A Comprehensive Health Data Management System for Healthcare Facilities in Rural Areas

Student ID:XXXX

An information system project 2 submitted to the School of Computing and Engineering Sciences in partial fulfilment of the requirements for the award of the bachelor's degree in Business Information Technology of Strathmore University

School of Computing and Engineering Sciences
Strathmore University
Nairobi, Kenya

November, 20XX

Declaration and Approval

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

Student's signature:

…….…….. [*Signature*]

…….…..……. [*Date*]

Approval

This work was reviewed and approved *(for examination)* by:

Supervisor's signature:

…….…….. [*Signature*]

…….…….. [*Date*]

Abstract

Non-communicable diseases are the leading causes of death in the world today. This is in spite of the fact that most NCDs are considered preventable because they are caused by modifiable risk factors, such as a person's background; lifestyle and environment which are known to increase the likelihood of certain non-communicable diseases. Other factors include age, gender, genetics, exposure to air pollution and behaviours such as smoking, unhealthy diet and physical inactivity.

With lack of adequate infrastructure and health worker shortages especially in rural areas of our country it becomes increasingly difficult to access, treat and track the progress of elderly NCD patients who have difficulty in accessing medical care.

This also introduces the challenge of storage and retrieval of the patients' medical history as these records are not always stored in a reliable manner and may end up getting lost. This makes it nearly impossible to keep track of patients with NCDs and creates a difficulty in managing resources in healthcare facilities especially in rural areas. The health data management system's aim was to enable the CHWs and medical doctors to keep a consistent record of patients especially those living with NCDs in rural areas as this is likely to make it easier for the medical personnel to monitor the condition of their patients. It also purposed to manage data that pertains to specific health facilities in the county, such as the medical doctors, CHWs, other workers in the facility and other administrative records for the facility.

Acknowledgements

I would like to thank God for enabling me to get this far and enabling me to have the resources to complete this project. I would also like to thank my supervisor, Dr. Allan Omondi and the coordinator, Dr. Henry Muchiri for the guidance that they have given me from the very beginning to the end of this project. I would like to thank my classmates for valuable advice on several aspects regarding this project. Last but not least I would like to thank my family for their unwavering support.

Table of Contents

List of Figures

List of Tables

Abbreviations/Acronyms

CHW - Community health worker

EMR - Electronic medical record

HIV/AIDS - Human immunodeficiency virus/ acquired immunodeficiency syndrome

HTML - Hypertext markup language

IDE - Integrated development environment

ICT - Information and communications technology

LMIC - Low and medium-income countries

NCD - Non-communicable disease

MRS - Medical record system

MySQL - My structured query language

OOAD - Object oriented analysis design

PHP – Hypertext pre-processor

UI – User interface

WHO - World health organisation

Operational Definition of Terms

Data management - The practice of collecting, keeping, and using data securely, efficiently, and cost-effectively.

Non-communicable diseases - A disease that is not transmissible directly from one person to another. NCDs include Parkinson's disease, autoimmune diseases, strokes, most heart diseases, most cancers, diabetes, chronic kidney disease, osteoarthritis, osteoporosis, Alzheimer's disease, cataracts, and other

Chapter 1: Introduction

1.1 Background

Noncommunicable diseases are the leading causes of death in the world today. Risk factors such as a person's background; lifestyle and environment are known to increase the likelihood of certain non-communicable diseases. Some of these factors include age, gender, genetics, exposure to air pollution and behaviours such as smoking, unhealthy diet and physical inactivity which can lead to hypertension and obesity, in turn leading to increased risk of many NCDs. Most NCDs are considered preventable because they are caused by modifiable risk factors.

The WHO's world health report 2002 identified five important risk factors for non-communicable disease in the top ten leading risks to health. These are raised blood pressure, raised cholesterol, tobacco use, alcohol consumption, and being overweight. The other factors associated with higher risk of NCDs include a person's economic and social conditions, also known as the social determinants of health. (*World Health Report 2002: Reducing Risks, Promoting Healthy Life - World*, 2002)

In our country High healthcare costs, a lack of adequate infrastructure, and health worker shortages all decrease our ability to deliver primary healthcare services especially to the population in rural areas. (Kirigia et al., 2004) It becomes increasingly difficult to access, treat and track the progress of elderly NCD patients who have difficulty in accessing medical care.

Records of the patients' medical history is not always stored in a reliable manner and may end up getting lost or destroyed especially if stored in a manual manner. In some areas, measures have not been put in place to ensure that records of medical history are recorded and stored.

Retrieval of these records also becomes a problem because of the nature in which they are recorded and stored making the work of the health workers more difficult and inefficient. Ultimately it becomes almost impossible to keep track of the condition of patients suffering from NCDs.

1.2 Problem Statement

Three-fourths of the Kenyan population lives in rural areas. Kenya faces a health workforce crisis in the sense that we do not have enough medical personnel. In fact, for every 10,000 people, there are only 1.9 doctors and 8.6 nurses and midwives (WHO, 2014). This is a problem especially when NCDs such as cancers, diabetes and others account for 27 per cent of the total deaths and over 50 per cent of total hospital admissions in Kenya. High healthcare costs, a lack of adequate infrastructure, and health worker shortages all decrease the ability of these areas to deliver primary healthcare services to their populations. Moreover, the older population are more likely to suffer from NCDs. Their age and condition therefore limit their mobility and ability to access the already scarce medical facilities. (Kirigia et al., 2004) For this cause, the CHWs are tasked with attending to these patients. This poses a challenge to the CHW to record and access medical records of the patients' medical history remotely when visiting patients to evaluate their condition, as most of the healthcare facilities lack proper infrastructure to be able to record or access medical records remotely.

1.3 Aim

The aim was to develop a comprehensive health data management module to be used by medical doctors in health facilities to view the historical medical record of NCDs patients including data collected by community health workers. This would help the health workers monitor their patients' condition over time and render their service more efficiently.

1.4 Specific Objectives

I. To identify challenges faced by medical personnel when recording health data of NCD patients in rural areas of Kenya.

II. To review current methods used to obtain, record, store and retrieve patients' medical data by community health workers and medical doctors.

III. To develop a system that medical doctors and community health workers would use to record and retrieve patients' medical data.

IV. To test the functionalities of the system and whether it operates as intended by using a prototype.

1.5 Justification

This solution was intended for the benefit of the CHWs, medical doctors and ultimately, patients living with NCDs in rural areas.

Quality of healthcare, especially for elderly patients living with NCDs in rural areas, would increase because it would enable better monitoring of their condition by providing an orderly and efficient system to record, store and track their medical records.

As for the CHWs, this system would make it easier for them to retrieve their patients' medical records and help them keep track of their condition. It would also help with coordination among the CHWs because they would be able to assign themselves patients to attend to over a period of time.

The system would also enable medical doctors to attend to more patients by increasing their efficiency and reducing time spent accessing patients records and analysing their medical history, as this information would be displayed on a dashboard. This enables them to redirect their time and attention to the patients.

1.6 Assumptions

Assumptions made while developing this solution were as follows:

I. Existing medical records were well stored and are easily accessible in order to feed into the management system.
II. Remote medical facilities have access to electricity and network coverage.
III. Healthcare facilities have some form of data management system.

1.7 Scope and Limitations

The scope of the project was to develop an online system that would be able to record, store, edit and retrieve patients' medical information

Due to the time frame the project was only focused on developing a general system that is applicable in most rural areas and not specific to a certain area.

Chapter 2: Literature Review

2.1 Introduction

This chapter contains a review and analysis of operations in the public healthcare facilities in Kenya. It aims to review the method of data management employed and the current data management system being used by most of these facilities. It also aims to understand the effectiveness of the current methods in use.

