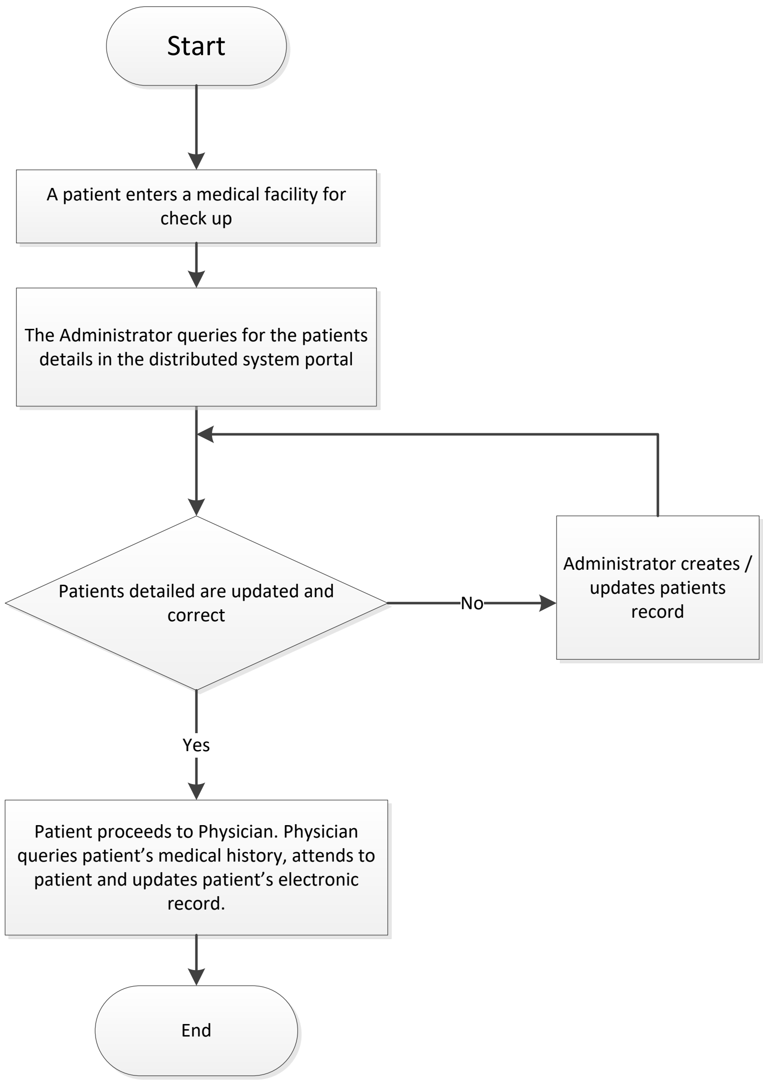

Figure 1: System flow chart

This project report document is oragnised as follows: Chapter 2 summarises the literature review, Chapter 3 highlights the research methodology, Chapter 4 focuses on system design and implementation, Chapter 5 summarises the research results and discussions and Chapter 5 concentrates on the conclusions and recommendations.

CHAPTER 2: LITERATURE REVIEW

The need for integrated shared platforms in the health sector in emerging economies can not be overstated. The snergy realised through collaboration and boundless communication is enormous. This does not only underscore the fact that we shouldn’t be focusing only limiting factors like cost and complexities involved but rather pull resources towards building distributed sytems that adopt and cater for the unique challenges facing patients who may to move from one geographical location to another due to resource constraints among other factors. Unlike other sectors of the economy, for example the banking sector, where associations are using integrated information systems to cut fraud by sharing customer information, there are no similar efforts to unify the health segment. Another missing element in the local health scene is the lack of cooperation in sharing information among health practioners and health practioners (Omete, May 2017).

Building reliable computer systems that run over unreliable communication network(s) seems like an difficult goal. We are forced to deal with uncertainty. A process knows its own state, and it knows what state other processes were in a moment ago. The processes have no technique of knowing each other's current state. They lack the equivalent of shared memory and accurate ways to detect failure, or to distinguish a local software/hardware failure from a communication failure. Distributed systems design is obviously a challenging work. How then do we do it when we are not permitted to assume anything, and with so many complexities? We will start by limiting the scope. We will focus on a particular type of distributed systems design, one that uses a client-server model with mostly standard protocols. It turns out that these standard protocols provide considerable help with the low-level details of reliable network communications, which makes our job easier.

Health organizations have interest in distributed data processing arnchored on strong and reliable integration of information assets that include physically distributed databases. Web systems and applications have evelved over time and have become powerful computing facilities which provide functional entities besides the emerging unique needs on their integration with commercial databases and other community applications (Saini, April 2015).

Times are fast changing and there exists reasonable need to connect remote sites places using wireless based technologies especially internet on portable telephone devices. Late 19th century and early 20th century, health benefits leveraged on huge advancements realized in the area of analogue telephone systems. Patients could call the doctor whenever they were in need through this advanced technology.

Medical centers utilized this innovation by sending electrocardiograms through tele-phone During this early days health care was delivered remotely. This was also called “tele”- medicine and this specific advantage came with the shortcomings of inadequate bandwidth, low rates of data transfer through copper cables, interference and numerous noises hinder these particular tecchniques from expanding. Consequently, computerization coupled with digitization and computer networks indeed have paradigm shifted tele-medicine to a whole new era connecting practioners and patients through electronic tools. Healthcare facitlites are spread across throughout regions with a perception that communication methods employed presently may not necessarily be optimal and posses limitations. There is a perception that medical care environments in remote areas are not adequate in all facets and that health care specialists are more engaged in the collection, preparation of requisite reports instead of consulting the clients which is their core responsibilty.

The involvement of health care practitioners in administration makes it difficult for them to provide better health services. The distributed internet or web based architectures should be implemented for such like organizations. Consequently, each health center will be treated as a client point and thus we can build well-designed distributed information system for these environments. These particular models will be valuable by way of improved and user friendly, movable and self-computing client points with a server machine in a well networked environment. Telemedicine plays an important role in the contemporary healthcare system. The benefits of telemedicine especially in provision of improved medical care in remote areas can not be overemphasized. There is significant reduction in overall costs and improved quality of medical care.

2.1 Distributed Systems

These type of systems consist of multiple independent computer systems that pass messages through a computer network. The computers work together purposely to execute a joint task throught a distributed program or a distributed application. In this particular type of systems information processing is distributed across numerous computer systems as opposed to being limited to a single computer. This systems make it possible to process huge chunks of data within limited time and is highly available due to redundant data stores acorss the infrastructure.

2.2 Traditional Computer Systems against Distributed Systems

Tradional databases were geared towards centralization and this yielded inherently complex databases. The data stores were single-user or multi-user with computing exclusively centralized at the server end. In the world today the users' needs are unlimited and not based upon single geographical location but users would rather prefer to have access to decentralised informationand that updated on a regular basis. Traditional systems made it possible for users to only read information. This possed limitations to networks installed in remoted areas owing to client end computing inability.

2.1.1 Traditional Computer Systems

Database Management Systems, Relational database Management constituted traditionally available solutions. These are basically centralized systems which don't have capacity to run web applications for online transaction processing roles. Consequently such systems cannot jointly utilize resources worldwide for medicare communication. Limitations associated with traditional system include being very expensive hardware-wise coupled inherent difficultly in sharing information. Other limitations include the need for isolated licensing which is uneconomical and only from client nodes or terminals are the read operations are allowed.

These two tier systems are depicted in the block as shown in figure 2 diagram below.

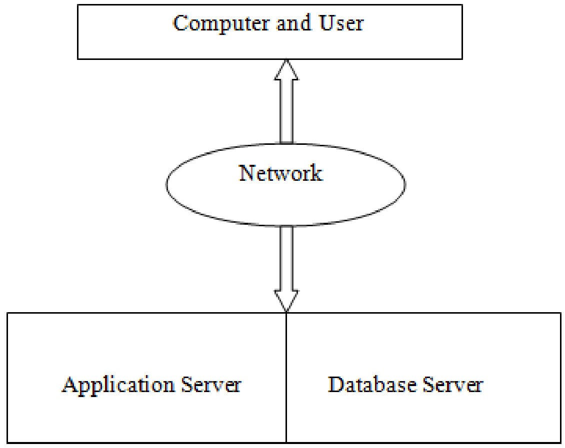

Figure 2: Two tier Architecture

2.1.2 Distributed Systems

Distributed systems being web based applications are supported by the Internet. These systems not only share resources locally but also on a global wide scale. In the modern world Internet is rapidly developing technology and tis is essential for purposes of data transfer operations. A client-server architecture of distributed computing system is as shown in figure 3 below.

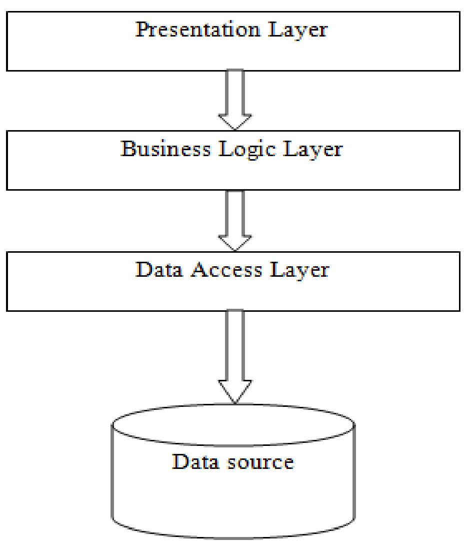

Figure 3: Client-Server Architecture: Three-tier Architecture

When compared against traditional computing information systems distributed systems perform better courtesy of concurrent processing and in terms of systems availability. Therefore distributed systmes could play an important or vital role healthcare industry.

Some limitations of distributed system include but not limited to security challenges, complexity of the system, the element of unpredictability and manageability challenges. When weighed against the strengths of thses systems and on the basis of their application in the health care industry, the merits outweight the demerits.

2.1.3 Distributed Systems Architectures

A typical distributed system adopts one of the following types of designs:

1) Peer- to -peer Architecture

Figure 4: Peer to Peer Architecture

2) Client-Server Architecture

This is a computing architecture with two types of computers: Client (can request or send) and Server (receives requests) which use standard data communication techniques or message passing purposes.

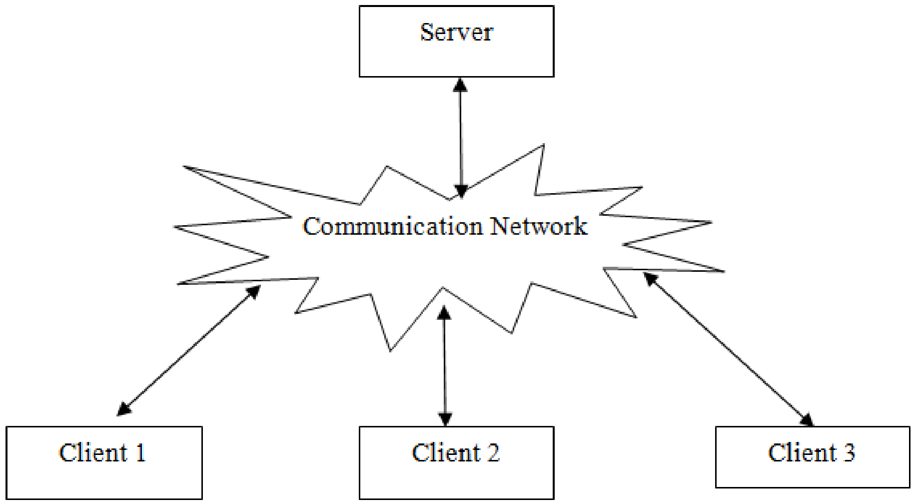

Figure 5: Client Server Architecture

2.2 Health Information and Distributed Systems Technology

Healthcare information and associated technology offers the umbrella framework to describe the comprehensive management of health information over computerized systems and its secure exchange between healthcare providers, the government through its quality assurance entities, insurers and healthcare service consumers. Health information and technology is in general increasingly perceived as the greatest promising instrument for successiful delivery of the overall quality, efficiency and safety of the health delivery system(Chaudhry et al., 2006). Aggresive and consistent utilization of health information technology through distributed systems will:

i. Enhance the quality of health care services through collaboration.
ii. Prevent avoidable medical errors.
iii. Reduce unnecessary healthcare costs.
iv. Improve administrative efficiencies.
v. Mimimize paperwork.
vi. Expand accessibilty to affordable healthcare

2.3 Health System

A healthcare information system is a collection of users together with the requiste resources and institutions that provide medical services that adequately satisfy the health needs of the populace in question. Contemporary evolution and advances in medical science and engineering insights and information technologies & communications have been leveraged the exponential growth of Internet technology.

Web technology through distributed systems delivers an effective, efficient, and better improved health information platform with respect to patients especially with chronic ailments and their medical and healthcare related challeges. Healthcare by way of face-to-face interactions between healthcare specialists and their patients or even betweem doctors themselves are not only essential but equally vital. Whenever it is practically impossible to have such meetings, then tools or models by way of imitations would play a substantially critical in collecting important information as far as better treatment methods, regimes and care are concerned.

All means of communication amongst system users, healthcare specialists and patients via electronic gadgets or even through shared systems linking remote areas are taken care of. Interoperability design considerations in healthcare systems makes it possible for two, three or more system components and applications share critical information. At the moment there is obviously a major technological challenge as far as healthcare industry players achieving interoperability amongst systems and applications provided by different system developers. Each hospital facility or hospital department may choose to use a number of applications in sharing patient related and vital administrative information among heterogeneous applications. As far as healthcare specialists are concerned this greatly improves access to health related recorded data and important healthcare information at anytime and from anywhere. On the other hand, the service quality of healthcare provided is improved through improved data and information sharing coupled with quality of data flow and access of patients' information by health specialists and practitioners. Consquently data collection will be greatly improved. This will directly enhance statistical and economic analysis through availability of patients'and other relevant medical data that will be useful in medical research.

Distributed health or distributed patient data and information systems are integral in handling geographically distributed patient data and records. Each patient health record has a distributed architecture and every client computer system will have a resident database or data store. In distributed database design data and information won't be stored completely in one physical geographical location but rather is spread across a high performance computer network via reliable communication associations and linkages. We thus end up with an enormous database facility whose capacity is reliable and readily available besides being inherently flexible. The most important merit of such an a architecture is that an inherently distributed database facility not only allows faster local query excution but equally potential to minimize network traffic hence sustain network performance.

The important healthcare processes coupled with application of distributed system applications has enormous potential in transforming the healthcare is administered to patients especially those suffering from chronic ailments. The present health services and operations are inadequate based on the fact that they do lack communication services amongst themselves. On the other hand the procudures that are used to record data in many health facilities are ineffective. The manual data collection and storage systems employed are not only inaccurate but also consume a lot of time, space and sometimes have huge cost implications. Considering that they lack decent computing system facilities coupled with lack of current data and complete recent information is adeqauate impetus for need of modern and better communication system that reduce wastages of vital resources such as time and will also be cost effective. In an effort to minimize these drawbacks we have to build a distributed information system running on a networked technology and driven by a web based or internet technology. The designin of reliable and quality distributed information systems is entirely dependent on network technologies and is without a doubta better technological solution in form of computing tools that have capacity to handle different query concerns (Saini, April 2015). Once the medical records are significantly adopted then patient data and information shall be electronically captured in any healthcare service delivery environment. This is solely intended to increase healthcare nformation exchanges and eventually maintaining a nationwide health information network which solely purposes to provide a secure and interoperable health information platform that allows all stakeholders including but not limited to specialists, medical failities, state agencies and other relevant networks to share healthcare information digitally (Cline, 2012) .

2.4 Main Features and Benefits of a Distributed System

A common misconception among people and sometimes even healthcare stakeholders when discussing distributed systems is the idea that this is just another name for a computer network. This is seriously erroneous as it overlooks an important distinction. A distributed system is basically built on top of a network and tries to hide the existence of multiple autonomous computers. An impression of a single entity that provides users with whatever services required is created. Central to this is a network which is medium for interconnecting entities (such as computers, media and devices) enabling the exchange of messages based on well-known protocols between these entities which are explicitly addressable using IP addresses. Distributed storage systems such as NFS (Network File System) provide users with a unified view of data stored on different file systems and computers which may be on the same or different computer networks.

The main features of a distributed system include the functional separation. Based on the functionality/services provided, capability and purpose of each entity in the system. Second to that is the inherent distribution whereby entities such as information, people and systems are inherently distributed. For example, different information is created and maintained by different people. This information could be generated, kept or stored, analyzed and used by different systems or applications which may or may not be aware of the existence of the other entities in the system. Another feature is reliability long-term data preservation and backup in form of replication at different geographical locations. Distributed systems are also highly scalabile. This facilitates addition of more resources to increase performance or availability. Eeconomy is also another main attaribute of a distributed systems as this creates an environment condusive for sharing of resources by many entities or users thereby significantly reducing the overall cost of operations and capital.

Due to these inherent features the various entities in a distributed system environment can possibly operate autonomously and concurrently. Computing tasks ar carried out independently and actions are coordinated in defined stages by exchanging messages. In addition entities are heterogeneous and failures are independent. In general there is no single process or entity that has the knowledge of the entire state of the system as a whole.

2.5 Web Service

Over the years computing technologies such as DCOM and CORBA have provided the means to build component-based distributed systems. These technologies allow systems to interoperate at the component level through provision of a software layer and a suite of protocols that offer the interoperability needed for components built in different programming languages and environments to exchange messages. Unfortunately these technologies present scalability challenges when applied to especiallyto the Internet and some restrict developers to specific programming languages. Consequently approaches based on web protocols and XML (eXtensible Markup Language) have been suggested to permit interoperable distributed systems irrespective of the programming language in which they are built.

