A Hybrid Medical Consultancy Tool for Health Service Delivery

Kinyanjui Andrew David
Student ID: 95969

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School of Engineering and Computing Sciences
Strathmore University
Nairobi, Kenya

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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:

……Andrew Kinyanjui…….. [*Signature*]

……January 2021…….…….. [*Date*]

Approval

The work of 95969 was reviewed and approved *(for examination)* by:

Supervisor's signature:

…….…….. [*Signature*]

…….…….. [*Date*]

Abstract

This paper presents the issues revolving around online healthcare and whether it should be implemented. Technology is improving every day and this is forming a base for the implementation of solutions to medical issues that benefit all. Many people now have access to smartphones and even more, have access to the internet based on the rapid technological growth that has paved the way for the expansion of connectivity.

Medical consultancy over the internet has been a delicate topic in previous years.

I have focused on the current systems, seen their weaknesses, and strived to improve those using newer and better technologies that will ensure optimal reach to all who are willing to use the system. This is based on using hybrid applications to ensure that everyone with access to the internet is able to access an online medical consultancy application from wherever they are. The system links the physician with the patient and they are able to conduct basic medical check-ups, make appointments and get referrals among other functions in the application.

The results of the implementation of the online health consultancy system will strive to show the advantages of using the system to see a physician as opposed to having a physical meet up. The application is to be subjected to constant review to be up to date with the health standards required to provide optimal delivery of service.

Keywords: Online, Consultancy, Medical

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List of abbreviations

GVRC Gender Violence Recovery Centre

API Application Programming Interface

APP Application

CRUD Create Read Update Delete

COVID- Coronavirus disease

CSS Cascading Style Sheet

DE4MHA A data encryption solution for mobile health apps

GB Gigabit

HTML hypertext mark-up language

HTTPS Hypertext Transfer Protocol Secure

iOS iPhone operating system

OOAD - Object-oriented analysis and design

OS operating system

IDE Integrated development environment

IBM International Business Machines

MD5 message-digest algorithm

NoSQL not only SQL- Structured Query Language

RAM Random Access Memory

VCS Version Control System

Chapter 1: Introduction

1.1 Background

Information and communications technologies have played a critical role in the medical industry today. We have seen various advancements that bring together information with the aim of solving particular problems in the health industry. In Kenya, many people succumb to death due to them encountering an illness, injury, lacking a quick pre-diagnosis, and insufficient efficient mode of transport to the nearest member health facility.

The system is designed to

have the capability to link medical staff and the end-users, through a platform that enables remote diagnosis of any symptoms that the user may relay to the doctor. The most recent instance is where we have seen people suffering in silence with no known way to help them out with their medical needs. This factor has been critically exposed during the 2019-2020 COVID-19 outbreak whereby hospitals and crowded areas are considered hotspots for contracting the virus.

There are also instances where people want to see doctors but they are scared of victimization and judgment because of their condition. The application will give a platform to air one's grievances. This has been proven to reduce the fear of communication psychologically thus, more cases are likely to be resolved.

1.2 Problem Statement

The matter of people having insufficient access to health care resources as well as the inefficient distribution of medical resources has become a menace, especially in Kenya. There have been instances where we have seen the healthcare industry face challenges financially and insufficient numbers when it comes to skilled labour. This continues to portray a more shocking drift because there is a high demand yet a low number of skilled personnel. There has been an average of 0.2 physicians per 1000 people in Kenya (World Bank, 2015) as of 2010 to 2014. The problem is still present because of factors such as the ongoing outbreak of the COVID19 and the reduced number of the qualified number of medical practitioners among others that hinder people from being unable to get medical attention because of the toll it has taken on the medical sector in our country, Kenya.

The people who are mainly affected by the matter at hand are the people who are in need of medical services. The proposed system is to bring the services closer to the medical fraternity without physical interaction. Doctors and medical staff are also bound to gain from the project. This is because it will ease the doctor to patient ratios. This will improve the quality of healthcare per individual because there will be more detail.

1.3 Aim

There is a need to find a way to ease the population in hospitals. There has been the need to create a low-cost solution to have evolution to healthcare that will address the matter of the uneven ratio of patient to doctor, as well as ease the process of getting a medical opinion on symptoms that may be diagnosed without physical interaction.

The importance of the developed system is to bring convenience when it comes to seeking medical assistance through the aid of the internet. There is a vast number of people who have access to the internet (Makini 2020), hence it is noted that it is an opportunity to introduce the internet-based way of communicating with a doctor from anywhere and at any time. The system delivers healthcare that is more cost-friendly to its users as compared to physical meetups with physicians. Hospital charges are inclusive of maintenance and hygiene among others, while these costs are not applicable when it comes to the online consultation. Privacy is also a matter to be addressed by the system. A normal general hospital will never have at most privacy since you have to avail yourself publicly to have your consultation done. The internet gives a platform to enable people to ask sensitive questions as well as what some may consider embarrassing too (Singh, 2018). There are factors such as shame, insufficient knowledge on the risks associated with the disease, openness, limited access to health services and aspects of gender inequality are determinants that influence the willingness to seek help from qualified medical staff (Vandauli, 2019). A rapport between a doctor and patient online can ease the pressure of disclosing their matters and having a solution made.

1.4 Specific Objectives

i. To identify the challenges in the delivery of medical services.
ii. To review the existing online consultancy services and to find out better ways to implement the system.
iii. To develop a Hybrid Application that offers efficient Medical Assistance over the internet.
iv. To test the developed application through unit testing.

1.5 Justification

The main deliverable targeted by the system will not be a full diagnosis of the patient's disease but instead, a list of differential methods to deal with the symptoms can be administered to the patient. The prevention of further damage from the 'illness' should be a prior goal of the system.

In case of non-availability of doctors or busy schedules, the appropriate waiting time to be mentioned to the patients. This is to be set upon standards of quality so that there is a way to ensure optimal quality of healthcare over the internet. The system is to be able to form a ground for the development of systems that provide healthcare through the phone on an auditable and real-time basis. It is indeed a project worth undertaking because of its extensive capability of assisting to prevent further damage from delayed medical attention that result from factors such as distance to, availability, and reliability of medical facilities. An example of this is when you need medical assistance during a home delivery of a baby and you have no experience in that field, assistance can be made over the internet.

1.6 Scope and Limitations

The challenges outlined above have been noted and ways have been formulated to enforce timely online diagnosis with the aid of the application to be developed. I propose the development of A Hybrid Application that offers efficient Medical Assistance over the internet. A Hybrid mobile application is essentially like a website that runs in a browser shell within the app. The application integrates a communication medium within the application to allow for the physician and the user to interact in a safe space with the aim of diagnosis of the patient's symptoms or questions, hence it can be used at the comfort of one's preferred location. There will be an array of multimedia features used to relay communication back and forth to ensure that the client is fully satisfied with the feedback they are getting.

A health solution over the internet may have limitations, which tend to be very drastic. This is shown where we have absolute client dissatisfaction when either the client or the server experiences an issue or when the doctor does not give feedback that is up to standards due to the norm where man is prone to error.

There are also instances where medical solutions may not be able to be achieved over the phone, such as orthopaedic related cases and matters that require physical interaction with the doctor. It is a norm for hospitals to conduct a triage before one sees the doctor, but this system assumes that stage of consultation and dives straight into the diagnosis by a description of the symptoms. This may erroneous because some vital signs might be noted only through physical examination of the patient's status.

This takes a toll on the doctors, for they may not fully understand the medical background of the patient.

There is also the factor of having a global pandemic that may hinder the data gathering from relevant bodies for most companies that have shut down or are having strenuous times hence operations may be abnormal.

Chapter 2: Literature Review

2.1 Introduction

The Government of Kenya rolled out the Big 4 agenda and among them was for Kenya to achieve a universal health coverage status, among others. The United Nations sustainable goal development 3 also pushes to have healthy lives and promote well-being for all at all ages. Based on an article by Kruk (2017), a survey done on different hospitals across different countries shows that lack the basic infrastructure needed to provide essential medical care on a consistent basis. There is also noted that there is a high hospitalization rate with over diagnosis and overtreatment. This is a major issue in the infant and maternity wing of hospitals. 7 Examining variation in quality is one way to diagnose drivers of good or poor performance. Kruk et al. find that the quality of antenatal and paediatric care in seven African countries varies greatly and that this variation may result from the different approaches governments take in training providers and funding and organizing their health systems.

2.1.1 Existing Online Medical Consultancy Systems

There is a very vast number of people with access to smart devices and the internet. There has also been a large population of people who prefer to look up their symptoms online as opposed to going to see a physical doctor. According to Morahan-Martin, (2004) 4.5% of searches on the internet are health-related. This is backed by Google's statistics on the same, but narrowed down to Kenya as of May 20th, 2020. See the Compared breakdown by the city on Google Trends for Health, disease, symptoms, and hospital.