In this chapter, section 2.2 discusses the various data management systems that have been implemented in public health care facilities in Kenya and the problems faced by these systems. Section 2.3 discusses this system and how it aimed to solve the problems faced by the current systems. Section 2.4 contains the conceptual framework of the system and section 2.5 gives a conclusion of the entire chapter.

2.2 Data management Systems in public health facilities in Kenya

Public healthcare facilities in Kenya had begun to adopt data management systems as they replaced paper-based systems with digital systems. The healthcare system in Kenya had been devolved, and through the ministry of health, the central government had provided support for the counties. In matters of digital health, the ministry of health had established an eHealth unit which guides overall policy, sets standards and supports national-level systems. (Kang'a et al., 2017)

2.2.1 Current Data Management Systems

Kenya National eHealth Strategy was developed in 2010, with an aim to harness ICT for improved health care delivery by supporting informed policy, improving access to clinical evidence for care providers, fostering interoperability, and creating linkages between service providers and researchers. It focused on 5 key areas: telemedicine, health information systems, information for citizens, mHealth, and e-learning. The health information systems had 5 functional domains: patient centric information, pharmacy and medical supply chain information, financial information, health workforce management, and training and regulation.

KenyaEMR(2012-2013) is a tailored distribution of Open Medical Record System (OpenMRS), an open source EHR system that has been widely used in several African countries to support the management of HIV/AIDS patients. It had also been used for other diseases such as TB and noncommunicable diseases.

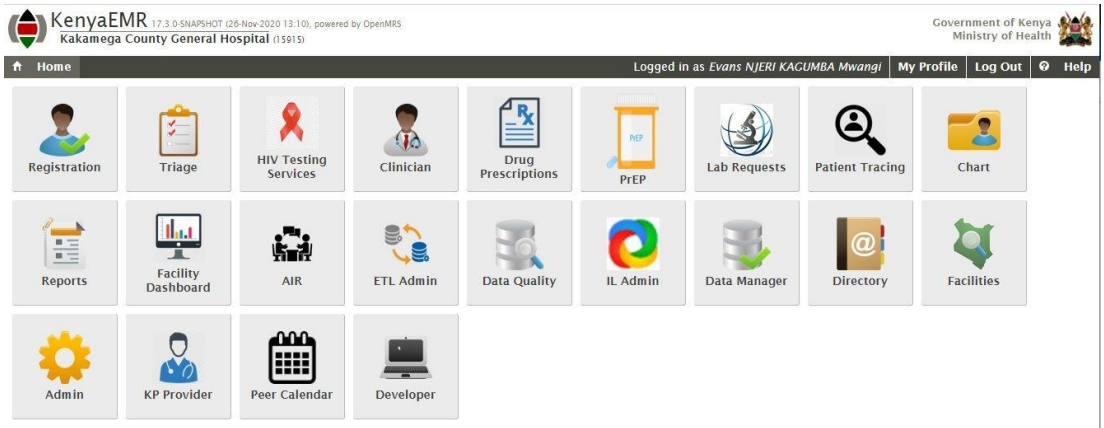


Figure 2.1 KenyaEMR home page

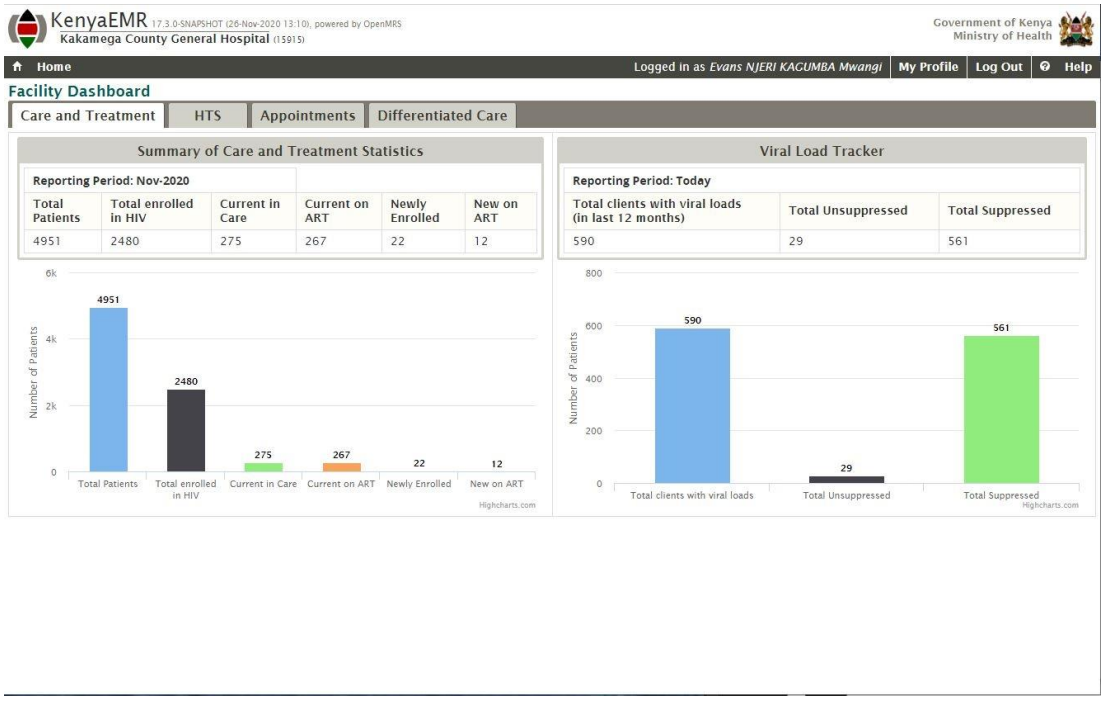


Figure 2.2 KenyaEMR Dashboard

OpenMRS was developed to provide a core system and range of plug-in modules from which clinical health information systems could be created to allow flexibility to include or exclude particular modules depending on the needs of the health care facilities where the software was to be installed.

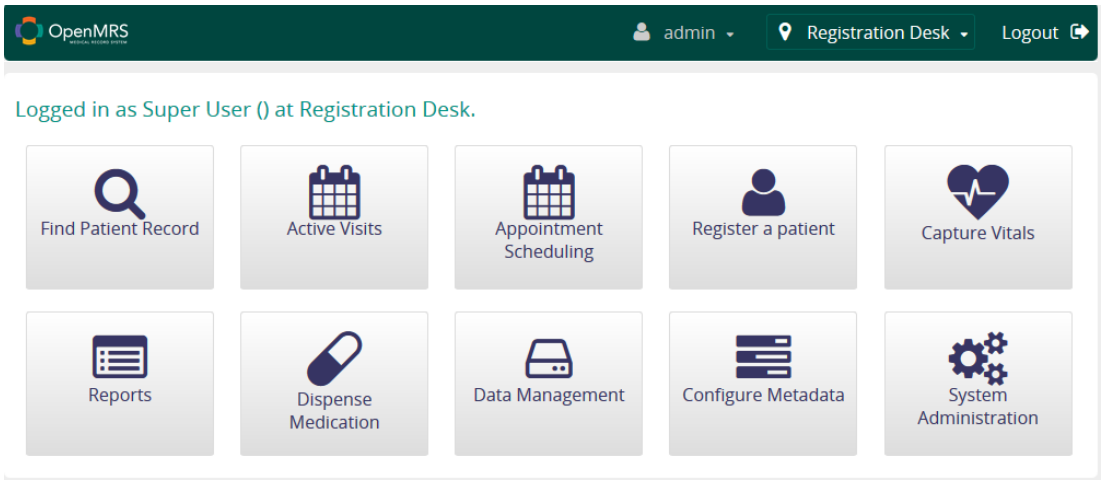


Figure 2.3 OpenMRS homepage.

