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A mobile application used for the implementation of home based care: a case study of COVID-19 in Uganda

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A MOBILE APPLICATION USED FOR THE IMPLEMENTATION OF HOME BASED CARE: A CASE STUDY OF COVID-19 IN UGANDA

Kaluuma Hillary

A Project Report Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Embedded and Mobile Systems of the Nelson Mandela African Institution of Science and Technology

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ABSTRACT

With the outbreak of Coronavirus Disease 2019 (COVID-19) the health sector around the world has been faced with many challenges. This has created a need for alternative methods of offering treatment; and among them is Home Based Care (HBC). Home Based Care is a health system where patients are offered treatment in their localities or homes. The main objective under this project was to develop a mobile system application to facilitate and support monitoring of patients in Home Based Care so as to handle pandemics like COVID-19, and at the same time meant to be used by Village Health Teams (VHTs) to capture information from patients under treatment in their localities. The evolutionary prototyping methodology was used to develop the application system. Furthermore, both qualitative and quantitative data collection methods such as document review, interviews, observation methods and questionnaires were used to collect data about this research project. At last, a government Home Based Care application to facilitate the handling of pandemics like COVID-19 was developed. It shows that majority of the respondents believe the system will be able to reduce or solve the identified problem in this dissertation. Majority of the users and those who got to use the application agree that the application is easy to use and navigate. The respondents also expressed their confidence in the application's ability to enable the implementation of Home Based Care as an alternative to offering health care in situations of pandemics like COVID 19. In this project, we carried out unit testing, integration testing, and system testing and user acceptance testing as a means of carrying out software validation. The developed application passed successively all of the tests meaning that the developed application perform as it was expected. Based on the scope of this project, many of the features were not included in this prototype. Some of the known future works will be to add an admin account which will be managing the application. This account will be able to oversee all the VHT Officer accounts and will also be able to monitor the patient's progress

DECLARATION

I, Hillary Kaluuma hereby declare to the Senate of the Nelson Mandela African Institution of Science and Technology that this dissertation titled "*The use of a mobile application in the implementation of Home Based Care (HBC) for COVID-19: A case Study of Uganda"* is my own original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

Kaluuma Hillary

15th/11/2021

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The declaration above is confirmed by:

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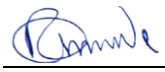

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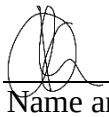

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CERTIFICATION

The undersigned certify that, have read and hereby recommend for acceptance by the Nelson Mandela African Institution of Science and Technology a dissertation titled, "*The use of a mobile application in the implementation of Home Based Care (HBC) for COVID-19: A case Study of Uganda",* in partial fulfilment of the requirements for the degree awards of Master of science in Embedded and Mobile Systems of the Nelson Mandela African Institution of Science and Technology."

Dr. Ramadhani Sinde

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Thank you.

DEDICATION

I dedicate this dissertation to my mum Mrs. Tukube Pauline and my sister Ms. Nabukenya Beatrice who has always been my role model in academics and the field of ICT.

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LIST OF ABBREVIATIONS AND SYMBOLS

AIDS	Acquired Immunodeficiency Syndrome
APIs	Application Programming Interfaces
ARDS	Acute Respiratory Distress Syndrome
C4L	Call For Life
COVID-19	Corona Virus Disease of 2019
DB	Database
DFD	Data Flow Diagram
DHIS2	District Health Information Software
ERD	Entity Relationship Diagram,
GUI	Graphical User Interface
HBC	Home Based Care
HIV	Human Immunodeficiency Virus
HTML	Hypertext Markup Language
ICT	Information and Communications Technology
IDI	Infectious Disease Institute
JSON	JavaScript Object Notation
MOH	Ministry Of Health
MySQL	Structured Query Language
ODK	Open Data Kit
OS	Operating System
PDO	Hypertext Pre-processor Data Object
PHP	Hypertext Pre-processor
SORMAS	Surveillance Outbreak Response Management and Analysis System
UAT	User Acceptance Test
UNDP	United Nations Development Programme
USSD	Unstructured Supplementary Service Data
VHT	Village Health Team
SOPs	Standard Operating Procedures
WHO	World Health Organization
XML	Extensible Mark-up Language

CHAPTER ONE

INTRODUCTION

1.1 Background of the Problem

The Corona Virus Disease of 2019 (COVID-19) is an infectious disease caused by the corona virus, SARS-CoV-2 which is a respiratory pathogen. The World Health Organization (WHO) got to know about this pathogen in a city called Wuhan in China, in December, 2019 (Dowdy, 2020). It is said that majority of the people who get infected by the virus and get sick fully recover from the disease without need to get admitted into hospitals or health centres. That percentage is estimated to be around 80% but depends on the location or country as the disease has affected different countries and continents differently (Dowdy, 2020). It is also stated that around 20% of those who fall sick of the disease became much more ill requiring admission into hospitals needing extra services such as access to oxygen (Dowdy, 2020). The 5% among those become way worse and go in critical conditions requiring intensive care units and life support to survive. There are many health complications faced by patients of COVID-19 that could lead to their death and among them includes; acute respiratory distress syndrome (ARDS), septic shock and sepsis, respiratory failure, multiple organ failure which can damage to the heart, kidneys and liver and also thromboembolism (Dowdy, 2020). Some sources also show that children that fall sick of this disease get severe inflammatory syndrome which normally shows up a few weeks after infection (Dowdy, 2020).

It is stated that COVID-19 affects people in much different ways. The biggest percentage of the patients experience moderate or mild symptoms and recover with no admission into health centres. The most commonly reported symptoms of COVID-19 are dry cough, tiredness and fever (Dowdy, 2020). The other reported symptoms include; headache, diarrhoea, loss of taste and smell, a rash on the skin and discoloration of toes and fingers, sore throat, conjunctivitis as well as aches and pains (Dowdy, 2020).

The World Health Organisation recommended the use of these precautions to fight the spread of COVID-19 and they include; washing hands often using running water and soap, the use of hand sanitizers, social distancing in the public environments, keeping a distance of around 6 feet from other people in public (MacNeil, 2020), wearing a face mask when in public, minimising the tendency of touching in your mouth, eyes and nose, staying home if you feel sick, using handkerchiefs to cover the nose when sneezing and also covering the mouth when

coughing (Chaisson, 2020). Wearing masks can greatly reduce the possibility of spreading the virus from one person to another however, they are recommended to be used with maintaining physical distance and washing of hands to ensure safety (Chaisson, 2020).

With the outbreak of COVID-19, the world has been faced with a lot of health challenges due to the actions and measures that the governments take to control the spread of the disease (Mwebembezi, 2020). The measures totally disrupted the supply chain and health care service delivery system as all efforts are focused on COVID-19 (Otto, 2020). Governments diverted personnel and resources away from priority diseases, inability to access healthcare because of transport restrictions, curfew, and fear of contracting the virus from healthcare settings (Otto, 2020). The situation was made worse by existing healthcare system challenges which include among others inadequate human resources, financial, infrastructural, supply chain and logistical challenges (Mwebembezi, 2020).

As health workers look forward to get vaccinated and stay safe, there has been continuous crowding in the existing health facilities especially in large referral hospitals like Mulago (Buwembo, 2021). The overcrowding in closed settings such as prisons is even worse and constitutes an insurmountable obstacle for preventing further spread of COVID-19 (Byanyima, 2020). In most cases, governments admit all the patients into hospitals and offer treatment to them from there. However, this is not always possible especially when there are very many sick patients. This has created a need for alternative methods to offering treatment and among them is Home Based Care (HBC). Therefore, the present project focused on the use of a mobile application to enable the government to effectively implement support for monitoring patients in a Home Based Care (HBC) setup when handling pandemics such as COVID-19. The HBC is a health system where treatment is given to patients in their localities and it has been the root of human coexistence for generations (Joy, 2002).

1.2 Statement of the Problem

To date, there are many health application software developed in health systems. These applications are designed to handle different health aspects related to infectious disease outbreaks such as; surveillance, case investigation, contact follow-up, visualization of chains of transmission including secure data exchange on demographics, epidemiology, lab data, hospitalization/isolation events, and clinical outcomes (Wijekoon, 2019). Many of these applications can and are being used on COVID-19. Examples of these applications includes;

Go. Data, Open Data Kit, Surveillance Outbreak Response Management and Analysis System (SORMAS), the mHERO18 solution and Drones and Robots. Despite their promising usefulness in handling infectious diseases outbreaks, they all have limitations such that designed for epidemic responses at the front line to capture and trace more patients. Then need to send these patients to the health centres which would result into patients overcrowding into health facilities. In addition, some are very expensive to use in the long run, and are much slower to use text messages to text each and every symptom when reporting it to the health centres or Ministry Of Health.

Generally, all these applications relay patients into the health centres for them system to be relevant. In most cases, governments admit all the patients into hospitals and offer treatment to them from there. However, this is not always possible especially when there are very many sick patients. This has created a need for alternative methods to offering treatment and among them is Home Based Care (HBC). Therefore, the present project focused on the use of a mobile application to enable the government to effectively implement support for monitoring patients in a Home Based Care (HBC) setup when handling pandemics such as COVID-19. The HBC is a health system where treatment is given to patients in their localities and it has been the root of human coexistence for generations (Joy, 2002).

1.3 Rationale of the Project

There is an enormous amount of reasons for carrying out this study, among them are benefits to the Infectious Disease Institute (IDI), to the Ministry of Health (MOH), to the government and the whole world. The rationale of the study includes but is not restricted to the following points. Some of the features that are to be implemented in the application are to be used to improve on the existing products and systems around the world and the whole Africa. Already some IDI products such as C4L intend to use the mobile application as platform to access patient status during treatment in Home Based Care. The C4L system has been capturing this information from the government dedicated COVID-19 centres.

In this project, the developed application has the potential that will enable home Based Care to handle infectious diseases that will strengthen the existing health systems in the world. This project, has created a system which will transform the way the government deals with the infectious Diseases as it is expected that it is going to embrace Home Based Care over the hospital Based Treatment that has been commonly used in the country and all around the

world. With this Research project deployed, the government will have built capacity of its health sector to handle the biggest epidemics with ease and this will revolutionize the health sector for Uganda and Africa in general. This system will simplify life for the population as it will reduce the large expenses normally spent in hospital admissions.

This Research project will help assess the full potential of Home Based Care as a means to offer treatment to patients during the outbreak of Infectious Diseases. It will assess its efficiency and offer the world a new platform and means to handle infectious diseases

The main justification for this study comes from the fact that majority of the patients confirmed positive of COVID-19 have mild symptoms and as a result there is no need to get admitted into health centers or hospitals. It is estimated that around 80% recover from the disease with no need of getting admitted in health centres (Dowdy, 2020). However, that is not the only reason for conducting this study as there are many more.

In late 2020, the government of Uganda advocated for the use of Village health Teams (VHT) health system to assist with fighting COVID-19. However, this has been faced with a lot of challenges as there was no unified platform that the VHTs could use to operate effectively. Nevertheless, the government went ahead with using the VHTs to offer treatment and health care to patients in their localities. This has been faced with a lot of challenges that the developed application in this project solves. Amongst the challenges include:

(i) The first challenge is that there is no unified platform that would enable the VHTs to carry out their tasks during the treatment for patients. As a result, the VHTs have been using a paper based means of storing information for carrying out daily check-ups on the patients.

(ii) There was a delay in this information getting sent back to the Ministry of Health as the VHTs had to go to the head office in the district to send that information to the ministry after some days. This was tiresome and expensive to the VHTs as they had to travel to the head office of their respective districts several times in a month.

(iii) The process of accessing patient information also turned out to be slow and complex for the VHTs. They had to carry all the books with them and look through many pages to view the patient's previous check-ups and also to record the new patient's check-up information.

Due to those challenges above, there has been need to come up with a solution that fits in the existing health system as well as solve those existing challenges.

1.4 Project Objectives

1.4.1 Main Objective

To develop a mobile system application to facilitate and support monitoring of patients in Home Based Care so as to handle pandemics like COVID-19.

1.4.2 Specific Objectives

(i) To review and analyse the requirements for developing a mobile application for Home Based Care.

(ii) To design and implement the proposed system by programming the interface, the scripts and also designing the database.

(iii) To validate and deploy the developed system.

1.5 Research Questions

(i) What are the requirements that are needed for developing a mobile application for Home Based Care?

(ii) What are the interface, scripts and database for the developed application would be look like?

(iii) Will the developed application perform as it was proposed in the first place?

1.6 Hypothesis

1.6.1 Null Hypothesis

A proposed mobile application cannot support or facilitate the treatment of patients in pandemic situations under HBC much better that the Hospital Based Treatment.

1.6.2 Alternative Hypothesis

A mobile application can support or facilitate the treatment of patients in pandemic situations under HBC much better that the Hospital Based Treatment.

1.7 Significance of the Project

The application will enable timely and efficient collection of patient's information in HBC just as good as hospital admission. There are several advantages to this proposed and developed application. The first advantage is the limited spread of the infectious disease that home Based care offers to the government. The second advantage is the limited expenses on treatment offered by HBC, this comes from the fact that hospital facilities are paid for much more expensively than what would be used in the deployment of the home based Care system suggested in this project. The third advantage is in relation to the mild symptoms of most patients for COVID-19, majority of the patients of COVID-19 have mild symptoms and as a result do not need to be admitted into hospitals. This makes the HBC system more favourable for their situation. The other point is, there is a lot of pressure exerted to the government health system as a result of increasing admission of infected COVID-19 patients (Sayed, 2020), this creates a need for reducing the demand for health centre facilities by advocating for other alternatives like HBC which is the key this under this project. Furthermore, the proposed and developed application is meant to offer the Academy of Health Innovation as a department of IDI another product which the MOH can use to strengthen the existing health systems. There are several IDI health systems that the Uganda MOH uses and this system will be added among those. This system is a perfect fitting for an already existing system called Call for Life (C4L) which is being used to get feedback from patients in their communities. The IDI- Academy department plans on using this HBC application system to capture information for the C4L system patients during the HBC which is recommended by the MOH. This system also provides a proof of concept by Implementation an existing idea into a fully functional system that can be later refined and used to pitch for grants or even get deployed by any interested party such as MOH, USAID, just to mention a few.

1.8 Delineation of the Project

This study was carried out on all members of the public in Uganda. The study did not exclude most age brackets much as many age brackets were not closely involved. The study was also open to all genders as there was no specific gender that was favored or ignored. The

participants of the study include but are not limited to Health Care officials such as doctors, nurses and VHT officers. The other participants included the, engineers, social workers, ICT staff, researchers, Uganda MOH officials and IDI experts in health systems as well as other responsible citizens.

Additionally, the study aimed to develop a mobile application for android meant to be used by the Village Heath Teams during their work in the field. The application collects the daily checkups of the patients in the field and offers the VHTs a platform to monitor and track their patients and effectively offer care and treatment to them. The application also submits the collected data to the cloud offering an opportunity to interested institutions of health to access that information.

CHAPTER TWO

LITERATURE REVIEW

2.1 The COVID-19 Pandemic and its Challenges

In the year of 2020, the COVID-19 pandemic has redirected and reshaped the priorities of global health systems, this doesn't exclude Africa and East African countries as they have been equally affected as well. The challenges faced by European countries due to COVID-19 are similar but not identical to the ones faced by Sub Saharan African countries. Since European countries like Italy have very large aging populations where 23.1% of the total population is estimated to be aged 65 years and older (Varrella, 2020). The COVID-19 pandemic is using that as a basis to create havoc in their populations. The vulnerability of Sub Saharan Africa emerges from the weakness of the health infrastructure as well as the low numbers of health personnel in the population. There is also limited access to laboratory services as well as large numbers of the populations existing with poor health conditions such as malnutrition, anaemia, existing illnesses like Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS), tuberculosis and many others (David, 2020).

There are very many health systems designed to handle different health aspects related to infectious disease outbreaks such as; surveillance, case investigation, contact follow-up, visualization of chains of transmission including secure data exchange on demographics, epidemiology, lab data, hospitalization/isolation events, and clinical outcomes (Wijekoon, 2019). Many of these systems can and are being used on COVID-19, some of the existing systems are explained in the following sections.

2.2 Go.Data

The Go. Data is a software used for outbreak investigation and is normally deployed in the field to simplify data collection in situation of epidemics. The application enables the tracing of contacts to the reported cases, the analysis, patterns of transmission of the diseases and the investigation of cases on a number of diseases (Wijekoon, 2019). The Go.Data can be installed on Windows, Mac or Linux machines (either personal computer or on server) and allows the users to record details about (Wijekoon, 2019):

(i) An outbreak of an infectious disease.

(ii) Cases associated with that outbreak.

(iii) Events at which transmission of disease may have occurred (such as a community gathering or funeral).

(iv) Contacts that have been at risk of infection through exposure to a case or event.

The follow-up is performed (usually daily) with each contact to monitor their health following an expected exposure (Wijekoon, 2019). The Go.Data also includes a Smartphone/tablet application for iPhone and Android which has a cut-down set of functionality purely focussed on performing the follow-up in the field with contacts. The tool is targeted at any outbreak responder (Wijekoon, 2019). The Go.Data is the initiative of a group of public health partners and is managed by the Global Outbreak and Response Network coordinated by WHO (Wijekoon, 2019). This system is operational and has been deployed in a number of countries to deal with epidemics with COVID-19 inclusive. The architecture is elaborated in Fig. 1.