Web Services are primarily founded on XML and provide a feasible means to the development of distributed systems that adhere to a Service Oriented Architecture. Services therein are described in an XML based dialect (WSDL). Likewise the request and reply messages shared in such distributed systems are structured according to Simple Object Access Protocol (SOAP) principles. These Simple Object Access Protocol messages can be encoded and conveyed using web protocols such as Hypertext Transfer Protocol. Application platforms such as .NET from Microsoft, J2EE from Sun jointly with various industrial technologies are targeted at supporting the development of applications based on web services to leverage on the fast internet growth.

2.6 Distributed Systems in Healthcare

As key players in healthcare strive to treat and manage patients with terminal and or chronic ailments, the barrier in sharing patients' historical medical data poses the greatest challenge. In extreme circumstances, patients end up being prescribed with drugs that have already failed to effectively manage the ailments from other medical facilities and as such, patients end up taking drugs that do not any value. "Although these chronic diseases are relatively easy to monitor and manage, the health outcomes are severe and even fatal without consistent, longitudinal, high level care." [Bridging Income Generation provision of Incentives for Care –Kenya, 2013]

The world burden of chronic disease including diabetes and hypertension continues to rise. New culturally contextualized medical care models are critically needed to address the unique demands of this chronic disease epidemic especially in low and middle income settings “It is critical to address this chronic disease epidemic with a sustainable, longitudinal, care model that is both culturally contextualized and financially sustainable (Allotey , et al., 2011). The Problems with current chronic disease care implementation strategies range from poor clinic attendance, poor continuity of healthcare, to breakdowns in patient – provider communications. The ideal healthcare system should be contextualized to the populace it serves. This project will model healthcare that harnesses the strength of community and collaboration through shared information as a primary sustainable motivating force in provision of healthcare to patients with chronic ailments.

The use Information Communication Technology for public health promotion purposes is being practiced in developing third world countries. Considering that the number of mobile phone or broadband subscriptions have more than doubled from 2011 to 2013 (from 472 million to 1.16 billion subscribers) in emerging economies (ITU, 2013) there is enormous potential for the use of mobile phones to search for health related information. Appropriate mobile applications can be developed to allow customized search for health information by patients whenever they fall sick or generally to seek information on various ways of staying healthy. Internet continues to play a key role in public health promotion. One of the most common functions of Internet as a facility is that it provides a wide variety of health related information through use of different websites (Griffiths, et al., 2009). This can be of great benefit to citizens of developing countries who are able to identify the latest data and information regarding illnesses, treatments and best practices in healthcare and medicine in general.

2.7 eHealth Information and Systems Security

A number of definitions on the term ‘eHealth’ have been put forward by different authorities in the medical field. For the purposes of this research study, eHealth is considered to be the cost-effective and secure use of information and communications technologies in support of health and health-related field, including health care services, health surveillance, health literature, and health education, knowledge and research (World Health Organization, 2010). EHealth extensively covers the development and use of a wide range of ICT systems and technologies for healthcare such as electronic health records management, telemedicine, health information systems, mobile devices, e-learning tools and decision support information systems. The value of eHealth is in its inherent ability to help lower costs in healthcare or medical sector while delivering better care within a citizen centered approach (Currie & Finnegan, 2009). The systems and data security in this project will be addressed using appropriate Authentication (username and password) and database encryption to protect patient's data from unauthorized access.

Based on past documented contributions on healthcare information systems, it is evident that leveraging on strengths of distributed systems is useful in developing solution that can make it possible to share information in an efficient yet effective manner. Unfortunately, such systems are missing in Kenya resulting in poor follow-up and loss of patients. There is obviously a huge need for sharing medical data among the various stakeholders in the healthcare industry, especially when dealing with patients suffering from chronic ailments. A web-based distributed health information systems, owing to its strengths, definitely serves as a viable solution in managing patients with chronic ailments.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Research Design

An action research approach was employed to carry out research with an aim of contributing to knowledge and solving real-world problems. These were achieved by developing a web-based distributed health information systems as a viable solution in sharing medical data related to patients with chronic ailments. This research project was conducted in two phases namely; data collection through literature review and systems development. The research method will be critical in meeting the objectives listed (in section 1.3) above.

The action research approach preference was based on the fact it will help in meeting the research objectives. It is also appropriate for the project as it seeks to determine the applicability of the proposed solution hence practice informing research and research informing practice thus the synergy in the complement as described by Avision et al (1999).

The information systems' strengths and weaknesses were demonstrated through this approach. Whereas strengths dominating the weaknesses signified adoption, the contrary implied room for further research to develop better solutions.

3.1.1 Why Action Research

The approach's ability to consolidate theory and practice through change and reflection in an immediate problematic situation within a mutually acceptable ethical framework makes it a preferred choice for this research as explained by Avision et al (1999). This system, implemented using new techniques, is presented as the change with an aim of solving the current stand-alone information systems' isolated patients' medical data in a shared and distributed environment, after which its strengths and weaknesses are reflected upon.

Action research is a process consisting of or more iterations that involve researchers and practitioners working together to diagnose the problem, intervene with an action, and perform reflective learning on it as detailed by Avision et al (1999). McKay and Marshall (2001) describe an action researcher as one having two aims that lead to the action research approach having two cycles overlaying each other. As illustrated in the diagrams below, the first cycle relates to the researcher's' interests and responsibilities relating to the researcher's problem solving aim while the second cycle relates to the researcher's problem solving aim (McKay and Marshall, 2001). The diagram below represents the researcher's interests.

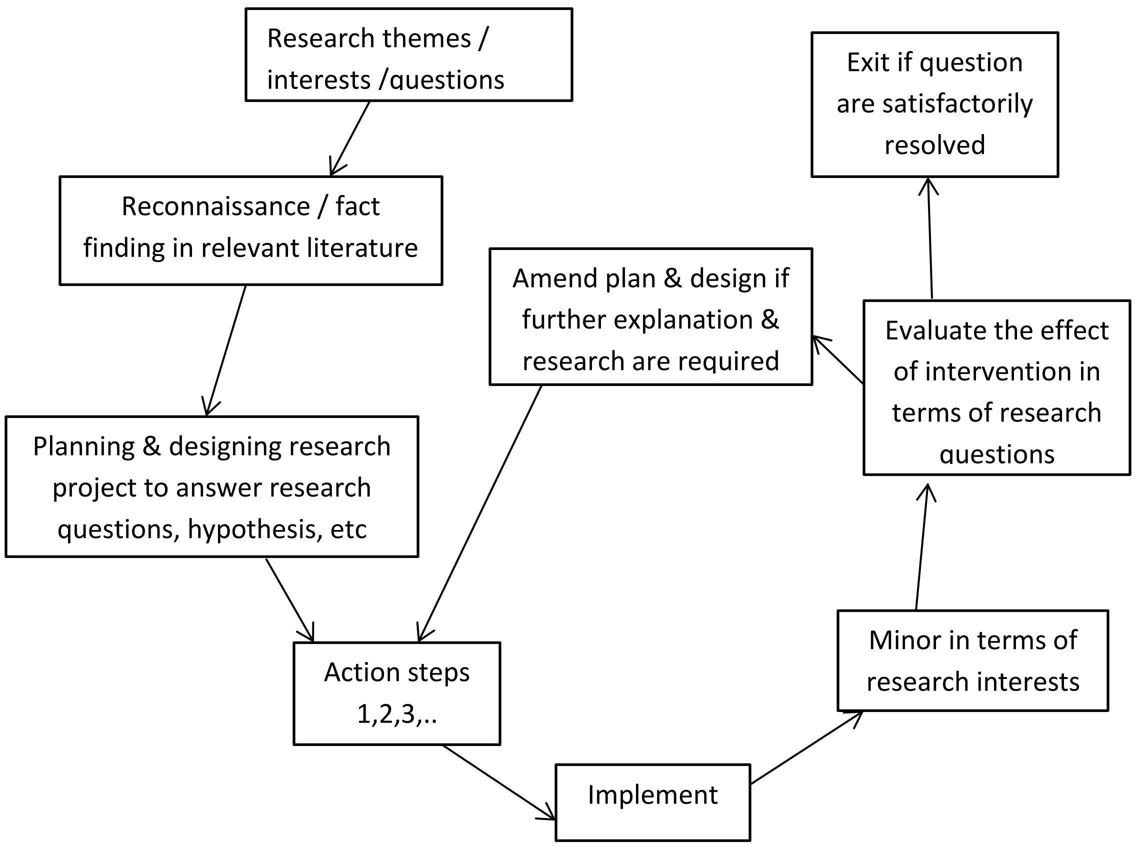

Figure 6: "The reseach interest in action research" (McKay and Marshall, 2001:p.50)

From the diagram above, the researcher has some research interests and questions, which are followed by fact-finding in relevant literature after which planning and designing of the research project is aligned to the interests. The main interest in this project is to evaluate the impact of using distributed healthcare systems in managing patients with chronic ailments. The iteration that follows then pursues to adequately resolve the research questions. The following nine steps (one of them being an iteration to accommodate any desired further change) cycle below represents a problem solving technique, as one of the aims of an action researcher.

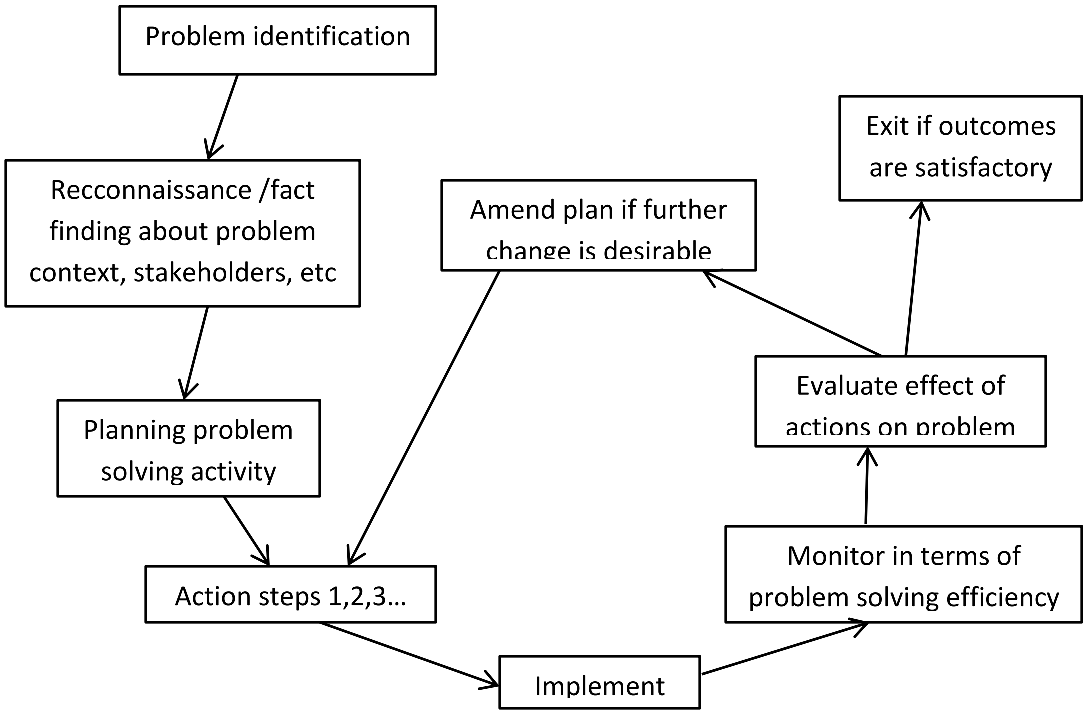

Figure 7: "The problem solving interest in action research"(Mckay and MArshall, 2001: p51)

The following diagram shows an action researcher's research interests and responsibilities beside the problem solving interest. The dual cycle process entails iterations of problem solving combined with research interests with an aim of helping the researcher contribute to knowledge and society.

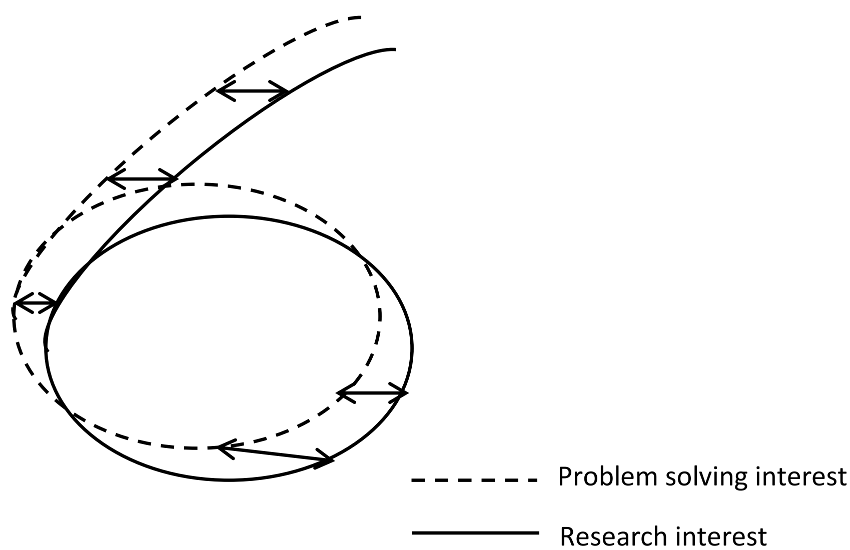

Figure 8: 'Action research viewed as a dual cycle process' (Mckay and MArshall, 2001: p.52)

3.1.2 Strategy

The following action research diagrams illustrate two aims with a common cycle. The cycle has five distinct phases: diagnosing, action planning, action taking, evaluating and specify learning.

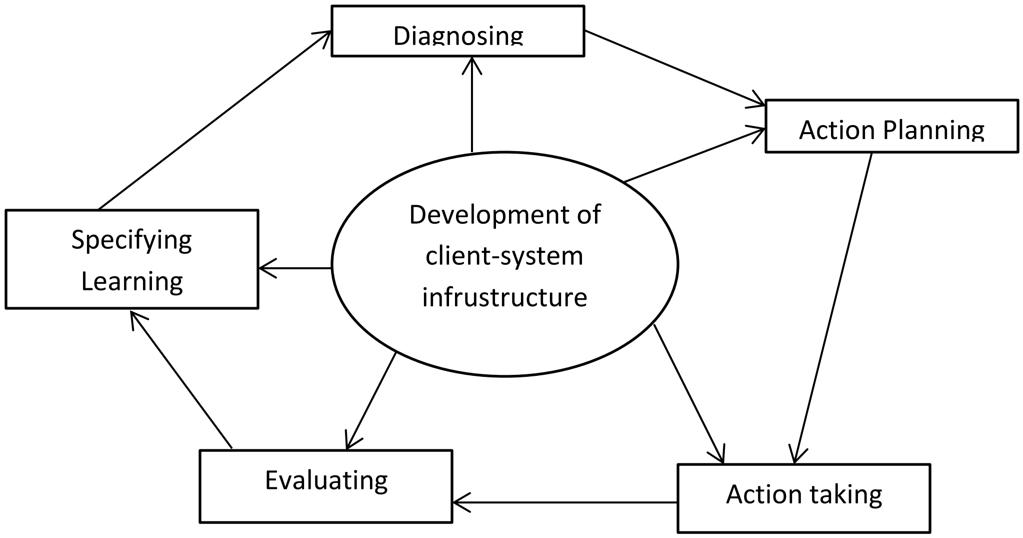

Figure 9: 'Represntations of the action research cycle' (McKay and Marshall, 2001: p.49)

From the figure above, it is clear that the development of a system infrustructure involves an action researcher meeting a client's requirements through the 5 phases.

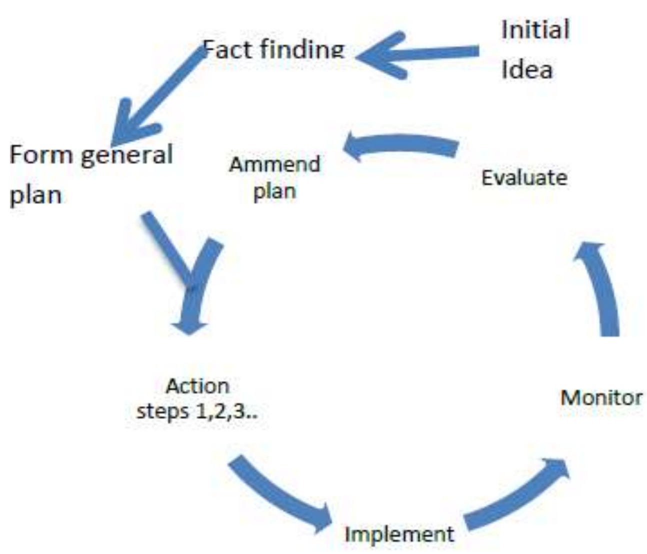

Figure 10: 'Representations of the action research cycle' (McKay and Marshall, 2001: p.49)

The diagram above demonstrates that an action researcher's common cycle involves a diagnostic period and a therapeutic phase, which involves introduction of an action as therapy towards problem solving. The main problem calling for the change is identified at the diagnostic stage. This is followed by the action planning phase where actions intended to bring to bring about a desired state, which is better than the current problematic one, are revealed. After this phase, follows the action taking phase which involves researchers and practitioners'' collaborative implementation of the action's planned to bring about changes that are expected to have some effect (Baskerville 1997, cited in Baskerville 1999, p.15).

Evaluation of the outcomes follows where the effects of the action taken are analyzed. If a positive effect, it must be carefully looked into before a conclusion is drawn that the action, introducing the change, exclusively caused it. If negative, a new framework for the next iteration in action research cycle should be established. The specifying learning activity then follows, upon evaluation completion, where the success or failure of the framework undergoes analysis and critique that contributes to knowledge base for researchers to use in future research (Baskerville 1997, cited in Baskerville, p.15).