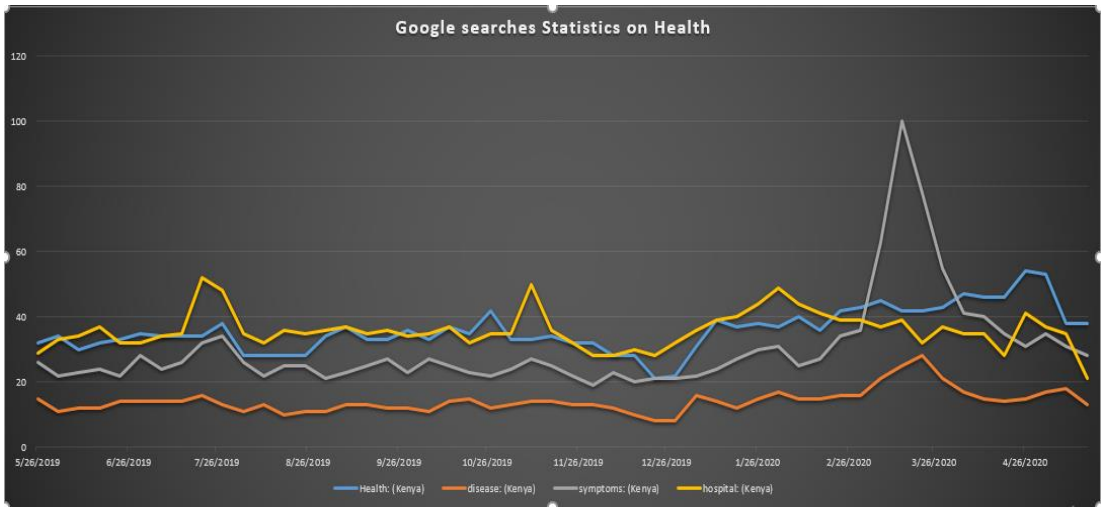


Figure 2-1 Statistics on the number of health-related searches on Google

This sector has untapped potential for there is the possibility of having a good rapport with an online doctor and avoiding the need to go to a hospital and can deliver service from anywhere and at any time.

There are existing applications that offer clinical health-related functions. According to Bulous (2014), there are many apps in existence that aim at medical intervention on specific specialties such as menstrual cycle monitors, Fitness, and Counselling apps among others. Many of these applications may not necessarily meet the user's expectations hence they may not satisfy the end-users. This has been in constant improvement since the publication of Bulous article in 2014. In recent years (2019 to present) another team by Stevens (2019) conducted empirical research on how the acceptance of health apps by users has been trending. This was done by following a methodology known as Arksey and O'Malley's scoping review methodology. It bases facts studied from the literature on a specific topic. This is important to have insights on the extent of the research at hand. It also gives a way in which one can summarise the findings collected and finally to identify the gaps left by the researched topic. In this case, it is the use of mobile health applications. From the 79 articles that were in line with the study, it was found that not many people have ventured into the use of apps for health consultancy as opposed to visiting a physician. Research is ongoing, based on the effects of engaging in consultancy over the internet which has brought about the basis of developing the system at hand. The research that has been done focuses on the methods by which the applications are being implemented, the value they bring as compared to physical visits to the doctor and implementation issues, whereas adverse effects are underexplored.

This has led to the focus of developing a health consultancy application that aims to focus on the challenges faced by the existing methods of implementation.

2.1.2 Challenges faced by existing medical consultancy systems

Mobile health applications have emerged and are indeed making an impact on the medical industry. They have an advantage over physical visits to physicians. However, they are very critical systems in that the smallest of hitches can cause drastic issues. One of the major concerns is the security of the applications that are in existence. According to Silva (2013), applications that use the internet as a medium of

communication are often points of vulnerability in regards to security. This is a risk to the integrity and the confidentiality of the information being relayed.

2.1.2.1 Technology Development Improvements made to online medical consultancy systems

Silva (2013) looked into the measures taken to improve the security and integrity of health systems. They proposed the use of a data encryption method called DE4MHA. This is a hint that implementing a security measure for the application. In Ionic Studio, one can implement end-to-end encryption of the communication of the app. Using firebase is an added advantage for the providers, Google, to encrypt its operations. Using HTTPS for methods like. push () when communicating with the database ensures that the connection is encrypted. Firebase only communicates with HTTPS traffic, which affirms that the data passed through remains safe.

Other concerns brought about by the system are the responsiveness of the application when it comes to the connectivity between the medical practitioners and the users. This is affected majorly by how the applications are built. Most are native applications. They are affected by availability. The proposed application is to take a hybrid application approach in that it will meet all target matter audiences, no what OS the user is running since the application will be available on iOS, Android and Web platforms. Hybrid applications also have high-speed performance depending on the reliability of the server they are running on.

Hybrid applications have attractive interfaces, which eases the learning curve because of their user-friendly interfaces.

Proper development of the application will guarantee the top performance of the system.

2.2 Conceptual Framework

The system has three main actors; the client, Medical Practitioner and later versions of the application will include an ambulance dispatch service that was implemented in my IS project 1. The client and the medic can converse through the application provided they have a stable internet connection and an account in the application. The communication is aided by video, voice, images, and text. This enables a better diagnosis over the internet where media is needed.

Chapter 3: Research Methodology

3.1 Introduction

This chapter presents a rather broad perspective on the concepts models and techniques used to provide the foundation of the system. It gets a basis from a business-oriented way where the requirements of the end system are noted and this chapter focuses on the way that the software will take form. Loucopoulos (1995).

The system will use structured system analysis and design. This is because Ionic is based on an object-oriented framework that is used to develop web applications. HTML is used as the main language and it is essential in building applications in a manner that is very clear and brief.

The system development methodology proposed is the evolutionary Prototyping model. Prototyping is the making of a model of a system in the form of a concept.

Evolutionary prototyping is used when the concept model is made and the developer deploys it to the client or tester. They give feedback and insights on what could be improved on which makes the system as close as possible to the user's requirements. The model will go through a series of steps that are;

1. Making of a prototype of the system to identify its strengths and what it lacks from the previous systems of a similar genre.
2. The prototype verification phase which will take place after relaying the information from the users of the system will give feedback by online surveys powered by google forms. However, due to the ongoing Worldwide pandemic, the prototype verification will be solely based on secondary data for reference.
3. Changes for the prototype will be made once the initial prototype is seen to have flaws in it, or it is rather unsatisfactory. Further amendments will be done during this phase to ensure that the system is as close to perfect as possible

3.2 Research Design

In this segment, the preferred method of research is quantitative research. This is ideal mainly, to determine the relationship between the variables involved. In this case, we are trying to find out why people succumb or have further effects from illnesses or accidents, despite the availability of medical and emergency services. Quantitative research is ideal because it focuses on the correlation between the variables in the question.

a. Study based on the number of contacts

This is the traverse study that gives an in-depth analysis of data gathered from a certain population at given the parameters of time. This gives the basis for the study of the reasons why people succumb or suffer the effects of delayed if not access to a medical facility in due time. The cross-section study gives a descriptive output to give an assessment of why the problem at hand is prevalent. The data is gathered from people who differ in some aspects but share other characteristics like their ethnic group or even education. The variable of interest, in this case, is the reasons for further ailment or death.

b. The period of study

Cross-sectional studies take place during a set time and the data gathered from different groups of people. The study will monitor the outcome of the data gathering. This is done using a prospective study design, which refers to the documentation of the presence or absence of exposure of interest is documented at a period before the beginning of the study. Slankind (2010) The final outcome attempts to show the solution of the matter, given the solutions are implemented.

c. Nature of investigation

This forms a basis where the conditions and external factors relating to the case study is done to establish the relation between the variables as well as the solution to the problem. This is a comparative experimental study where we try to contrast the matches and variations of instances in a natural setting. Once the experimental contrast is done, the best solution to the problem is outlined and the project kicks off to tackle the problem, which is to establish a method to deliver healthcare to all to avoid fatalities and further ailing.

3.2.1 Experiment Procedure

Step 1: Gathering of required data to conduct statistical analysis. Starting with the sample set that is intended to have the study deployed to.

Step 2: Get the sample size of the set used in the first step

Step 3: Gather data on reasons as to why people succumb or have further effects from illnesses or accidents, despite the availability of medical and emergency services.

Step 4: Utilize the comparative experimental design to gather facts and identify the best solution to the problem being focused on in step 3.

3.2.2 Evolutionary Prototyping Model

The evolutionary prototyping model is the preferred approach since it is iterative hence it ensures that the system has minimal errors for it undergoes in-depth and the customer must approve of its test versions before it is released finally. This is a guarantee that the project at hand will be guaranteed to be as diligent as possible. This will be an added advantage since the customers will get to give feedback on the developing system in contrast to the previous (if any) existing systems. This gives an upper hand for the project to have a solution for all the relative problems experienced by the users of the system. Carter (2001) says it also addresses problems in regards to the model that are not fully looked into by the traditional software process models. These problems include but are not limited to the ability to meet changing constraints for the system as defined by the client at later stages of development. This is key for it ensures that previously unknown requirements are investigated and implemented.

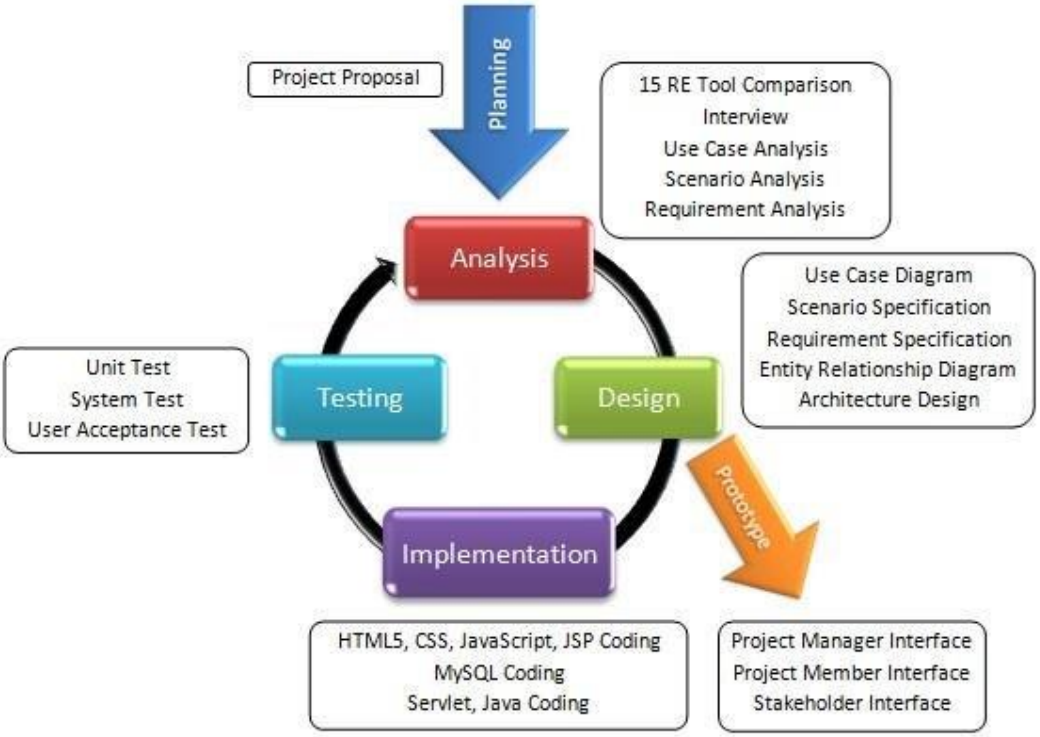


Figure 3-1 Evolutionary Prototyping model. Nordin (2018)

3.2.2.1 Quick Design

The system is designed carefully and in line with the first versions of the development phase.