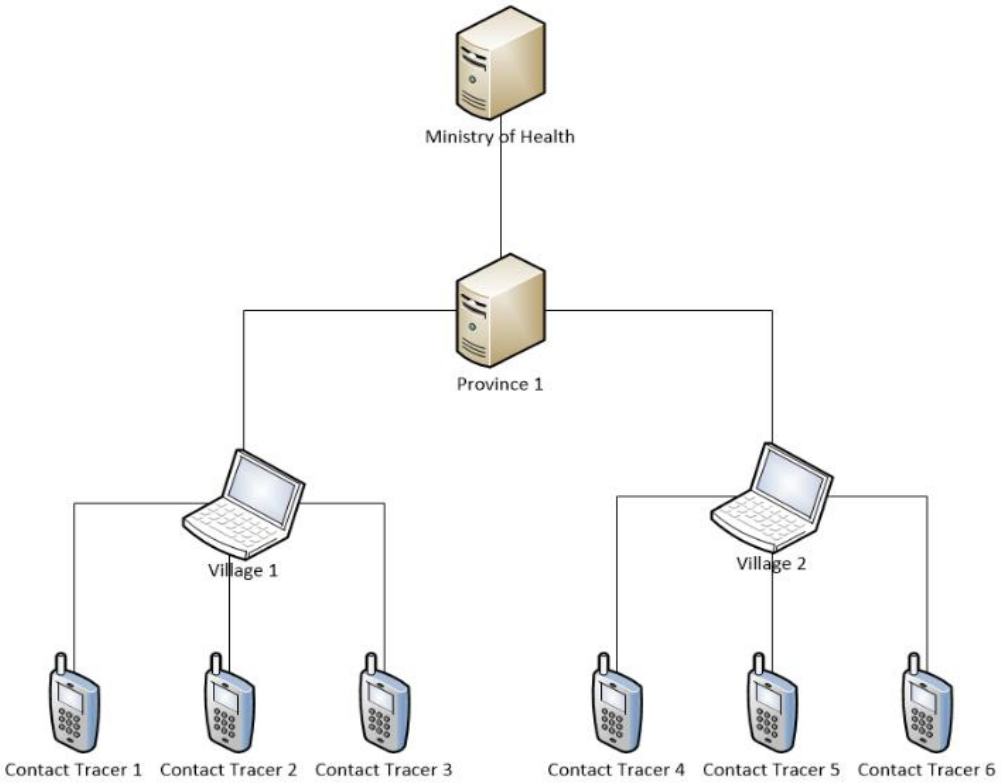

Figure 1: Go.Data architecture (Wijekoon, 2019)

This system was designed to quicken response to new cases of infectious diseases during outbreaks. It doesn't offer system call functionalities for follow up as health officials have to locate the patients on their own. Most of its users have complaints on the challenges they

face to trace the patients as it has no map functionality which would enable them identify their location and also trace their patients easily. The system has no images of the patients which makes it very difficult to identify the patients in case you want to follow up. The system users mostly use the laptop and desktop versions of the product which requires access to a laptop or desktop and makes field work more difficult. The application also doesn't have the MOH approved HBC check-up form making it not suitable for the case of Uganda.

This system cannot solve the problem that was identified in this research as the health systems will remain strained with large admissions in situations of pandemics like COVID-19. This system will not make use of any alternative means of offering health care like Home Based Care as it is not designed to fit in a Home Based Care setup. This system will only help health officials to identify cases in the public and trace more patients that were in contact with that specific case as that is what it was designed to do. That will not reduce the stress on the existing health system, instead more patients will be discovered and again taken to the same over strained and crowded hospitals resulting into the exact problem we are trying to solve.

2.3 Open Data Kit

2.3.1 Introduction of Open Data Kit

The Open Data Kit (ODK) is a software that enables the collection and management of data in environments that have very limited resources (Hommes, 2017). It has a functionality that enables it to collect data when offline on mobile devices in case it is used in an area with little or no internet connection. The captured data can later be submitted to the server when in a location with internet access. This application enables the different regions or communities to have full control of the data they have captured and also control where to save it (Hartung, 2010).

This software is ideal for regions that would like to collect data and also have all rights over their data. The application has a functionality that enables the users to aggregate the collected data putting in consideration the privacy concerns of the region (Hartung, 2010). The region or locality that owns the data should be able to access and make adjustments into the source code of the software as it is available due to its open source nature. The changes made in the codes can be adjusted to suite the region that is making the changes by removing the

unwanted features and adding any newly wanted ones. Due to the nature of this software or tool ODK is commonly used in areas and regions with limited resources such as internet, electricity, poor road infrastructure, and many others (Hartung, 2010).

The ODK currently provides four tools which are Collect, Aggregate, Voice, and Build. Collect is a mobile platform that renders application logic and supports the manipulation of data. Aggregate provides a "click-to-deploy" server that supports data storage and transfer in the "cloud" or on local servers (Hartung, 2010). Voice renders application logic using phone prompts that users respond to with keypad presses. Finally, build is an application designer that generates the logic used by the tools (Hartung, 2010). This project has produced two tool suites (ODK and ODK-X) and has become home to a community of users, implementers and developers. To broaden the community that has grown around the project, they are retiring the use of the "Open Data Kit" brand and forming a new umbrella organization, Data Software for Social Good (DSFSG) (Hartung, 2010). The DSFSG aims to enable collaboration within the data software for social good ecosystem and welcome a diverse and independent set of member projects.

2.3.2 Security, Integrity and Privacy

Security of any software application is of at most importance to the success of that application especially if the application deals with enormous amounts of data. It is necessary to ensure that the users of the system can trust the application because of the level of security it portrays (Cobb, 2018):

(i) Offline data collection on a mobile device that is later on aggregated with an ODK aggregator with physical connection to LAN that is disconnected from the internet does not require the submission of data over an insecure network.

(ii) Encryption of data on a mobile device with a public key that can be decrypted on a WAN and the disconnected ODK backend provides the security for the already collected data on the device.

(iii) Closed source applications for data collection do not provide an option for independent code analysis for backdoors. Because it is harder to detect backdoors that are injected in object code in comparison to the source code, the compilation of the source code by the organisation is possible for high requirements for privacy.

The data that is collected in ODK is sensitive and if this information leaks could have disastrous effects to the people it belongs to. The data can be medical and may also include some socioeconomic data, the data may be able to formulate information on political opinion and can derive conclusions that may hurt the data owners (Cobb, 2018). The application will not accept saved data on the servers to get altered if the person making the changes does not have the authority to do so (Boritz, 2005).

2.3.3 Governance

The ODK tool is managed by a team called the Project Management Committee which came up with a schedule and structure for development of the software product. The major development steps were assigned to different technical teams that were responsible for the delivery of the different functionalities into the application. The different contributors to the different functionalities to the ODK project can be accessed and monitored transparently on the GitHub-repository (Cobb, 2018).

This system offers some functionalities that are suggested in the HBC application developed in this project but has many flaws as shown below; ODK is used as a standard data collection tool worldwide as it offers forms for collection of data to be shared or even stored. Therefore, data will need to be adjusted to fit the domain for it to work effectively. It doesn't have images of the patients to enable VHTs to easily identify their patients when carrying out follow ups or daily check-ups. It does not have the standard approved Uganda MOH self-check-up form that has been passed by the ministry for daily check-ups of COVID-19. It was not designed to facilitate any form of Home Based Care functionalities that would enable effective operation in a Home Based Care setup. It does not offer an alternative means of offering health care as it only enables capture of more patient data from the field and as a result, it will not solve the identified problem in this project as more patients will be taken to the same over strained health centres resulting into stress in the whole health sector.

2.4 Surveillance Outbreak Response Management and Analysis System

The Surveillance Outbreak Response Management and Analysis System (SORMAS) is a mobile eHealth system that organizes and facilitates disease control and outbreak management. It is also used for disease surveillance and epidemiological analysis for all administrative levels of the public health system (Tom-Aba, 2019). The SORMAS was

designed to improve prevention and control of communicable diseases especially in resource-poor settings which are common in Africa. The system was designed by a team involved in public health surveillance and disease control (Tom-Aba, 2019). It is free of charge and adheres to the highest data protection standards, open access policies and good scientific practices. The SORMAS is characterized by the following: case-based surveillance, digital notification at point of care, bi-directional information flow, contact follow-up management, outcome monitoring, digital medical record, outbreak detection algorithms, open source, mobile offline capability, inclusion of all relevant actors and a user-centred design (Tom-Aba, 2019).

In the year of 2014, a consortium of Nigerian and German public health, research institutions and a global software company, coordinated by the Helmholtz Centre for Infection Research (HZI), designed SORMAS during the West African Ebola outbreak of 2014/15 (Fähnrich, 2020). After a period of nine months of software development, SORMAS prototype was tested in 84 private and public health institutions in two states of Nigeria. In July 2015, data was collected and entered about cholera, measles and highly pathogenic avian influenza. In addition, a simulation of a complex Ebola outbreak was carried out (Fähnrich, 2020).

In the year of 2016, SORMAS was transformed into an open source software application. This fulfils the objective to ensure a sustainable software product independent from IT companies and can be used within the open source software community to develop health sector goals (Fähnrich, 2020). The Ghana Community Network and Ghana Health Services deployed SORMAS as a test pilot in some districts in Ghana in 2019. The HZI team travelled to Ghana to help set up and train future SORMAS users.

During the COVID-19 pandemic in early 2020, the team quickly implemented COVID-19 into SORMAS which lead to a wide spread use of SORMAS in Switzerland, Germany and France. Some other countries like Fiji, Burkina Faso, Nepal and Ivory Coast are planning to implement it in the near future. The regional bosses and the German Chancellor recommended for SORMAS to be used by 90% of all health departments in Germany (Fähnrich, 2020). The SORMAS architecture is elaborated in the Fig. 2 and the structure in Fig. 3.

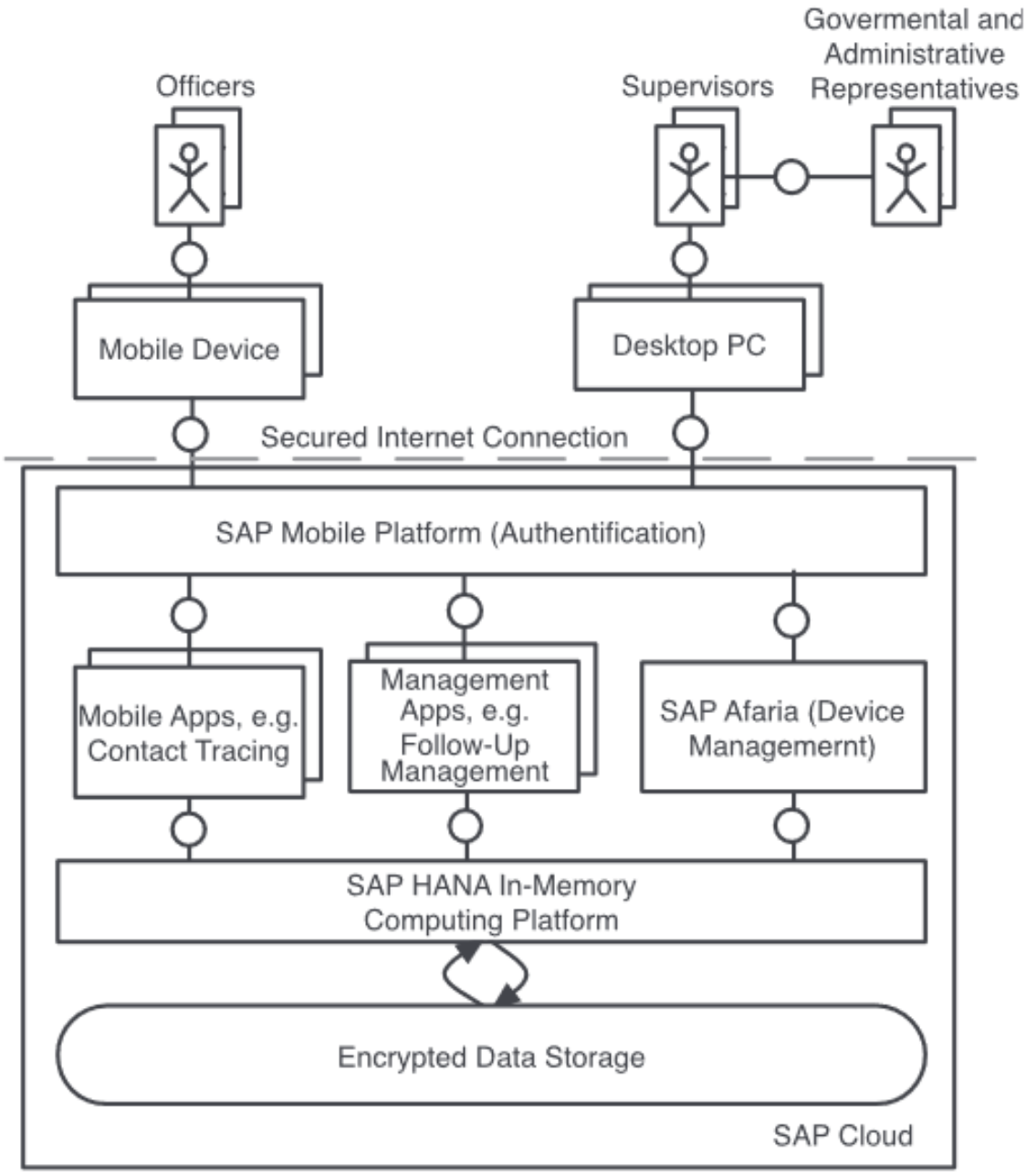

Figure 2: Surveillance Outbreak Response Management and Analysis System Architecture (Kirchner, 2015)

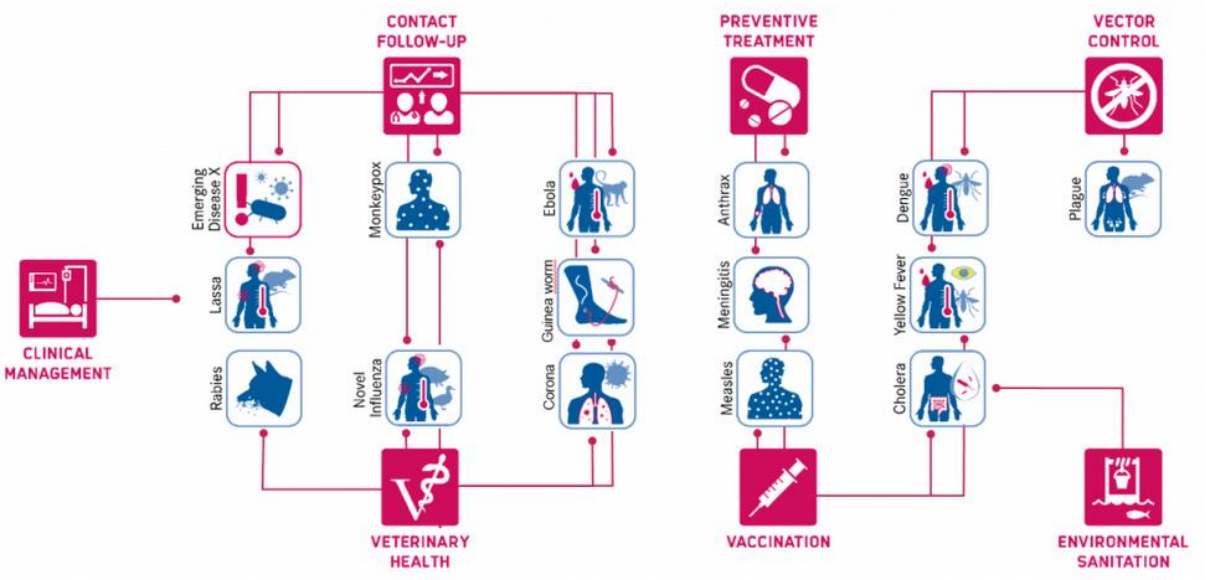

Figure 3: Surveillance Outbreak Response Management and Analysis System Structure (Fähnrich, 2020)

The SORMAS was meant for surveillance and just like the previous systems that have been covered, it has no functionalities to enable home based Care. It also cannot help reduce the number of patients admitted in existing health centres. The application does not have images that would enable VHTs to identify patients in the locality during the check-ups as recommended by the Uganda MOH. The application does not have maps functionality to enable the health officials to identify their location on google maps as well as identify how to reach their patients in the field. It doesn't has the approved MOH check-up form that the developed application has making it not suitable for the case of Uganda as a country. It is not designed to fit in the existing health structure in Uganda which has VHTs as the application was not designed to be used by the VHTs in a HBC setup.

All the systems above have one main limitation, there are mostly designed for epidemic responses and are suited to assist health officials at the front line to capture and trace more patients. These systems will then need to send these patients to the health centres which would result into the exact problem that is the main focus of this project. These systems need to be feeding their data on positively confirmed cases of patients to alternative means of offering health care. The system proposed and developed under the present project can now receive these patients so that they get the treatment through Home Based Care instead of

going for hospital based treatment which faces enormous challenges in situations of pandemics.

2.5 The mHERO 18 Solution

The mHERO18 solution was initially developed in 2014 for the fight against Ebola and used in Uganda, Guinea, Liberia, Mali and Sierra Leone (Abandza *et al.,* 2020). It has enabled many countries that have adopted it to continue their fight against pandemic situations. The mHERO 18 is a two-way mobile phone-based communication system that connects ministries of health and health workers (Abandza *et al.,* 2020). Communication can reach the healthcare workforce in rural areas with no internet coverage by using simple talk-and-text phones. While the platform is built on free technologies, countries are only responsible for the cost of sending texts through mobile network operator and employees' time for using and maintaining the system.