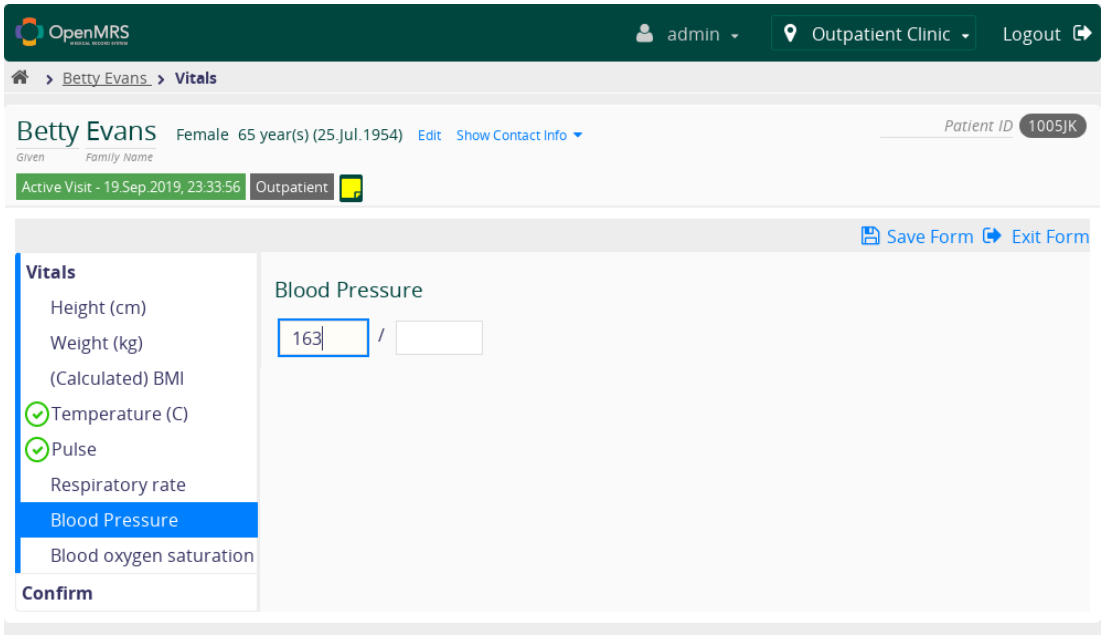


Figure 2.4: OpenMRS Capture Vitals page.

Table 2.1: Summary of reports and projects deployed

Reports and projects	2007-2009	2010	2011	2012-2013	2014-2017
Reports	HMIS, CDC, and NASCOP EMR Evaluations	EMR Standards and Guidelines Report	EMR Review Toward Standardization; Kenya National eHealth Strategy (2011-2017)		
Deployments			DHIS2 Rollout	KenyaEMR Rollout; IQCare Rollout	AfyaEHMS Rollout

2.2.2 Problems that arise with current systems in use

In research from Muinga et al. (2020), the system usability was affected by issues such as lack of integration with other systems both within and outside the facility, lack of computerisation in other departments, system workflow issues, poor uptake by other system users and software crashes.

The research also shows varying levels of interoperability between systems within the same facility. In some instances, systems were integrated and able to exchange data while in another case, one department had access to two systems that were not interoperable. This created a challenge in ensuring all the relevant data was captured. Non-entry of clinical data by nurses and clinicians was also reported to be a persistent issue and this affected the generation of certain reports as there was mismatch between diagnosis offered in the system and what the clinicians wanted to enter for their patients while in some cases, some reports were still not available from the systems.

2.3 Medical Data Management System

The medical data management system aimed to improve on the shortcomings of the existing systems. The system would be a web-based system which would eliminate the need for complicated installation processes. It would use an online database which would enable data to be entered and retrieved remotely by medical doctors and CHWs

while eliminating the need for local storage of data which would mitigate the risk of permanent data loss through loss or damage of computers by various factors. The system also aimed to be very user friendly in order to encourage wide usage and easier adoption by the users (Medical Doctors and CHWs).

2.4 Conceptual Framework

This contains the conceptual framework for this system which shows how the system would function.

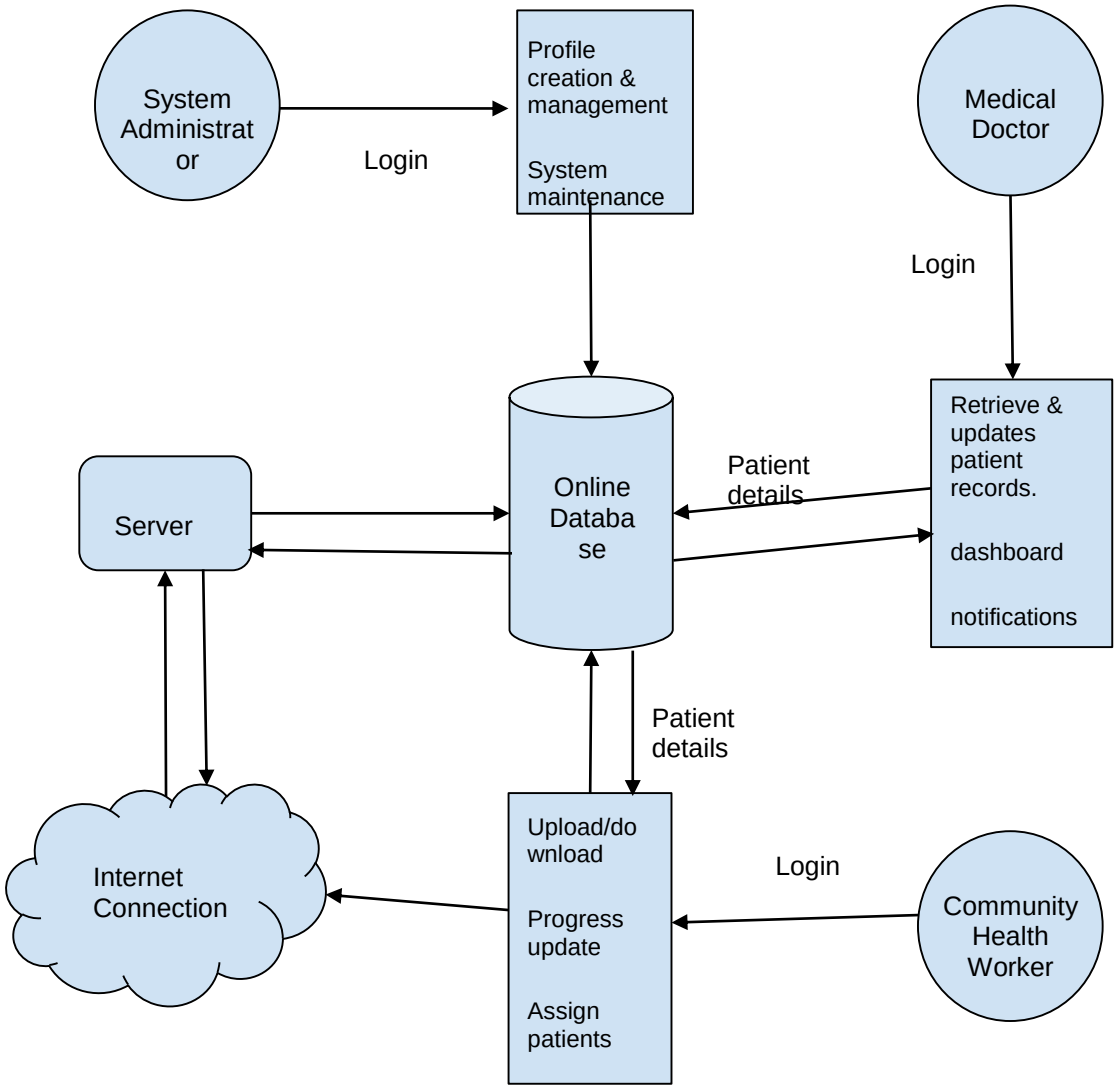


Figure 2.5: Conceptual framework

2.5 Conclusion

Effort had been made by the government to improve healthcare in our country by rolling out systems that aim to improve management of healthcare facilities and medical records of patients, however, as revealed in section 2.2.2 above, the current systems still had a few shortcomings that hindered them from accomplishing their purpose and had introduced new gaps and problems.