3.2.2.2 Develop prototype

The system is developed and fine-tuned to the best of its capabilities at the given time.

3.2.2.3 Evaluation of prototype by the end-user

The system is reviewed and given guidelines on what should be improved, added, or removed from the system.

3.2.2.4 Refine Requirements

Feedback gets back to the developer who implements the changes, but this goes back to the design phase once again to follow the iteration cycle.

3.2.2.5 Setbacks of the Evolutionary Prototyping Model

It may be an uphill task to have a clear prediction of the time schedule of the project life cycle since the number of times that users report complains about the system, it will have to undergo the evolutionary prototyping iterative cycle once again until the system is closest to perfection.

This method is quite fragile as well, in the sense that the developers must be very careful to not make errors that may lead to time wastage because the model will require that the whole process start again to identify and amend the error made.

3.2.2.6 List of Design Diagrams that will be drawn in Chapter 4

The system at hand will use the evolutionary prototyping model hence it will require the use of the following diagrams to illustrate the operations of the system.

1. Use case diagrams used to describe a set of actions that should perform in collaboration with one or more users in the system.
2. Class diagrams to illustrate the object-oriented perspective of the system during the execution of every process.
3. A Sequence diagram to illustrate the data elements related to the entities in the system's processes.
4. A database schema is also key to illustrate how the database blueprint is organized to store data.
5. A graphical user interface mock-up that will enable the users to have access to the system in a very easy and appealing way as they access the application on their devices.

3.2.3 Experiment Test Data

The proposed testing method will be Unit testing. It will be conducted on a small scale basis, preferably with a hospital with many branches. I identified Nairobi Women's Hospital, Gender Violence Recovery Centre as a start. The testing is to be done using the dummy data to test that the processes are being handled well. The main purpose is to validate that each module is functioning well. White box testing may also be integrated to confirm the internal structure of the modules of the system to ensure that the user interface and the back end of the system are working

The next phase will be done by giving them access to the system to relevant users just to test the beta version, but this system cannot be used yet until its completion, rather closest to perfection because it will be putting lives on the line if it encounters problems underway.

3.2.4 Experiment Test Bed

The App is used to communicate between the medical staff and the client. This is made possible by communication APIs that are compatible with the Ionic framework. CometChat that offers one on one conversations as well as Voice and video engagements over the app. This is a key feature when it comes to communication.

The preferred database service is Google's Firebase, which is a NoSQL Database that operates and transmits data on a real-time basis.

The language used by Ionic Framework is Majorly HTML with CSS, Angular and Typescript. To run Ionic, we will need Node.js that is used to interact with the Ionic Ecosystem. Preferred IDE is Atom by Facebook. A command-line interface is also essential to run the ionic tools such as creating the project and setting up. On the hardware side, the development requires a powerful computer, with at least 8GB RAM, Core i5 processor and mobile phone for emulation purposes.

3.3 Data Collection Methods

3.3.1 Population Description

The target population is the people of Kenya as a whole and the medical fraternity of the country. The main objective of developing the system is to identify a way to provide an alternative method of getting medical assistance to Kenyans. We try to get answer the main question behind the problem at hand which is " Why people succumb or have further effects from illnesses or accidents, despite the availability of medical and emergency services."

3.3.2 Sampling Distribution

The sample size of the population that are tied to this experiment can be gotten by getting a sample (random people) per a given area and gathering data using a method that allows for quantitative representation on what they think about the problem at hand and the proposed method of improvement. However, due to the worldwide pandemic, this may not be possible for there is a go-slow and most of the branches of

the Nairobi Women's Hospital Gender Based Violence Centres are on a go slow. It is advised by the government to avoid physical interaction, which limits this stage. The ideal number of people who can be interviewed via phone call interview, is 25. Five from the medical fraternity and 20 from the public.

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

At this stage of the system development life cycle, we look at the methods used to collect functional and non-functional data. This section also dwells on the requirement engineering process, which is the manner, which system requirements are defined, refined, documented, and maintained. It entails the functional and non-functional system requirements. It is a stage that is very important in defining the system's sensitive parts because the proper definition of the system ensures that there is optimum utilization of time and resources for there is a defined goal objective as opposed to proceeding to develop without an in-depth requirement definition stage. It is used to ensure that as you develop you focus more on the problem stated instead of the solution.

The recommended method would have been one on one interviews but due to the state of the Nation as of 2020, this was not possible due to the worldwide pandemic that caused the limited movement. The second alternative is relying on secondary sources of data to validate the system requirements. These are scholarly articles from, but not limited to, journals, books websites, and data from censuses and surveys from accredited sources.

3.4 Data Analysis Methods

When tackling the question "Why people succumb or have further effects from illnesses or accidents, despite the availability of medical and emergency services?" we will use regression analysis because it is able to capture more than two variables of interest. In this case, the independent variable is the instances of fatalities and the dependent variables are the causes of death. This will be able to find out whether deaths or further effects of physical damage are caused by the alleged causes being studied.

3.5 Ethical Considerations

Every research should adhere to some ethical guidelines depending on the field of research. In the medical research field, there are a number of codes to be followed, among them, the Nuremberg code. Among the considerations given, the ones that are applicable to this research include

1. Voluntary consent to take part in any of the procedures involved with the project. All subjects to the research should be informed of what they are to engage in and they have a right to accept or reject the chance to take part.
2. The research is based on the strive for a better quality of healthcare, which is the greater good of society
3. Subjecting people who are involved in physical or mental suffering should not happen or avoided at all costs.
4. The procedures undertaken by the application should be done by qualified personnel only. In this case, the developer and the medical practitioner should be ethically and morally upright.
5. One is free to discontinue in the research/use of the application in this case
6. Researchers are prepared to terminate the experiment if they had cause to believe, in their good faith, skill, and judgment, that continuation was likely to result in injury, disability, or death to a subject

Among others, we also have matters of confidentiality, where the users of the system should not have their identity disclosed to the public.

The application also should be secure and the users are to maintain anonymous identity unless they opt to reveal who they are.

Vollmann (1996) ensured that these guidelines were put out to ensure safe health-related research. The Nuremberg Code was made formal in the Geneve World Medical assembly and is adhered to by all physicians in the world.

Chapter 4: Chapter 4: System Analysis and Design

4.1 Introduction

This chapter documents the planning process for designing and modelling the proposed system, through specifying the functionalities of the system and how the various components of the system will be integrated together. The data collected in the research survey was used to shape the design and architecture of the proposed system. A UML and data models have been used to illustrate the design and architecture of the proposed system.

4.2 Requirement Gathering

The requirement specifications are a description if the behaviour of the proposed system derived from the information gathered in the literature review. This section covers the functional and non-functional requirements.

Functional requirements

Functional requirements are those utilities that a system must offer. They include the details of the operations of the system.

i. The system should be able to enter data for registration. The super user who is able to approve and reject users based on their authenticity does this.
ii. The system should be able to validate users in the system in order to have factual data in all transactions in the system. This includes sessions and authentication.
iii. The system should be able to generate reports to monitor how the system is functioning. The attachment of Firebase Analytics API is used to keep real-time statistics on the reports of the system.
iv. The system should be able to update user records via the super user who is the overall key to all the operations. They can perform full Create Read Update and Delete functions.

Non-functional requirements

Non-functional requirements are the attributes of a system that define the system based but not limited to the portability, security usability all of which are critical to the performance of the system.

i. **Scalability** is the ability of the application to expand without any adverse effects on its performance. Firebase offers support that is able to scale in a linear motion with the data that is being run through it so there will be at most performance without any alterations of the code. For test purposes, firebase offers 1GB per day, which is more than sufficient for test purposes. It can scale up to having Kshs. 12 per GB of storage, which is relatively affordable. (Google, 2020)

ii. **Reliability** is the ability of the system to function given a certain set of conditions for a given time. The system will run on a local server temporarily during the development phase. This is guaranteed reliability for the development stage. Having a reputable server for the application such as IBM, which is ideal for non-stand-alone applications that work in conjunction with external services. IBM has availability monitoring services that ensure that the app has optimal if not full uptime. This helps identify potential issues before it gets to the client, this way the application will have maximum reliability.

iii. **Recoverability** is ensured by the use of a version control service during the development, in this case, git VCS is an ideal solution to ensuring that there are no losses incurred from failure that is bound to happen in any given system in that there is no impact on the user experience

iv. **Usability** is the ease at which the customer is able to use the system. The UI will be easy to use and in line with the platform's navigation and appearance criteria. The learning curve should have a very low gradient to enable the best integration of the system to the industry.

v. **The security** of the application is an added benefit to the operations. It is a necessity for every application to have some level of security. This application will ensure optimal security by the use of secure code because most security breaches are results of bugs in code. Writing code in a manner that is easy to develop but difficult to reverse engineer is key. All data passing through the app should be encrypted using a good method of encryption such as MD5. This is important when passing sensitive data. Using certified libraries will also

prevent the cases of insecurity where attackers use malicious code to affect the system. The use of authorized APIs only can also limit the instances of attacks through loopholes. Ionic authorizes the APIs used for maximum security. (Woo et al., 2005). Authentication is done using firebase authentication which is used to identify users in a way that is secure and guaranteed by an internally modified version of the script to hash passwords.

vi. **Compatibility** of the system. A Hybrid Application offers efficient Medical Assistance over the internet across all mobile operating systems as well as web applications. A Hybrid mobile app is essentially like a website that runs in a browser shell within the app. This gives it compatibility for most of the people who run Android, iOS, Windows and Web App platforms (Xiao et al., 2019).