The main limitation of this system is in regards to the cost of sending the messages which is very expensive to use in the long run. It is also much slower to use text messages to text each and every symptom when reporting it to the health centres or Ministry Of Health. This system will need improvements in minimising the costs of operation on text messages. The application is also not designed to suit the Home Based Care set up thus making it not suitable for the case of Uganda.

2.6 District Health Information Software 2

The Belgian development agency and other partners have worked to roll out District Health Information Software (DHIS2) for health data (Ambarka *et al.,* 2020). District Health Information Software is an open source, web-based health management information system platform (Ambarka *et al.,* 2020). The DHIS2 has recently released a digital data package for COVID-19 detection, reporting and surveillance.

The DHIS2 is has one main limitation, it is designed to suit management of patients in a hospital environment. "I" has no functionalities for field work activates and as a result will not be able to work for a Home Based Care Setup.

2.7 Drones and Robots

In April 2020, as the coronavirus was circulating in Ghana, an American start up, Zipline17, started using drones to collect test samples from health facilities in rural areas, and deliver them to medical laboratories in the country's two largest cities, Accra and Kumasi (Abandza *et al.,* 2020). Zipline drones were already being used in Ghana and Rwanda for blood transfer between healthcare facilities. This technology performs 600 deliveries per day in Ghana and covers more than 500 hospitals. The company has a contract with Ghana to make those 600 deliveries a day for four years at a cost of about $12.5 million. Drones are covering an area that serves nearly 22 million people (Abandza *et al.,* 2020).

This system is very helpful for enabling the delivery of hospital supplies for patients but is suited for patients in critical conditions. This system would only cater for 5% of the total of the COVID-19 patients making it not scalable for the pandemic but good to support severe cases and only in hospital. This system cannot solve the problem identified as it is meant to be used for patients in hospitals while the developed application under this project is trying to avoid patients getting admitted into the hospitals. In conclusion, this system needs to adjust its focus to also patients that are not in hospitals to enable it work for Home Based Care or solve the problem we specified in this project.

Rwanda, in partnership with the United Nations Development Programme (UNDP), uses four humanoid robots in coronavirus treatment centres to minimise physical contact (Abandza *et al.,* 2020). These robots can screen 50 to 150 people per minute. The robots can deliver food and medication to patient rooms and monitor patient status (Ambarka *et al.,* 2020). These robots protect health workers' lives by minimising physical contact and can speed up service delivery.

These robots have the same limitations as the previous section above, the robots are meant to be used in a hospital environment meaning the patients have to be admitted into the health centres for this system to be relevant. In conclusion this system will need improvements and many adjustments for it to assist patients before they reach severe symptoms of COVID-19 infections thus cannot handle HBC at the moment and will not solve the identified problem.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Chosen Materials, Methodology and Solution

At the beginning, the user requirements were identified through the requirements elicitation, then, followed the requirements specification, worked on the system modelling, worked on the prototyping step which was the implementation of the systems. This has been done hand in hand with the software testing process and lastly is the software maintenance stage which would exist as long as the software is being used.

The first step in the implementation of this system was to develop a model or a means of collecting health information from patients in their homes, in this case a mobile application was chosen as some other alternatives proved complicated and way more expensive. One of those alternatives was the use of Unstructured Supplementary Service Data (USSD). The USSD is an interactive, menu-based technology communication protocol available on every GSM-enabled mobile device (Ivanovic, 2006).

It is a session-based text communication without a store-and-forward mechanism (unlike SMS) that is practical for interactive communication, such as banking or education (Ivanovic, 2006). The USSD messages can have up to 182 alphanumeric characters and the time it takes from a request to a response is 2 seconds while it takes 6 seconds for an SMS to reach a mobile phone (Ivanovic, 2006).

The prices of USSD are also very expensive making them not favourable to use in large scale operations in business. According to a Uganda Communications Commission (UCC) study, a short code in Uganda costs $250 in application fees; a USSD short code attracts a $10 000, and an SMS code attracts $2000 excluding applicable VAT in each case as the annualized maintenance fees (Mwesigwa, 2018). Rwanda charges $30 application fee short codes. Allocated USSD codes are subject to a $1000 annual fee while for SMS codes ranges between $200 and $1000 (Mwesigwa, 2018). Tanzania charges a one-time $2000 “registration fee” for allocation of “ordinary” USSD and SMS short codes and a $3000 “annual maintenance fee” thereafter. “Ordinary” codes are assigned serially by the Tanzania Communications Regulatory Authority (TCRA), but other categories of codes which are assigned based on customer preference range from BRONZE to GOLD as they become

increasingly more “memorable” and have a higher registration fee but with the same $3000 annual maintenance fee (Mwesigwa, 2018).

Considering the prices of USSD around East Africa, it was not favourable to use USSD technology as a means to implement this system. The other alternative was web technology such as web system or websites, this technology had a limitation since it fully depended on internet and also was not consistent on its display on the different devices. Different devices have different display sizes and specifics and therefore, web systems appear differently on laptops and phones and other devices.

As a result, the best alternative found was the use of Android mobile application for use of phones since it was the most convenient to use in this case.

3.2 Development Approach

In this project, evolutionary prototyping methodology was used to develop the system. The method involves the users of the system throughout the system development which creates a good level of satisfaction for the users (Zamperoni, 1995). The Fig. 4 elaborates the evolutionary prototyping methodology cycle.

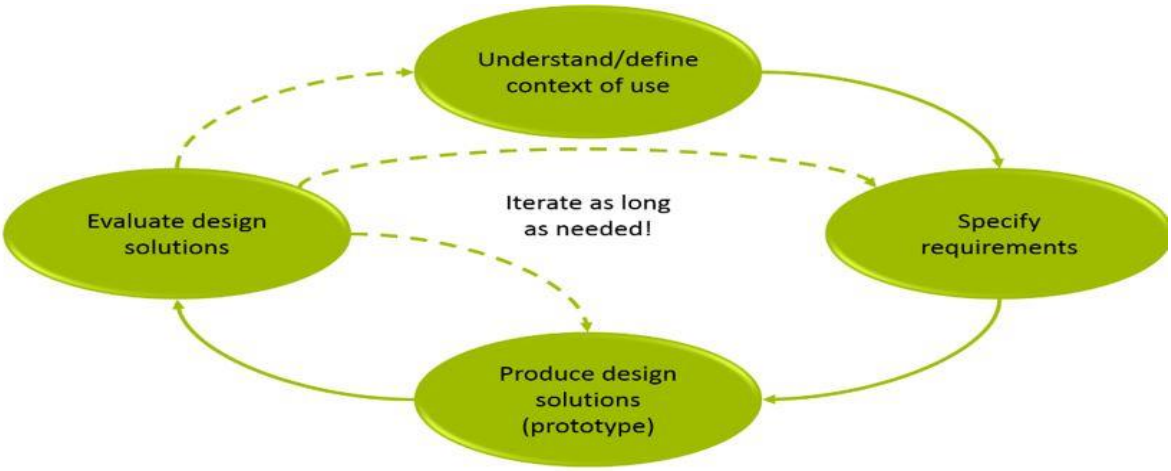

Figure 4: Prototype Development Lifecycle (Asiimwe, 2020)

The evolutionary prototyping was chosen because it enables us to start implementation after having understood the requirements (Chen, 2001). Table 1 compares the evolutionary prototyping with the waterfall and spiral methods in terms of Client interaction, flexibility and phase containment of errors.

Table 1: Comparison of Evolutionary Prototyping with other Methods

Methodology	Phase Containment of Error	Flexibility	Client Interaction
Evolutionary Prototyping	High	Fully	Frequent
Waterfall	Low	No	One time
Spiral	Low	Few	Some time

Chandra (2015)

3.3 The Sampling Technique and Sample Size

The study comprised of the general public majority of which were in Uganda. It includes the VHT staff, medical staff, IT staff and many others. The study is not limited to any gender, professional specialities and education levels. However, it specifies the demographics of the population sample to get a good understanding of the results captured. The sample mostly includes of adults as they would be the best to assess the use of an application to solve a health challenge of the community.

3.4 Data Collection Methods

Data collection has been carried out for a month although most of the data has been captured from a survey form which has been sent out for a week in April 2021. In this study, both qualitative and quantitative data collection methods were used such that there were document review, interviews, observation methods and questionnaires were used to collect data about the research.

3.4.1 Interview

The structured interview was used among different stake holders. The goal of the interview was to have a general understanding of what the public thinks about the project that is; the research and the application. Also to get an understanding of the challenges the VHTs face, the tasks they perform when doing their work and how best to improve them.

3.4.2 Questionnaire

The google forms were used in the surveys, it contained multiple-choice questions, straight forward questions and lastly the close-ended questions. The main intention was to have a good understanding of what the public thinks the application should work like. Also, this

research interested with what medical staff perceive of the system as the system's operation depends on both the VHTs and the general public which includes all professions of all age brackets.

3.4.3 Observation

Observation was done from the VHTs operations in some sample sites, this got involved to follow some VHTs to their field work and as well getting a good understanding of what they were doing and how they do it. There were a lot of things to consider, and to add into the application that were not in the initial design of the application such as images, though it was possible to only capture them from observations.

3.4.4 Document Review

This is a data collection method where by different works related to the research area are read and studied from document sources such as reports, manuals, research papers, websites and other documents. This is done to get more information and a better understanding of the subject of interest in the research. This was done mainly to obtain a general understanding of what the VHT officers are and what they do. Also it was possible to get access to the MOH approved check-up form for COVID-19. The sample MOH check-up form is shared in Appendix 1.

3.5 Data Analysis Methods

Through questionnaires of the google forms, the captured data was transformed into different graphs that were giving a detailed overview of how the different respondents were giving feedback on the different things asked about in the questionnaire. The graphs formed mostly included bar graphs and pie charts. The graphs were made for each specific question which was raised in the questionnaire and the graphs depend on how the question's answers were setup or structured.

3.6 Requirements Analysis

The user requirements were collected and analysed, and finally were categorized as functional requirements and non-functional requirements. The first objective of the study is satisfied from this section as it comes up with the functional and non-functional requirements of the system which were covered in detail in the following sections:

3.6.1 Functional Requirements

The functional requirements are the user requirements that describe what the designed system should do (Gabriela, 2017). This project could consider what input the system should be able to take in such as the datatypes and the outputs the system should produce such as data images and information. In Table 2, there were listed the functional requirements of the HBC application.

Table 2: Functional Requirements

Requirement	Description
Registration (VHTs)	The mobile app shall allow the user to register and login to access the other application functionalities and patient information, as well as update of patient's information into the system.
Add Patients	The application should enable the VHT officers to add patients in to the system.
Search Check-ups	The VHTs will be able to search for a specific patient check-up using the patient's names. We shall have a search functionality to quicken information retrieval for the check-ups because they will be many.
View Patients info	A system shall be able to display the patient's information such as check-ups, names, age, status, etc.
Upload Images	The system shall also enable the VHTs to upload images for their patients to enable them easily identify their patients during check-ups.
Maps	The system shall provide access to google maps functionalities to the VHTs which will enable them see their location and also to trace their patient's locations.
Discharge Patient	The system shall enable the VHTs to discharge a patient from the system in case they feel the patient has healed.
Readmit Patient	The system shall allow the VHTs to readmit a patient into the system in case the patient feels sick again or is confirmed to be sick again.

Requirement	Description
Do Check-ups	The system shall enable the VHT Officers to carry out daily check-ups by inputting patient information during the daily check-ups and storing it into the application.

3.6.2 Non Functional Requirements

Non-functional requirements refers to the restrictions or constraints on the development and design of the system (Shahid & Tasneem, 2017). In this case, they are used to describe how the HBC application system should perform. The Table 3 explains some of them:

Table 3: Non Functional Requirements

Requirement	Description
Performance	A system shall enable the user to carry out functionalities in a very short time. It will be able to save and retrieve information in less than a second, it will also login as well as logout in a very short time.
Security	A system shall enable authentication of users. It will save and encrypt user's password. Later on in future versions, it should remember the password and username of the user once the session management functionalities are implemented.
Usability	A system shall be easy to use so that it can be used by all types of VHTs from different education levels and age categories.
Robustness	The system shall be able to handle internet connection failures or any bugs resulting from unfriendly user inputs or even recover in case of failure.
Availability	The system shall be available when needed for use by the VHTs or any other users.
Language	The system shall be available in English as English is used as the lingua franca in Uganda.

3.7 Unified Modeling Language Use Case Diagram

The Use Case Diagram represents the interaction of users and the system. They describe what actions a user can perform in the system. When designing Use Case Diagrams, actions are called Use cases. Entities that interact with the system as well as other external systems are called Actors. The actors of the system that are being developed are mainly the VHT Officer

and the Call for Life System. The Use cases are: Login, Register for a new account, add patient to the system, view patient details, submit check-up, view check-ups, Add image, etc. There are both the base use case and included use cases in the developed system use case diagram. The base use cases like: Login, Add image, View patient, View Check-up need the included use cases to operate. They require input from the included use cases in order to operate effectively. The included use cases are: Verify password, fetch data and capture image. There is also cases like Display login error which are in the category called extended use cases. These use cases work with the base use case in such a way that they may sometimes occur but are not always supposed to occur. In the developed use case diagram, the Display Login error may occur if a user entered a wrong username or password but otherwise it will not appear in the system operations. The use case diagram of the HBC application is elaborated in Fig. 5.

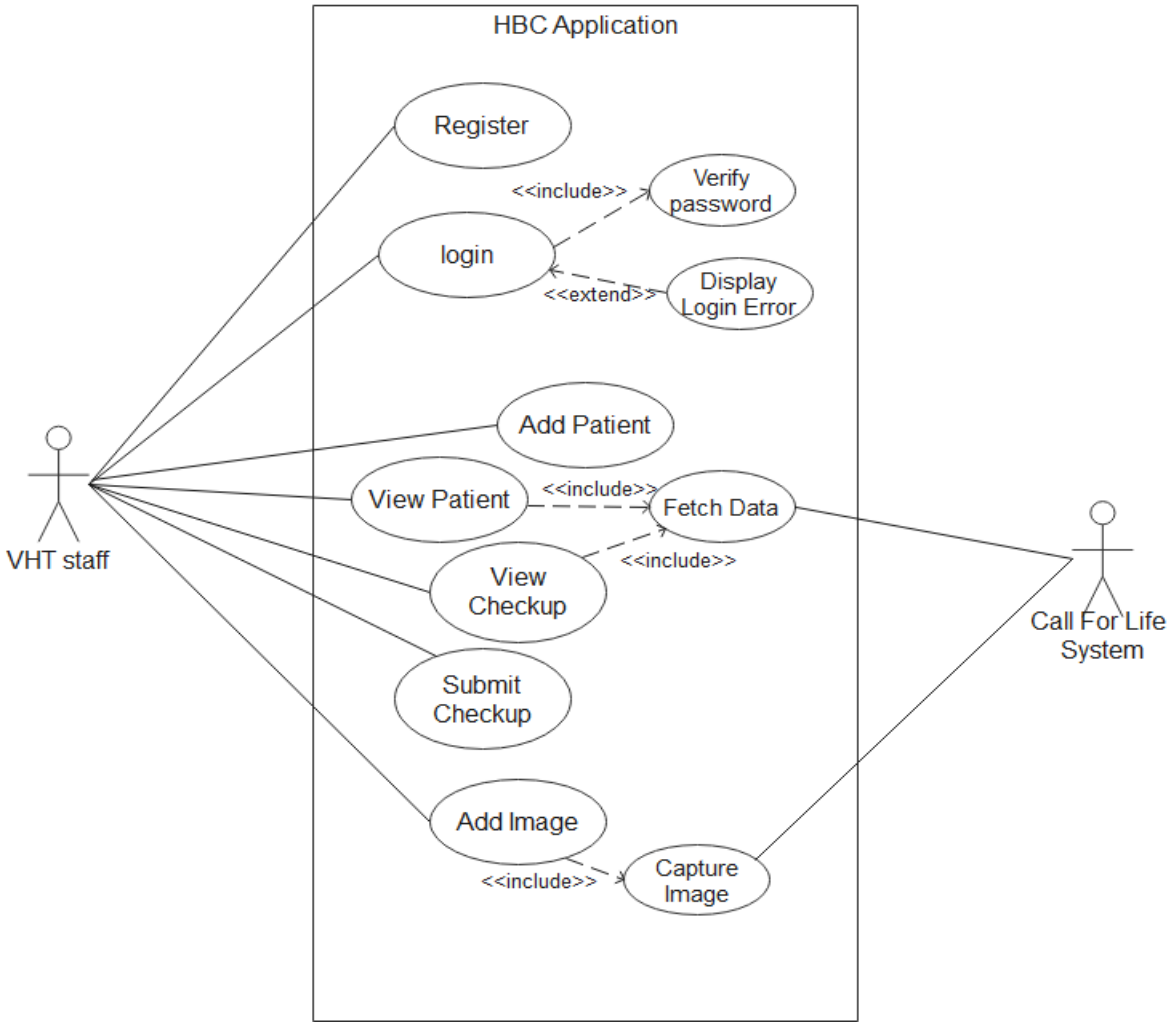

Figure 5: Home based Care use Case Diagram

3.8 System Overview

This section shows the overview of the developed system. It elaborates the scope of the system including the flow of the different components and how they are involved into the system. It also describes the full functionality of the system from the user's perspective. It explains how the user will be able to use the system to complete all the expected tasks on the different functionalities and the feedback information that will be displayed for the user.