The medical data management system was aimed at eliminating the problems brought about by the current systems as well as improving on their functionality in order to bridge the gaps that were not covered by the existing systems.

Chapter 3: Research Methodology

3.1 Introduction

This chapter contains the specific techniques or procedures that were used to identify, review and analyse a particular problem or an idea and the various methodologies that were used by the project to formulate, develop and test the solution. The project applied the Object-Oriented Analysis and Design (OOAD) technical approach to solve the problem. OOAD is a technical approach for analysing and designing a system. It models a system as a group of interacting objects which represent some entities of interest in the system being modelled, and is characterised by its class, its state (data elements), and its behaviour

The system development methodology that was applied was the prototyping methodology which Attempts to reduce inherent project risk by breaking a project into smaller segments and providing more ease-of-change during the development process. The prototype was developed and evolved following an iterative modification process of small-scale models of the system until it met the users' requirements.

Prototyping is useful in realistically modelling important aspects of a system during each phase of the traditional life cycle. It improves both user participation in system development and communication among project stakeholders. Especially useful for resolving unclear objectives, developing and validating user requirements, experimenting with or comparing various design solutions, or investigating both performance and the human computer interface.

In this chapter, section 3.2 discusses the research design used for this system and contains the methods and procedures that were applied. Section 3.3 describes the population under study, the sample size and the methods used to gather functional and non-functional requirements. Section 3.4 discusses how the data collected will be analysed and finally, section 3.5 contains the ethical considerations upheld by the research.

3.2 Research Design

Research design refers to the overall strategy that was chosen and applied for logical and coherent integration of the different components of the study, thereby ensuring that the research problem was effectively addressed. Research design constitutes the blueprint for the collection, measurement, and analysis of data.

There are two general classifications of research design; Qualitative research design and Quantitative research design. Qualitative research design is normally used to gain understanding of concepts, opinions and experiences. (Twycross, 2004) It is especially useful for gaining in depth insight on a particular topic under study. Methods under this design include open-ended interview questions, observation with literal descriptions and literature reviews. Quantitative research design on the other hand is mainly based on numbers and graphs and is used to test and confirm theories. Methods under this design include experiments, observation with numeral descriptions and surveys with closed- ended questions. (Streefkerk, 2021)

The project applied a mixed method approach, which entailed a number of considerations: (Schoonenboom & Johnson, 2017)

I. Purpose for which qualitative and quantitative methods, methodologies, and paradigms can be mixed which for this case is for the project to obtain an in-depth as well as a broad understanding of the study thereby expanding and strengthening the study's conclusions.
II. Theoretical drive, which considers which design will predominantly drive the study, which in this case is the quantitative design.
III. Timing, which has two aspects: simultaneity which refers to whether the components are to be implemented concurrently, sequentially, or a combination of these in a multiphase design; and dependence, which refers to whether a later component depends on the results of an earlier component,
IV. Point of integration, which is where the qualitative and quantitative components are brought together and integrated.
V. Typological vs. interactive design approaches. This refers to whether the project will select a design from a typology or use a more interactive approach to construct its own design.
VI. Whether a design will be fully specified during the planning of the research study or if the design will be allowed to emerge during the research process, or a combination of these.

VII. Dimension of complexity. When designing a mixed methods study the design of the study can either take a simple or complex approach.

3.2.1 Experiment Procedure

Since the project was predominantly taking a quantitative approach, it applied a comparative experimental approach which followed the steps below:

Step I: Develop two versions of a web application for data entry and retrieval, one using database transactions and the other using independent SQL insert statements that are not embedded in a database transaction for insertion of records.

Step II: Create a test database.

Step III: Obtain sample test data for medical records of patients.

Step IV: Create two test user accounts that will be used for simulation of the two user types.

Step V: Compare the results of the two versions to determine the more efficient one

Step VI: Make a comparison between the current system in use and the system being developed.

3.2.2 Prototype Methodology

The prototype methodology is a software development model in which a prototype is developed, tested and redeveloped until an acceptable prototype is obtained. It can also be utilised as a basis for production of the final system. It is best suited for instances where the project's requirements are not known in detail. It is an iterative, trial and error method which takes place between developer and client.

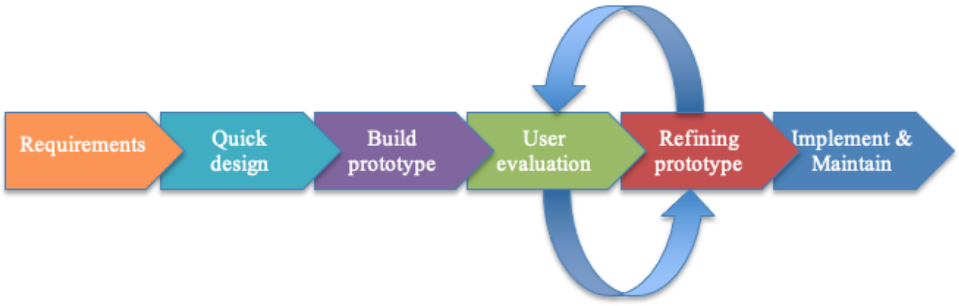


Figure 3.1: Prototype Methodology

3.2.2.1 Requirements gathering and analysis

A prototyping model starts with requirement analysis. In this phase, the requirements of the system are defined in detail. During the process, the system users are interviewed to determine their expectations for the system.

3.2.2.2 Quick design

The second phase is a preliminary design or a quick design. In this stage, a simple design of the system is produced. However, it is not a complete design. It gives a brief idea of the system to the user. The quick design helps in developing the prototype.

3.2.2.3 Building a prototype

In this phase, an actual prototype is designed based on the information gathered from quick design. It is a small working model of the required system.

3.2.2.4 Initial user evaluation

In this stage, the prototype is presented to the client for an initial evaluation. It helps to find out the strength and weakness of the working model. Comments and suggestions are collected from the customer and provided to the developer.

3.2.2.5 Refining prototype

If the user is not satisfied with the current prototype, the prototype needs to be refined according to the user's feedback and suggestions. This phase will not be over until all the requirements specified by the user are met. Once the user is satisfied with the developed prototype, a final system is developed based on the approved final prototype.

3.2.2.6 Initial user evaluation

Once the final system is developed based on the final prototype, it is thoroughly tested and deployed to production. The system undergoes routine maintenance for minimizing downtime and preventing large-scale failures.

3.2.2.7 Research Design

I. Use Case Diagram

A use case describes the sequence of actions a system performs yielding visible results. It shows the interaction of things outside the system with the system itself. Use cases may be applied to the whole system as well as a part of the system.

II. Database Schema

The database schema is a logical representation of how the data used in the system will be structured. The schema shows the relationship between the tables.