4.3 System Architecture

The online doctor consultancy system was designed to have a seamless communication mode between the doctor and the client, which is entirely based on the system design. It is comprised of two main users who are the doctor and the client who have a platform, which they interact on. The figure bellow illustrates how the system is distributed across different platforms to achieve its functionality.

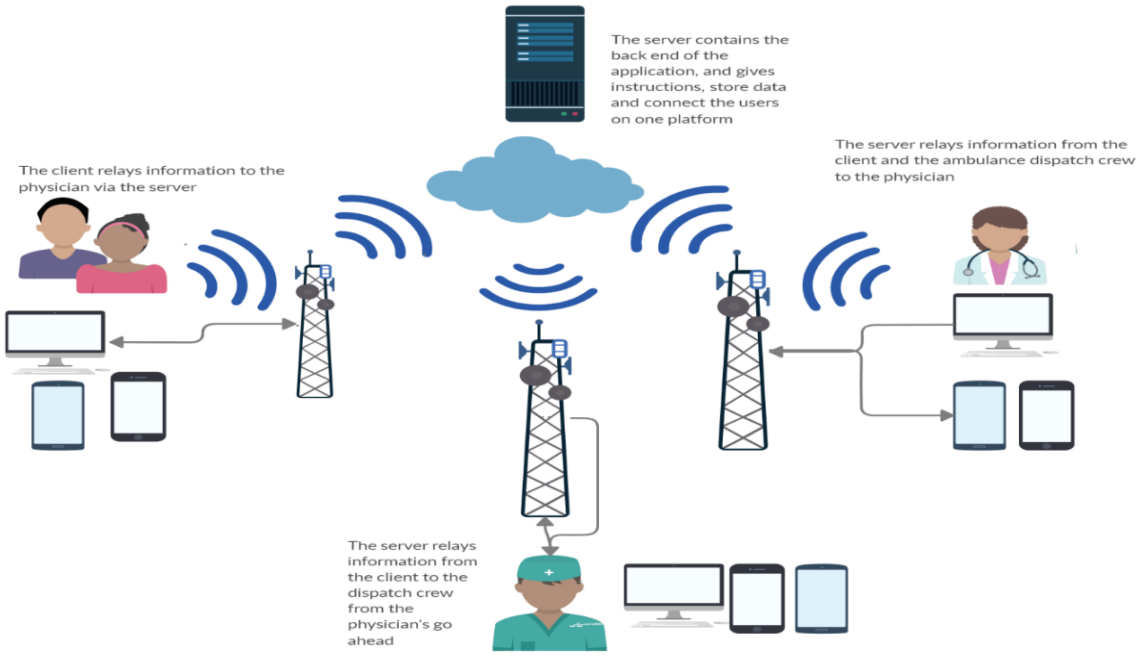


Figure 4-1: System Architecture

4.3.1 Client-side Architecture

This consists of a user interface that gives a vast array of options on the services that the system offers, which include but are not limited to a login, GVRC blogs, medic assistance and communication channels for further queries

4.3.2 Doctor-side Architecture

The doctor is able to receive communication from clients and schedule meetings over the application, which is their primary objective on the application.

4.4 System Design

This segment is where the system blueprint is formed where we use related figures to illustrate the flow of processes in the system and how they are correlated. There are figures that are used to illustrate this and they include:

4.4.1 Use Case diagram

A use case diagram is used to represent the functions of the various actors in a system. The use case diagram was used to model the relationship among the actors and the use cases within the proposed system.

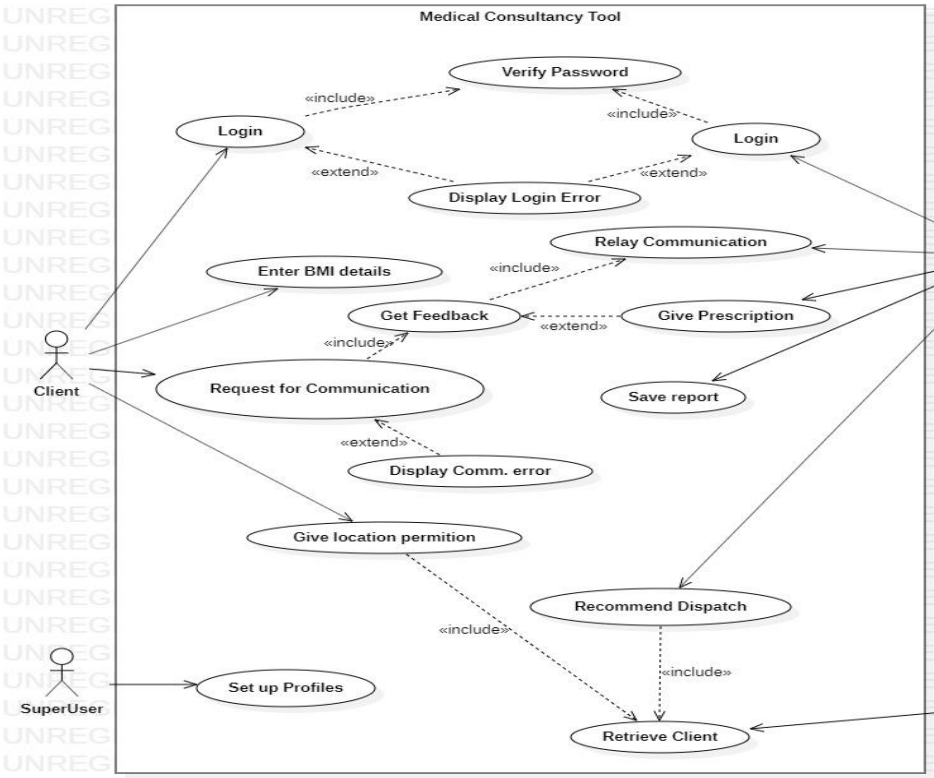


Figure 4-2: Use Case Diagram of the System

4.4.2 Use case description

i. Request for Communication

This use case shows the client requesting for the doctor to open a portal for communication. This cannot be certain because you will not always find doctors online because of the work structure of the GVRC.

Use Case Name:	Request for communication
Description:	The confirmation is relayed back to the user
Primary Actor:	Client <patient>
Trigger:	Feedback from the doctor
Pre-condition:	Patient is logged into the application
Post-condition:	User has a scheduled meeting with the doctor

Table 4.1: Use Case for requesting for communication

ii. Authentication Use Case

This use case shows the process of authentication. Signing up is not an option for control measures that can term medical applications very sensitive when signing up random people.

Use Case Name:	Login
Description:	All users must login to the application to access its features
Primary Actor:	All Actors
Trigger:	Authentication
Pre-condition:	Having an account and the application on a web browser, android or iOS device
Post-condition:	Credentials are correct

Table 4.2: Use Case Authentication

iii. Give Location permission Use Case

This use case shows how the client is prompted by the system to use the location feature of the application.

Use Case Name:	Give location permission
Description:	The user gives the application the right to access location for the dispatch process to occur
Primary Actor:	Client
Trigger:	User enters a geo-fence
Pre-condition:	Doctor sets up the geo-fences
Post-condition:	Client is now able to be sought after by the dispatch team.

Table 4.3: Use Case for authorizing the application to use device location

4.4.3 Entity Relationship Diagram

An entity relationship diagram is used represent a conceptual data model by showing the relationship between the database entities. It illustrates the logical structure of the database and usually translates to the actual database. The figure bellow shows the Entity Relationship Diagram of the proposed system.

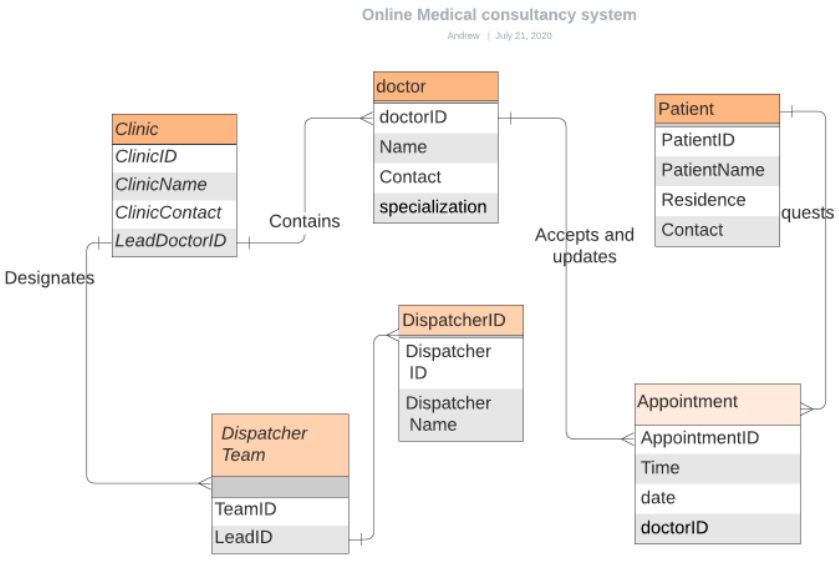


Figure 4-3: Entity Relationship Diagram of the System

4.4.4 Firebase Database

Firebase Real-time Database is a cloud-hosted database. Data is stored as JSON and synchronized in real-time to every connected client. This is a cross-platform application with iOS, Android, and JavaScript SDKs, all of your clients share one Real-time Database instance and automatically receive updates with the newest data.