The system has an android application which the VHT Officers use to carry out daily check-ups for the patients. The application can also be installed on an android phone and later used when on site. On launching the application, the user will be presented with a login page. In case the user is using the application for the first time, they will need to create an account using the create account page. The account credentials are then submitted into the database on the server. On login, the application compares the user's username and password with what exists in the database and verifies if the user exists and will give access to the user if they exist in the database. The VHT Officers are the main users of the application, they will be able to create accounts, login and use their accounts to carry out their work.

The VHT Officer will check on the application for their patients that exist on the application, in case they would like to add a new patient into the system, they will use the add patient option on the navigation drawer. The VHT Officers will carry out the daily check-ups to the patient once they reach the patient's residence and will submit that information using the application in the check-up page. If the VHT staff want to view previous check-ups they can view them from the view check-ups page on the navigation drawer.

The application interfaces are designed using android Extensible Markup Language XML and work with the activities whose code is written in Java. In the java file of some of the activities, there are links or APIs to the php scripts that are saved on the server. The application database is called hbc_db and is stored on the same server heroku that hosts the PHP scripts. The PHP scripts pick data from the java files and interact with the database. The IDI would have to use a junction database which will fetch the wanted information from the application. In Fig. 6 is an illustration of the system overview showing all the components that have been explained in previous sections.

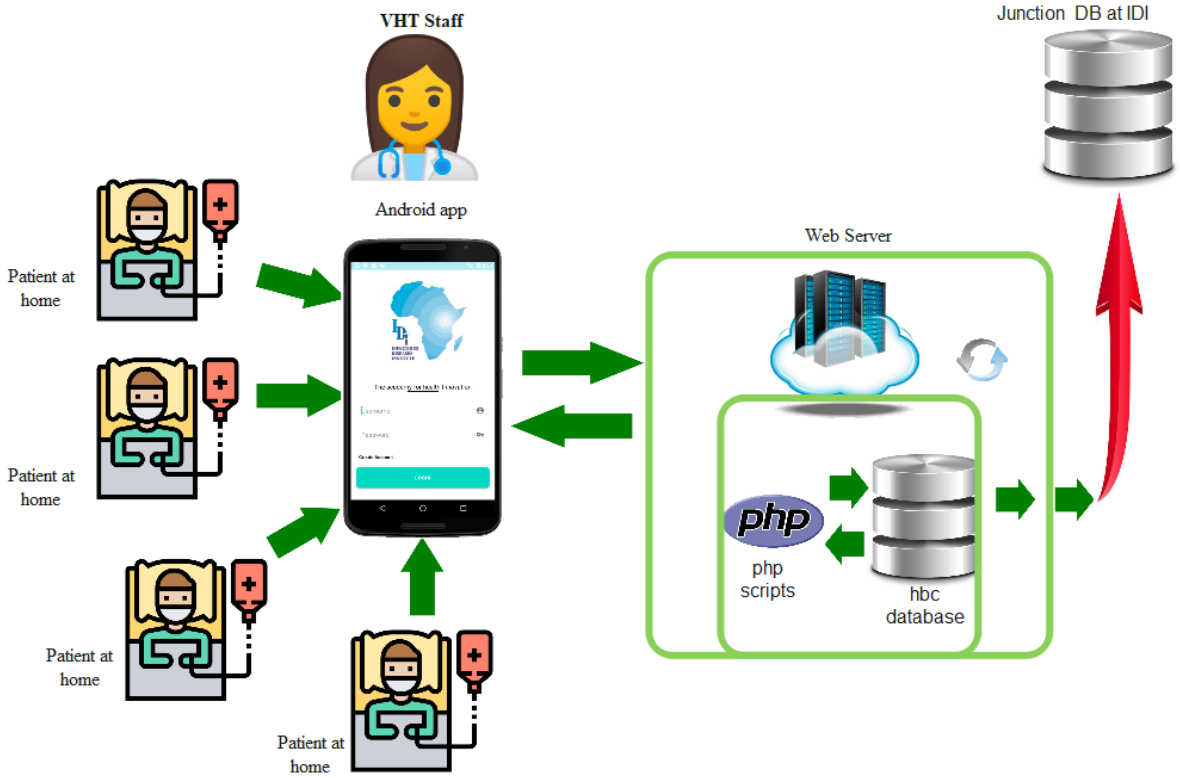

Figure 6: System Overview

3.9 Design Rationale

The home based care application shall be accessed using an android mobile phone because its widely accessible around this region of Africa and that is who the system expects to be a VHT officer.

3.9.1 Client-Server System

The reasons for selecting Client- Server System include the following:

(i) Centralized; it supports applications where data from multiple sources is integrated.

(ii) Scalable; it favors large scale applications with hundreds or thousands of clients.

(iii) Flexibility; client server system allows easy installation and adaptation of upgrades as many changes can be made in scripts on the server at once.

3.9.2 Layered Architecture

The reasons for selecting the layered architecture was because of:

(i) Manageability; separation of core concerns helps to identify dependencies and organizes the code into more manageable sections.

(ii) Testability; this arises from having well-defined layer interfaces as well as the ability to switch between different implementations of layer interfaces.

(iii) Reusability; the layers can be reused with other compatible layers to provide different views on the data and functionality.

3.10 Home Based Care Software Architecture

The designed mobile application is designed to be used by VHT Officers, the VHT officers are the main administrators of the application and are capable of carrying out most functionalities. The system keeps information of patients that are tested or are feeling sick for infectious diseases such as COVID-19 in this case. The architecture design is made using the layered architecture pattern which shows how the different components interact under different layers of the system. The architecture in Fig. 7 shows the components involved in the system flow. There is an overview of the architecture which shows us the overall scope of the whole system. It shows the logical design and a more physical like summary/ overview of the system. The physical design on the architecture shows the physical components along the logical components on the left of the diagram. The physical components include an illustration of the database, server, phone and the VHT user as shown in Fig. 7. The HBC application architecture overview is elaborated in Fig. 7.

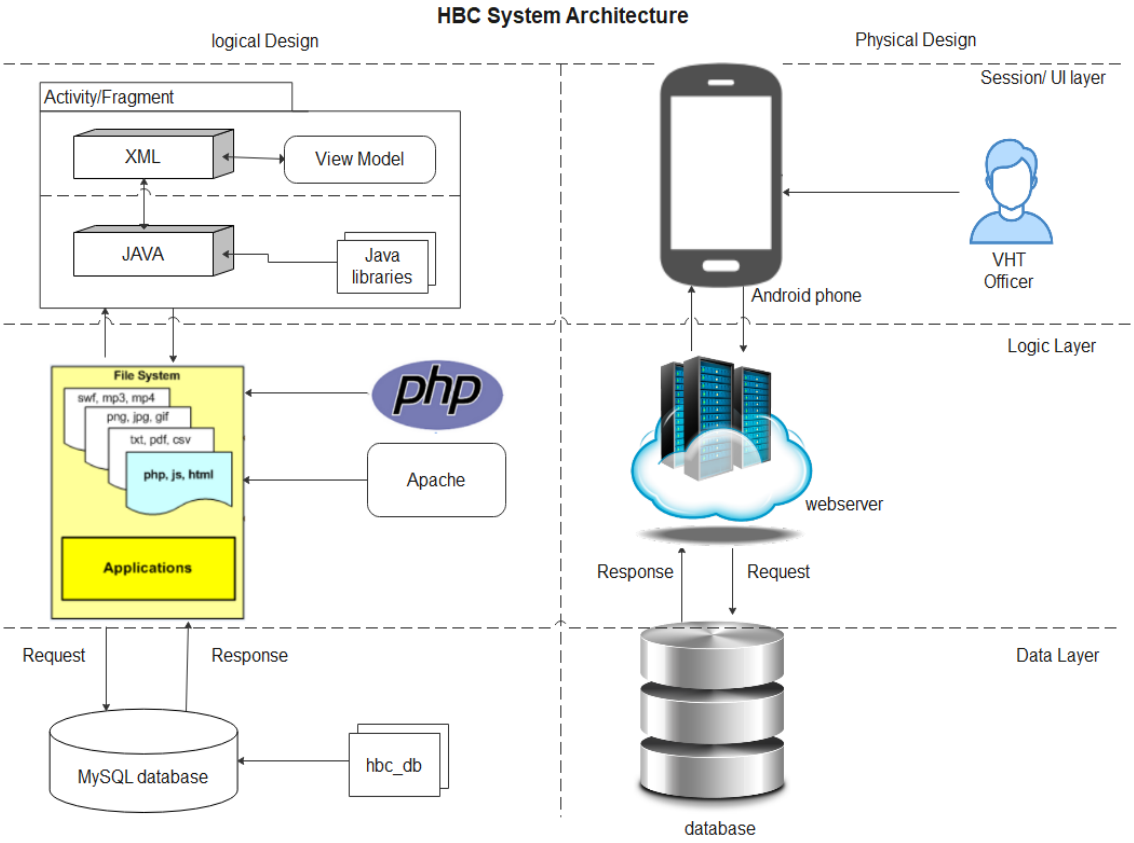

Figure 7: Home based Care Software Architecture Overview

The logical design of the software architecture shows the detailed components of the system. The android components are put in a package named activity which includes all the components involved in an android app activity such as XML, Java, and java libraries. This package replicates the activity in android application development. In the logical layer of the logical design of the architecture, represents the components of the server environment which include the scripts used for the sever side scripting, the file formats handled in the scripts such as jpeg, png, mp3 and mp4. The server side scripting languages can vary depending on the specific programmer's preference as well as the advantages that the specific language can offer to the application. The webserver elaborated in this architecture is called apache and is commonly used to run Hypertext Pre-processor scripts (PHP). The bottom of the architecture diagram shows the data layer of the architecture design. It hosts the database of the application as well the data components. The database is designed in MySQL and the database name is hbc_db. The database also has around three tables which are: Patients, VHT officer and checkup which contain several attributes or columns. The HBC architecture logical design is elaborated in Fig. 8.

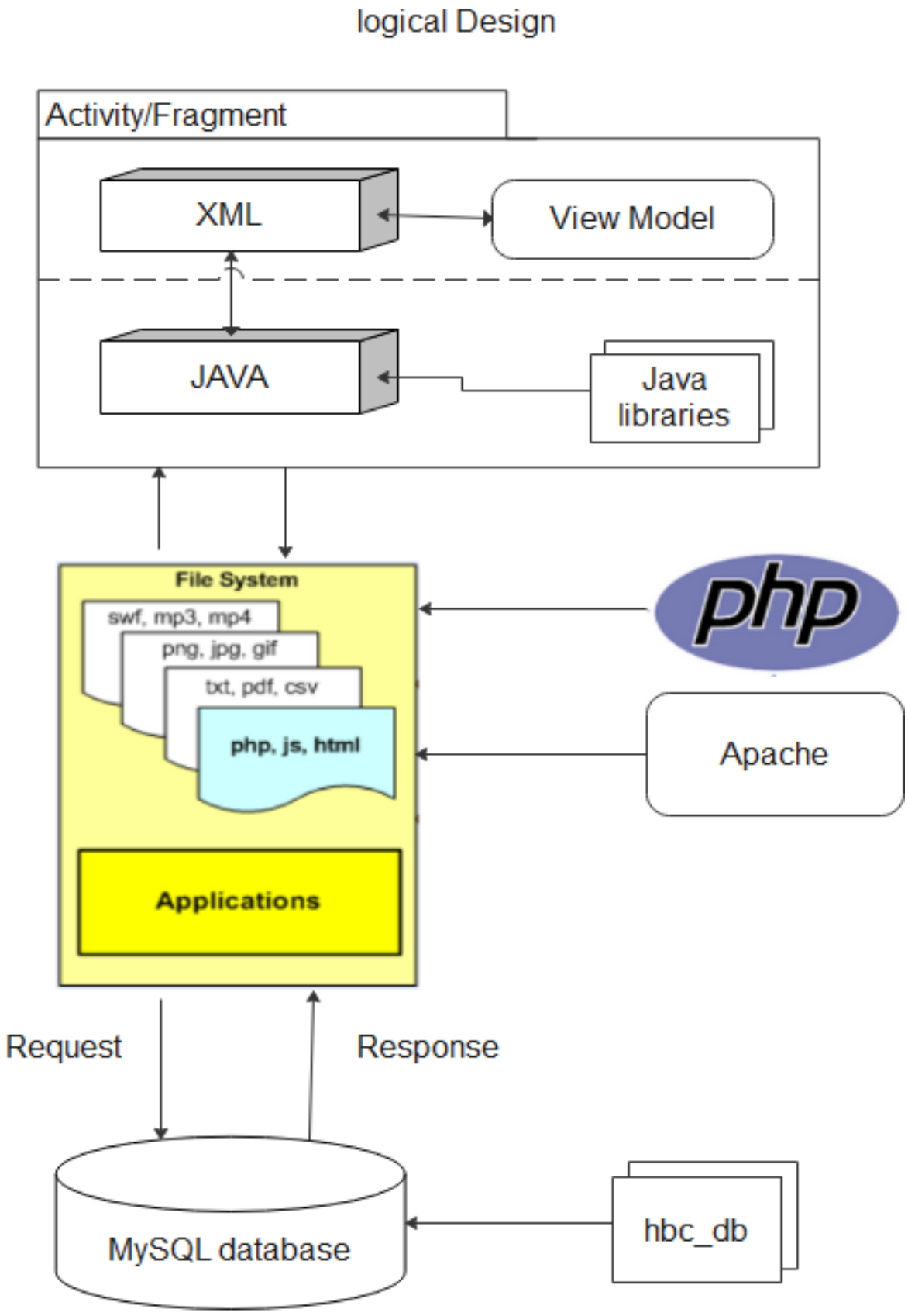

Figure 8: Software Architecture Design

3.11 Unified Modelling Language Class Diagram

The UML Class diagram is a graphical notation used to construct and visualize object oriented systems (Ian, 2020). A class diagram in the Unified Modelling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the following:

(i) classes

(ii) their attributes

(iii) operations (or methods)

(iv) The relationships among objects

A Class is a blueprint for an object. Objects and classes go hand in hand. Its impossible to talk about one without talking about the other (Ian, 2020). And the entire point of Object-Oriented Design is not about objects, it's about classes, because classes are used to create objects. So a class describes what an object would be, but it isn't the object itself (Ian, 2020).

In fact, classes describe the type of objects, while objects are usable instances of classes. Each Object was built from the same set of blueprints and therefore, contains the same components (properties and methods). The standard meaning is that an object is an instance of a class and objects have states and behaviours (Ian, 2020). The use of object oriented system designing and modelling, is due to its advantages and because of the fact that android structure is object oriented in nature. The advantages of object-oriented programming are listed below and they include (Half, 2017):

(i) Modularity for easier troubleshooting

(ii) Reuse of code through inheritance

(iii) Flexibility through polymorphism

(iv) Effective problem solving

In this system class diagram, There is a supper class person with sub-classes VHT officer and patient which inherit some common attributes like name and location of datatype string,

id and phone number of datatype integer, email of datatype varying character and lastly reg_date of datatype datetime. Most of the variables have public and protected visibility because they would need to be used in the subclasses and any other associated classes to the subclasses. Therefore, the person class has an inheritance relationship with the VHT Officer class and the patient class.

The VHT officer class has most methods because the VHT officer is the main user of the system and as a result will need most of the methods that enable him/her to implement the different actions. Some of the VHT officer methods are ViewPatients(), addpatient(), uploadImage(), call() and logout(). Most of these methods return nothing as they have void return type and can have any visibility from private, protected and public depending on the developer's view on security of the application.

The VHT officer performs check-ups and therefore the VHT officer class can have a one to many multiplicity relationship named "performs" with the check-up class. The patient class also has a one to many multiplicity relationship with the check-up class. The relationship between the patient class and the check-up class is called composition. Composition is one of the fundamental concepts in object-oriented programming (Janssen, 2018). It describes a class that references one or more objects of other classes. This allows you to model an association between objects (Janssen, 2018). The HBC class diagram is elaborated in Fig. 9.

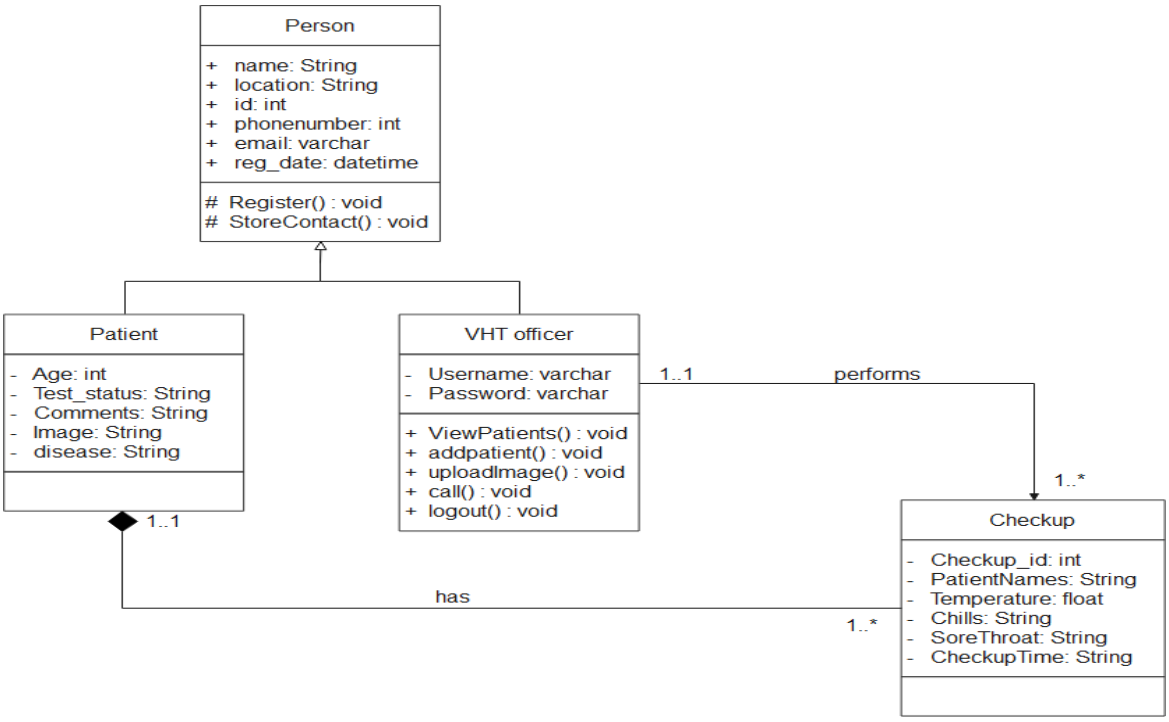

Figure 9: Home based Care Class Diagram

3.12 Data Design

This section has the entities and entity relationship diagrams, which are to be used to model the data of the system, these Entity Relationship Diagrams (ERDS) will later on be modelled into the database. The ERD is a diagram that displays the relationship of entity sets stored in a database (Rungta, 2021). In other words, ER diagrams help to explain the logical structure of databases. The ER diagrams are created based on three basic concepts: entities, attributes and relationships (Rungta, 2021). The ER Diagrams contain different symbols that use rectangles to represent entities, arrows to show relationships as shown in Fig.