A reflection is made on the problem situation falling within the researcher's interest and which can be solved using a particular practical method, on action research as the research method, on the problem situation in which the organization is interested and on the practical problem solving method hence experimental learning or learning from doing (McKay and Marshall, 2001).

In light of above, through diagnostic collaboration, it was established that there exists isolated medical care providers that are geographically separated and that keep data associated with patients with chronic ailments in their facilities. This data if shared could within the various medical care providers could go a great mile in helping bridge gaps especially where patient either voluntarily or by virtue of unavoidable circumstances (e.g. work transfers, etc.) had to change medical care providing centers.

For this to be achieved, a web based distributed system based on a conceptual framework that seeks to achieve accessibility and availability of patient's medical history in a distributed environment, was presented as an action to bring about the change expected to have an effect. This effect was analyzed during the evaluation phase to help determine the success or failure of the framework serving as the basis of the system. Further, as demonstrated in Chapter 4, reflection was made on integrity, security and accessibility of patient's medical history in a web based distributed environment, on the research method used, and on the practical problem solving method used. The realization of the research method's and framework's providence then serves as a basis for the next framework to be used by researchers and practitioners in future problem-solving and research endeavors.

3.1.3 Philosophical Approach

Action research is commonly carried out with a critical theorist ontological assumption. However, this research is based was based on a pragmatist methodology which is a combination of positivist, constructivist and critical approaches. Whereas a concern exists of comparing the status before and after the action completion for a positivist, for constructivist, a concern exists of the kind of views and perceptions participants have towards the change process (Easterbrook et al. 2008). A critical theorist's view assumes that a real problem exists that requires to be solved, that the adopted solution is desirable , and that emphasis is laid on the lessons learnt which will in turn help subsequent researchers who wish to venture into the same field(Easterbrook et al. 2008).

3.1.4 Methodology limitations

Action research has three common threats namely uncontrollability, contingency and subjectivity (Kock, 2004). The first one refers to a scenario where a researcher has incomplete control over the research environment (Kock, 2004). As vision et al. (2001) cited in Kock (2004, p.268) describes, seldom will an organization yield complete authority to an external researcher. This is partly because an action researcher has dual goals as earlier explained.

An action researcher also faces the contingency threat which is the difficulty of generalizing research findings in contexts different the one in which the findings were discovered (Kock, 2004). This could be attributed to the different constructs usually being used by action researchers dynamically based on the nature of the problem and research cycle's outcomes. The subjectivity threat is based on the assumption that personal involvement of an action researcher is likely to persuade him/her interpret the findings in some ways that may lead to incorrect conclusions (Kock, 2004). It is inherent that deep personal involvement of an action researcher has the potential to bias results for it is impossible for the researcher to be in a detached position while at the same time introducing a positive intervention (Kock, 2004)

3.1.5 Remedies to the validity threats

The use of units of analysis, grounded theory, and iterations were implemented as strategies to counter the threats indicated above. Units of analysis are the entities whose reactions or behavior is probed to help in generalization. The more the analysis of several instances of these units in different contexts, the higher the external validity (Kock, 2004).

Grounded theory is specifically used to work against the subjectivity threat by employing a coding process that promotes objective data analysis besides ensuring that different coders will produce the same results (Kock, 2004). The coding process involves identification of variables, links between the variables, and depended variables to which certain effects are associated (Kock, 2004). The variables identified included system's efficiency, system's impact, system's availability among others. This gives the researchers ample time when tracing to present the facts serving as the basis of models and theories.

Iterations are usually used to collect cumulative data about units of analysis in different contexts hence being able to develop evidence gathered from different iterations in the action research cycle (Kock, 2004). In the event that challenges occur, outside the control of the researcher, and that affect data collection and analysis, the researcher always has an option of going through another iteration hence neutralizing the uncontrollability threat (Kock, 2004).

Further, the iterations help in expanding the research scope with an aim of improving on the generality and external validity through identification of invariable patterns hence countering the contingency threat (Kock, 2004). This was a suitable approach in limiting the presence of bias since it allows iterations until research objectives are met. The uncontrollability aspect was countered by termination of research cycle in the event something beyond our control occurred.

Contingency was encountered by provisioning for small units of analysis from the start. Units of analysis that are important or closely related to the earlier ones were identified and examined in the course of the research process. The system, system users and the framework are examples of these units. Subjectivity was encountered by having variables and establishing the relationship between them. These included the system's efficiency, availability, impact, usability and the perception of users regarding the new system and service quality. The expectation was that if the framework was applied successfully, it would positively affect system's efficiency, availability, impact, usability and the users' perception of the new system and service quality. The likelihood of introducing bias was minimized through the use of these variables.

3.1.6 Tools, procedures, data collection and data analysis.

In this project, we collaborated with 15 medical practitioners from three different facilities in the healthcare industry, which is an adequate sample from the large set of healthcare providers in various medical facilities in Kenya. Based on action planning, requirements analysis was achieved using prototyping and open-ended interviews while action taking involved use of continuously developed and modified prototype as the opinions and observations were received from the system users. Additionally, integrated system testing was done to ensure that the system delivered the desired output. The full prototype was subjected to adequate user tests and qualitative and quantitative feedback collected. It was evident that the system made it convenient to develop, update and share information regarding patients between various healthcare facilities.

Regarding evaluation, the feedback was analyzed with a view of determining the effect of the framework and system had on the ease with which healthcare providers could access patients' medical history with the system acting as an instrument of research. This was achieved through participatory observations and user interviews.

Primary data was interrogated in generating useful additional facts on the subject. Interviews, participatory observations, data archival and set up of a quasi-experiment formed our major source of data and data collection methods in developing both quantitative and qualitative data. Further, data analysis was performed through statistical analysis with the help of Microsoft Excel and coding done on the textual data collected through interviews. Qualitative and qualitative analysis approach were employed complementally to improve the research validity.

The suitability of these data collection and data analysis methods was underscored by sample size and their ability to counter research validity threats. They also adapt well with action research approach, which allows development of practical solutions that solve real-world using software development principles, tools and techniques. As later detailed in chapter 4, during the specifying learning stage, outcomes of evaluation were carefully reflected on where a positive effect, about the web based distributed systems in managing patients with chronic ailments, and the applicability of the research was anticipated. It was expected that this outcome would in effect serve as a contribution to knowledge and a basis for the subsequent framework to be used in future in seeking better solutions through research. The system was expected to improve quality of healthcare administered to patients with chronic ailments that would lead to an overall economic growth.

Challenges, recommendations and conclusions have been documented in Chapter 5 to facilitate future research. With a view that this would contribute to use of distributed computing in healthcare and distributed computing in general, techniques and methods used in developing the system to meet the research project's objectives have also been documented.

3.2 Theoretical Framework

As shown in the figure below, the model shows that the quality of healthcare given to patients, especially those with chronic ailments is affected by accessibility of past medical data, the system's usability, system's availability, system's efficiency, and user's perception. It therefore indicated that the Quality of healthcare as service is affected by distribution and accessibility to patient's previous medical data. That was evident from the information gathered from the interviews

Independent variables	Intervening variables	Dependent variables
Data Accessibility, and Distribution	System's availability	Quality of healthcare
	System's usability	
	System's efficiency	
	Users' perception	

Table 1.3: Theoretical Model

3.3 Conceptual Framework

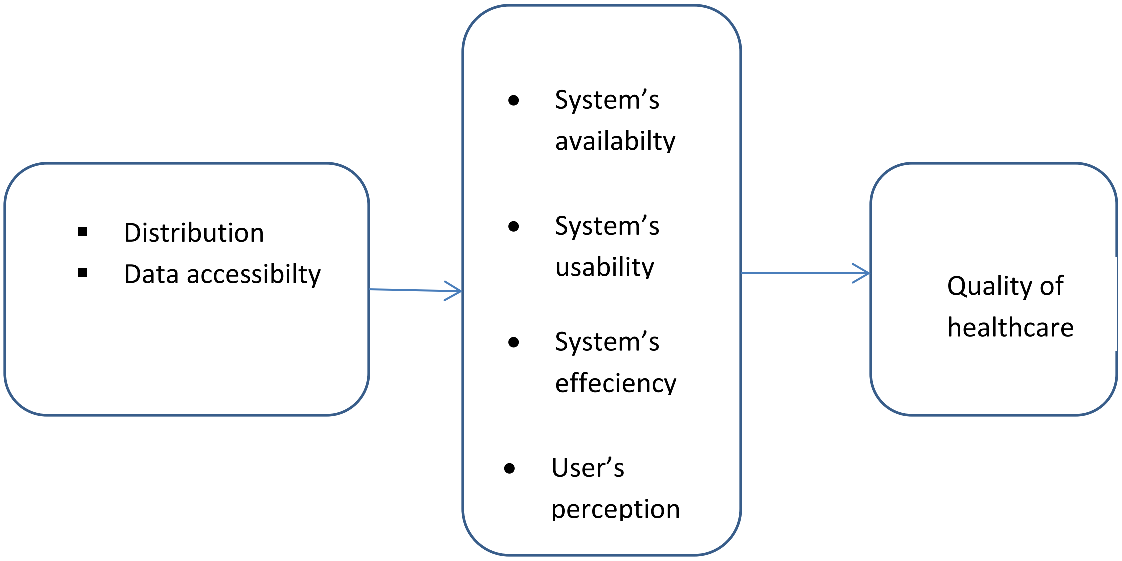

Figure 21: Conceptual Framework

The project succeeded to meet it objectives within the above shown conceptual framework. It was evident that using distributed systems in managing patients with chronic ailments - due to its ability to facilitate accessibility to past medical history for the affected patients – improved the overall quality of healthcare.

CHAPTER 4: SYSTEM DESIGN AND IMPLEMENTATION

In this chapter, high level design and implementation the system will be explained. In the first section, we explain the system requirements and components that have most direct influence on the system. We then describe the tools, libraries and packages that we used to build this application.

4.1 System Design Requirements

4.1.1 System's Functional Requirements

a) The system should allow for creation of individual hospital's own copy including database
b) The system should allow doctors to login
c) The system should allow registration of patients
d) The system should allow entry of patient prescriptions
e) The system should allow for sharing of data with the main database
f) The system should allow for sending of SMS to patients
g) The system should allow sending of confirmation codes via SMS

4.1.2 Non- functional Requirements

a) The systems should be efficient
b) The analysis and presentation of results should be fast
c) The system should be able reliable and available all the time

4.1.3 Hardware and Software requirements

a) Server Operating system for the master database (Linux preferred)
b) Databases for both the master and node systems (MySQL preferred)
c) SSL keys for enabling HTTP security
d) Apache server
e) PHP environment

4.2 System Analysis

A description of the current and proposed system is described at this phase as part of action planning and action taking.

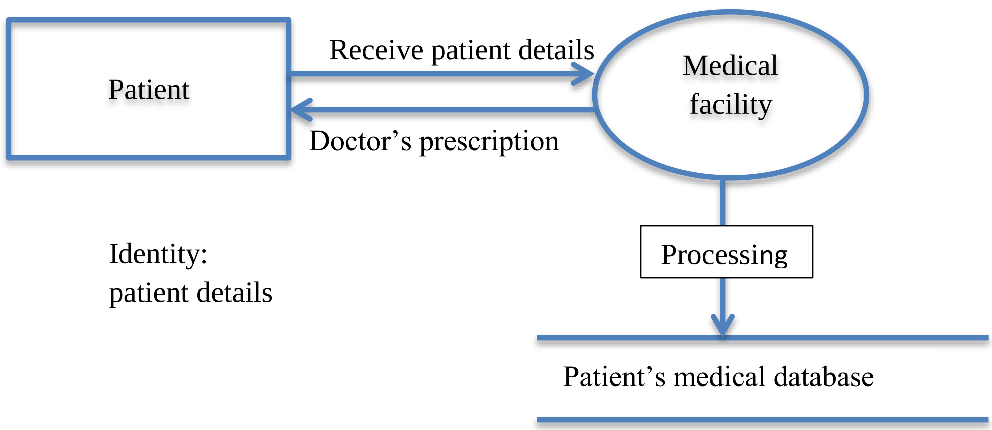

Figure 32: The current system DFD

The data flow diagram above illustrates the flow of documents (Physical aspect of the DFD) and the flow of data (logical aspect of the DFD) into and around the current isolated healthcare information systems. The patient visits a medical facility, provides identification for registration and is taken through various medical tests after which a prescription is issued for collecting drugs for treatment while his/her medical record is kept in local database.

4.2.2 Description of the proposed system.

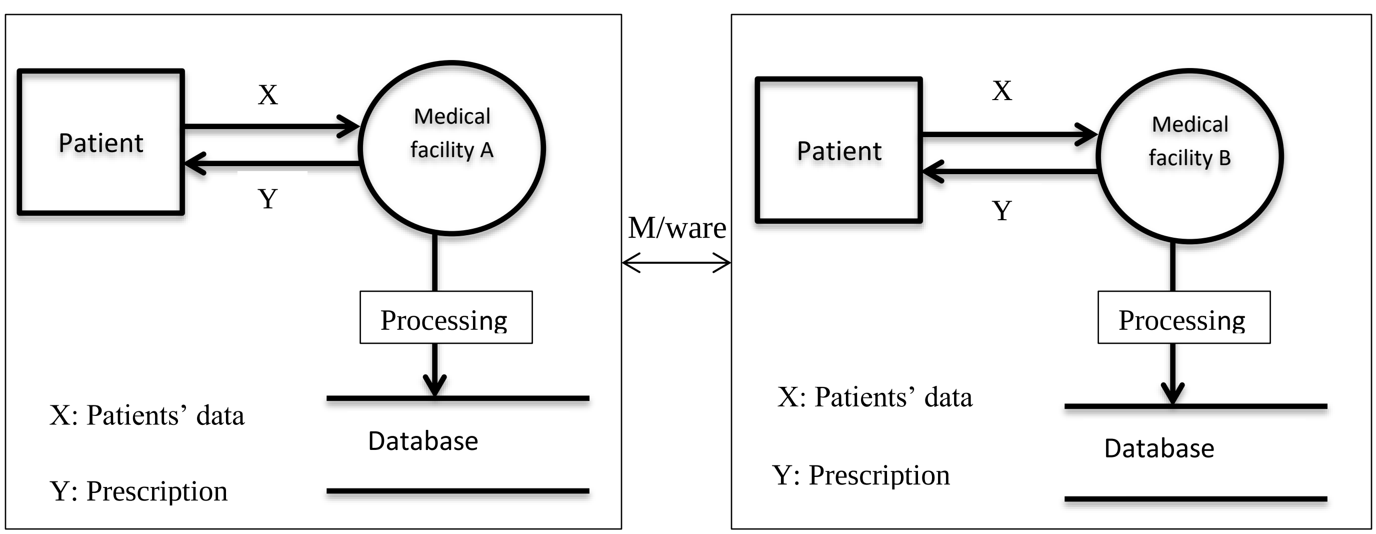

Figure 13: Proposed system DFD

The data flow diagram above depicts the flow of documents (physical aspects of the DFD) and the flow of data (logical aspect of the DFD) within the environment a web-based distributed system. The patient visits a medical facility, identifies himself or herself by providing an identification document. The doctor uses the details to establish if the patient is registered in the shared system.

If the patient is registered, the doctor goes through the patient's medical history searching any useful information. If not registered, the doctor goes ahead to search from peer facilities, a process that is authenticated by entering an sms sent to the patient's mobile phone. The doctor then peruses the patient's medical history searching for information that may be useful in managing the patient.

4.2.3 Functional Requirements.

The proposed distributed system prototype must meet several functional requirements as apart of action taking, as shown below.

a) The system should allow for creation of individual hospital's own copy including database
b) The system should allow doctors to login.
c) The system should allow registration of patients.
d) The system should allow entry of patient prescriptions.
e) The system should allow for sharing of data with the main database.
f) The system should allow for sending of SMS to patients.
g) The system should allow sending of confirmation codes via SMS.

4.2.4 Non-Functional Requirements

a) The systems should be efficient.
b) The analysis and presentation of results should be fast.
c) The system should be able reliable and available all the time.

4.3 Systems Design

This section details the system architecture the distributed database design as part of action taking and action taking. The proposed distributed system's database design is as illustrated below. A simulation of three medical facilities that consists of local databases and data shared through synchronization is as illustrated below.