III. State-Chart Diagram

A state–chart diagram shows a state machine that depicts the control flow of an object from one state to another. A state machine portrays the sequences of states which an object undergoes due to events and their responses to events.

IV. Sequence Diagram

Sequence diagrams are interaction diagrams that illustrate the ordering of messages according to time.

V. Class Diagram

The class diagram is used when developing object-oriented system models. Since the project proposes to use the OOAD technical approach, the class diagram is a critical model in the OOAD technical approach. The class diagram shows the different classes on the system and the relationship between each class. The class diagram also shows the attributes and methods to be used in each class.

3.2.3 Experiment Test Data

The experiment test data should be highly comprehensive data as it is used in carrying out the experiment and enables the observation of any shortcomings that the system might exhibit.

The sample test data was used to test the systems data management capabilities such as retrieval and creating useful information on the dashboard. This was to ensure that the system was able to deliver on its functionalities.

3.2.4 Experiment Test Bed

The experiment test bed is the platform that was used for testing the system. The tools that will be required in order to carry out the experiment are sublime text for HTML, PHP and JavaScript, MySQL for the database and a domain.

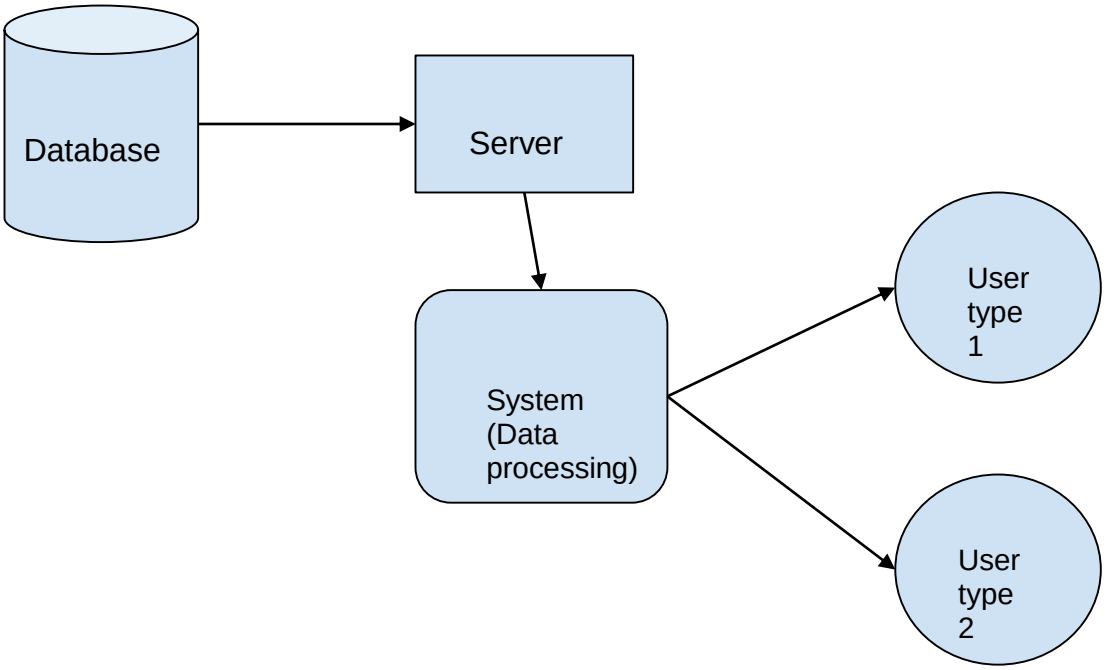


Figure 3.2: Experiment testbed

3.2.5 List of Development Tools

I. IDE: Visual Studio Code: Visual Studio Code is a shareware cross-platform source code editor. It natively supports many programming languages and markup languages, and functions can be added by users with plugins. The project used Visual Studio Code in developing the code for the solution.

II. Database: MySQL Database. MySQL is an open-source relational database management system. The project will use MySQL to handle data.

III. Repository: GitHub was be used for backing up and keeping track of the code for this project as a safeguard against the risk of losing progress in the event the code is lost.

IV. Programming Languages: HTML, PHP, JavaScript. Since this project was web based, it used web scripting languages to develop the solution.

3.3 Data Collection Methods

3.3.1 Population Description

The project carried out its research in Kericho County.

The county has a population of about 901,000 people spread across its six constituencies; Ainamoi, Belgut, Bureti, Kipkelion-East, Kipkelion-West and Sigowet-Soin. Kericho has 136 public healthcare facilities with a total of 2,084 medical personnel. The distribution of medical personnel to people was about 1 to 433. The study population included:

I. Medical personnel (doctors, nurses and clinic officers)

II. Community Health Workers

III. NCDs Patients

3.3.2 Sampling Distribution

The project chose a sample size of at least two individuals from each category of the population defined under section 3.3.1. The individuals were interviewed through an online questionnaire.

3.3.3 Method to be used to Gather the Functional and Non-Functional Requirements

The project used the prototype methodology and for that reason the methods that were used to gather functional and non-functional requirements used interviews and surveys, as well as references from recent studies and publications.

3.4 Data Analysis Methods

The project used information gathered to come up with the requirements that developed the solution. The project sought to determine the validity of the problem statement by sorting the different sets of categories of data into tables for comparison and judging whether the study population agrees with the problem statement. This would help further inform various aspects of development of the solution to better suit the population that is intended to benefit from it.

The Chi-Square method of statistics was used to evaluate tests. Calculating the Chi-Square statistic and comparing it against a critical value from the Chi-Square distribution allows the research to assess whether the results from the sample distribution are significantly different from the expected results. (Statistics Solutions, 2021)

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

χ^2 = chi squared

O_i = observed value

E_i = expected value

Figure 3.3: Chi-Square method

3.5 Ethical Considerations

The project had measures put in place to ensure that the patients' right to privacy and confidentiality is upheld. It will ensure that the individuals that will be interviewed do not share personal or confidential information by obtaining only the data that is necessary.

Chapter 4: System Analysis, Design and Architecture

4.1 Introduction

This chapter provides a list of the functional and non-functional requirements that were identified for this system and highlights the approaches that were taken in the process of gathering said requirements during the system analysis stage. This chapter also contains the system architecture of the system and the system designs which are the sequence diagram, the class diagram and the database schema.

4.2 Requirement Gathering

The method used to gather system requirements is quantitative in nature. That is, questionnaires were presented to a sample of the target population and the results were analyzed to understand the user's requirements in relation to the current manual or automated medical data management system.

Interviews, a qualitative method, was also used to gather more system requirements. Some potential users of the system within the target population were interviewed to analyze the efficiency of current methods used for patient records storage and retrieval. The system requirements were also gathered by analyzing the existing medical facility management systems.

The requirements include registering doctors, patients and CHWs, entering patient data into the system, keeping track of patients' medical condition over time by use of records and keeping track of patient visits.

4.3 System Analysis

The system requirements, which are the features and functionality of the medical data management system, comprise of functional and non-functional requirements as shown respectively in sections 4.3.1 and 4.3.2 below.

4.3.1 Functional Requirements

The system's functional requirements, which are the requirements that are related to the functional elements of the medical data management system are as listed below.

Table 4.1: Functional Requirements

FR1	The system should allow users to log into their respective modules
FR2	The System should allow the admin to log into his/her module
FR3	The System should allow the admin to register new users
FR4	The System Should allow users to request for accounts
FR5	The System should allow the admin to receive account requests

4.3.2 Non-functional Requirements

The system's non-functional requirements are the requirements that do not relate to the functional elements of the medical data management system and are the expected characteristics of the system. That is, they describe the behaviour of the system under normal circumstances. They are as listed below in the table below.