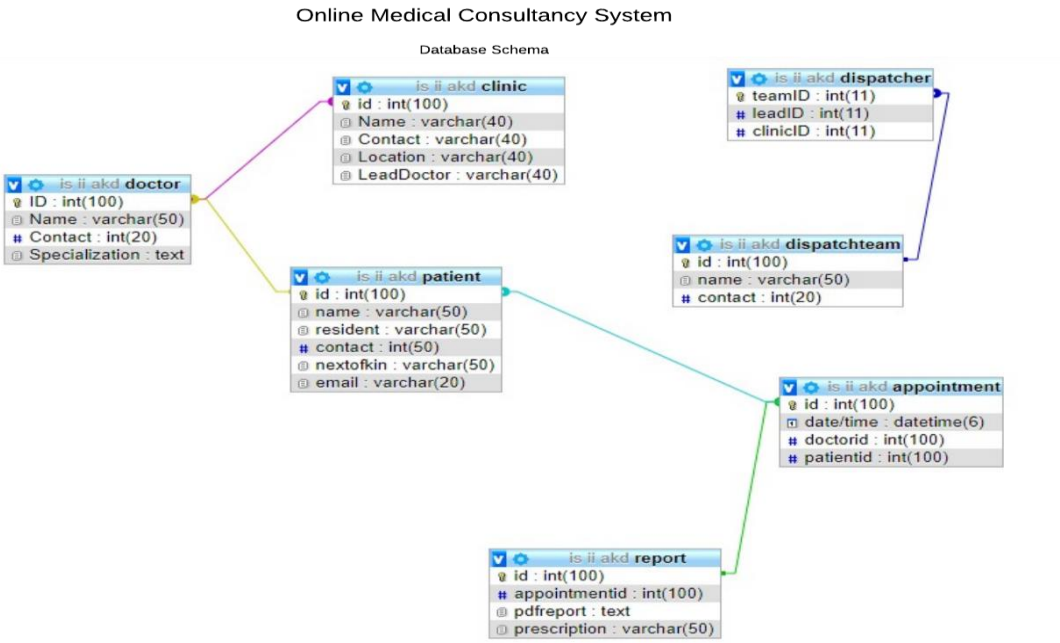


Figure 4-4: Database schema of the system

Chapter 5: Chapter 5 System Implementation and Testing

5.1 Introduction

In this chapter, we will cover the implementation of the outline of the system in the previous chapters of the documentation. We focus on the modules that were created and their functionalities. We also focus on how these modules interact with the users. This section also focuses on the checking of the testing measures put together satisfy the functional requirements.

5.2 Client-Side Development

This segment allows communication from the user interface to the database and vice versa. This connects the different actors of the system.

5.2.1 Development Tools

The language used by Ionic Framework is Majorly HTML with CSS, Angular and Typescript. To run Ionic, we will need Node.js that is used to interact with the Ionic Ecosystem. A command-line interface is also essential to run the ionic tools such as creating the project and setting up. On the hardware side, the development requires a powerful computer, with at least 8GB RAM, Core i5 processor and mobile phone for emulation purposes. The browser tools needed come with basic Chrome browser where we can use the console and inspect to debug code as well as acting as an emulator. This is key because running actual emulators may be draining to the computing power of the development PC. Git is a very important tool when it comes to handling vast projects like these because of the version control capability.

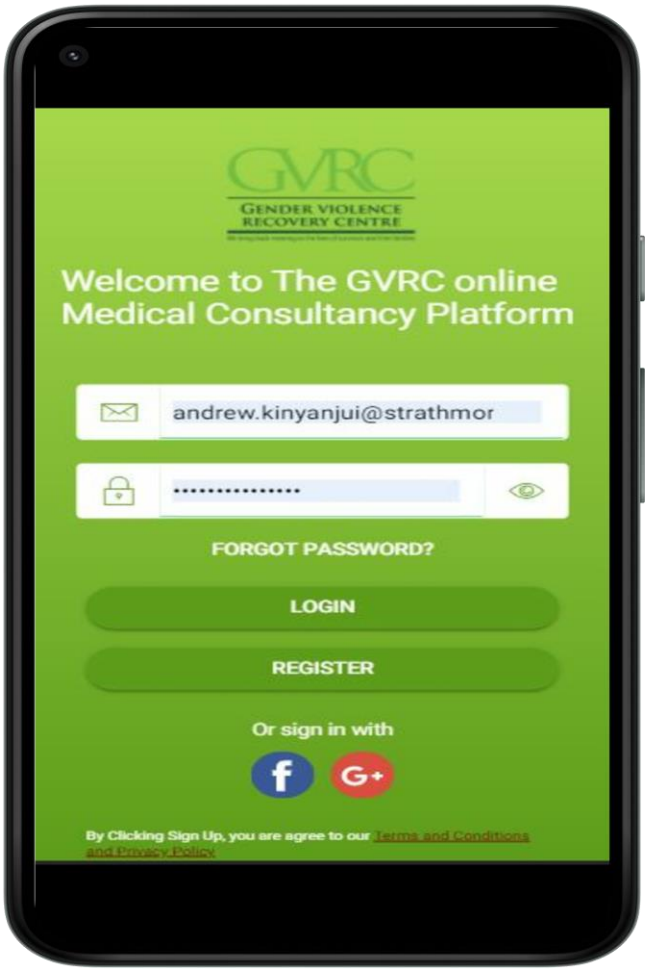
5.2.2 System Components

5.2.2.1 Login & Signup Page.

The administrator application system is required to authenticate the administrator. The administrator is required to provide their email and passwords for authentication. There is a password recovery feature in case an administrator forgets their password. Other users' application system does not require authentication.

The reset password feature sends an email to the user, upon entering their emails, with instructions on how to reset their password.

Figure 5.2 shows the Slider tabs of the ionic framework general template



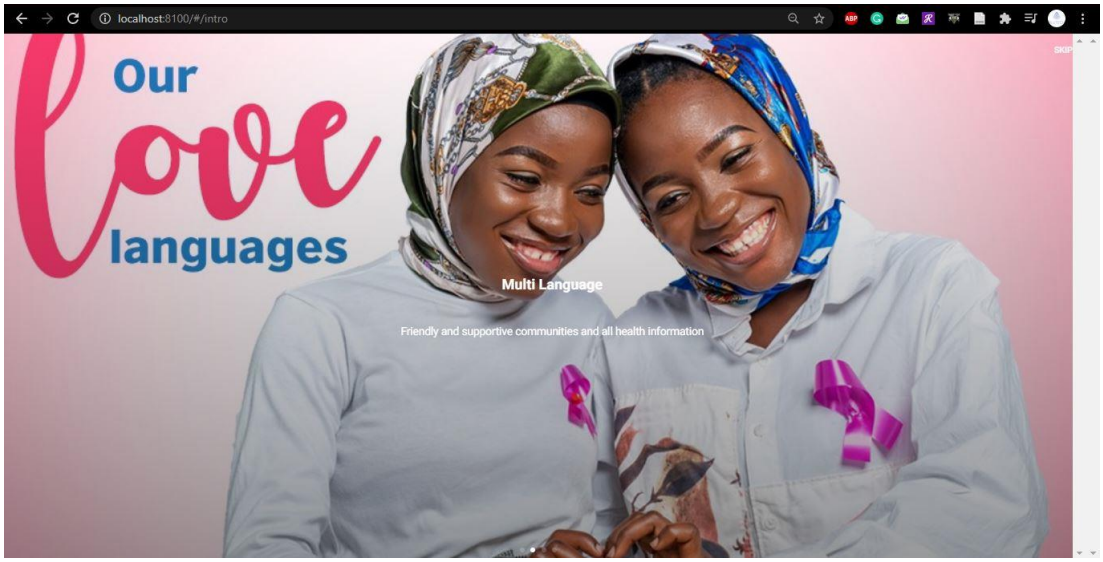
5-1 Login and reset password pages of the user

5.2.2.2 Dashboard Page with Slider.

This component is the basic introduction to the application where the user is able to have a brief introduction to what the application does by the use of modified sliders,

which take the tabs approach of the interface to give it a slider like interface. At the end, you are able to skip to the main dashboard

Figure 5.2 shows the Slider tabs of the ionic framework general template



5-2 Slider view of the introduction to the application

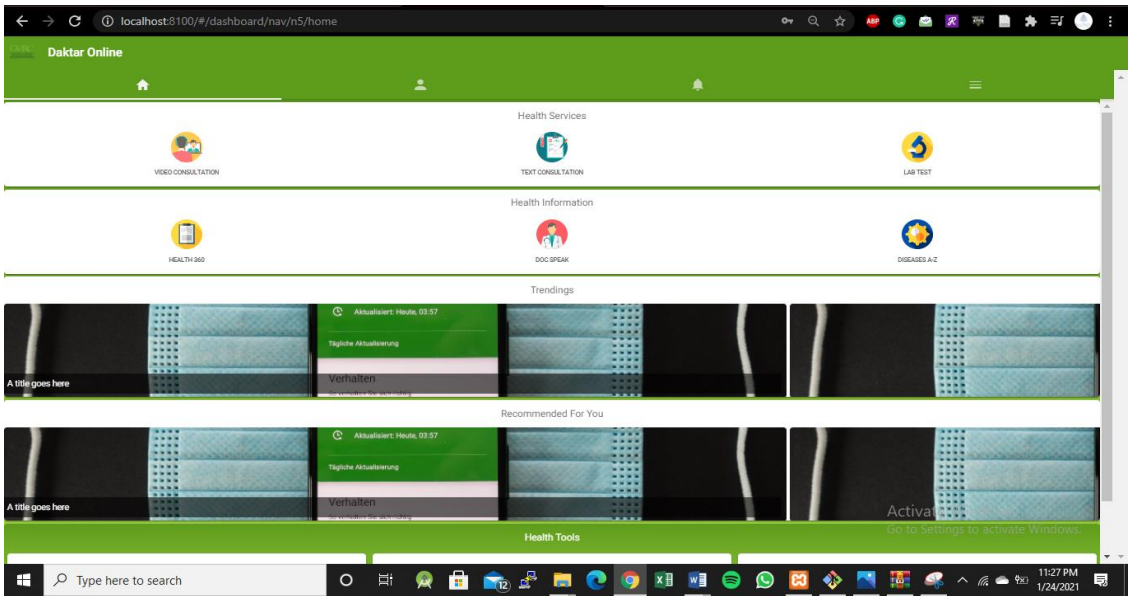
5.2.2.3 Main Dashboard

This is the basic home screen where you are able to select the service you would like to access from the system. This designed to enable a seamless interaction with the application on all platforms intended. The user interface is responsive on all platforms, which gives a very appealing interface.