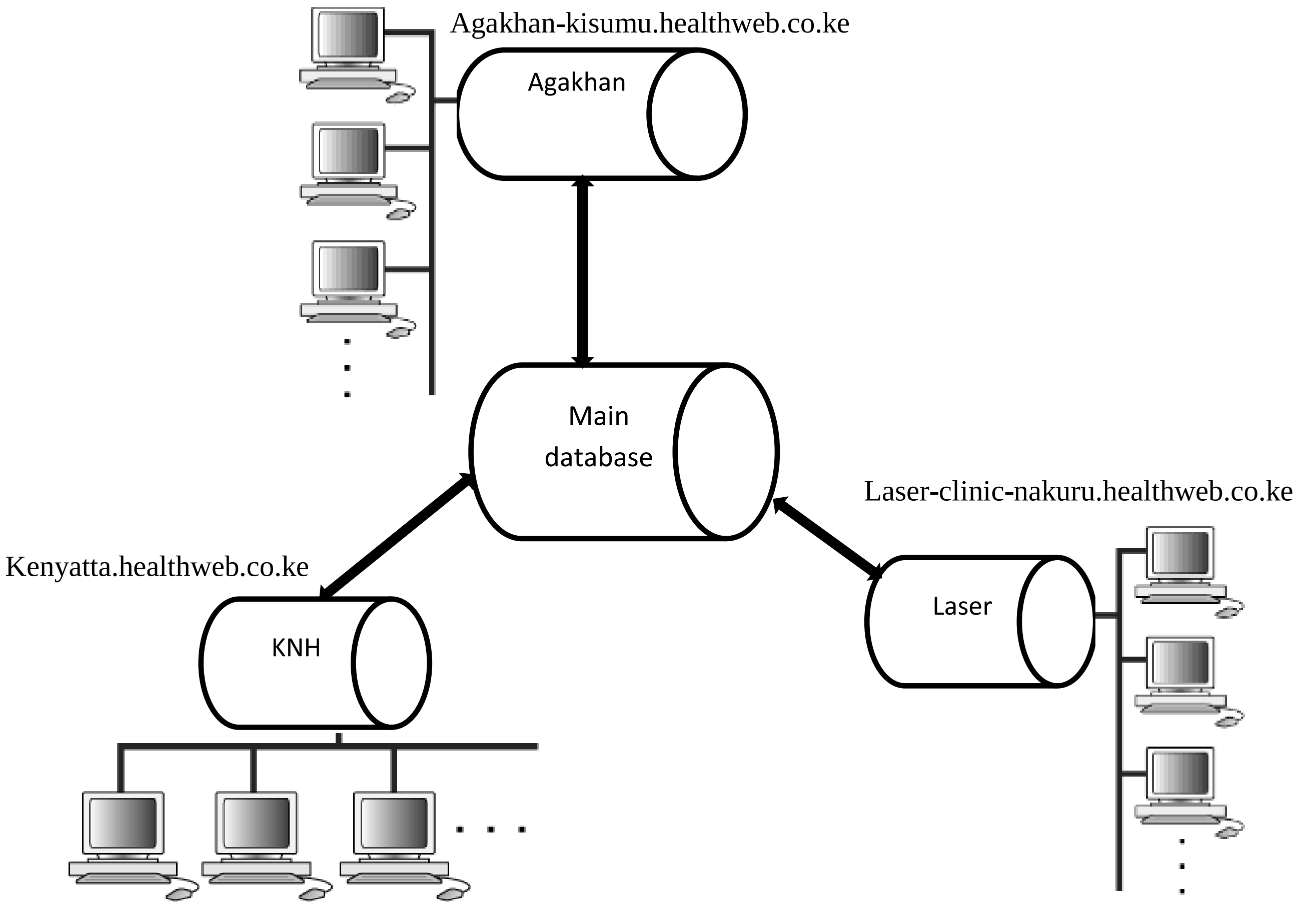

Figure 14:The proposed distributed system's design

4.3.1 Systems Architecture

Many organizations have abandoned centralized databases in favor of the modern distributed databases (in which the database as its name implies is distributed throughout an array of servers in various geographical locations) and for a variety of reasons. A distributed database is a set of databases stored on multiple computers that appears to system applications as a single database. Distribution is important today due to a number of reasons.

a. *Reliability*: Building a system infrastructure is synonymous to investing by way of diversifying in aeefort to reduce your chances of loss. If failure occurs in any one area of the distribution the entire database facility will not experience a total setback.

b. *Security*: Permissions can be given to sections of the database. This offers better internal and external protection.

c. *Cost-effective*: Network bandwidth coosts go down significantly since users will access remote data less frequently.

d. *Local access*: Like (a) above, in case of failure in the umbrella computer network, you still can access your portion of the database system.

e. *Growth*: In case a new location is added to your business, it will be simple to create additional node(s) within the database system making distribution even highly scalable.

f. *Resource efficiency*: Majority of the requests and other activities with the database are performed at a local level thus decreasing remote traffic.

g. *Responsibility & containment*: Considering that any glitches and/or failures occur locally, the issue is contained and can be handled by the IT staff designated to handle that department or section of the company.

The following diagram illustrates a distributed database management systems, architecture with a distributed database. A distributed database is a collection of multiple but logically interrelated databases that are distributed over a computer network. The data is such an environment is physically distributed and essentially stored in multiple computers in a networked infrastructure. The middleware communicated with the distributed nodes through web-services whose implementation is at the peer and middleware levels.

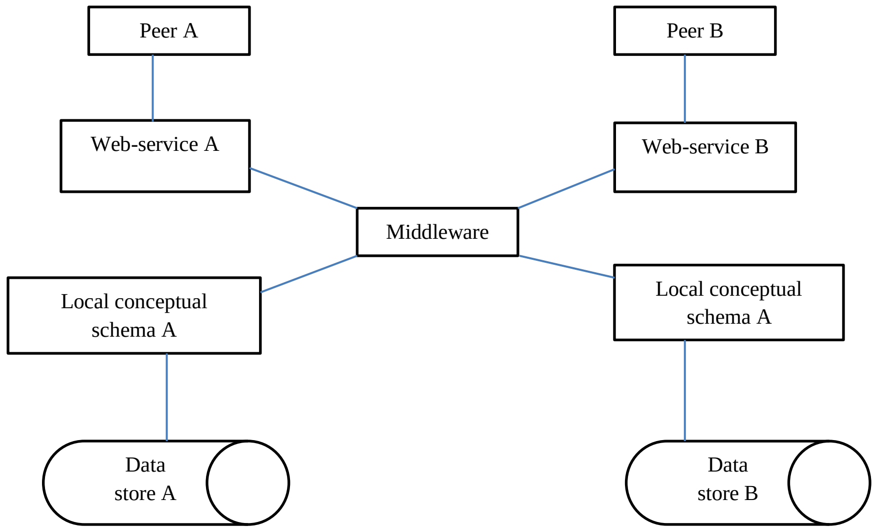

Figure 15: Distibuted system’s architecture

The global conceptual schema describes the logical structure of all the sites and is a combination of all the local conceptual schemas. The local schema is significant since it helps in handling data fragmentation and replication. These schemas provide location, replication, and transparencies in the network infrastructure. This allows users to query data without concern of its location and irrespective of which local component/schema/database will service it.

4.3.2 Distributed Database Design

Distributed database design refers to the following problem: given a database and its workload, how the database should be split and allocated to sites to optimize certain objective function (e.g., to minimize the resource consumption in processing the query workload). There are two issues namely data fragmentation, which determines how the data should be fragmented; and data allocation, which determines how the fragments should be allocated. While these two problems are inter-related, the two issues have traditionally been studied independently, giving rise to a two-phase approach to the design problem. The design problem is applicable when a distributed database system has to be built from scratch. In the case when multiple existing databases are to be integrated (e.g., in multi-database context), there is no design issue.

Data in distributed databases is usually spread across the nodes. Part of this data is fragmented and replicated in distributed sites especially data that is frequently requested to reduce the time it takes to access such data. Data is fragmented for purposes of avoiding unnecessary redundancy. Replication only occurs when it is necessary. With transparency, users will be able to access data without concern of details about its location, fragmentation and replication. Most of the data considered important and frequently accessed is replicated to eliminate single points of failure. This useful strategy is used besides any existing recovery and backup procedures.

4.4 System Implementation

In this section, details about implementation of the system are highlighted, with a keen emphasis on the tasks undertaken to deploy the system. The system was implemented in three parts; frontend or presentational part, backend and API part.

4.4.1 Front End Implementation

HTML 5 and JavaScript libraries were used in the development and implementation of the front end of the prototype.

4.4.2 Application Logic

PHP language through the Laravel framework was used for the backend. This provides the access to various logics, connections to databases and implementation to the API.

4.4.3 Backend Module

MySQL database was used to implement backend objects, which include tables, relationships, constraints and sequences.

4.5 System's Business Logic

4.5.1 Introduction

The system is installed at each medical center and a connection made to the master database for synchronizing data. The master data stores all the data but a node system must request authorization from a patient to access data that belongs to another node. The following use cases and architectures demonstrate how the master system and its node systems interact.

4.5.2 Doctor Use Case

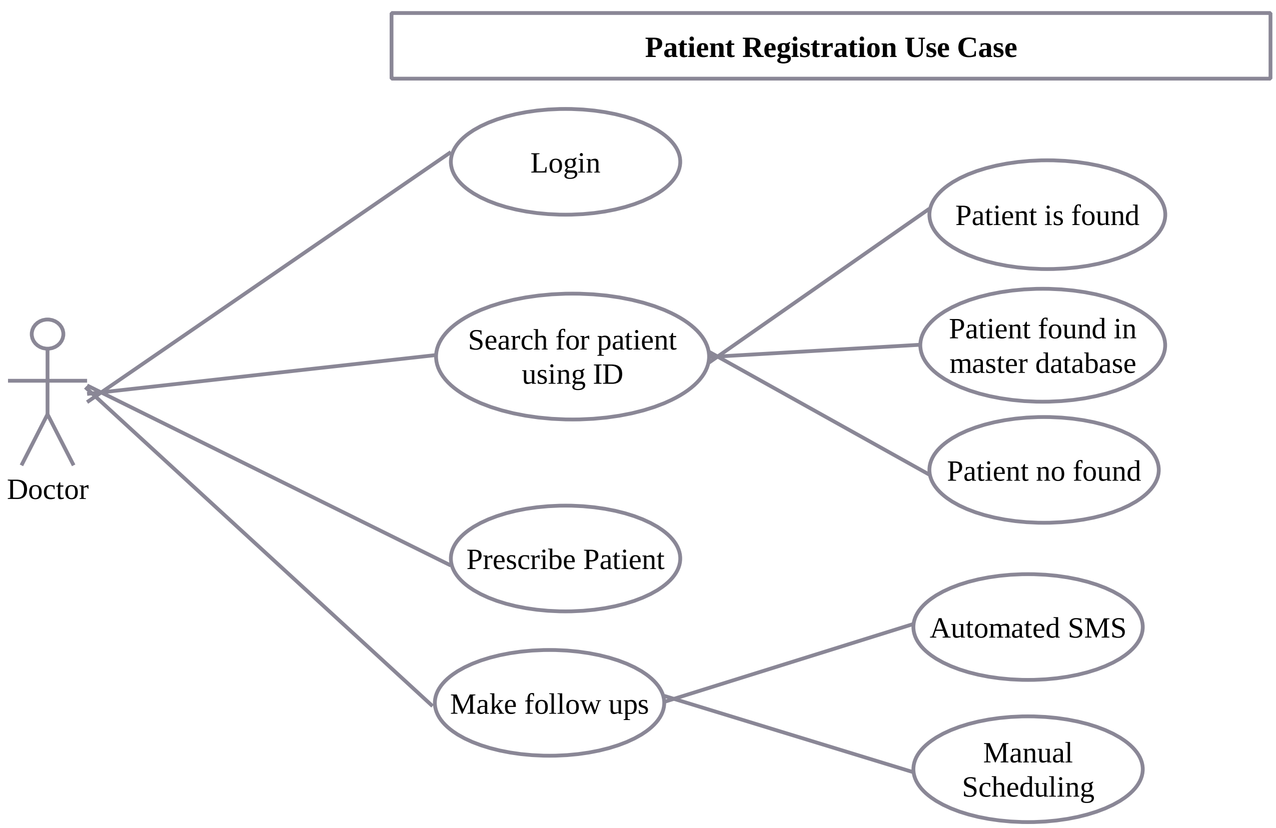

Figure 46: Doctor's use case

The doctor logins into the system presents names for searching. If the patient is not found, the doctor can go ahead and register the patient.

If the doctor presents the patient's identification such as ID number or passport number, if the patient is not found in the local database, the system through the API extends the search to the main database. If the patient is found in the main database, a notice is displayed to the doctor asking them if they are okay to start the data sharing process. If the doctor continues, an authorization code is sent to the patient's phone. The patient can then proceed to enter the code into the prompt to complete the process of data sharing and synchronization.

When the code matches, patient's data is synchronized and made available to the current node system. If the patient does not have a phone or is in a state they can't communicated, the doctor can invoke the system to send the authorization code to a third part person whom the patient had presented as the next of kin

4.5.2 Patient's Use Case

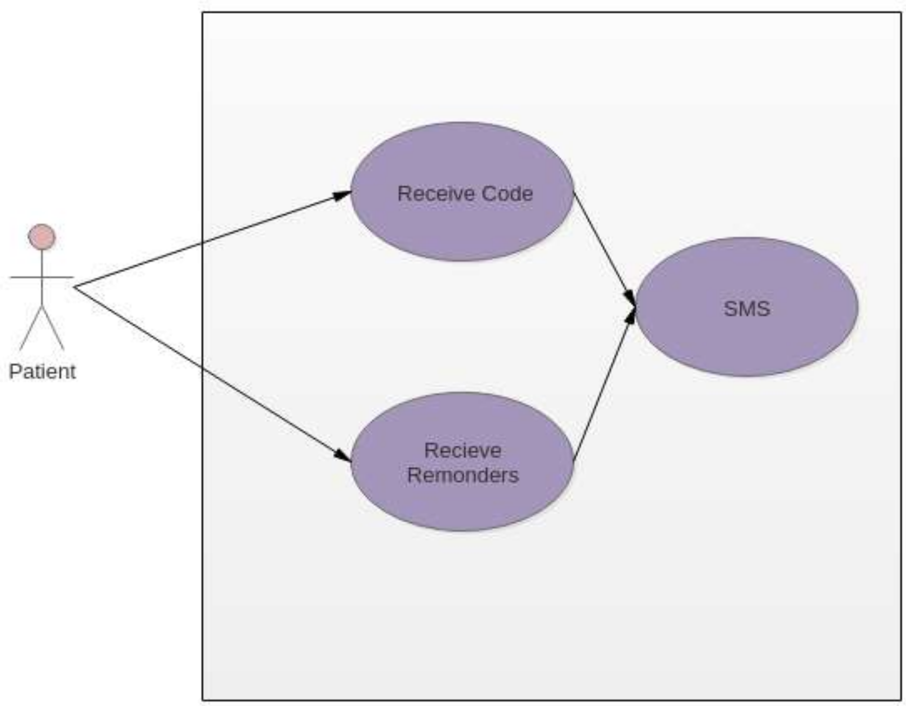

Figure 5: Patient's use case

The patient will receive the authorization code, provide it to the doctor. The doctor will then use the code to input into the system to facilitate data synchronization. The patient also receives SMS notes notification either for appointment reminders of reminders to take medication at a particular time.

4.5.2 System Flow

The above two use cases can be simplified in one architectural flow as show in the diagram below.

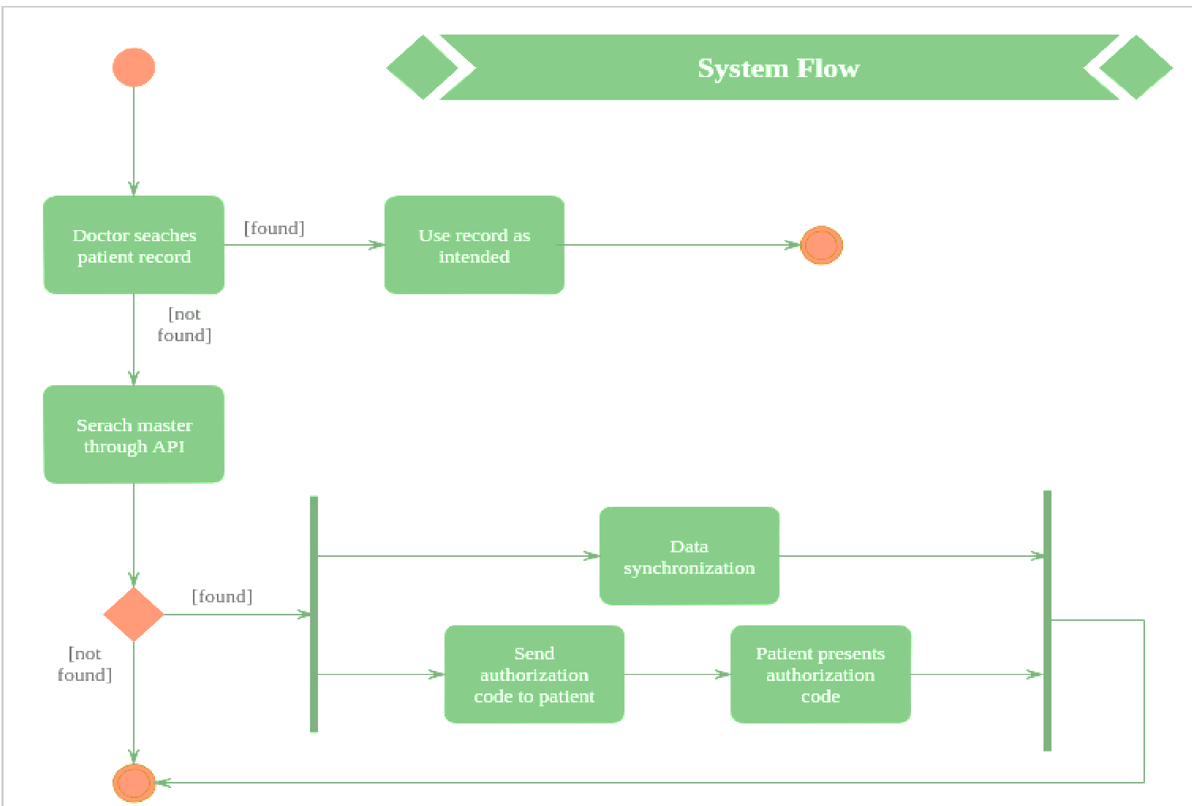

Figure 6: System flow Chart

The interface above has been implemented using PHP. After filling in all the required fields, the doctor clicks register. An Internet connection is required in deploying the prototype. A representation of the code can be found in the appendices section.