The system has the following entities:

(i) VHT officer (vht_username, vht_id(PK), vht_phone_number, vht_reg_date, vht_location, vht_password, vht_fullname, vht_email)

(ii) Administrator (admin_id, admin_password, admin_username, admin_names)

(iii) Patient (p_fullnames, patient_id(PK), admin_id(FK), vht_id(FK), p_test_status, p_location, p_status, p_age, p_phonenumber, p_email, p_disease, p_comments, p_imag)

(iv) Checkup (check_up_id(PK), p_fullnames(FK), vht_username(FK), patient_temperature, cough, chills, new_chest_pain, heaedache, difficulty_breathing, fatigue, runny_nose, diarrhea, sore_throat, check_up_time)

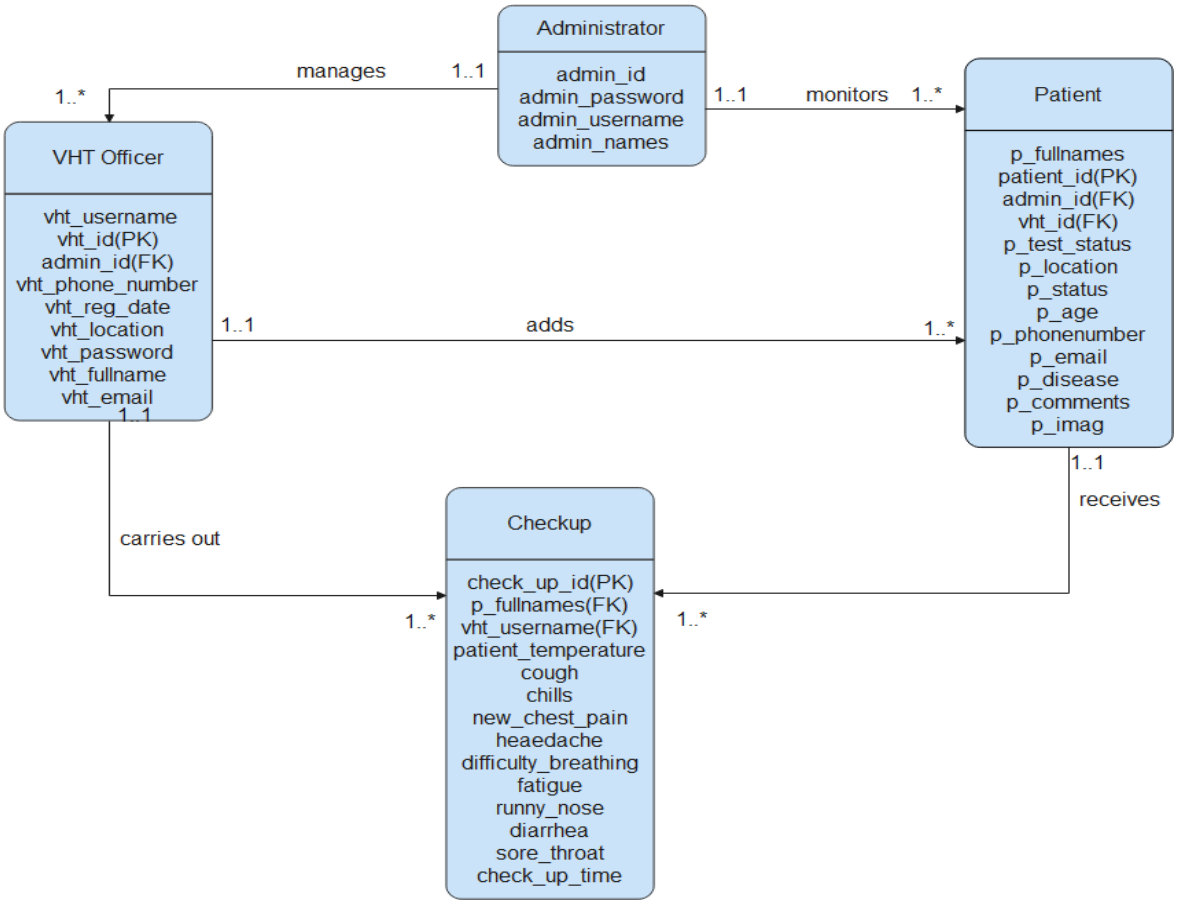

Figure 10: Entity Relationship Diagram

3.12.1 Data Dictionary

The data dictionary below shows the data entities, which are to be used in the database. It summaries the ERD entities showing their names, attributes and their data types as will be in the real system. It also shows the size of the data types, the data types, primary keys, secondary keys and composite keys if used. Each unique database Table is split into the different columns in the section shown in Table 4.

Table 4: Admin Database Table

Entity	Attributes	Data type	Constraints
admin	admin_id	Int(5)	Not Null, Auto Increment
	admin_username	varchar(20)	Not Null
	admin_password	varchar(30)	Not Null
	admin_names	text	Not Null

Table 5: Checkup database Table

Entity	Attributes	Data type	Constraints
Check_up	check_up_id	int(10)	Not Null, Auto Increment
	patient_names	text	Not Null
	patient_temperature	float	Null
	cough	text	Not Null
	ills	text	Not Null
	new_chest_pain	text	Not Null
	headache	text	Not Null
	difficulty_breathing	text	Not Null
	fatigue	text	Not Null
	runny nose	text	Not Null
	diarrhea	text	Not Null
	sore throat	text	Null
	check up time	timestamp	current_timestamp()

Table 6: Patient Database Table

Entity	Attributes	Data type	Constraints
Patient	p_fullnames	varchar(25)	Not Null
	patient_id	int(6)	Auto Increment, Not Null
	p_test_status	varchar(10)	Not Null
	p_location	varchar(25)	Not Null
	p_status	varchar(10)	Not Null
	p_age	int(6)	Not Null
	p_phonenumber	varchar(15)	Not Null, Unique
	p_email	varchar(50)	Not Null, Unique
	p_disease	varchar(20)	Not Null
	p_comments	text	Not Null
	p_img	text	Not Null

Table 7: Village Heath Team Officer Database Table

Entity	Attributes	Data type	Constraints
VHT officer	vht_id	int(6)	Auto Increment, Not Null
	vht_phone_number	varchar(15)	Null
	vht_username	varchar(25)	Null
	vht_reg_date	timestamp(6)	Not Null
	vht_location	varchar(25)	Not Null
	vht_password	varchar(20)	Not Null
	vht_fullname	text	Not Null
	vht_email	varchar(50)	Not Null

3.13 User Interface Navigation

The different pages of the application can be navigated as elaborated in the sections below. The first page seen on loading the application is the splash screen which introduces the application to the user and also hosts the IDI logo. The application then loads the login page which enables the user to enter their user name and password. The login page also has a link to the create account page which enables unregistered users to create accounts and then finally using those new credentials to login into the system. The home page has a navigation drawer which enables navigation to the several pages of the application. The navigation drawer has the following buttons listed below:

(i) Home

(ii) Add Patient

(iii) Show Checkups

(iv) Daily Checkups

(v) Upload Photo

(vi) Discharge Patient

(vii) Maps

(viii) Contact Us

(ix) Logout

The Home Page also lists the patients available on the system and the user can see more details about the patient by clicking on the image or names of the specific user they are interested in. In case the user is using the application for the first time, they will not be able to login and as a result they will have to create an account on the application by clicking on the create account button on the login page. The daily check-up page enables the user to submit check-up information got from the patient during the VHT's visit to the patient. The show Check-ups button shows the previous check-ups when the user clicks on the "show" button on that page. It also can be used to search for the previous check-ups by typing in the user's names and clicking on the view button.

The Contact Us page enables the user to contact the system administrators, it also enables the user to call the admins, to email the admins and also to access social media. The navigation drawer also offers the user the google maps functionality which enables the user to use maps to locate their patients when there is need. By using the navigation functionality of the google maps, the VHT officer can be directed to the patient's location. From those pages, the user can also upload a photo to a specific patient, to simplify their ability to identify the patients. The navigation drawer also has the logout button that logs out the user from the system thus closing the user's session. The user interface navigation is illustrated in Fig. 11. The Table 8 shows the different pages and what they do or contain.

Table 8: Application Pages Summary

Application Page	Contents/ what it is used for
Splash Screen	Introduces the application to the user, it also host the logo of the application.
Login Page	Enables the user to login into their account in the application.
Home Page	Acts as the central control point of the application enabling smooth navigation through the other sections of the application. It hosts the navigation drawer and the existing patients on the system.
Patient Details Page	This page enables the user to view patient details and any comments that are added to the patient.

Application Page	Contents/ what it is used for
Daily Checkups Page	Enables the user to create and submit the daily patient checkups.
Add Patient Page	Enables the user to add patient into the system.
Show Checkups	Enables the user to search and also view the patient checkups on the system.
Contact Us Page	Enables the user to access, email, to call the company helpline and also access social media.
Upload Photo Page	Enables the user to browse for photos on their device and upload them to the server.
Logout Button	This is a button on the navigation drawer that enables the user of the application to logout.

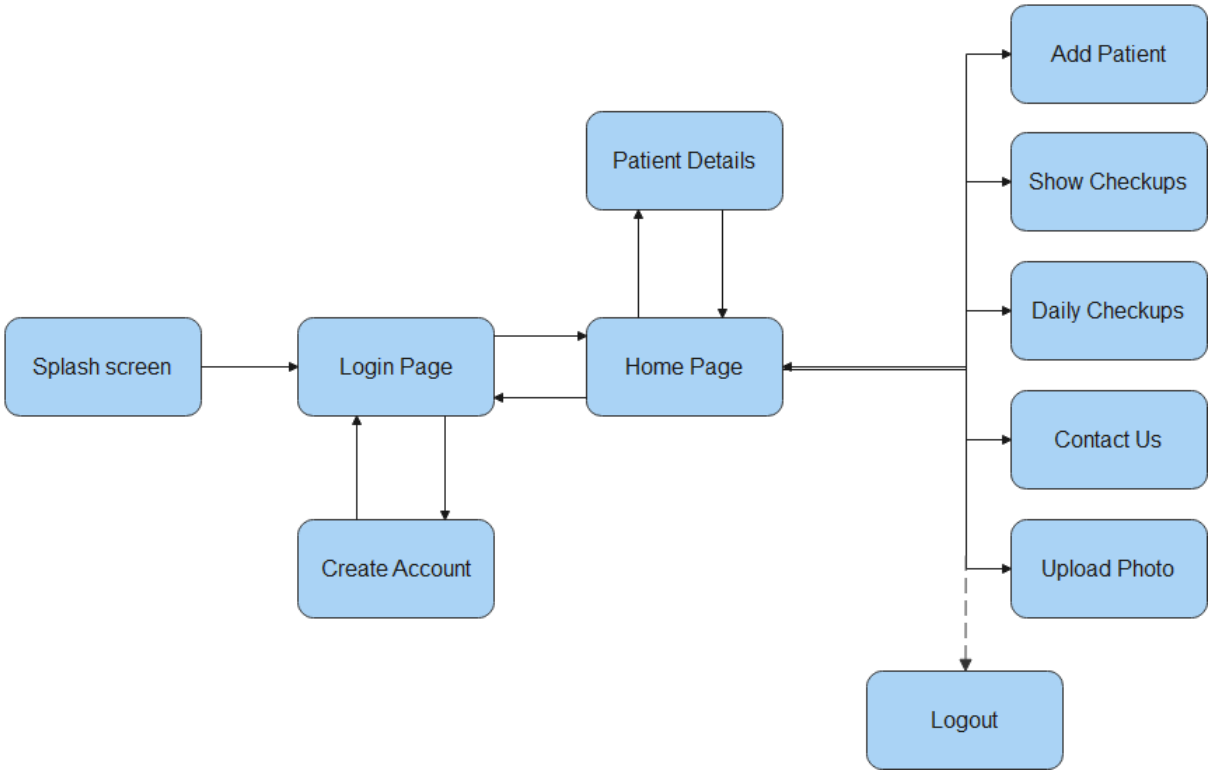

Figure 11: Application Interface Navigation Diagram

3.14 System Operation

This application collects data on how patients in HBC are responding to their treatment in quarantine. The information collected answers questions associated with headache, cough, flu and many other symptoms that the doctors and MOH in Uganda recommends. The system gets as much detailed information from the patient as possible so that the doctors can make sense out of it. The system uses Village Health Teams (VHTs) with a mobile application to collect the data from the patients during the daily check-ups. The VHT officers offer the medical check-ups to the patients and submit the data captured through the application. In this process, an android was designed that is similar form to the recommended MOH checklist that is being used for daily check-ups for COVID-19 patients in health centres. This has enabled the VHTs to collect the necessary information needed and submit it to the system in real-time.

Secondly, this study enabled VHTs to send and store data in a database where IDI and MOH can access the information from. The Ministry of Health (MOH) can also access that information though and API could be created for them if there is need. In this case, the phone application shall have access to internet connection so that it can be able to communicate with the server which hosts the Database (DB). The application captures the patient addresses and this information is shared with the VHT officers assigned for that community through the application. It is then up to the VHT officers to check through the patients, visit them for the daily check-ups and submit their daily check-up data through the app. The application can also be integrated with IDI C4L systems in future and shall also be able to raise alerts in case the data submitted symbolizes that there is need for further medical intervention such as admission into a health centre.

The system also has a functionality to automatically display only patients that are still sick on the system. The system gives a functionality to enable the VHT officers to remove patients that are stable or probably healed after a specific time frame basing on the reported symptoms from daily check-ups. According to the government Standard Operating Procedures (SOPs) these patients may need to be tested to confirm they are negative and have healed from the disease and should be free to move on with their lives.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Results

The previous chapter in this dissertation presented the methods and materials used in designing the software system and also to carry out the research project. The study area was specified, the architecture, the interface flow design, the database design, the class diagrams and also the use case diagrams which elaborated the design of the system. In this section, the results from the whole project such as the data collected and the software product produced are presented. Also, discussion and analysis of the meaning of the results of the research are presented as well. The second objective of the study is satisfied in this section of the results.

4.1.1 Survey

(i) Demographics of the Respondents

Demographics

A survey was carried out with a google form and got a sample of 20 responses from the different people that got access to the survey form which was shared on email and social media. 9 (45%) where males and 11 (55%) where females. It was a priority to have gender balance in the respondents as this provides a realistic view of the public. To meet this gender balance, efforts to get as many male respondents as possible was done. This is because, they were not responding that well to the survey form. However, much efforts have been taken to offer the questionnaire to as many male respondents as possible so as to balance up the genders as shown in Fig. 12.

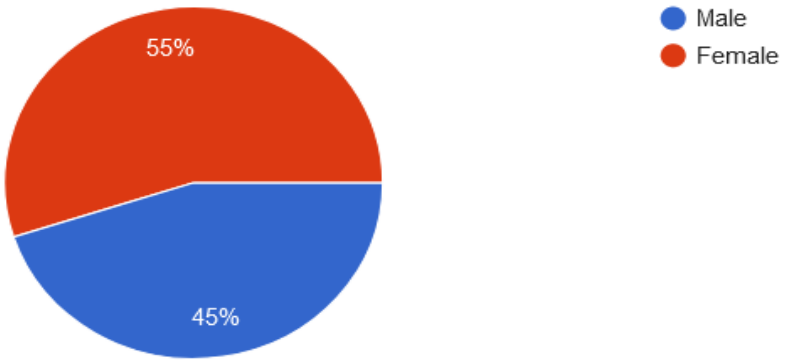

Figure 12: Gender Analysis of Respondents

Also, the respondents were categorized based on age groups such that; four were less than 25 years, 15 were from 26 to 35 years, one was from 36 to 45, zero were from 46 to 55 years and lastly zero were above 55 years. According to the responses, it can be seen that most of the respondents in the survey were in the youth bracket as elaborated in Fig. 13.