Table 4.2: Non-functional Requirements

NFR1	The system should allow the user to navigate the UI with ease
NFR2	The system should allow the user to sign out
NFR3	The system should allow the doctors to see number of reports
NFR4	The system should allow the doctors to see number of patients seen
NFR5	The system should allow the CHWs to see number visits

4.4 System Architecture

The system architecture comprises of two main components; the web-based application and the database. The web-based application has two phases, one for the administrator and the other for the other users (doctors, CHWs and patients). The database is used to store all the data input into the system. It is accessed only by the administrator.

4.5 System Designs

System diagrams illustrate the visual model of a system's components and their interactions. Below are the system diagrams that are to illustrate the visual model of the medical data management system's components and their interactions. They include: a use-case diagram, a sequence diagram and a database schema, as previously mentioned in section 3.3.3 and 3.3.4.

4.5.1 Use Case Diagram

The use-case diagram illustrates the requirements of the various users of the medical data management system. The requirements are represented by the use cases and the users are represented by the actors.

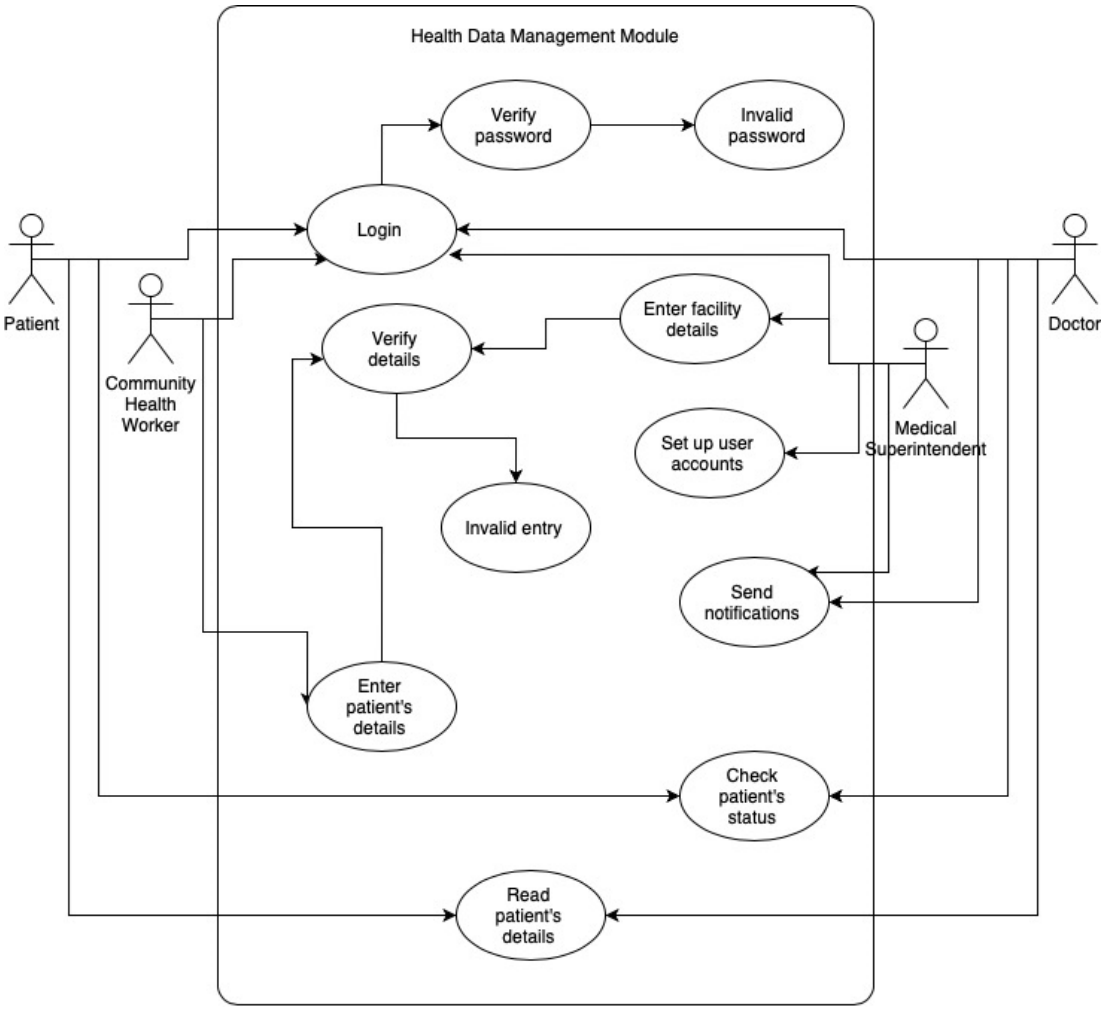


Figure 4.1: Use Case Diagram

4.5.2 Sequence Diagram

The below sequence diagram illustrates the objects involved during the development of the medical data management system and the sequence of messages exchanged between them so as to fulfil the specified requirements.

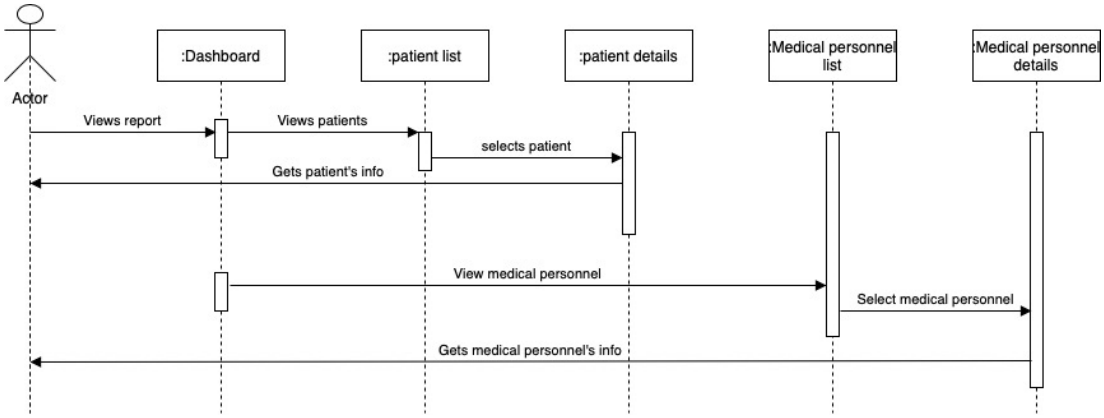


Figure 4.2: Sequence Diagram

4.5.3 Class Diagram

The class diagram above depicts the classes of models of the web-based application system and their interactions.