4.5.3 Pseudocode

The pseudo code for searching patient in the system is given below;

```
PROGRAM SearchPatient:

        enter patient's name on search bar

        IF(patient is found on the local database)

           Display Patient's Data

        ELSE IF(patient is found on the master database)

           EXECUTE AuthorizeData:

      ELSE

          Create Patient's Record on Local Database

END

PROGRAM AuthorizeData:
        IF(Patient has Phone)

                Send Authorization code via SMS
                Read Authorization code into system

                EXECUTE ProcessAuthorization:

        ELSE IF(Patient is with next of kin)
                Send Authorization code to kin's phone via SMS
                Read Authorization code into system

                EXECUTE processAuthorization:
        ELSE
                Request code to be generated from the Hospital Holding the Patient's Data
END
PROGRAM ProcessAuthorization

        If(code matches)
                Sync data from master database
                Display synced data
        ELSE
                Repeat the authorization process again
END
```

4.6 Data Integrity and Concurrence

The main database maintains integrity of the data across all the nodes. This means that, if a patient's data appears across two or more node systems, the main database does synchronization of and updates the missing data instead of creating a new record. In this case, the patient's identification is used as a unique identifier across all node systems.

The system also uses A Universally Unique IDentifier (UUID) algorithm to generate primary keys for the records. The UUID's ensure that each node system will generate a unique primary key for each record, such that when the data is synced to the main database, it does not cause key integrity issues.

4.6.1 System set-up

- Set up Ubuntu server & Install and configure Apache server
- Install MySQL server
- Installation PHP on Ubuntu server
- Configure virtual hosts on Ubuntu server
- Install the system codes using GIT and Run migration

CHAPTER 5: RESULTS AND DISCUSSION

5.1 Data collection

Performance evaluation of the prototype through a quasi-experiment was done and the results from its use collected for analysis to establish its contribution towards healthcare services quality. Archived data and participatory observation methods were used to complement the experiment in data collection. Evaluation before and after the introduction of the action was achieved through pre-test and post-test data collection.

5.1.1 Pre-test data collection

Interviews and data archival methods were employed to collect both quantitative and qualitative data. It was noted that 16 out of 45 patients' previous medical with chronic ailments attended to in a month could not be accessed and hence doctors had to entirely rely on information that patients could provide. Archived records revealed that the trend was similar in most cases for the previous months.

Day	No. of patients with chronic ailments	Previous medical exists	Medical record accessible	Medical record NOT accessible
1	11	8	5	3
2	7	5	2	3
3	8	3	2	1
4	14	10	7	3
5	5	5	5	0
6	7	6	2	4
7	10	7	3	4
8	15	11	8	3
9	9	7	5	2
10	12	9	6	3

Table 1.1: Pre-test sample data

From the above data, the range of patients' whose medical data exists but could not be accessed is 4 while the median is 3. From the table above, a bar graph was plotted using data for patients' whose previous medical data exists and compared against those whose previous medical records exists but could not be found.

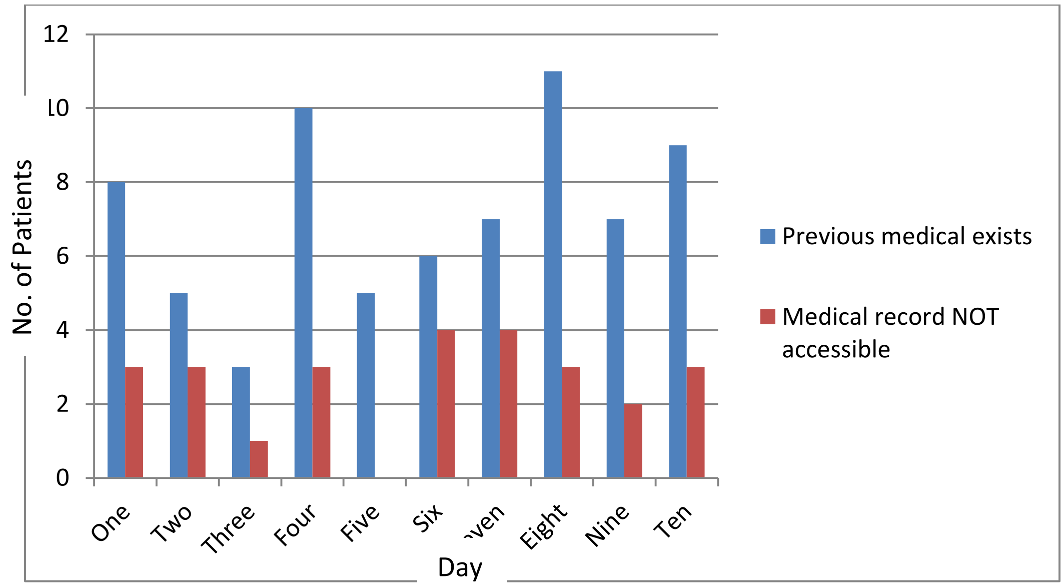

Figure 19: Pre-test distribution

The questions that were asked during the interview can be found in the appendices. Here are some of them.

- “Kindly explain challenges faced when managing patients with chronic ailments, list them?”
- “What are some of the main reasons that cause the above challenges?”
- “What is your opinion(s) regarding the challenges you have mentioned?”
- “How frequent do the challenges occur and explain how you handle the situation whenever it happens?”
- “How do patients react whenever access to their previous medical history is not accessible and some sometimes are prescribed with drugs that have failed before?”

The questions were answered as follows:

- “The patients need constant monitoring which sometimes in not possible. Sometime we lose track of our patients and therefore miss out on follow-up. Another main issue is lack of their previous medical data, especially if they had been attended to in other facilities”

- “The loss of follow up is mainly due to the fact that some patients end up changing medical facilities. We fail to access previous medical data due to the fact that some of our patients may have previously been treated in facilities whose data we cannot access ”
- “It be better if a facility that would help facilities dealing with such patients are able to access and share patients’ medical data ”
- “Quit often, such cases do occur almost on daily basis. Usually, whenever we can cant access previous data, a new record is created in our facility”
- “Patients get disappointed and at time feel like we are not keen with their conditions.”

From observation, doctors anticipated cases of handling patients whose previous medical records could not be access, simply because some could be visiting their facility for the first time.

5.1.2 Post-test data collection

As part of post-test data collection, data archival methods and interviewing were used to gather both quantitative and qualitative data. Different numbers of dummy patients were created on the system for purposes of testing accessibility and availability of such data among a month 3 dummy healthcare facilities. It was found that if records were accurately captured on the system, such information was available to any of the 3 facilities, 0 patients’ previous medical history lacked accessibility.

Day	No. of patients with chronic ailments	Previous medical exists	Medical record accessible	Medical record NOT accessible
1	10	8	8	0
2	8	6	6	0
3	7	3	3	0
4	9	5	5	0
5	8	7	7	0

Table 1.2: Post test sample data

From the above table, it was evident that as long as previous medical record existed, accessibility was guaranteed and this eliminated cases of where doctors had rely on the patients’ recollection regarding their previous medical history. We therefore encourage and recommend its adoption especially in the government and non-governmental agencies that deal with such patients.

Some of the questions asked during the post-test interview were:

- “From your experience, describe your interaction with the system…”
- “Would you recommend the system to any other organisation and why?”
- “Do you encounter any hitch when interacting with your terminal?”
- “How long does it take to register a new patient or search for patient’s data locally and in other sister facilities?”

Their general responses to these questions were as follows:-

- “Very impressive, especially the fact that it was easy to register and retrieve a patient’s medical record irrespective of the facility they were attended at. The fact that it uses sms sent to patients for access to record kept in peer facilities make it significantly secure.”
- “Yes, definitely. I will”
- “None at all, as long as my Internet connection is sound”

“It takes approximately 3 minutes to register a patient and about 2 minutes to access medical records in sister facilities”

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION.

From the results obtained, it evident that sharing of patients' previous medical history has a **positive impact** on the quality of healthcare patients receive whenever they visit medical facilities for treatment especially those suffering from chronic ailments. The use of web based distributed system to facilitate the access and availability of this data as demonstrated in Chapters 3, 4 and 5: Research on the use of web-based distributed systems in healthcare was done; studied the use of openMRS, and reviewed papers that underscored the importance of sharing medical data, especially for patients with chronic ailments, who may move from place to place. web-based distributed health information system prototype was developed; as demonstrated in chapter 4. The system prototype was tested, evaluated as shown in Chapter 5. The results were analysed & findings interpreted as shown in Chapter 5.

6.2 RECOMMENDATION.

Further research in the use of blockchain technology, its successes in bitcoin is recommend as an emerging technology and especially how it can be used in development and deployment of healthcare systems that can be employed to help manage patients with chronic ailments in Kenya and Africa in general.

6.2.1 Blockchain in Healthcare.

Blockchain seems to be showing up everywhere online as the answer to prevent hospital ransomware attacks and the critical technology to create pervasive electronic health records to streamline healthcare, improve quality, and save billions. It is conceivable to imagine of blockchain in healthcare by thinking back to a world where IBM System computers by an collection of serial RS-232 cables and an unknown assortment of custom cables with pin-outs. Not only were there a variety of cables, but communications over these cables followed an alphabet soup of protocols. These interfaces, cables, and communications protocols became much more streamlined with the introduction of TCP/IP. Considering this elementary foundation, it is possible to understand the excitement of a blockchain connected world (Bukstel, 2011).

6.2.2 Blockchain Solves the Master Patient Identifier Problem

Not only is the blockchain way beyond pretty good privacy presented by today's healthcare information systems, but also the very nature of blockchain incorporates the comparable of a Master Patient Identifier. This in esssnce means every person on the globe will ultimately have a unique identifier sometime in future. That unique identifier can be regarded as one of the very large prime numbers that created the stack of paper to the moon. With this "Private Key" one can unlock the multiplication result by simple division, which, hypothetically opens up the health records contained on the blockchain backbone. 'Imagine suddenly visualizing binary code flying all around. If you have a Chrome Extension that allows your browser to view blockchain, you and your service provider can actually view your medical record, your real estate holdings, and every temperature reading from your Nest thermostat" (Bukstel, 2011).

6.2.3 Barriers in the current healthcare system to implementing blockchain.

The biggest barrier to the introduction of any new technology no matter how "disruptive" is inertia, and Health System that do don respond or adapt quickly. Fundamentally, requirements for blockchain adoption is the use of a Unique Patient Identifier, or one of those really big prime numbers. Imagine Cerner or Epic modifying their respective systems to hold a "representation" of this patient identifier. When you go to the ambulatory Magnetic Resonanse Imaging center, for a diagnostic procedure, there is no interface with Cerner or Epic, the result simply gets shot out into the Internet using blockchain as its carrier. The prescription is written to the blockchain with your personal identifier. The blockchains flying around the Internet and are checked constantly for errors, some of the error checking will incorporate a notation that the drug prescribed has an adverse interaction with the drug prescribed at another healthcare facility. Data from your social media sites regarding health conditions will also be found in your blockchain. The autocorrecting nature of the blockchain should ensure a correct record is always available upon request, anywhere in the world (Bukstel, 2011).

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BUDGET

Estimated costs in this project are as indicted below.

	Item	Cost
1.	2 Computers	Ksh. 75000
2.	Printers	Ksh. 15000
3.	Routers	Ksh. 5000
4.	Internet connection	Ksh. 5000
5.	Printing costs	Ksh. 1500
6.	Binding	Ksh. 350
7.	Photocopying expenses	Ksh. 700
8.	Training costs	Ksh.7500
9.	Travelling	Ksh. 4500
10.	Miscellaneous	Ksh. 8000

APPENDIX I: PRE-TEST INTERVIEW

1. Kindly explain challenges faced when managing patients with chronic ailments, list them?
2. What are some of the main reasons that cause the above challenges?
3. What is your opinion(s) regarding the challenges you have mentioned?
4. How frequent do the challenges occur and explain how you handle the situation whenever it happens?
5. Kindly describe the perception created when such challenges occur.
6. Please explain any lessons learnt from such an experience.
7. Are there any measures that have put in place to solve such challenges? If there are any, kindly explain how effective the have been.
8. How do patients react whenever access to their previous medical history is not possible and some sometimes are prescribed with drugs that have failed before?
9. Does failure to access patients' previous medical data affect the quality of healthcare given?
10. How many patients with chronic ailments on average do you handle in a week that lack previous treatment data? How hard or easy is it to deal with the situation?
11. What do you foresee happening if the current trend continues for the next 5 years?
12. What do you think is the solution to the current situation?
13. Who is greatly impacted whenever the patients' previous medical data is not accessible?
14. Do you know of other alternatives that be employed to solve the current situation?
15. Given the choice, how soon would you prefer to have the solution to accessing patient's previous medical data, irrespective of the facility in which they were attended?

APPENDIX II: POST-TEST INTERVIEW

- From your experience, describe your interaction with the system…
- Would you recommend the system to any other organisation and why?
- Do you encounter any hitch when interacting with your terminal?
- How long does it take to register a new patient or search for patient's data locally and in other sister facilities?
- How easy or hard is to commit a mistake during data entry?
- What is the possibility of accessing a patient's medical history without the customer's consent?
- Please describe the level of accuracy in the system…
- Does the system now affect the way you handle patient's whose previous medical data is held in other healthcare facilities?
- How many patients' record have you been able to access especially those whose previous medical data is held in other facilities?
- How would you generally rate the system? Has it offered any significant help?
- Please describe your opinions about the system as a whole and the role it has played in solving the problem of managing patients with chronic ailments.
- What impact will the continued use of the new system create in 5 years' time?
- What are the merits and demerits of using the system if any?
- What is your general opinion about the quality of service offered through the use of the system?

APPENDIX III: RESEARCH REQUEST COVER LETTER

Morris Murimi Onduko

P.O. Box 39513-00623, Forest Rd, Nairobi
Phone: +254723 450496 | Email: monduko@hotmail.com

August 25, 2016

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

REF: <u>USE OF DISTRIBUTED SYSTEMS TO MANAGE CHRONIC AILMENTS</u>

I am writing to humbly request for an opportunity to collaborate with you on my research project that seeks to investigate the impact of using distributed systems to manage patients with chronic ailments developed for use by providers handling such patients with Kenya. I am systems administrator and currently pursuing a Master’s degree at the University of Nairobi.

Herewith attached, please find updated copies of my CV and detailed project document for your perusal. Feel free to get in touch with me through any of the contacts listed above for any clarification or assistance. I will appreciate if I will receive your response by 15th September 2016.

The opportunity to evaluate with you the impact and how its strengths can best serve your organization is highly welcome.

Yours Faithfully,

Morris Murimi Onduko

APPENDIX IV: DOCTOR’S INTERFACES AND THE MIDDLEWARE INVOCATION CLASSES.

Doctor’s login interface: Below is the screenshot taken from the doctor’s login page. The code used to implement it can be found in the appendices V.