The colour scheme is in line with the GVRC theme, which is green and white with a hint of red.

The navigation icons are not at specific areas because the different platforms intended have their own preference. This wraps the interface to the platform's characteristics. E.g., Web applications will have the navigation bars at the bottom whereas Android applications will have them at the top of the screen.

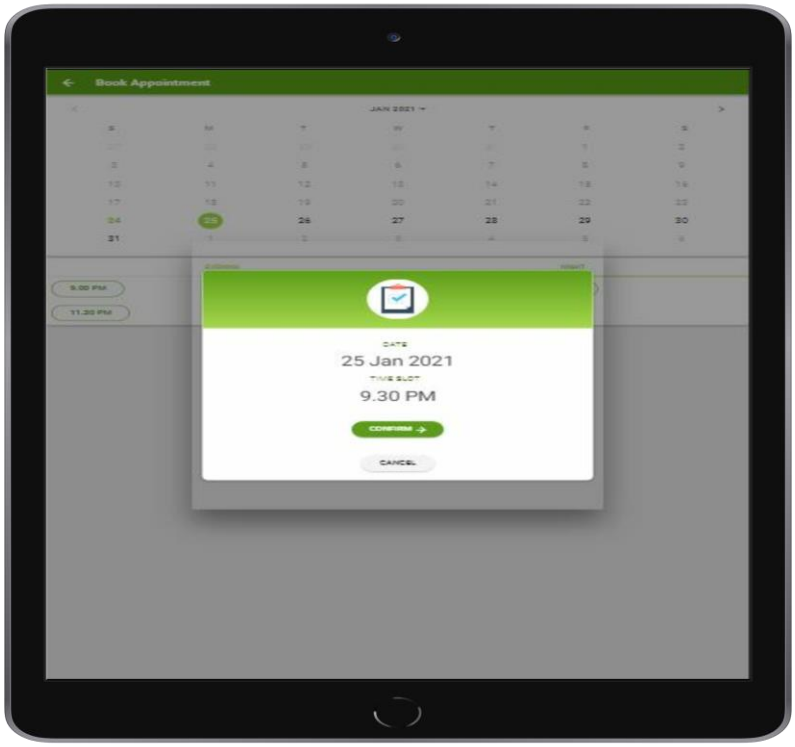
Figure 5.2 shows the main dashboard of the online medical consultancy application



5-3 The main dashboard in Web view

5.2.2.4 Video Consultation & Booking Page.

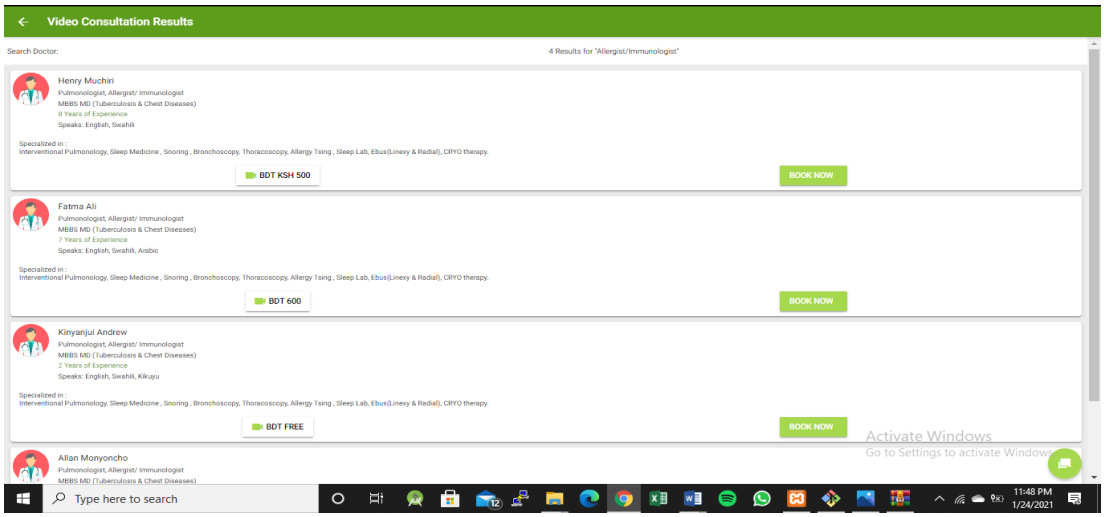
This function enables the patient to connect with the doctor for the online consultancy experience; this is made possible by a plugin called Comet Chat SDK



5-4 Responsive view on the Tablet view

5.2.2.5 Live Chat Page.

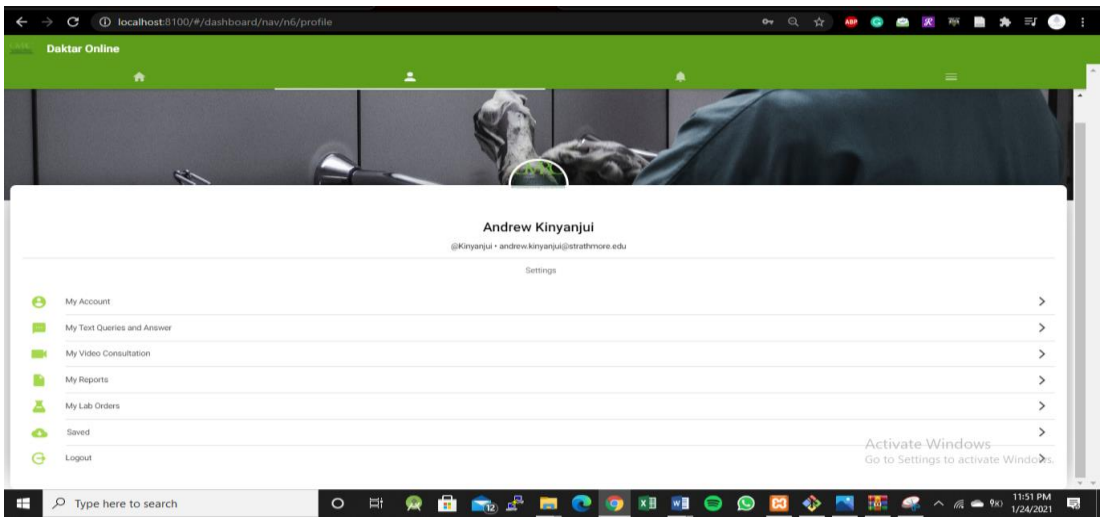
This gives different users the chance to seek medical questions answered by the medical practitioners in the application. This gives real time feedback, which relies on the Comet Chat plugin. This is not implemented because the comet chat requires the payment of a premium of 49 dollars per month for the lite package.



5-5 Request to have a video conference interface on web application view

5.2.2.6 Profile Page.

You get to enter details about you as the client. This is limited to the selected data that can be edited. This is because the super user is the one who has the rights to edit all data that has to be verified for safety purposes. This is where the features like Queries, video consultations, reports, lab orders and Logout features are located.



5-6 Client Profile

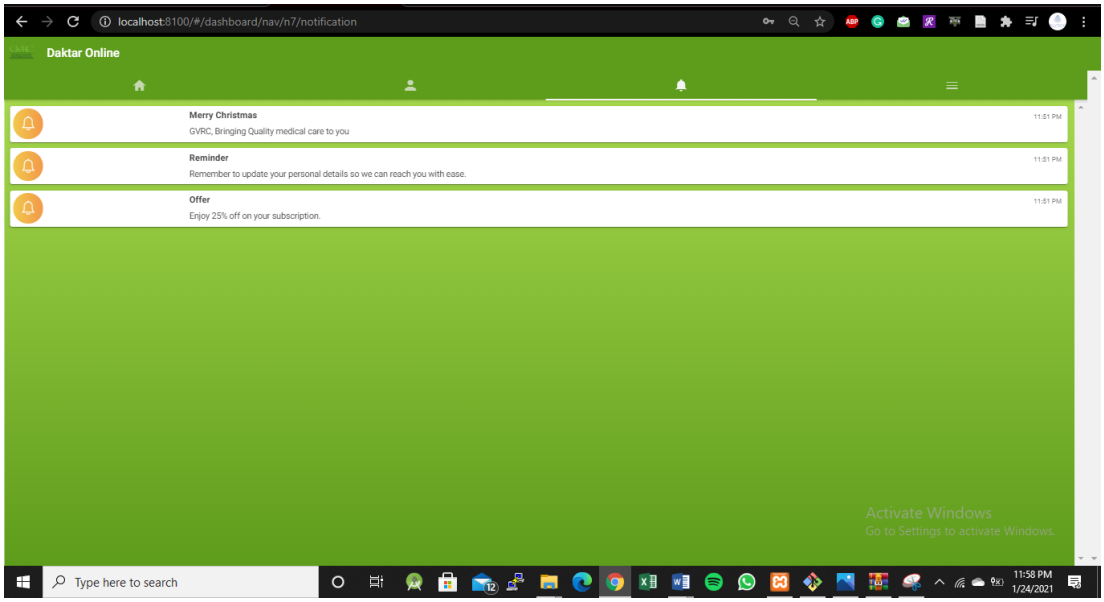
5.2.2.7 Blog Post with Share Actions Page.