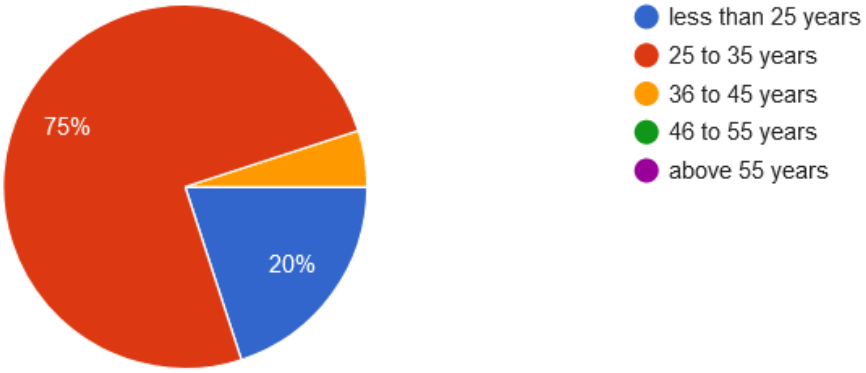

Figure 13: Age Group Analysis of Respondents

Also the respondents were sampled by their levels of education so that it is possible to know if education level has any influence to the feedback. The levels including Primary level, Ordinary level, Advanced level, Diploma, Bachelors, Masters and PhD. There were zero for primary level, zero of the respondents had O level, one was in Advanced level, two have Diploma level, 12 have Bachelor's degrees, five had master's degrees and zero had a PhD. This has been elaborated in Fig. 14.

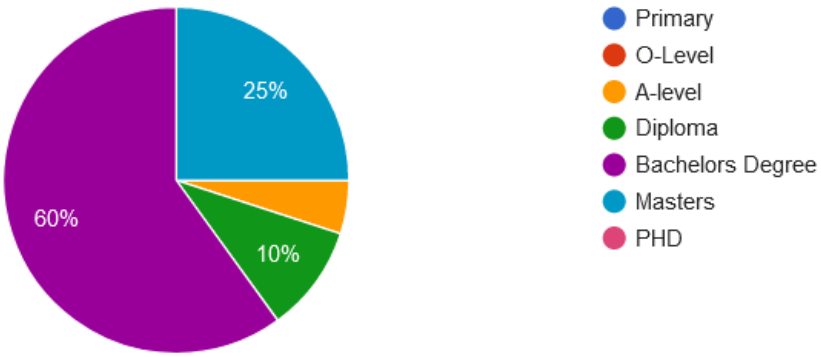

Figure 14: Education Analysis of Respondents

Also the respondents were sampled by their professional Career field and the results were as; zero were in Agriculture, Food and Natural Resources, four of the respondents were in Business, Management and Administration, five were in Engineering, Manufacturing and

Technology, one was in Human Services, two of the respondents were in Health Science Technology, five were in communications and information systems and three belonged to none of the above as shown in Fig. 15.

Figure 15: Professional Career Field

(ii) The Application's Ability to Deliver what it was Designed to do

To know if an application is successful, you need to assess its ability to do what it was meant to do. In this section we shall assess the application's ability to deliver some of the functional requirements and many other functionalities that are needed for smooth operation.

The Application will Quicken Delivery of Information to Ministry Of Health

At first the respondents were asked on the ability of the application to quicken the delivery of information to the MOH once the deployment at the MOH is done and they gave this feedback; 19 say yes the application will quicken delivery of information, zero say No, the application will not quicken the delivery of that information and lastly one responded maybe as they are not sure of it but neither disagree with it as shown in Fig. 16. Some other functional requirements are included in the User Acceptance Test (UAT) section of this dissertation.

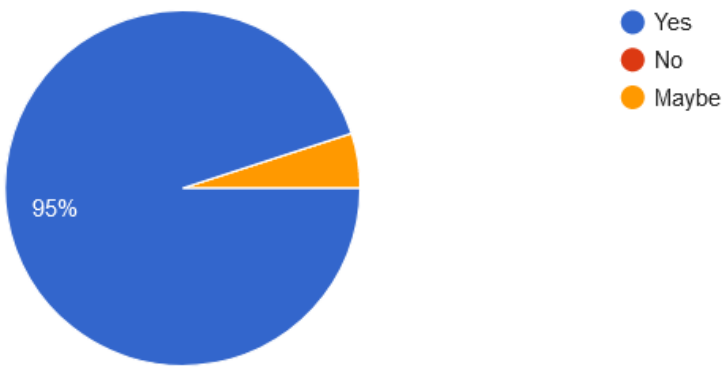

Figure 16: Shows Opinion of how the Application will Quicken the Delivery of Patient Information

The Extent the Application will be able to Carry out daily Check ups

Then the respondent's opinion on if the application would enable the VHTs to carry out daily check-ups on the patients they visit in the field was assessed. The respondents gave feedback as follows on a scale of one to five; 0 gave 1, 0 gave 2, 2 gave 3, 5 gave 4 and 13 gave 5. This shows that the respondents feel the application will be able to enable daily check-ups as elaborated in Fig. 17.

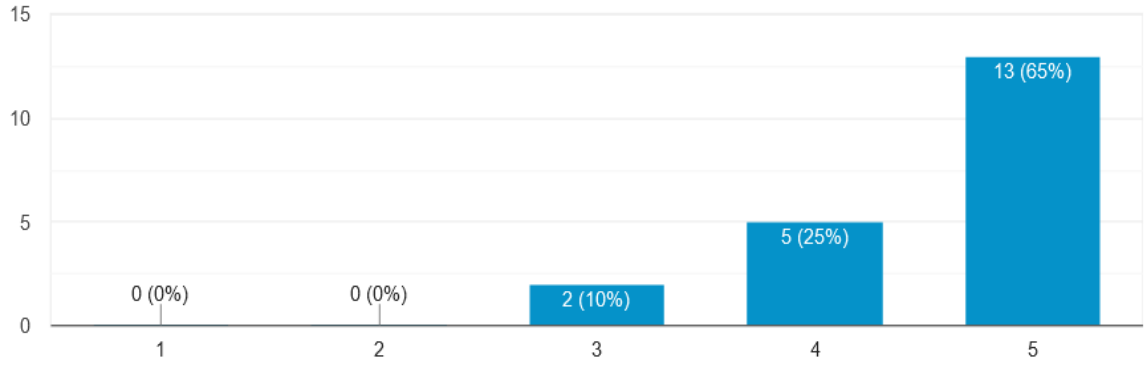

Figure 17: Extent to which the Application will be able to Facilitate Daily Checkups

Access to Smart Phones

In the survey, there were 20 (100%) of the respondents having access to smart phones and zero (0%) without smart phones as shown in Fig. 18. This means that all of the respondents have access to smart phones and thus can access the mobile application if they are using android phones.

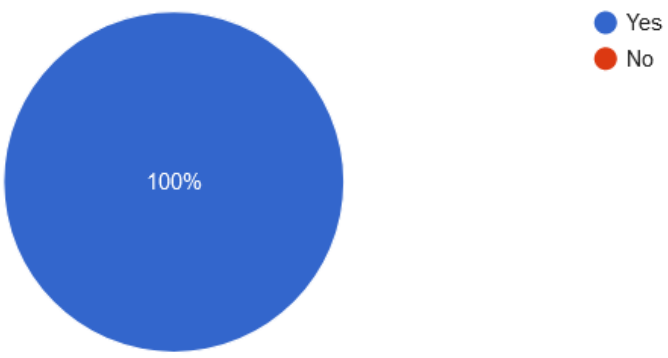

Figure 18: Access to Smart Phones

(iii) Respondent's General View on the Research and Product

In this section, the respondent's general view of the research and the product was sampled. The problem was stated and the solution was identified as well as suggesting to solve the problem. Then the justification for taking that approach towards solving the problem was made, and asked respondents on their view on the following points:

The Application will be able to Implement Home Based Care

Firstly respondents were asked for their opinion on a scale of 1 to 5 on if they feel the application will be able to implement Home Based Care as an alternative to hospitalization in health centres. The respondents gave the following feedback; 0 filled in 1, 1 filled in 2, 0 filled in 3, 7 filled in 4 and 12 filled in 5 as shown in Fig. 19. From this feedback, it could be seen that most people feel the application would be able to implement home Based Care as an alternative form of providing health services in situations of pandemics like COVID-19.

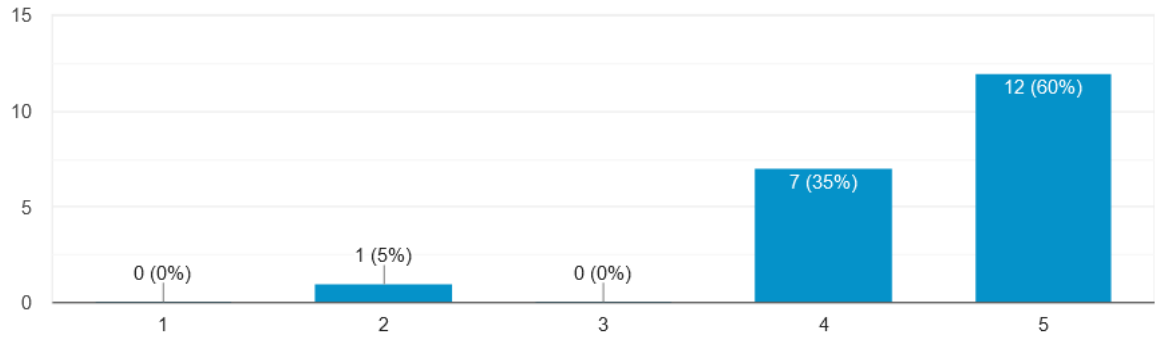

Figure 19: Extent to which the App will be able to Implement Home based Care

Extent to which the Suggested Solution and the Application will Solve the Identified Problem

Then, the respondents were asked about their opinion towards the possibility of the suggested solution of the application to solve the identified problem in under the present study. The response from the questions were as follows; 0 filled in 1, 0 filled in 2, 4 filled in 3, 4 filled in 4 and 12 filled in 5 as shown in Fig. 20. From this feedback you can see that most people feel the application will be capable of solving or even reducing the impact of the identified problem by reducing on the pressure on the existing health systems in situations of pandemics.

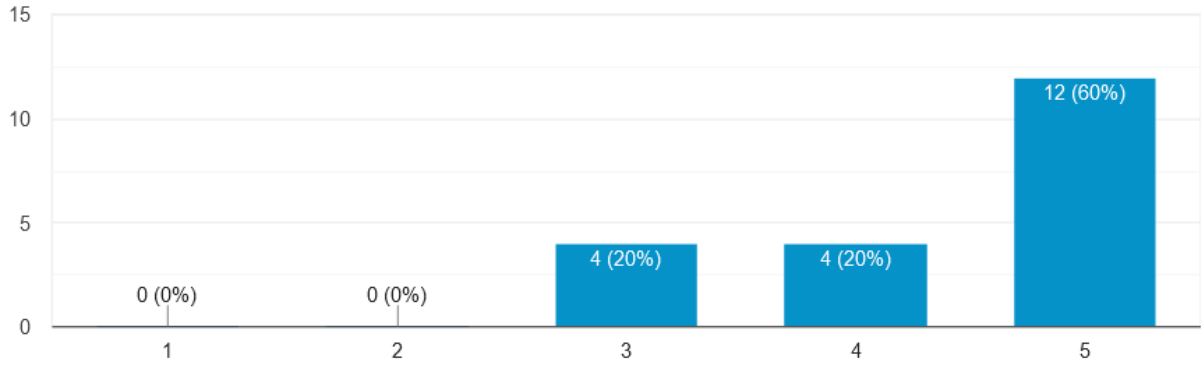

Figure 20: Extent to which the App will Solve the Identified Problem

Reasons for the Above Reply

Also the respondents were given an opportunity to give any reasons for their choice of response in the above section. Why they feel the application would be able to solve the identified problem to that level on a scale of 1 to 5 as they answered. The respondents gave the following feedback:

- N/A
- I strongly agree because this application because it allows the patient to maintain their routine and lifestyle in familiar home environment.
- Smart phones are mostly owned by people in urban centres so what happens to people who can't afford smart phones during the same outbreak. Hence there will still be pressure on the health sector.

- Reduces overcrowding hence low levels of COVID-19 spreading.
- The remote quick real time tracking and google maps functionality to find the patient location.
- Yes, because sometimes self-diagnose go to the clinic use resources and yet they aren't sick with HBC a health worker sorts that out before you get to the clinic.

Recommendation of the Application for the Village Health Team

We also assessed the respondent's opinion on a scale of 1-5 on the degree at which they would recommend this application to VHTs. The respondents shared their feedback which is represented in the graphs in Fig. 21. The respondents answered as follows; 0 filled in 1, 0 filled in 2, 1 filled in 3, 3 filled in 4 and 16 filled in 5. From these responses you can clearly see that the respondents would recommend the application for health workers at the front of fighting infectious diseases like COVID-19.

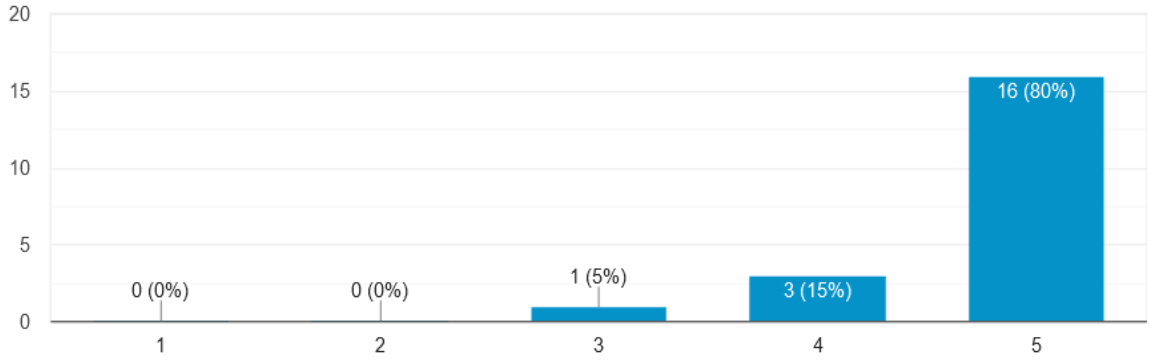

Figure 21: Recommendation of the Application to the VHTs

(iv) Suggestions for Improvement of the Application

Lastly, the respondents were given an opportunity to share their opinion on what they feel should be added to the application or to the research in general. The respondents gave some responses which were stated in detail in the recommendations section of this document.

4.1.2 The Developed Mobile System Application for Handling of Pandemics like COVID-19

The results section of this document is meant to report on the results and to get a good understanding of the value of the research results in consideration to what was stated in

proposal. The technology is elaborated in the product and it can be seen how it was used to solve the identified problem in the problem statement. Main objective has been to develop a mobile system application to facilitate and support monitoring of patients in Home Based Care so as to handle pandemics like COVID-19 and is meant to be used by Village Health Teams (VHTs) to capture information from patients under treatment in their localities. Under the present study, it was developed, a government Home Based Care application to facilitate the handling of pandemics like COVID-19. The system has a mobile application which is used by VHT teams to insert health data about patients during their daily check-ups into a centralized database. This system is intended to reduce pressure on existing health systems (Sayed, 2020) by encouraging Home Based Care over hospital based system of offering treatment. This system can be deployed by any government in the world facing a pandemic like COVID-19. The system also helps to reduce on the expense of maintaining patients in hospitals. It can reduce crowding in hospitals and health centres which will enable effective operation of health centres in situations of increased cases of infections.

(i) Mobile Application Overview

The mobile application has been developed to be accessed via an android phone. The database and the PHP scripts are hosted on a server. The mobile application functionalities such as login, VHT registration, add patient, discharge patient, readmit patient, check-up, view check-ups, view patients, logout, call, email, show location and upload image. The users of the system are the VHT officers as the system was designed for their use. The current super admin is me but a super admin account will later be made when the application is to be rolled out on a large scale.

(ii) Login Page

The user will need to create an account from the login page on a link named “create Account” which is a text view. On clicking he/she is taken to the registration page which enables the user to enter their details and register in to the system. On successful registration the user can now be able to login into the system. There is input validation on the registration page and the login page to catch errors quickly. The user password and username on login should match what is in the database for the user to be able to login. The login page is elaborated in Fig. 22.