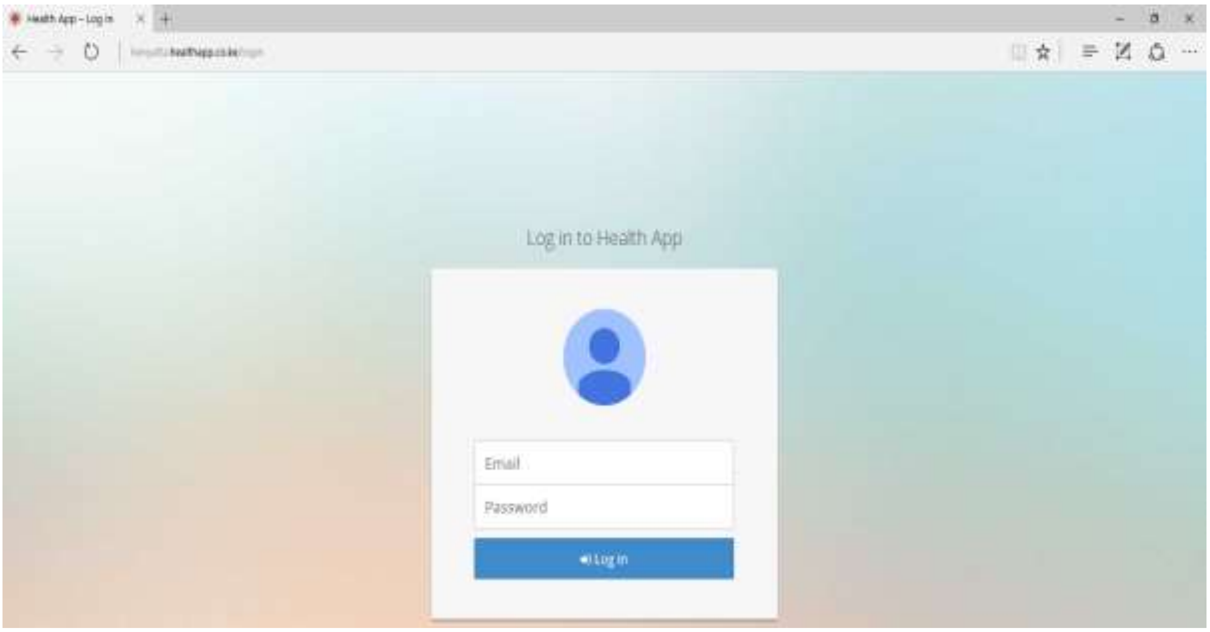


Figure 7: Prototype’s log-in page

New patient’s registration interface

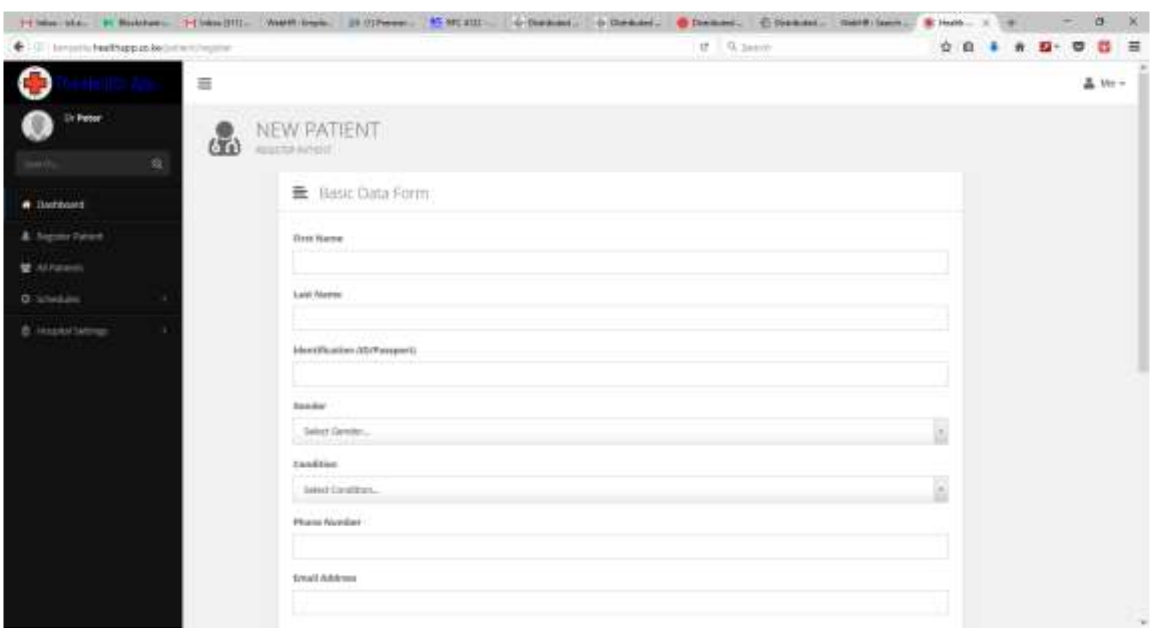


Figure 8: New patient’s registration form, part 1

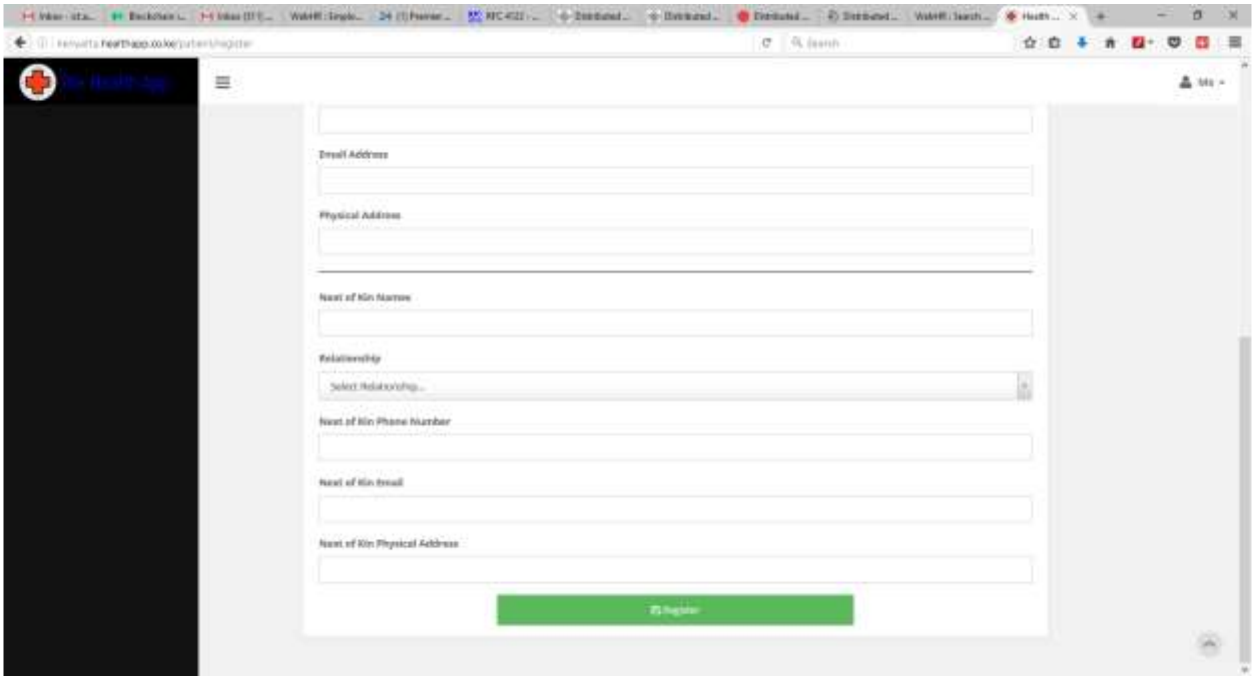
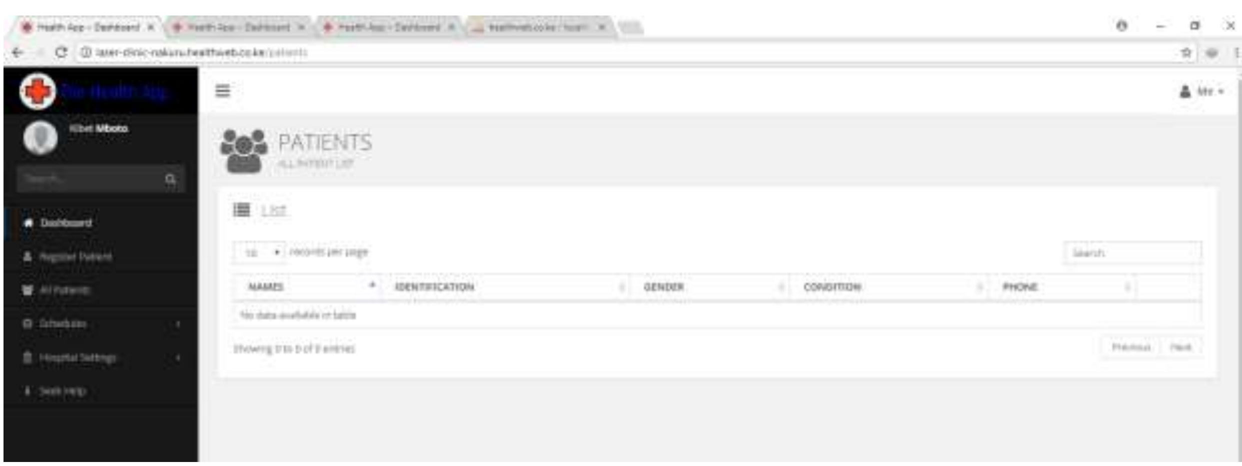
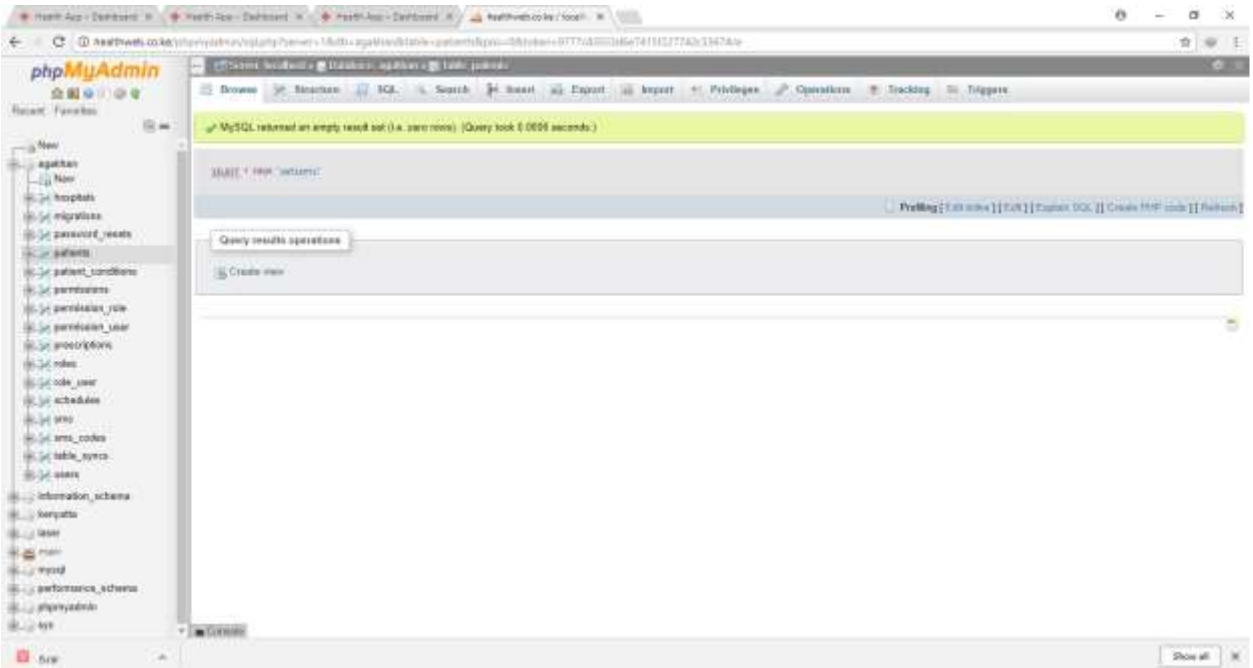
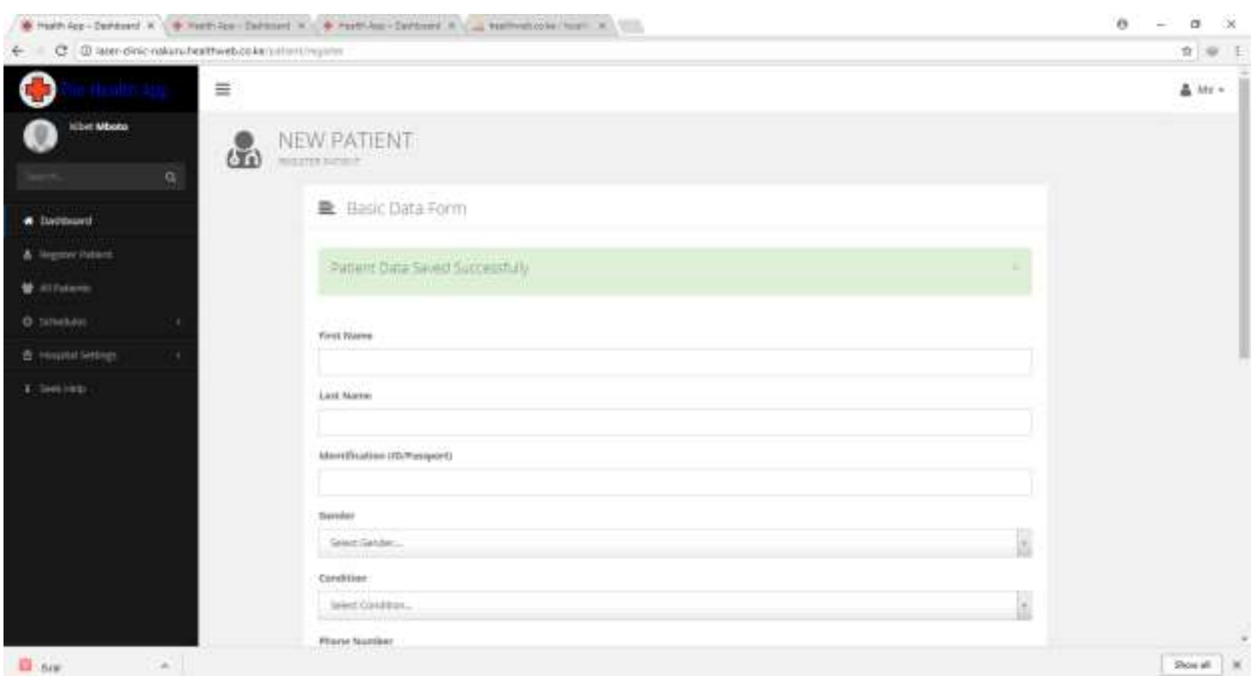


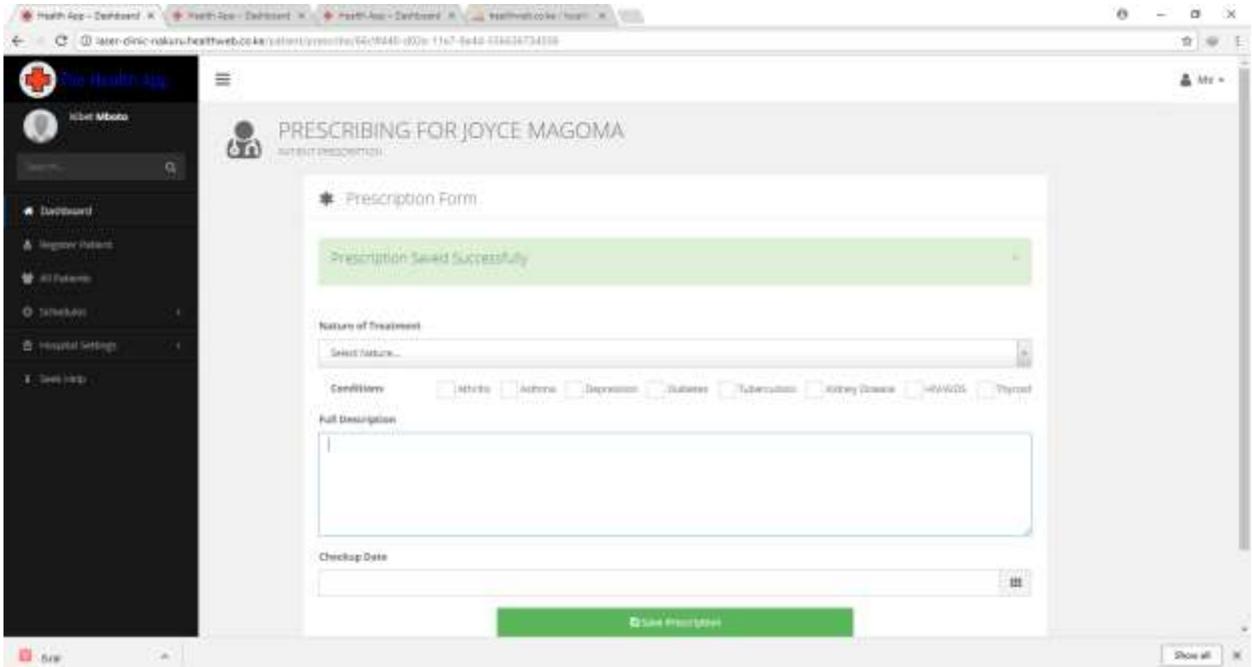
Figure 9: New patient’s registration form, part 2

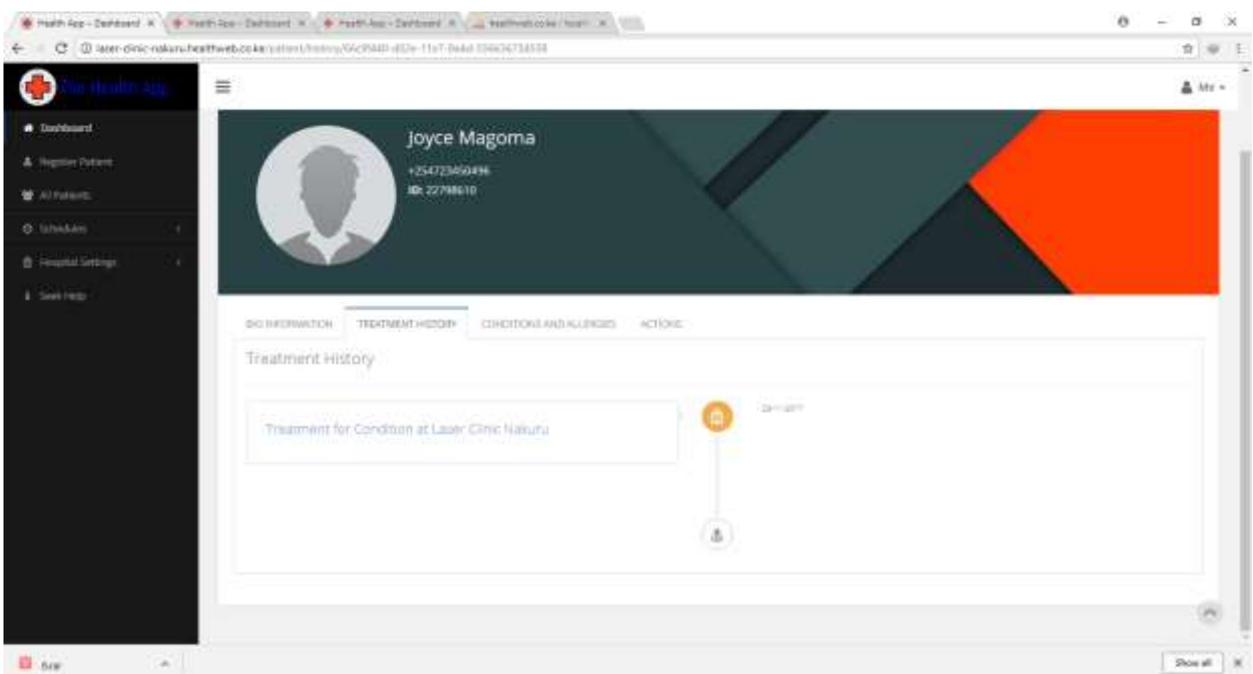
The following screenshots show a scenario where no patient has been registered in any of the three dummy facilities and blank backend databases. One dummy patient ‘Joyce Magoma’ is then registered in one facility and a prescription done for her. The data is automatically replicated in the main database. The other peer facility databases, through random mobile sms aunthetication, are consequently able to access the data via the main database.