This incorporates the GVRC blogs on their social media handles and their YouTube channel, which gives all the users a more interactive platform to communicate. This is also important in the aspect of digital marketing where the social media plugins are used to pull more users onto the business for better image of the GVRC and this boosts their online reputation and increases the clientele of the GVRC and Nairobi Women's hospital as a whole.

5-7 Blog on various Medical Topics

5.2.2.8 Notification Tab

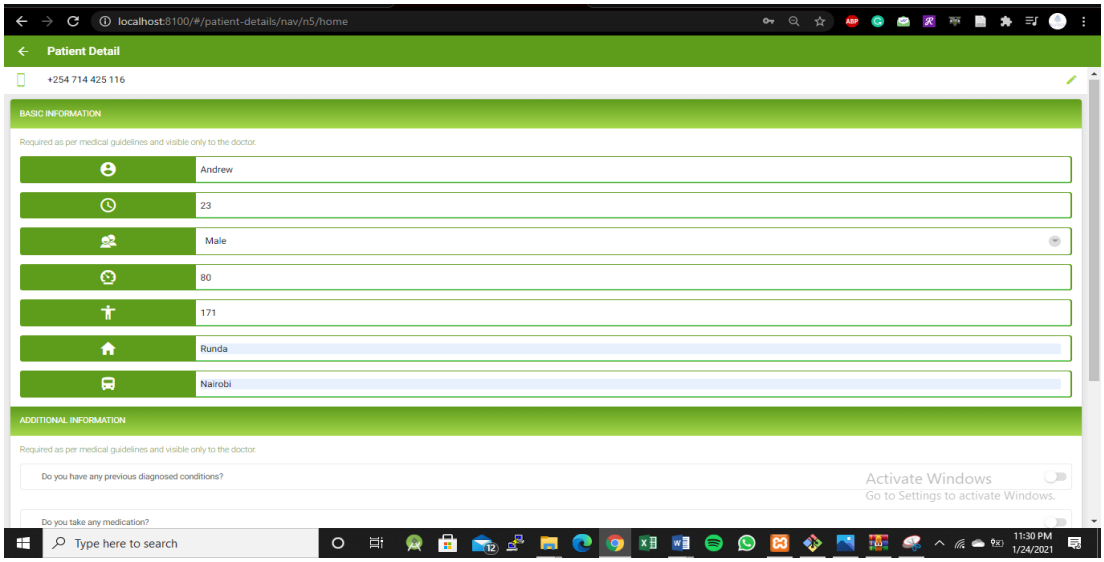
If you had a scheduled meeting, or any new content is available on the application, it will appear on the notifications page, which is accessed from the notification icon.



5-8 Notifications Tab

5.2.2.9 Basic information collection

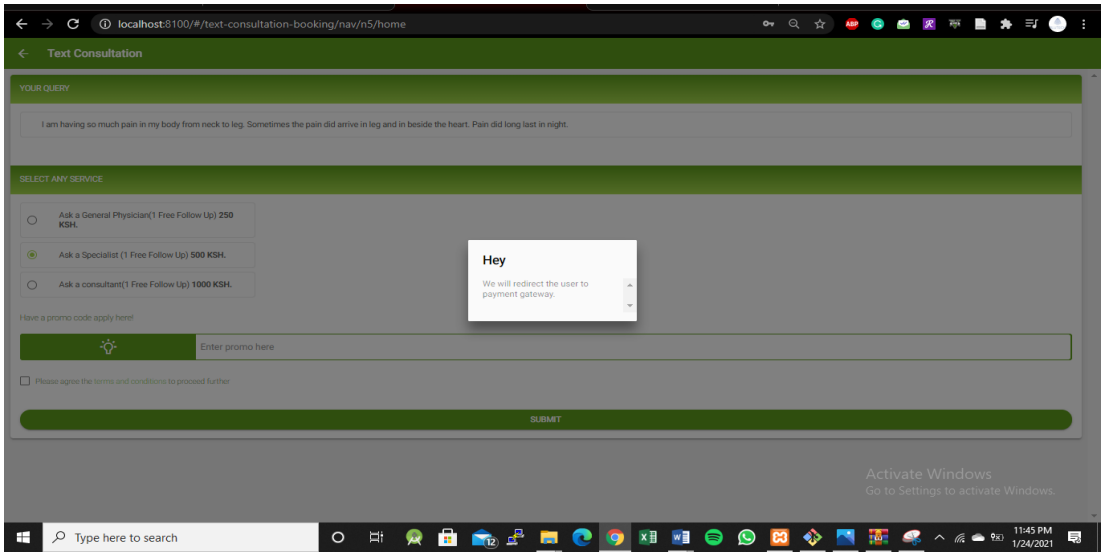
Basic diagnosis comprises of the collection of data about the description of the symptoms as would be done in the triage stage of being in hospital.



5-9 Basic Triage

5.2.2.10 Payment Module

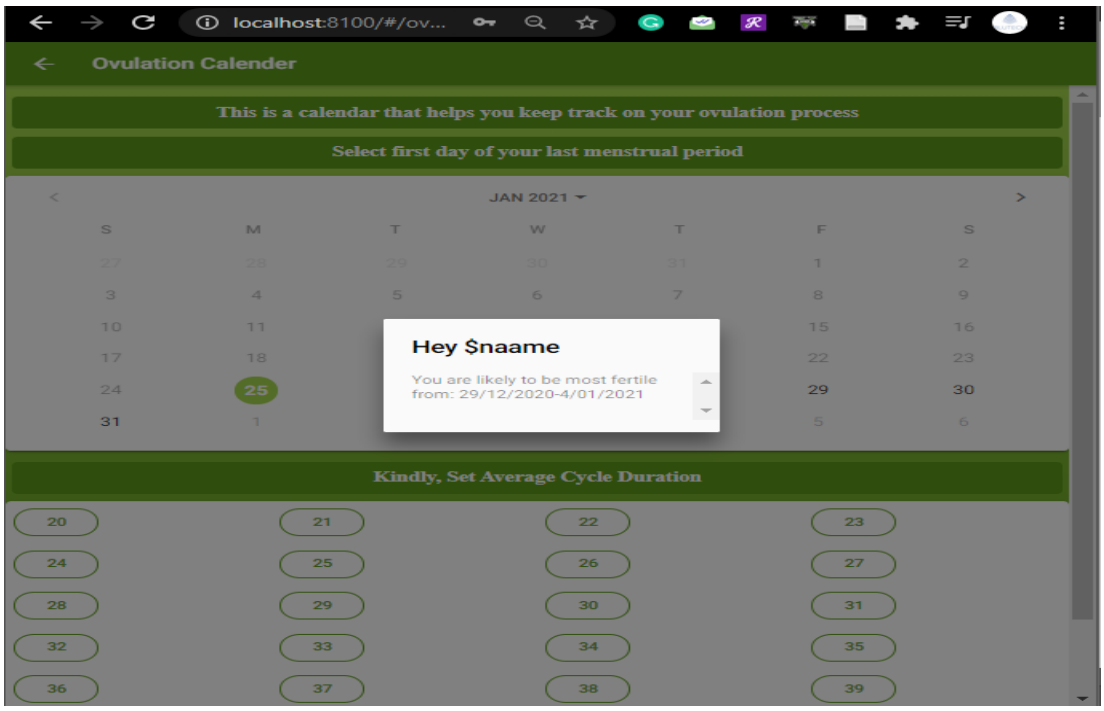
This is to be implemented once the final stage of the system is complete. This is to have a balance between the clients of the GVRC and NWH. It also will give time to know how to manage finances when it comes to insurance and subscribers of the system.



5-10 Payment Module

5.2.2.11 Ovulation, Pregnancy and BMI calculator

After consultation, it has been noted that there is a standard method of calculating one's cycles in ovulation pregnancy and BMI. There is an implementation of the calculators to give the users a very interesting user experience.



5-11 Ovulation Calculator

4.5 Server-Side Development

The server side development consists of the external services that are pulled onto the system such as the social media platform, geolocation services and storage capabilities. Figure 5.6 and 5.7 shows the real-time database and the authentication database respectively.

To sign an actor into your system, you first get authentication credentials from the user. These credentials can be the user's email address and password or an OAuth token from a federated identity provider. Then, you pass these credentials to the Firebase Authentication SDK. Our backend services will then verify those credentials and return a response to the client.

4.6 Testing

Software testing is an investigation conducted to a program or application with the intent of finding software bugs (errors or other defects) and verifying that the software product is fit for use. It's basically a verification and validating process. The online doctor consultancy system underwent the following series of tests that are discussed below.

4.6.1 Unit Testing

In unit testing the various components of the system were tested independently. This was to ensure that each component was working as it should. The codes, especially for the user's capabilities, were tested compiled and tested before upload to the firmware to ensure they were functional. Integration testing was done after each unit was tested. The integral unit was also tested for functionality. At this stage, the errors recognized were modified. What was to be pushed to the next development phase was also stated.