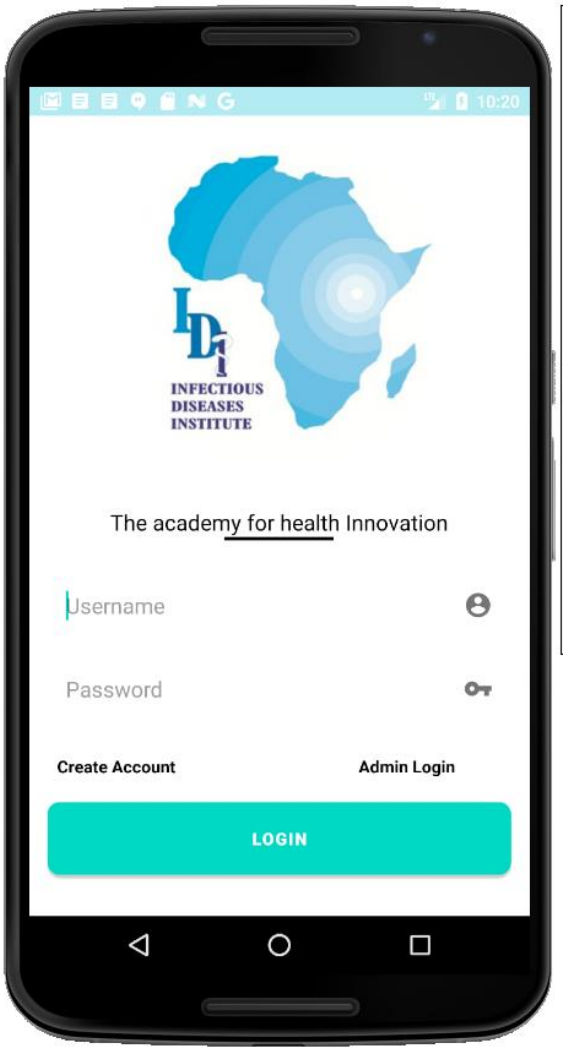

Figure 22: Login page

(iii) Village Health Team Registration

The application allows the VHT officers of all kinds to register and create for themselves accounts. In this project there is only one kind of account that one can register for and that is a VHT officer account. The registration is done on the registration page which is accessed from a “Create Account” clickable link on the login page. On the registration page the user is supposed to enter their full names, usernames, password, a confirmation of password, location, phone number and email. In case there are any fields that are not filled in, the submission into the database will fail and there will be an alert which will be showing the field that needs input. In case the password and the confirm password form inputs are not the same, the application will still fail to submit and raise an alert saying the password and the confirm password fields are not matching. Once all those issues are eliminated the system

shall submit successfully into the database. In case the email and phone number of the customer are already submitted, the system will show registration successful but will not create a new account as it leaves those fields as unique values in the database to avoid duplication of VHT Officers on the system. The create account page is illustrated below in Fig. 23.

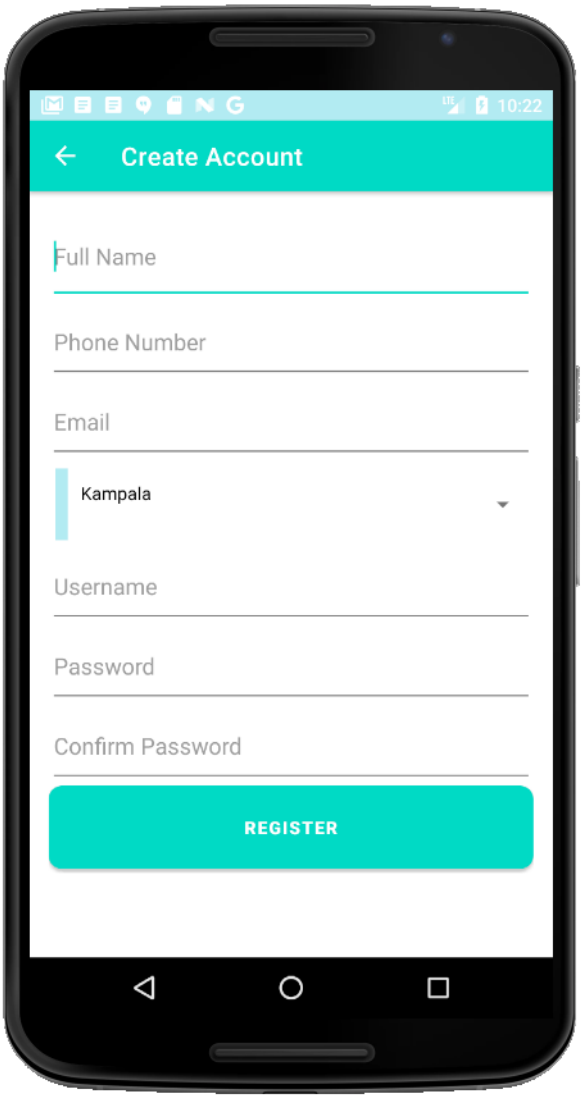

Figure 23: User Registration Page

(iv) View Patient Details

The app also has functionalities to show the patient information on the system. The patient details can be captured on two different pages. After login, the application takes the user to the "MainActivity" which is the home page. This page shows the patients that are currently

existing on the system. It shows the patients names, the status, the age, the location, the phone number and the disease they are suffering from.

The other page on which the application has patient's details on is the "Patient Details page" this page shows more details of the patients including all the status notes and comments that the VHTs or other medical personnel made to the patient. This page can be accessed after clicking the patient on the home page and it will be showing the details of the patient you have clicked on. The home page and patient detail pages are illustrated in Fig. 24.

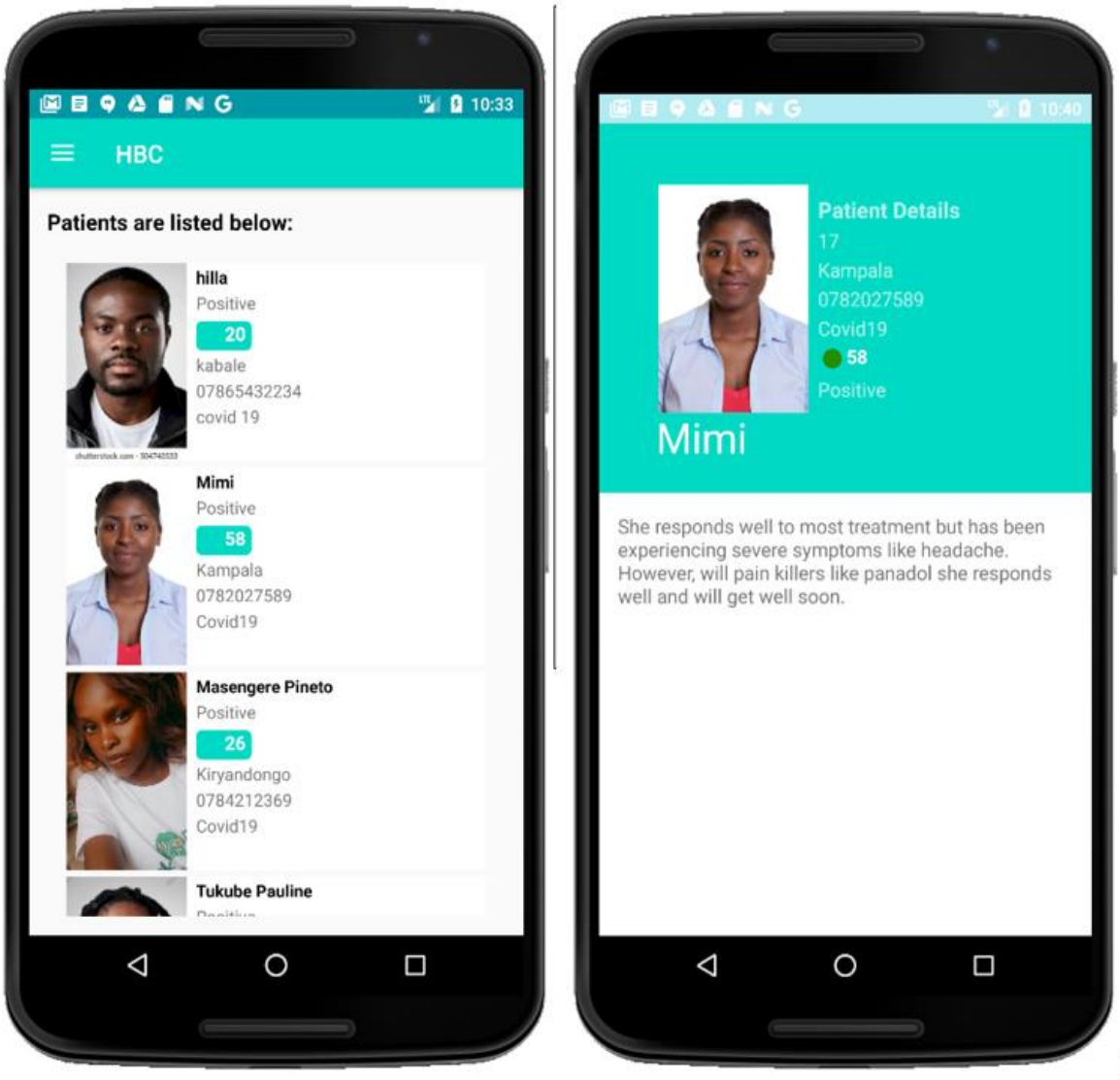

Figure 24: Home Page and Patient Detail Page

(v) Navigation Menus and Add Patient Page

The navigation menus of the application are on the home page, the navigation menus are implemented using the navigation drawer in android. The navigation menu has nine buttons or links that take the user to different pages or carry out new functionalities. The add patient page is accessed from the navigation menu on the home page. The add patient page gives an opportunity for a user to add a new patient into the system. It has fields that enable the user to add patient's full names, add patient's phone number, add patient's email, add the patient's location or address, specify the disease the patient is suffering from which will be COVID-19 for this case, enter the patient's age, the status on the disease and other comments that the medical personnel may consider relevant towards the treatment of the patient.

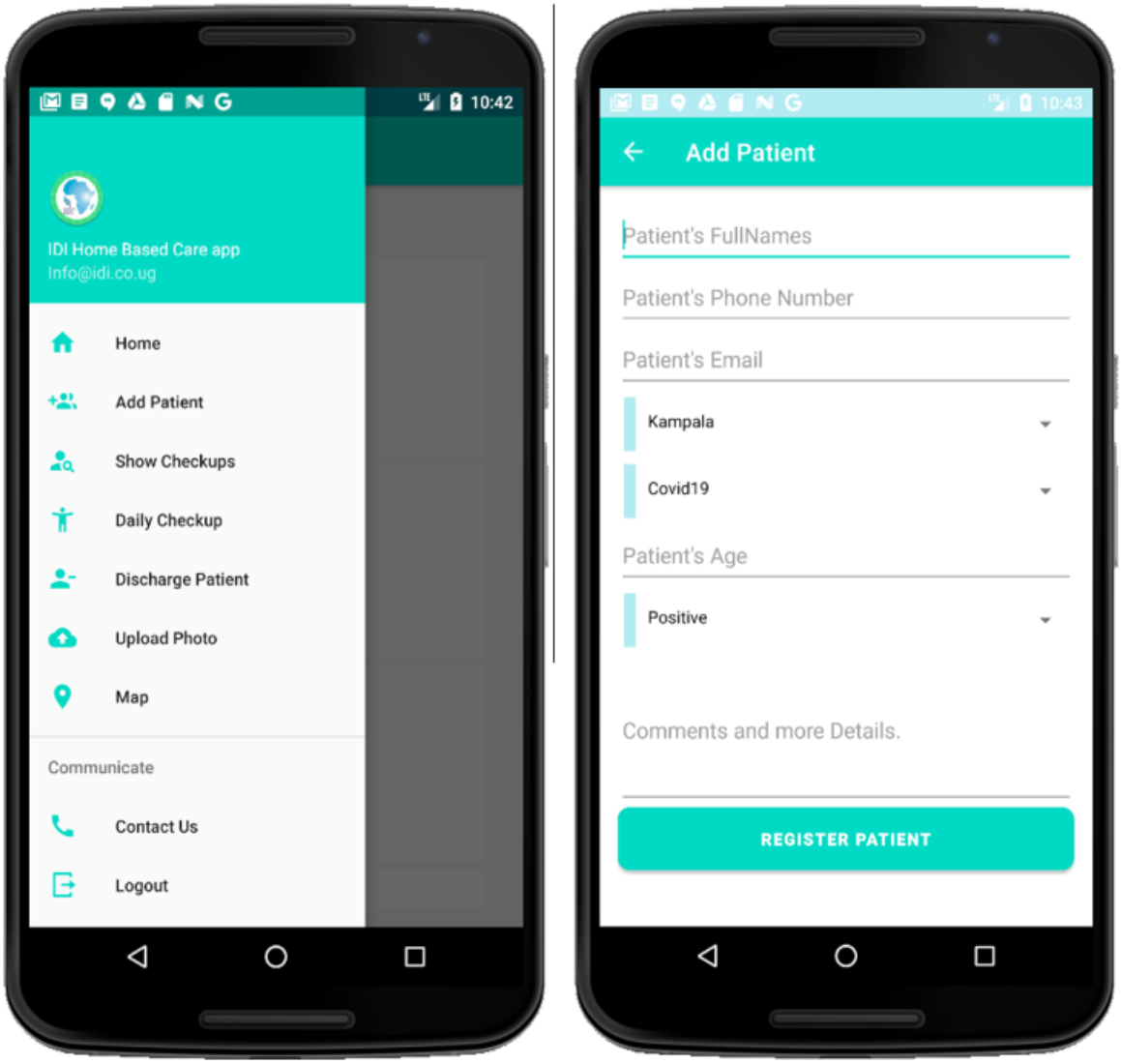

Figure 25: Navigation Menu and Register Patient

(vi) Show Checkups and Checkup Details

The navigation drawer menu has a button for showing checkups which loads the Patient's checkups page. The checkups page shows all the patient checkups starting with the most recent on top. The checkups shown on the checkup page are a summary of that specific checkup and a user can view the details of that checkup once they click on that specific checkup as elaborated in Fig. 26.

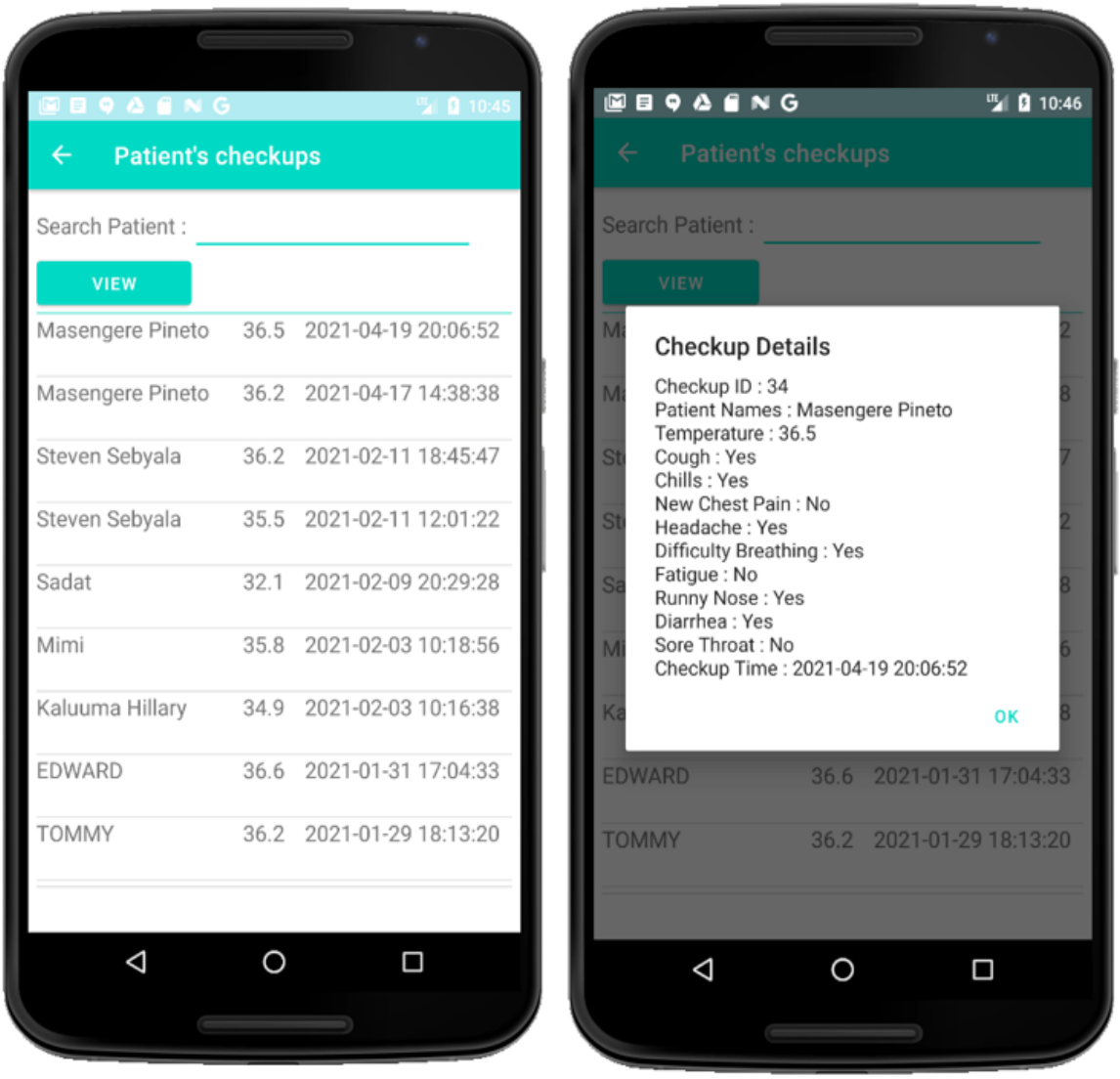

Figure 26: Patient Checkups and Checkup Details

(vii) Search Check-ups and Patient Checkup

The navigation drawer menu also has a button labeled as “Daily Checkup” which enables the user of the app to navigate to the patient checkup page. The patient checkup page enables the user to carry out the daily checkups for the patient. It allows the user to select the patient, select “yes” or “no” on the different dropdown lists specifying the symptoms that the patient is claiming to experience. The symptoms checked for include: Temperature, chills, chest pain, headache, cough, difficulty breathing, fatigue, running nose, diarrhea and sore throat. On filling in the different symptoms, the user of the application can then submit this informtaion by clicking the “Submit Patient Checkup” button below the page.

The search patient’s checkups button enables the user of the application to input the patient names and search for the patient’s checkups. The checkups will also be displayed in order with the most recent one on top. The user can still click on the specific checkup to view its details. The patient’s checkup and the checkup page are elaborated in Fig. 27.