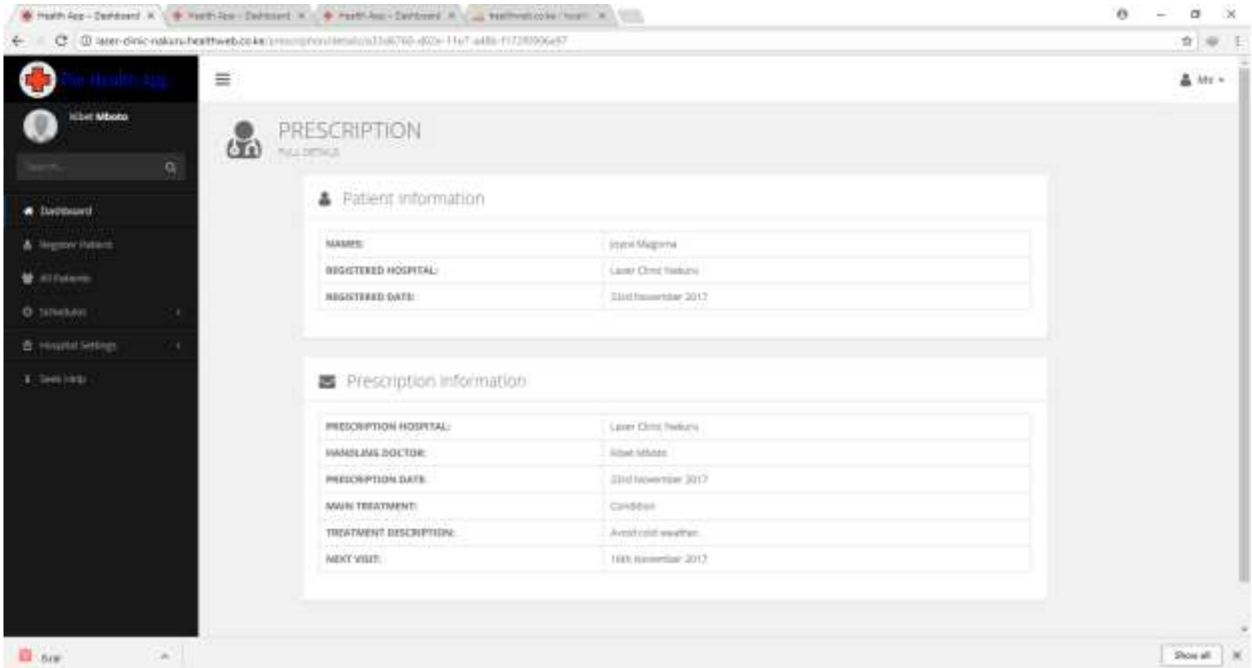


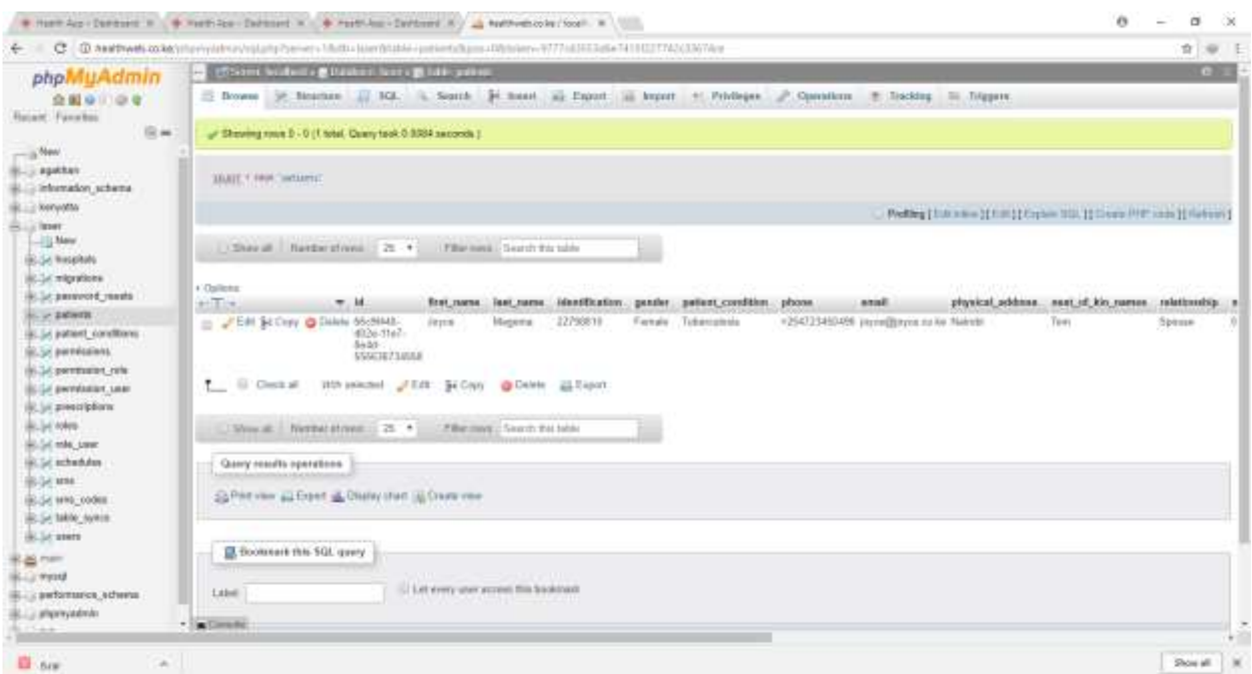

phpMyAdmin
MySQL returned an empty result set (i.e. zero rows).
Query results operations
Create view

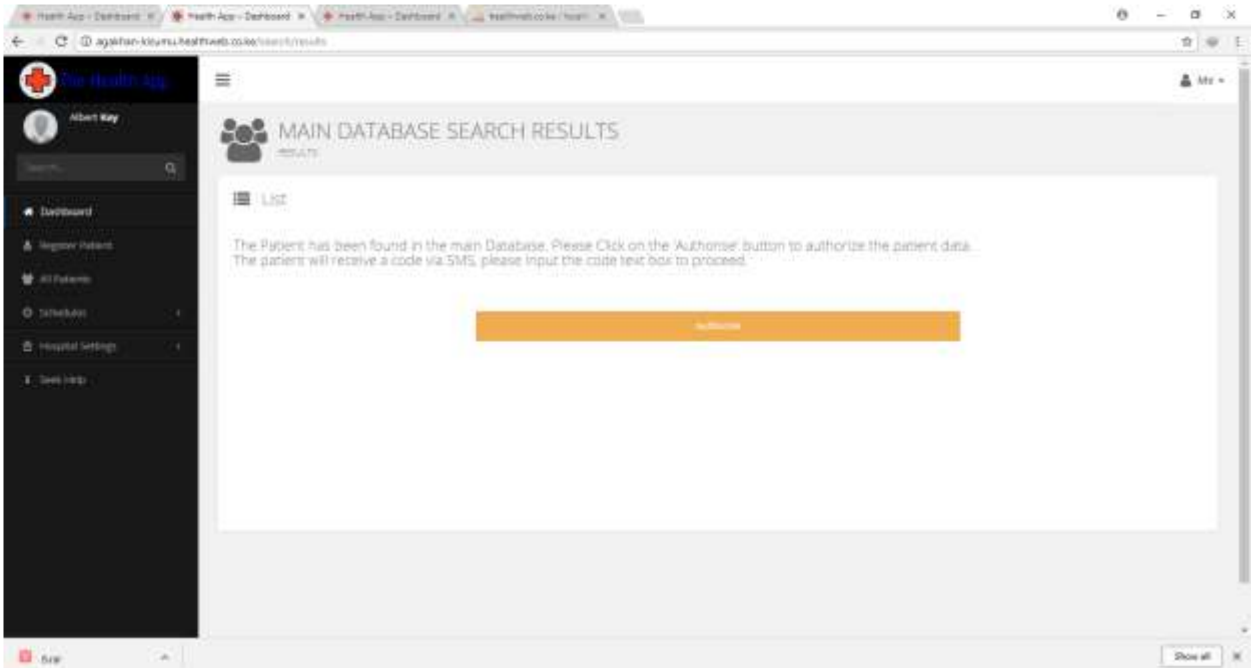

NEW PATIENT
Basic Data Form
Patient Data Saved Successfully
First Name
Last Name
Identification (ID/Passport)
Gender
Condition
Phone Number

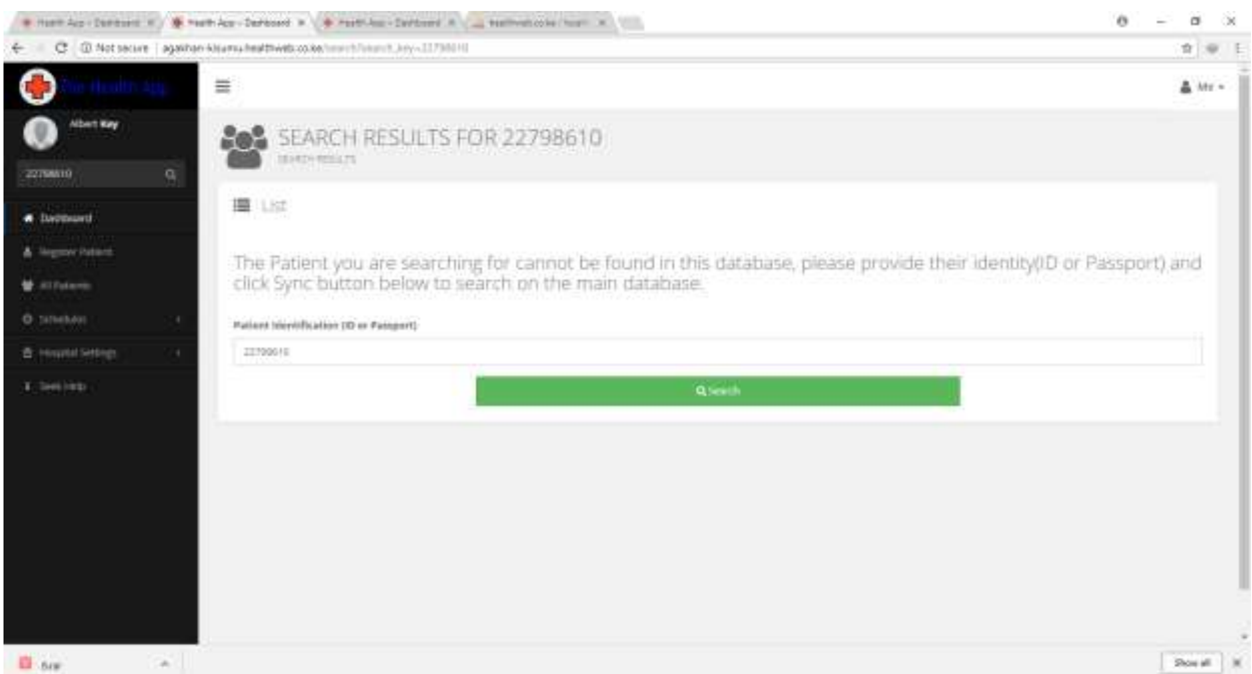

PRESCRIBING FOR JOYCE MAGOMA
Prescription Form
Prescription Saved Successfully
Nature of Treatment
Conditions
Full Description
Checkup Date

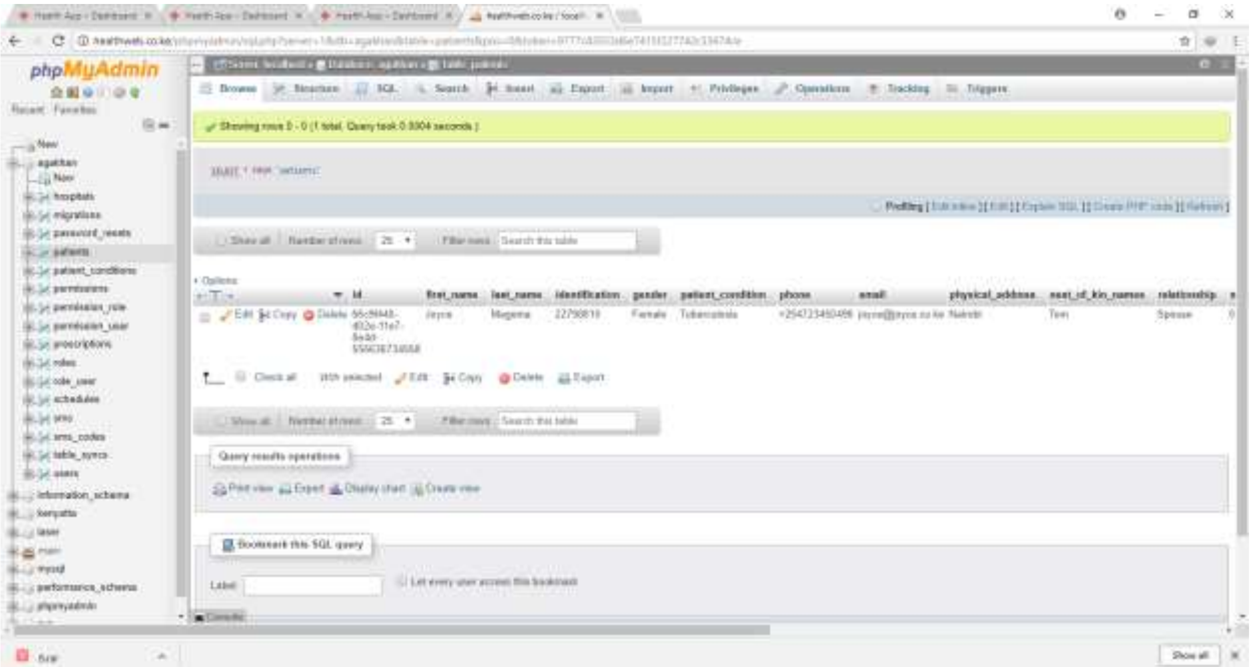

Joyce Magoma
Treatment History
Treatment for Condition at Laser Clinic Nakuru

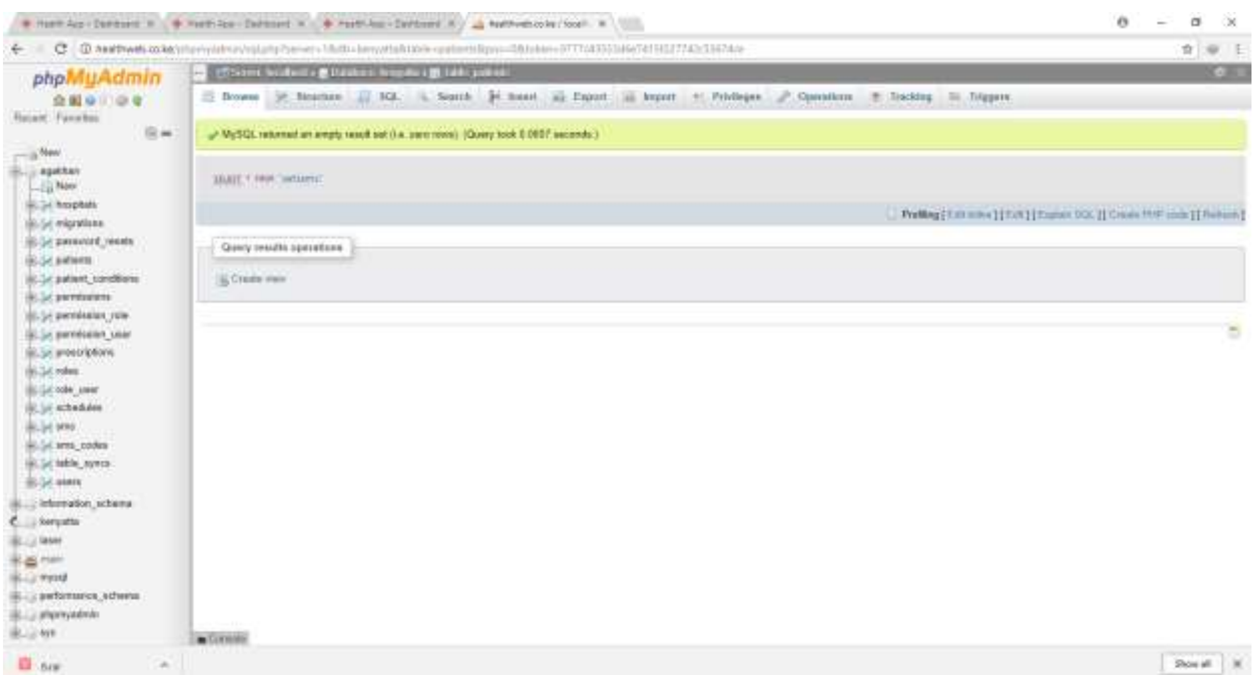

PRESCRIPTION
Patient information
NAMES:
REGISTERED HOSPITAL:
REGISTERED DATE:
Prescription information
PRESCRIPTION HOSPITAL:
HANDLING DOCTOR:
PRESCRIPTION DATE:
MAIN TREATMENT:
TREATMENT DESCRIPTION:
NEXT VISIT:


phpMyAdmin
Browse
Structure
SQL
Search
Insert
Export
Import
Privileges
Operations
Tracking
Triggers
id
first_name
last_name
identification
gender
patient_condition
phone
email
physical_address
relationship
Query results operations
Bookmark this SQL query


MAIN DATABASE SEARCH RESULTS
List
The Patient has been found in the main Database. Please Click on the 'Authorise' button to authorize the patient data.
The patient will receive a code via SMS, please input the code text box to proceed.


SEARCH RESULTS FOR 22798610
List
The Patient you are searching for cannot be found in this database, please provide their identity(ID or Passport) and click Sync button below to search on the main database.