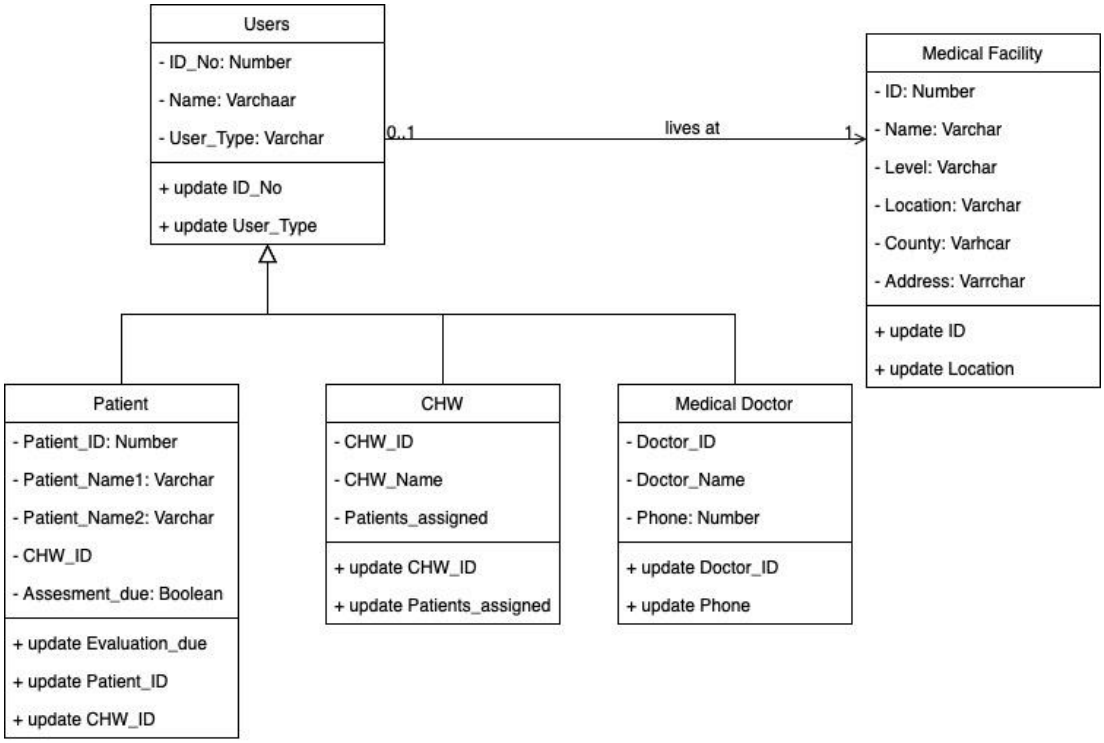


Figure 4.3: Class Diagram

4.5.4 Database Schema

The figure 4.7 is a depiction of the design of the medical data management system's database in terms of entities and their interrelationships as well as an illustration of the constraints of data stored in the database.

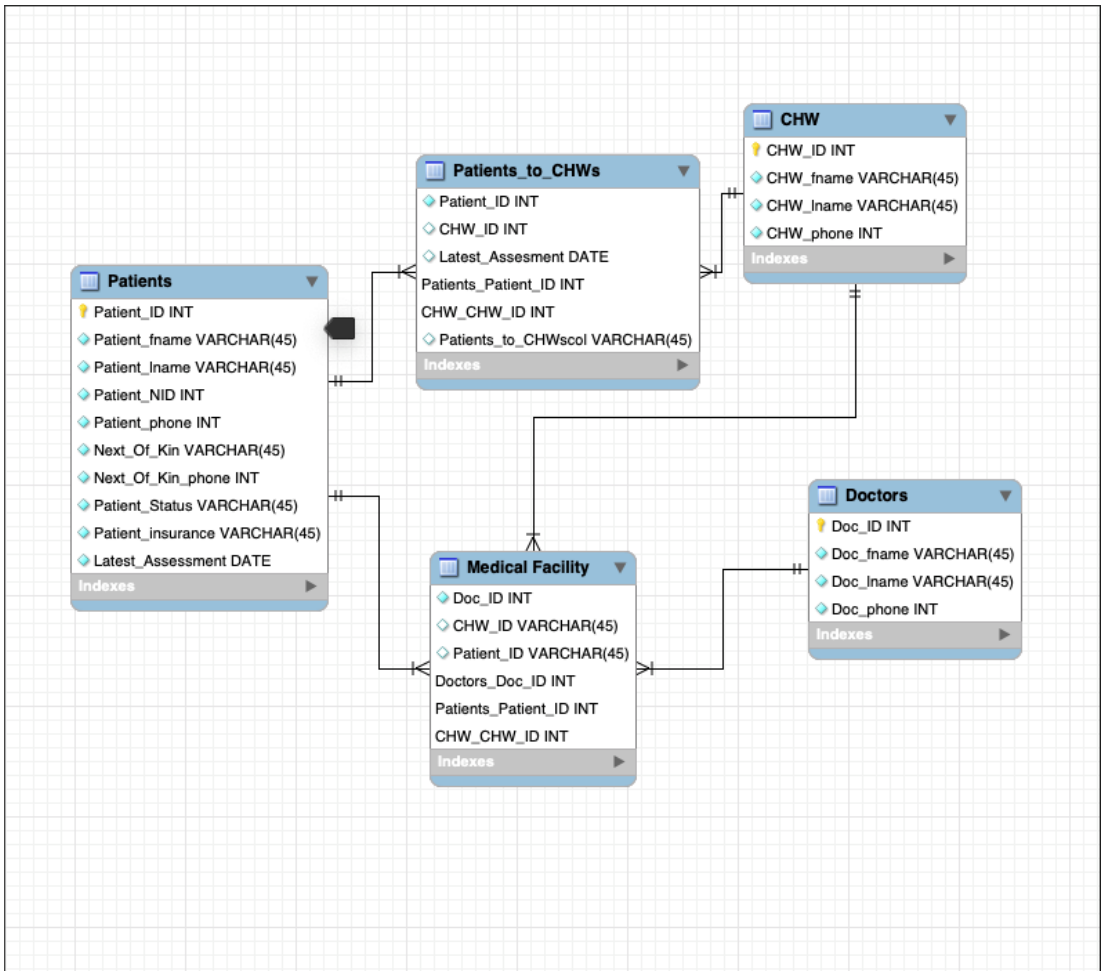


Figure 4.4: Database Schema

Chapter 5: System Testing

5.1 Introduction

This chapter purposes to focus on describing how the system was developed; the modules of the medical data management system, the back-end and the front-end (user interface) of the system. In addition to that, it provides a description of how the system was tested to ensure that it fulfilled specified requirements with the aim of achieving the general objective.

5.2 System Testing

The functionality testing, usability testing and unit testing, done to ensure that the system meets the specified requirements as per chapter 4.

5.2.1 Hardware Specifications

The table below shows hardware specifications used in the development process.

Table 5.1: Hardware Specifications

Hardware	**Characteristics**
Machine	Apple MacBook pro
Processor	2.5 GHz Dual-Core Intel Core i5
Primary memory	10 GB

5.2.2 Software Specifications

The following are software specifications that were used in the development process.

Table 5.2: Software Specifications

Software	**Characteristics**
Database management system	phpMyAdmin
Internet browser	Google Chrome
Operating System	MacOS Catalina 10.15.7

5.3 Test Cases

The following tests were carried out to find out how the system was working

Table 5.3: Test Cases

Test No.	Related Requirements	Inspect Element	Pre-condition	Test Data	Priority Level
1	User authentication	Was the system able to authenticate users	Registered users were to be able to log in to their respective modules	User email address/Phone number and password	High
2	Registration of new users	Was the system able to register new users	The admin was responsible for registering new users	Personal details of users	High
3	Keeping records for patients	Was the system able to store patient records	Doctors and CHWs were responsible for inserting records	Patient data	High
4	Requesting for appointments	Was the system able publish an appointment request	Patients were supposed to request for appointments	Appointment details and patient details	Medium

5.4 Test Results

Test results of how system was recorded after tests were carried out.

Table 5.4: Test Results

Test No.	Expected Results	Actual Results	Status	Remark
1	Authentication was to log in users into their respective modules	Authentication was able to log in users into their respective modules	Pass	Good Performance
2	The admin was to be able to register new users	The admin was able to register new users	Pass	Good performance
3	Doctors and CHWs were to be able to insert patient records	Doctors and CHWs were able to insert patient records	Pass	Good performance
4	Patients were to be able to request for appointments	Patients were able to request for appointments	Pass	Good performance

Chapter 6: Conclusion, Recommendations and Future Works

6.1 Introduction

The aim of this chapter is to summarize the discussion on the objectives mentioned in chapter 1 above, and to provide conclusions related to the discussion on each of the objectives. Furthermore, it seeks to delve into the technical aspects that will ensure the proper working of the system; the recommendations. Lastly, the chapter purposes to mention what can be done to enhance what the project aims to achieve in addressing the problem as mentioned in chapter 1 above.