4.6.2 Functionality Testing

It is testing to ensure that the specified functionality required works. White box testing was used to test the system. The system was tested at every stage of development by the developer to ensure that the functionalities were working. Other developers who already had an idea of the structure and implementation of the system also tested the application.

4.6.3 Usability Testing

The application was tested to determine its usability about user experience. This test was based on how easy and efficient people found the application to be. Some of the criteria that were studied include:

i. Portability

This was based on how easy is was for the application to be used on the go. The application runs on a cross platform basis therefore most people found it highly portable and convenient to carry around.

ii. Ease of use

This was based on how easy it was for people to use the application with minimal to no prior training. The application was found to be easy to use, even for a person seeing it for the first time. The application has optimal design and page transitions, which makes it easy for people to use.

iii. Level of distractibility

This test was done to determine how much the application would be distracting to the users. It was noted that there was no significant distraction because it is just like any other application on your device and free will is exercised when using the application.

Chapter 6: Conclusion, Recommendations and Future Works

6.1 Conclusion

The developed system has bridged the gap between the doctors and patients who were in need of the application especially during the emergence of the COVID19 pandemic. This has also been key when identifying the most vulnerable and giving them access to the application on a cross platform basis. Recently, we have seen the emergence of the online basis of education, meetings and business has taken a turn to online consultation.

This project reviews evidence indicating the need to develop and/or strengthen the emergency Medicare systems in Kenya. Arguments are made for the role of online medical care options and systems meeting the expectations for the access to the service. We have seen that over the past week, the Nairobi Women's hospital has allowed even civil servants to seek medical attention using their medical cover which has drawn the advantages of a public institution to the private sector. This all strives to achieve the SDG 3 by the United Nations tat aspires to ensure health and well-being for all. Cost is then eliminated from the conditions to which the system should not be implemented. The GVRCDoc system is a basic but effective level of medical care that responds to perceived and actual community needs and improves the health of populations.

6.2 Recommendations

Subscribing to a more agile external service for the communications module so that the voice and video call can have a better reliability. Conducting a pilot project of the application and getting at most response from the clients.

I would recommend that we should have a better developer-doctor guide that enables the cover a wide variety of clinical topics relevant to the GP practice. During the development of this application, I tried to keep regularly updating our CPD modules by publishing new content.

Patching of the Turbo Ambulance dispatch service onto the system, which will need conversion of the web application to a hybrid application.

Creating a module that is able to find home-based care nurses who are certified by the relevant authorities. This gives them a job since most people in Kenya have faced some level of unemployment over the past one year due to the COVID19 pandemic. On the other hand, COVID patients may find it very expensive to stay in hospital, yet they

can recover from home and they may need the same nurses who were laid off to come into play. Introduction of a hiring module is highly recommended.

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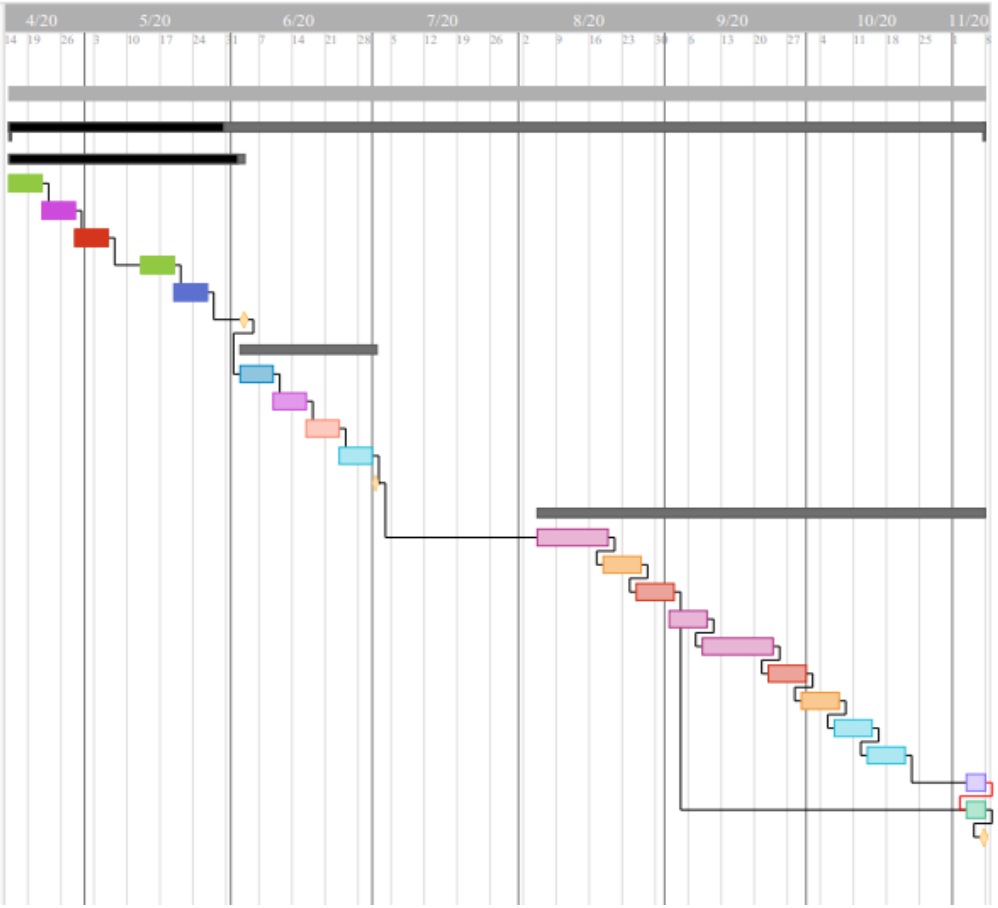
Appendix A: Timeline of Activities

Online Doctor Consultancy Service ...	start	end	22%
Project Outline	**15/04/20**	**07/11/20**	**22%**
Research + Discovery	**15/04/20**	**03/06/20**	**97%**
Define Project Scope	15/04	21/04	100%
Supervisor Selection and meet	22/04	28/04	100%
Chapter 1: Introduction	29/04	05/05	100%
Chapter 2: Literature Review	13/05	19/05	100%
Chapter 3: System Development Methodology	20/05	26/05	100%
Handing in proposals	03/06	03/06	0%
System analysis and Design Phase	**03/06/20**	**01/07/20**	**0%**
Behavioral diagram (use case diagram)	03/06	09/06	0%
Structural diagrams (class diagram/Sequence ...	10/06	16/06	0%
Entity-Relationship Model	17/06	23/06	0%
Database Schema	24/06	30/06	0%
Progress Presentation	01/07	01/07	0%
Coding, Class Presentations and Documentati...	**05/08/20**	**07/11/20**	**0%**
Coding	05/08	19/08	0%
Testing	19/08	26/08	0%
Maintenance	26/08	02/09	0%
Design Review	02/09	09/09	0%
Coding	09/09	23/09	0%
Testing	23/09	30/09	0%
Maintenance	30/09	07/10	0%
Final Documentation Review	07/10	14/10	0%
Final System Review	14/10	21/10	0%
Class presentation	04/11	07/11	0%
Final Presentation	04/11	07/11	0%
End of Project	07/11	07/11	0%

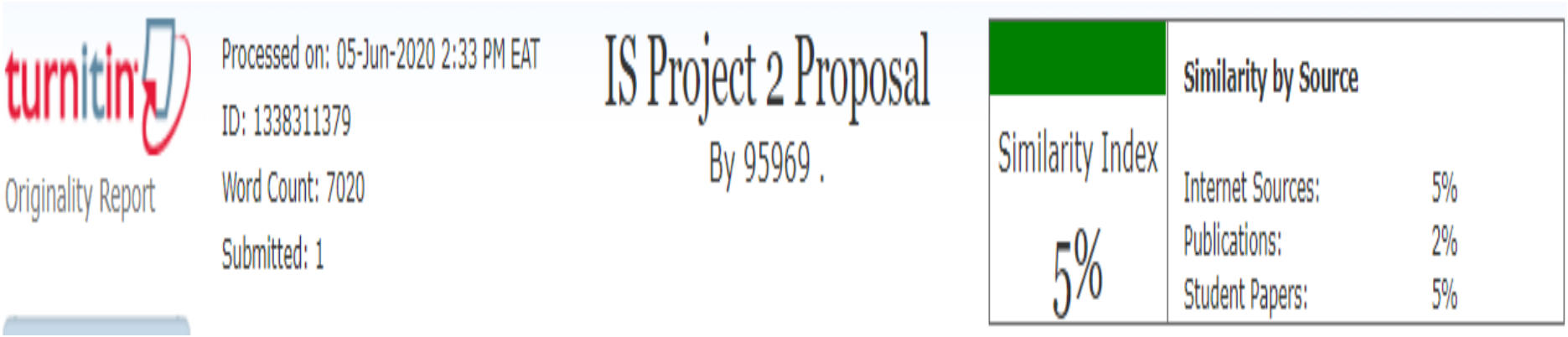


Appendix B: Data Collection Tool

The preferred data collection tool is an interview over the phone to the desired audience. The following questions were set to be asked over the phone call.

1. How far do you have to go to access medical attention?
2. Is it easy to make an appointment via the phone?
3. Do you get an appointment booked within a reasonable time?
4. Can you call in for services in the after-hours?
5. How long do you wait to access medical assistance, from the booking of the appointment to the time you enter the doctor's office?
6. Is there anything you would prefer not to go to the doctor face to face to consult on?
7. Do you get good satisfaction with the privacy of your meetings with your doctor?
8. Is the doctor always willing to listen to you?
9. Do they explain things in a manner that can be understood with ease?
10. Have you ever sought medical assistance from the internet?
11. Was the result fruitful?
12. Would you be welcoming to an online medical consultancy application?
13. May you have any recommendations that may assist in the delivery of medical services over the internet?

Appendix C: TurnItIn Similarity Index



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