APPENDIX V: LOG-IN PAGE CODE

```
<?php
namespace App\Http\Controllers\Auth;
use App\User;
use Bican\Roles\Models\Role;
use Illuminate\Support\Facades\Hash;
use Illuminate\Support\Facades\Validator;
use Illuminate\Support\Facades\Auth;
use Illuminate\Support\Facades\Mail;
use Illuminate\Support\Facades\URL;
use App\Http\Controllers\Controller;
use Illuminate\Foundation\Auth\ThrottlesLogins;
use Illuminate\Foundation\Auth\AuthenticatesAndRegistersUsers;
use Illuminate\Http\Request;
class AuthController extends Controller
{
    use AuthenticatesAndRegistersUsers, ThrottlesLogins;
    protected $redirectTo = '/';
    protected $loginPath = '/login';
    public function __construct()
    {
        $this->middleware('guest', ['except' => 'getLogout']);
    }
    public function register()
    {
        return view('auth.register');
    }
    public function getRegisterSuccess()
    {
        return view('auth.register_successful');
    }
```

```
    public function getLogin()
    {
        return view('auth.login');
    }
    public function getForgotPassword()
    {
        return view('auth.password');
    }
    public function postRegister(Request $request)
    {
        $validator = Validator::make($request->all(), [
            'first_name' => 'required|max:255|min:2',
            'last_name' => 'required|max:255|min:2',
            'email' => 'required|email|unique:users',
            'country' => 'required_with:phone',
            'password' => 'required|valid_password',
            'password_confirm' => 'required|same:password',
        ]);
        $country = Country::findOrFail($request->country);
        $country_code = $country->code;

        $validator->after(function ($validator) use ($request, $country_code) {
            if ($request->phone != '' && !valid_mobile($request->phone, $country_code)) {
                $validator->errors()->add('phone', ' phone should be a mobile number and valid for the
selected country');
            }
        });        if ($validator->fails()) {
            return redirect('/user/register')
                ->withErrors($validator)
                ->withInput();
        }
```

```
        $user = new User;
        $user->first_name = $request->first_name;
        $user->last_name = $request->last_name;
        $user->email = $request->email;
        $user->email_confirm_token = base64_encode(str_random(60));
        $user->last_name = $request->last_name;
        $user->mobile_number = phone_format_E64($request->phone, $country_code);
        $user->country_id = $request->country;
        $user->password = Hash::make($request->password);
        if ($user->save()) {
            $role = Role::findOrFail(5);// manual: default role
            $user->attachRole($role);
            Mail::send('emails.auth.activate',
                ['link' => URL::to('/user/activate', $user->email_confirm_token),
                    'first_name' => $user->first_name,],
                function ($message) use ($user) {
                    $message->to($user->email, $user->full_name)
                        ->subject('Welcome to Acres & Wheels');
                });
            return redirect('/user/register/success')->with('message', 'Registration Successful .An
email has been sent to you with a confirm link . Please click the link in the email to activate your
account')->with('flash_type', 'alert-success');
        } else {
            return redirect('/register')->with('message', 'Registration Failed. Please try again or
Contact us for assistance if the problem persists')->with('flash_type', 'alert-danger');
        }
    }
    public function postLogin(Request $request)
    {
        $this->validate($request, [
            'email' => 'required|email',
```

```
            'password' => 'required',
        ]);
        $email = $request->email;
        $pass = $request->password;
        $remember = $request->remember ? true : false;

        $auth = Auth::attempt(['email' => $email, 'password' => $pass, 'active' => 1], $remember);
        if ($auth) {
            return redirect()->intended('/');
        }
        return redirect('/login')->with('message', 'Login Failed. Please check your Credentials or
Contact us for assistance')->with('flash_type', 'alert-danger');
    }
    public function getLogout()
    {
        Auth::logout();
        return redirect('/');
    }
    public function getActivate($code)
    {
        $user = User::where('email_confirm_token', $code)->where('active', 0)->first();
        if ($user) {
            $user->active = 1;
            $user->email_confirm_token = '';
            $user->save();
            return redirect('/login')->with('message', 'Account Activation Successful. Please Login
Below!')->with('flash_type', 'alert-success');
        } else {
            return redirect('/login')->with('message', 'Account Activation Failed. Please Contact us
for assistance')->with('flash_type', 'alert-danger');
        }    }    }
```

APPENDIX VI: PATIENT'S REGISTRATION CODE

```
<?php
namespace App\Http\Controllers;
use App\Hospital;
use App\Patient;
use App\User;
use Carbon\Carbon;
use Illuminate\Http\Request;
use App\Http\Requests;
use Illuminate\Support\Facades\Input;
use Illuminate\Support\Facades\Validator;
use Illuminate\Support\Facades\Redirect;
use App\Classes\Collections;
use libphonenumber\PhoneNumberFormat;
use App\Classes\UpdateMain;
use Illuminate\Support\Facades\DB;
use App\Classes\SMS;
class PatientController extends Controller
{
    public function __construct(SMS $sms)
    {
        $this->sms = $sms;
    }
    public function index()
    {
        $patients = Patient::all();
        return view('patients', compact('patients'));
    }
    public function register()
    {
```

```
    $relationships = Collections::getRelationships();
    $conditions = Collections::getMedicalConditions();
    $genders = Collections::getGender();
    return view('register', compact('relationships', 'conditions', 'genders'));
}
public function edit($id)
{
    $patient = Patient::find($id);
    return view('patient_edit', compact('patient'));
}
public function update(Request $request)
{
    $validator = Validator::make($request->all(), [
        'first_name' => 'required',
        'last_name' => 'required',
        'identification' => 'required|alpha_num',
        'gender' => 'required',
        'condition' => 'required',
        'phone' => 'required|phone:KE,mobile',
        'email' => 'email',
        'next_of_kin_names' => 'required',
        'relationship' => 'required',
        'next_of_kin_phone' => 'required|phone:KE,mobile',
        'next_of_kin_email' => 'email'
    ]);
    if ($validator->fails()) {
        return Redirect::back()->withErrors($validator)->withInput();
    } else {
        $patient = Patient::find($request->patient_id);
        $patient->first_name = $request->first_name;
        $patient->last_name = $request->last_name;
```

```
$patient->identification = $request->identification;
$patient->gender = $request->gender;
$patient->patient_condition = $request->condition;
$patient->phone = phone_format($request->phone, 'KE', PhoneNumberFormat::E164);
$patient->email = $request->email;
$patient->physical_address = $request->physical_address;
$patient->next_of_kin_names = $request->next_of_kin_names;
$patient->relationship = $request->relationship;
$patient->next_of_kin_phone = $request->next_of_kin_phone;
$patient->next_of_kin_email = $request->next_of_kin_email;
$patient->next_of_kin_phy_address = $request->next_of_kin_phy_address;
if ($patient->save()) {
    $data = array(
        'first_name' => $patient->first_name,
        'last_name' => $patient->last_name,
        'identification' => $patient->identification,
        'gender' => $patient->gender,
        'patient_condition' => $patient->patient_condition,
        'phone' => $patient->phone,
        'email' => $patient->email,
        'physical_address' => $patient->physical_address,
        'next_of_kin_names' => $patient->next_of_kin_names,
        'relationship' => $patient->relationship,
        'next_of_kin_phone' => $patient->next_of_kin_phone,
        'next_of_kin_email' => $patient->next_of_kin_email,
        'next_of_kin_phy_address' => $patient->next_of_kin_phy_address
    );
    //update main
    DB::connection('main')->table('patients')
        ->where('id', $patient->id)
        ->update($data);
```

```
            return Redirect::back()->with('message', 'Patient Data Saved Successfully')
                ->with('flash_type', 'alert-success');
        } else {
            return Redirect::back()->with('message', 'Error occurred while trying to save the data')
                ->with('flash_type', 'alert-danger');
        }
    }
}
public function create(Request $request)
{
    $validator = Validator::make($request->all(), [
        'first_name' => 'required|alpha',
        'last_name' => 'required|alpha',
        'identification' => 'required|unique:patients,identification',
        'gender' => 'required',
        'condition' => 'required',
        'phone' => 'required|phone:KE,mobile',
        'email' => 'email',
        'next_of_kin_names' => 'required',
        'relationship' => 'required',
        'next_of_kin_phone' => 'required|phone:KE,mobile',
        'next_of_kin_email' => 'email'
    ]);
    if ($validator->fails()) {
        return Redirect::back()->withErrors($validator)->withInput();
    } else {
        $p = DB::connection('main')->table('patients')->where('identification', $request-
>identification)->first();
        if (!empty($p)) {    return Redirect::back()->with('message', 'The Identification Number is
already registered with another patient in another hospital. Please use the search functionality to
discover them out.')
```

```
        ->with('flash_type', 'alert-danger');
} else {
    $hospital = Hospital::where('is_default', 1)->first();
    $patient = new Patient();
    $patient->first_name = $request->first_name;
    $patient->last_name = $request->last_name;
    $patient->identification = $request->identification;
    $patient->gender = $request->gender;
    $patient->patient_condition = $request->condition;
    $patient->phone = phone_format($request->phone, 'KE', PhoneNumberFormat::E164);
    $patient->email = $request->email;
    $patient->physical_address = $request->physical_address;
    $patient->next_of_kin_names = $request->next_of_kin_names;
    $patient->relationship = $request->relationship;
    $patient->next_of_kin_phone = $request->next_of_kin_phone;
    $patient->next_of_kin_email = $request->next_of_kin_email;
    $patient->next_of_kin_phy_address = $request->next_of_kin_phy_address;
    $patient->hospital_id = $hospital->id;
    if ($patient->save()) {
        $new_p = Patient::find($patient->id);
        $data = array(
            array(
                'id' => $new_p->id,
                'first_name' => $new_p->first_name,
                'last_name' => $new_p->last_name,
                'identification' => $new_p->identification,
                'gender' => $new_p->gender,
                'patient_condition' => $new_p->patient_condition,
                'phone' => $new_p->phone,
                'email' => $new_p->email,
                'physical_address' => $new_p->physical_address,
```

```
                'next_of_kin_names' => $new_p->next_of_kin_names,
                'relationship' => $new_p->relationship,
                'next_of_kin_phone' => $new_p->next_of_kin_phone,
                'next_of_kin_email' => $new_p->next_of_kin_email,
                'next_of_kin_phy_address' => $new_p->next_of_kin_phy_address,
                'hospital_id' => $new_p->hospital_id,
                'created_at' => $new_p->created_at,
                'updated_at' => $new_p->updated_at,
              ),
            );
            UpdateMain::patients($data, $new_p->identification);
            return Redirect::back()->with('message', 'Patient Data Saved Successfully')
              ->with('flash_type', 'alert-success');
          } else {
            return Redirect::back()->with('message', 'Error occurred while trying to save the
data')                ->with('flash_type', 'alert-danger');
          }
        }
      }
    }
    public function history($id)
    {
      $patient = Patient::find($id);
      $prescriptions = $patient->prescriptions()->orderBy('created_at', 'desc')->get();
      return view('patient', compact('patient', 'prescriptions'));
    }
    public function showHospitalPatients($id)
    {
      $hospital = Hospital::find($id);
      $patients = $hospital->patients()->get();
      return view('patients', compact('patients', 'hospital'));
```

```
    }
    public function search()
    {
        $search_key = Input::get('search_key');
        $patients = Patient::where('first_name', $search_key)
            ->orWhere('last_name', $search_key)
            ->orWhere('identification', $search_key)
            ->orWhere('phone', $search_key)
            ->orWhere('email', $search_key)
            ->get();
        return view('search', compact('patients'));
    }
    public function searchMain(Request $request)
    {
        $validator = Validator::make($request->all(), [
            'patient_identification' => 'required|alpha_num',
        ]);
        if ($validator->fails()) {
            return Redirect::back()->withErrors($validator)->withInput();
        } else {
            $results = DB::connection('main')->table('patients')->where('identification', $request-
>patient_identification)->first();
            return redirect('search/results')->with('results', $results);
        }
    }
    public function mainSearchResults()
    {
        return view('search_results');
    }
        public function sendCode(Request $request)
    {
```

```
        $code = rand(1000, 9999);
        $this->sms->send($request->patient_phone, $code);
        $data = array(
            array(
                'patient_id' => $request->patient_id,
                'patient_phone' => $request->patient_phone,
                'code' => $code,
                'created_at' => Carbon::now()->toDateTimeString(),
                'updated_at' => Carbon::now()->toDateTimeString(),
            ),
        );

        DB::table('sms_codes')->insert($data);
        $response = array(
            'status' => 'success',
            'message' => '<h3>Code sent to Patient</h3>',
        );
        return response()->json($response);
    }
    public function completeAndSync(Request $request)
    {
        if (!empty($request->code)) {
            try {
                $code = DB::table('sms_codes')->where('patient_id', $request->patient)->orderBy('id',
'desc')->first();
                if ($code->code == $request->code) {
                    $patient = DB::connection('main')->table('patients')->where('id', $request->patient)-
>first();
                    $hospital_exists_locally = Hospital::where('id', $patient->hospital_id);
                    if (!$hospital_exists_locally->exists()) {
```

```
            $hospital = DB::connection('main')->table('hospitals')->where('id', $patient-
>hospital_id)->first();
            $hosy_data = array(
                array(
                    'id' => $hospital->id,
                    'name' => $hospital->name,
                    'address' => $hospital->address,
                    'branch' => $hospital->branch,
                    'is_default' => '0',
                    'created_at' => $hospital->created_at,
                    'updated_at' => $hospital->updated_at,
                ),
            );
            DB::table('hospitals')->insert($hosy_data);
        }
        $patient_id = Patient::where('identification', $patient->identification)->first();
        if (empty($patient_id)) {
            $patient_data = array(
                array(
                    'id' => $patient->id,
                    'first_name' => $patient->first_name,
                    'last_name' => $patient->last_name,
                    'identification' => $patient->identification,
                    'gender' => $patient->gender,
                    'patient_condition' => $patient->patient_condition,
                    'phone' => $patient->phone,
                    'email' => $patient->email,
                    'physical_address' => $patient->physical_address,
                    'next_of_kin_names' => $patient->next_of_kin_names,
                    'relationship' => $patient->relationship,
                    'next_of_kin_phone' => $patient->next_of_kin_phone,
```

```
                    'next_of_kin_email' => $patient->next_of_kin_email,
                    'next_of_kin_phy_address' => $patient->next_of_kin_phy_address,
                    'hospital_id' => $patient->hospital_id,
                    'created_at' => $patient->created_at,
                    'updated_at' => $patient->updated_at,
                ),
            );
            DB::table('patients')->insert($patient_data);
            //sync prescriptions
            $prescriptions = DB::connection('main')->table('prescriptions')-
>where('patient_id', $patient->id)->get();
            foreach ($prescriptions as $prescription) {
                //sync doctor first
                //$presc = DB::connection('main')->table('prescriptions')->where('id',
$prescription->id)->first();
                $local_doc = User::where('id', $prescription->user_id)->first();
                if (empty($local_doc)) {
                    $doc = DB::connection('main')->table('users')->where('id', $prescription-
>user_id)->first();
                    $doc_data = array(
                        array(
                            'id' => $doc->id,
                            'first_name' => $doc->first_name,
                            'last_name' => $doc->last_name,
                            'email' => $doc->email,
                            'phone' => $doc->phone,
                            'password' => $doc->password,
                            'code' => $doc->code,
                            'is_synced' => 'yes',
                            'active' => 0,
                            'created_at' => $doc->created_at,
```

```
                'updated_at' => $doc->updated_at
            ),
        );
        DB::table('users')->insert($doc_data);
    }
    $presc_data = array(
        array(
            'id' => $prescription->id,
            'treatment_nature' => $prescription->treatment_nature,
            'full_desc' => $prescription->full_desc,
            'checkup_date' => $prescription->checkup_date,
            'patient_id' => $prescription->patient_id,
            'user_id' => $prescription->user_id,
            'is_synced' => 'yes',
            'hospital_id' => $prescription->hospital_id,
            'created_at' => $prescription->created_at,
            'updated_at' => $prescription->updated_at
        ),
    );
    DB::table('prescriptions')->insert($presc_data);
}
$conditions = DB::connection('main')->table('patient_conditions')-
>where('patient_id', $patient->id)->get();
foreach ($conditions as $condition) {
    $c_exists = DB::table('patient_conditions')->where('id',$condition->id)->get();
    $cond_data = array(
        array(
            'id' => $condition->id,
            'patient_id' => $condition->patient_id,
            'hospital_id' => $condition->hospital_id,
            'prescription_id' => $condition->prescription_id,
```

```
                    'patient_condition' => $condition->patient_condition,
                    'is_synced' => 'yes',
                    'created_at' => $condition->created_at,
                    'updated_at' => $condition->updated_at
                ),
            );
            if(count($c_exists)<1) {
                DB::table('patient_conditions')->insert($cond_data);
            }
        }
    }
    DB::table('sms_codes')->where('patient_id', $request->patient)->delete();
    $response = array(
        'status' => 'success',
        'message' => '<h3>Success! All data has been synced</h3>',
    );
  } else {
    $response = array(
        'status' => 'error',
        'message' => '<h3>Sorry, The code you have provided doesn\'t exist</h3>',
    );
  }
}catch (\Exception $e){
    $response = array(
        'status' => 'error',
        'message' => $e->getMessage(),
    );
}
} else {
    $response = array(
        'status' => 'error',
```

```
            'message' => '<h3>Sorry, Code can not be empty!</h3>',
        );
    }
    return response()->json($response);
}
public function delete(Request $request)
{
    $record = Patient::find($request->id);
    if ($record->hospital->is_default) {
        DB::connection('main')->table('patients')
            ->where('id', $request->id)
            ->update(['deleted_at' => Carbon::now()]);
        if ($record->delete()) {
            $response = array(
                'status' => 'success',
                'message' => 'Recorded removed successfully',
            );
        } else {
            $response = array(
                'status' => 'error',
                'message' => 'Something went wrong,record not deleted',
            );
        }
    } else {
        $response = array(
            'status' => 'error',
            'message' => '<h4><b>Sorry!</b></h4> Records can only be deleted from the
Hospital where the record was created.',
        );
    }
    return response()->json($response);   }  }
```