6.2 Conclusion

The system eliminates the problems brought about by the current systems as well as improving on their functionality in order to bridge the gaps that are not covered by the existing systems.

It has put focus on the quality of healthcare, especially for elderly patients living with NCDs in rural areas, because it enables better monitoring of their condition by providing an orderly and efficient system to record, store and track their medical records.

The system also enables medical personnel to attend to more patients by increasing their efficiency and effectiveness.

6.3 Recommendations

This system is a web-based system and the medical facilities implementing it are required to have computers with internet connectivity. The CHWs, due to the nature of their work are more suited to access the system from mobile phones or tablets.

6.4 Future Works

This project was aimed at solving problems caused by ineffective methods of data management faced by medical personnel in rural areas. However, due to the time frame and scope of the project, the system that was developed was specifically made to solve the major problems of data management. Therefore, future works on advancing this project may entail development of an inbuilt payment service with integration of medical insurance validation.

References

Kang'a, S., Puttkammer, N., Wanyee, S., Kimanga, D., Madrano, J., Muthee, V., Odawo, P., Sharma, A., Oluoch, T., Robinson, K., Kwach, J., & Lober, W. B. (2017). A national standards-based assessment on functionality of electronic medical records systems used in Kenyan public-Sector health facilities. *International Journal of Medical Informatics*, *97*, 68–75. https://doi.org/10.1016/j.ijmedinf.2016.09.013

Kirigia, J. M., Emrouznejad, A., Sambo, L. G., Munguti, N., & Liambila, W. (2004). Using Data Envelopment Analysis to Measure the Technical Efficiency of Public Health Centers in Kenya. *Journal of Medical Systems*, *28*(2), 155–166. https://doi.org/10.1023/b:joms.0000023298.31972.c9

Mohiddin, A., & Temmerman, M. (2020, July 27). *COVID-19 exposes weaknesses in Kenya's healthcare system. And what can be done*. The Conversation. https://theconversation.com/covid-19-exposes-weaknesses-in-kenyas-healthcare-system-and-what-can-be-done-143356

Muinga, N., Magare, S., Monda, J., English, M., Fraser, H., Powell, J., & Paton, C. (2020). Digital health Systems in Kenyan Public Hospitals: a mixed-methods survey. *BMC Medical Informatics and Decision Making*, *20*(1). https://doi.org/10.1186/s12911-019-1005-7

Schoonenboom, J., & Johnson, R. B. (2017). How to Construct a Mixed Methods Research Design. *KZfSS Kölner Zeitschrift Für Soziologie Und Sozialpsychologie*, *69*(S2), 107–131. https://doi.org/10.1007/s11577-017-0454-1

Statistics Solutions. (2021, June 18). *Using Chi-Square Statistic in Research*. https://www.statisticssolutions.com/free-resources/directory-of-statistical-analyses/using-chi-square-statistic-in-research/

Streefkerk, R. (2021, February 15). *Qualitative vs. quantitative research*. Scribbr. https://www.scribbr.com/methodology/qualitative-quantitative-research/

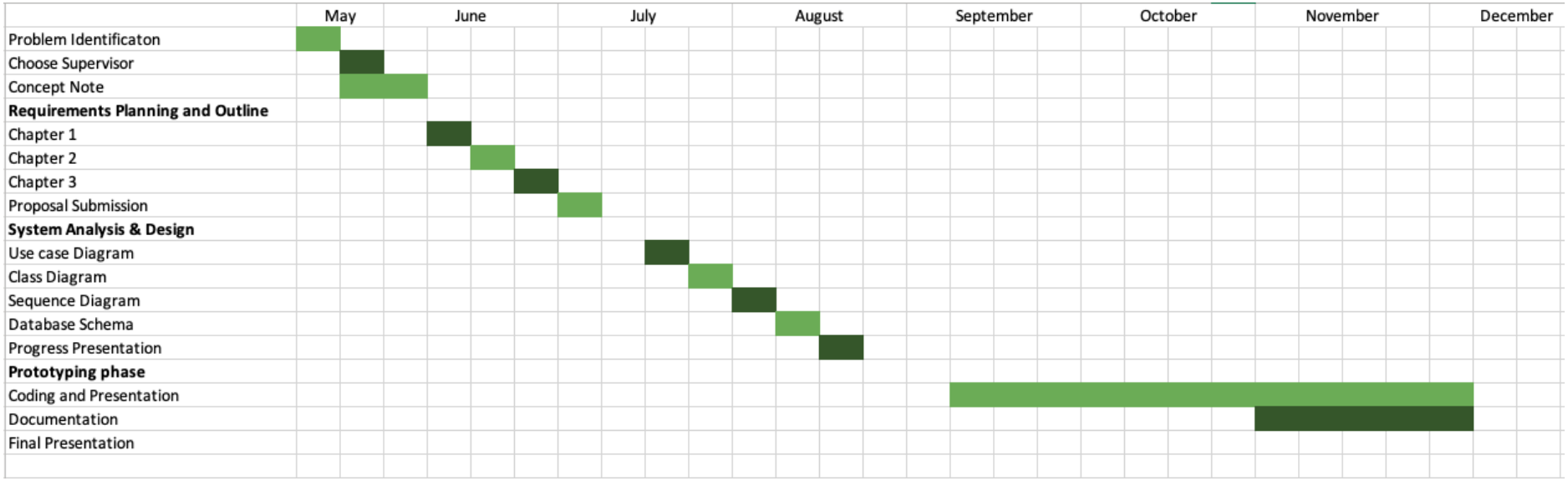
Twycross, A. (2004). Research design: qualitative, quantitative and mixed methods approachesResearch design: qualitative, quantitative and mixed methods approaches Creswell John W Sage 320 £29 0761924426 0761924426. *Nurse Researcher*, *12*(1), 82–83. https://doi.org/10.7748/nr.12.1.82.s2

USAID. (2015). *Publication Archive*. Health Policy Plus. http://www.healthpolicyplus.com/archive/browseHPP.cfm?get=291

World Health Report 2002: Reducing Risks, Promoting Healthy Life - World. (2002, January 1). ReliefWeb. https://reliefweb.int/report/world/world-health-report-2002-reducing-risks-promoting-healthy-life

WHO. (2014, May 15). *World Health Statistics 2014*. World Health Statistics 2014. https://www.who.int/news/item/15-05-2014-world-health-statistics-2014

Appendix A: Timeline of Activities



Appendix B: Data Collection Tool

Interview Questions

Doctors

Question 1: How many patients do you attend to in a day?

Question 2: Do you often use patients' medical records?

Question 3: How are medical records stored in your medical facility?

Question 4: How long is the approximate time taken to retrieve a patient's medical records?

Question 5: On a scale of 1-10 rate the level of difficulty for accessing a patient's medical record, 1 being effortless and 10 being very difficult.

Question 6: On a scale of 1-10 rate your level of satisfaction with the current data management system in your medical facility, 1 being dissatisfied and 10 being satisfied.

Community Health Workers

Question 1: How many NCD patients do you attend to away from the medical facility in a day?

Question 2: What method do you use to record the patients' data?

Question 3: How is the data transferred to the medical facility's data management system?

Question 4: How are patients assigned to CHW?

Question 5: Do you think the current system is adequate?