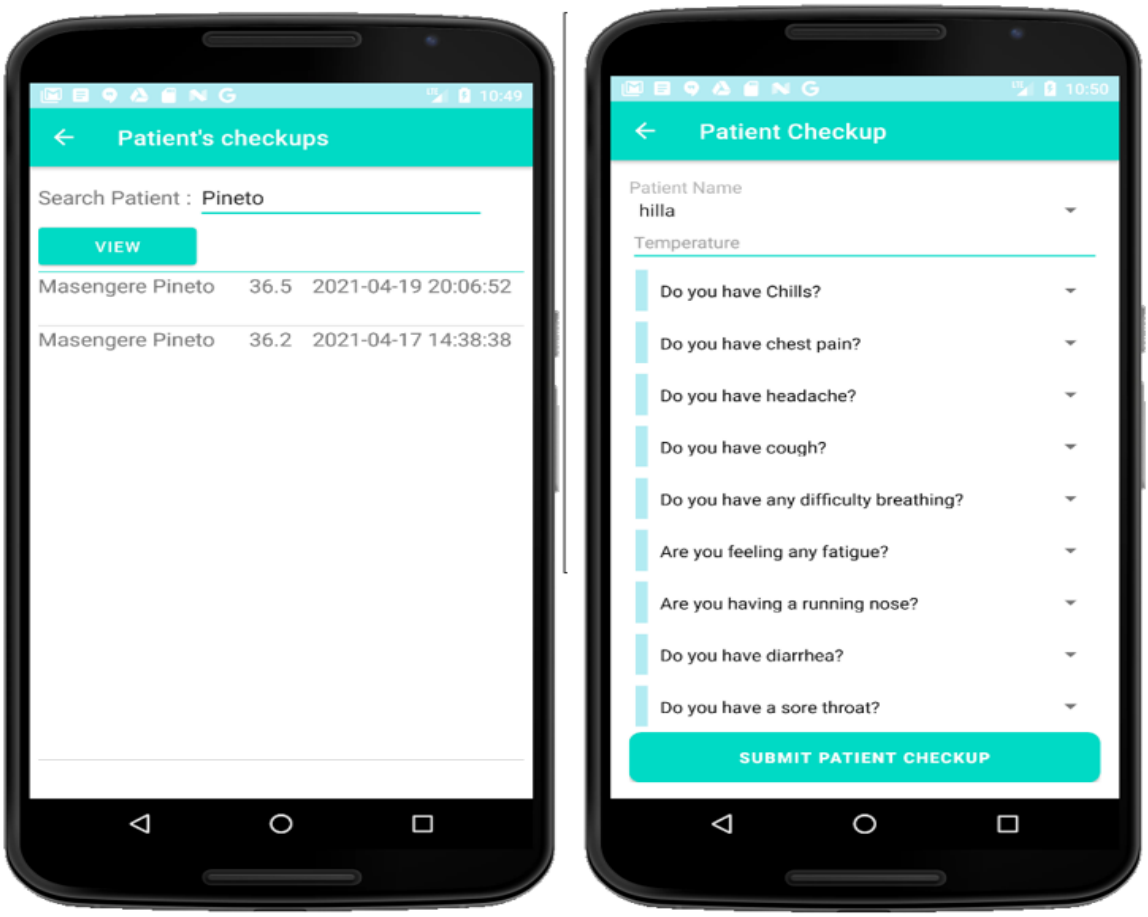

Figure 27: Search checkup and Submitting Checkup

(viii) Re-admit and Discharge Patient

This section of the application enables the user to discharge a patient from the system if they have healed and are fine. It also enables the user of the application to readmit the patient into the system if they begin feeling unwell again or fall sick again. When a patient is discharged from the system, they will nolonger appear in the system but will still be existing in the database with a status of discharged meaning they are nolonger considered sick. Only sick patients are displayed on the system. The two buttons are illustrated below in Fig. 28.

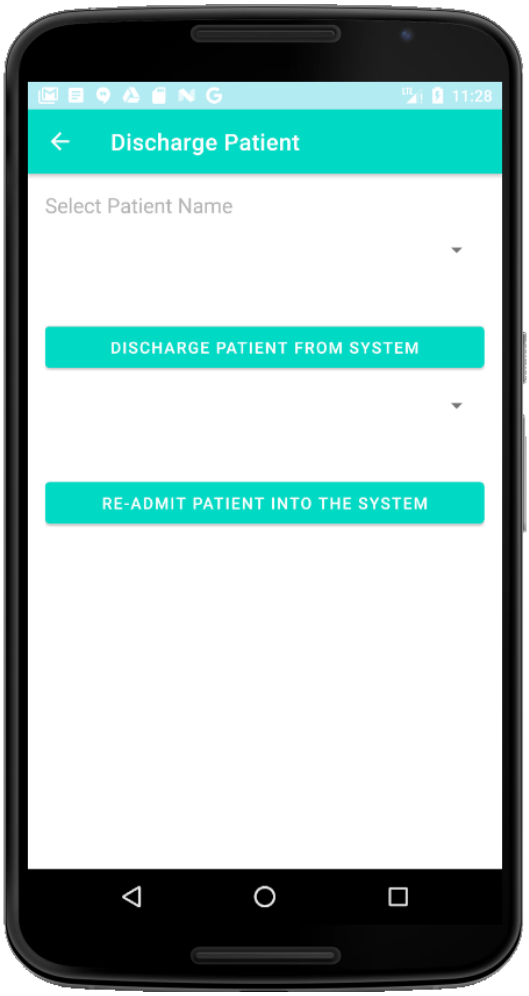

Figure 28: Re-Admit and Discharge Patient

(ix) The Upload Image Functionality

This enables the user of the application to select a patient on the system and then upload an image or picture of the patient. This enables the VHTs to easily identify their patients during their field visits to the patient's premises. Figure 29 shows what the page looks like.

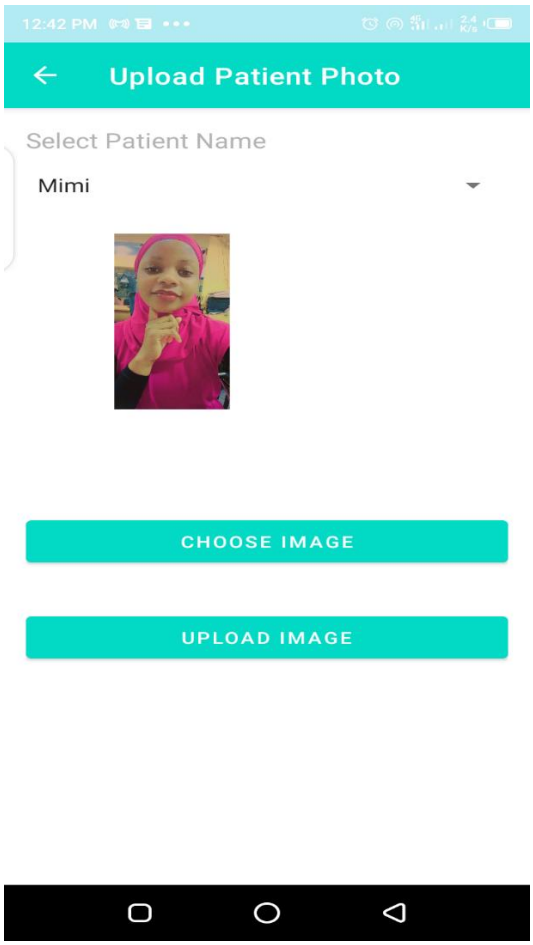

Figure 29: Upload Image Page

This page has many functionalities which may not be directly connected to the functional requirements of the application. It has the email button which enables the app to load the email account of the user, this enables the user to easily email the support team of the application if there is need. It has the call functionality which can be used to access a toll free number for customer support of the application in case they are having any challenges. It also has social media buttons which when clicked on can load the social media accounts of the system. At the moment there are no social media accounts but we believe they will exist in future. The contact us page is elaborated below in Fig. 30.

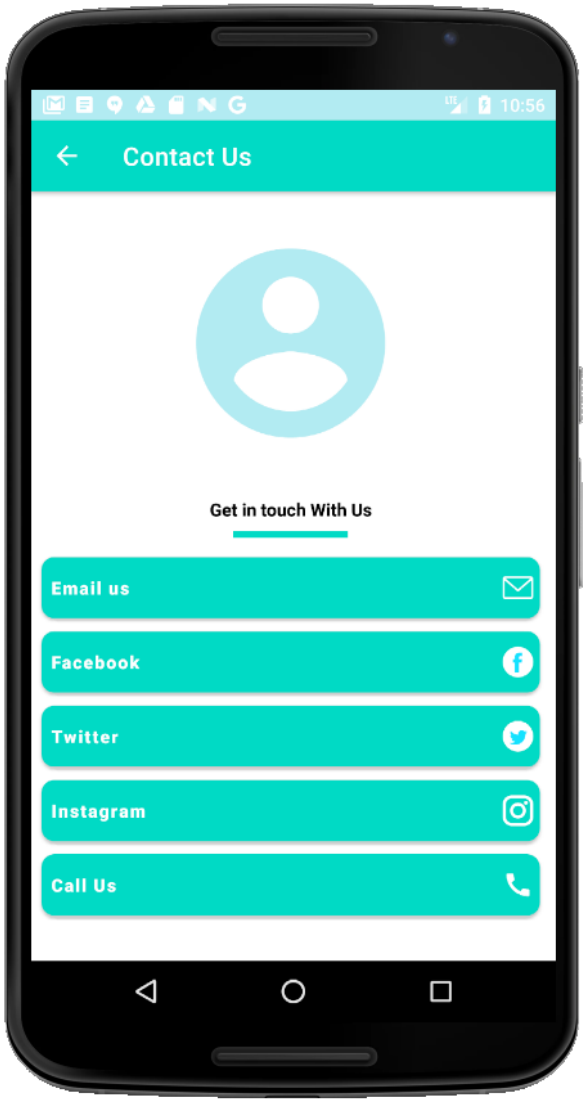

Figure 30: Contact Us Page

There are also other functionalities in the application which have not been specified in the sections above and among them are; the maps funtionality which enables the VHTs to track the location of their patients. It can also enable them to use the navigation functionality in google maps to direct them to the exact locations to find their patients.

4.2 Discussions

In this study, the findings show that majority of the stake holders in the health sector and the public are interested in the application. It shows that majority of the respondents believe the system will be able to reduce or solve the identified problem in this dissertation. Majority of the users and those who got to use the application agree that the application is easy to use and navigate. The respondents also expressed their confidence in the application's ability to

enable the implementation of Home Based Care as an alternative to offering health care in situations of pandemics like COVID-19. The majority of the respondents also feel that health staff will be impressed by the application. Furthermore, majority of the respondents would recommend the application to be used by the VHTs and other frontline health staff when dealing with pandemics like COVID-19. Much as the Ministry of health (MOH) and other health support bodies have not been using a similar system, the response and feedback from the public believes in the idea and there is reason for us to give it an opportunity to run it as a prototype in the existing health systems.

However, there will be need to have a more diverse population coverage for the survey. This prototype has mainly involved the educated and literate. The scope also involved majority youth and it would be safe to have more aged participants into the survey to get a more conclusive view of the public's opinion with no bias.

4.2.1 Validation

Software validation is the process of evaluating the software product to clarify if it satisfies the specified requirements. This is normally carried out at the end of the development of a software product to ensure that the software produced is correct as intended at the start of development. It is meant to ensure that the user's needs are met or satisfied in the software product that has been developed. The requirements should be clearly stated and evidence for the intended use should be well provided (Sidek, 2015). This project, carried out unit testing, integration testing, system testing and user acceptance testing as a means of carrying out software validation.

4.2.2 Unit Testing

The unit testing is meant to verify the functional behaviour of the smallest component of the system such as the functions in the code base (Dybå, 2008). In this system, the units that were tested include the function to check for internet connection, the function to submit information into the database, function to create JSON results in the PHP scripts from the database, just to mention a few. Under this project different functions of the developed application were tested to ensure they are giving the expected results so that those results can be used as input to the other functions.

4.2.3 Integration Testing

The integration testing is done after the unit testing. It is intended to ensure that the application components that have interdependencies among the unit tests code base are working together smoothly. There is need to verify that the operation of the components correlate with what was specified in the design of the application (Nidhra, 2012). An example of this situation in the application is the login functionality which needs an existing account to enable one to login. There is need for a user to be able to create account through the link on the login page before the user can have a valid account. In such a case, integration testing ensures that the application login will enable creation of an account first which will enable the two components to operate smoothly.

4.2.4 System Testing

The system testing was done after the unit testing and the integration testing of the system. It was done to verify if the system that was developed meets the specified business requirements of the clients as well as the functional requirements of the system users. It is said that it does not deal with the structure of the source codes but with the result functional features of the system (Nidhra, 2012). Both local and deployed version of the system were able to pass the different tests of the system test. Different functional requirements of the system were tested and the application passed as shown in the Table 9.

Table 9: System Test Results

Requirement	Description	Test Score
Registration	Mobile app shall allow the users to register and login to access information about the patients on the system.	Pass
Upload Patient image	The VHT user accounts should enable the users to upload and image to a specific patient of their choice.	Pass
Search a Check-up	The users should be able to search for previous check-ups belonging to a specific patient.	Pass
View Patients	The VHT user accounts should enable them to view the sick patients on the system.	Pass
Add a check-up	The mobile app should enable the users to add a new patient checkup to the system	Pass
Discharge Patient	The mobile application should enable the users to discharge a patient from the system.	Pass
Add Patient	The mobile application should enable the users to add a new patient to the system.	Pass
Re-Admit Patient	The mobile application should enable the user to Re- Admit Patient into the system.	Pass

4.2.5 User Acceptance Testing

The user acceptance test is done by the potential users or customers of the developed software system. The main intention of the user acceptance testing is to assess if the software produced is working properly as expected by the clients. The VHTs were allowed to interact with the different functional components of the system and shared their feedback on the degree at which it is offering what it was expected to deliver. Some of the functional and non-functional requirements tested are ease to use, speed and many others (Nidhra, 2012). In this case google forms were used to create a questionnaire that was presented to the different stake holders as a survey on the project and the mobile application. In this survey, the users

got a chance to give their own opinion and also assess the functionality of the application. There was a demo attached in the google form which gave the respondents an opportunity to see the operation and navigation of the application. This gave them a more conclusive view of the app and the project in general. The survey form had an alternative to give feedback on a scale of one (1) to five (5) where 1 was for strongly disagree and 5 was for strongly agree. Table 10 summarises the different alternatives to give as answers to the questions and their meanings.

Table 10: User Acceptance Test Response Alternatives

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

4.2.6 User Acceptance Tests Results

In Fig. 31 is a summary of the results we got from UAT tests of the application in the google form survey that was carried out about the application and the project.

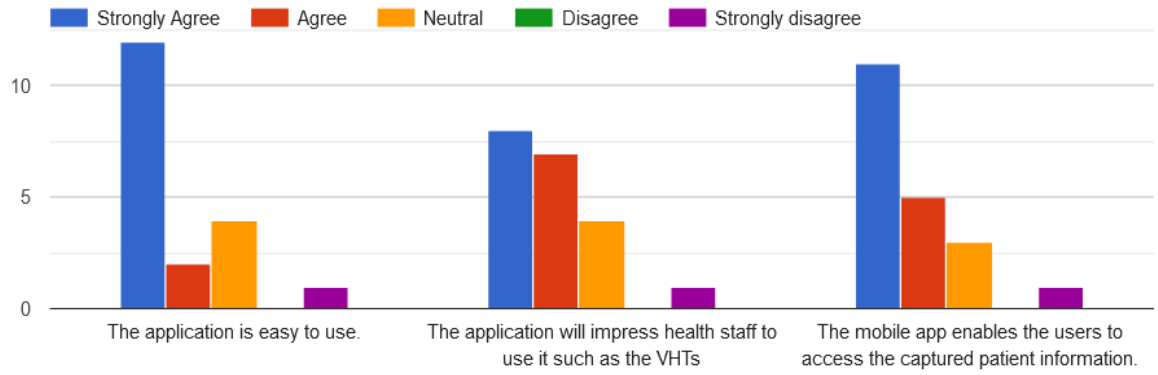

Figure 31: User Acceptance Test Result Graphs

Table 11: User Acceptance Test Results Table

Validation Feature	Respondents					Mean Score
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
The Mobile application is easy to use	1	0	4	2	12	4.05
The mobile application will impress the VHT and other frontline health staff to use it.	1	0	4	7	8	4.05
The mobile application will allow the VHTs to access captured patient information.	1	0	3	5	11	4.25

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In this project, a mobile application which will be used by the health officials to enter and manage patient's health information during daily check-ups carried out in the HBC setup has been developed. The application will send the information collected into a database on a server. This information can be accessed by IDI systems such as Call for Life (C4L) which is a system that works with the Interactive Voice Response (IVR) tool of IDI. This tool makes calls to interact with patients offering pill reminders, health tips and also follow up on how patients are responding to treatment (Beentjes, 2020). Therefore, it can be concluded by stating that there is a lot of work that has been done towards the development of software systems to assist with managing infectious diseases especially in outbreak response. However, there is limited work that has been done towards the use of Home Based Care supported systems to enable the treatment or manage patients in treatment of infectious diseases. With this system in place, it is possible to transform the way medical services can be delivered massively increasing the potential of the health sector to handle pandemics like COVID-19.

In this project, a mobile application which will enable VHTs to capture and share patient's information during health check-ups was developed. This will also enable the ministry of health to build capacity of the health system in the country.

(i) Once this system is taken up by the government, we expect it to transform the way the government deals with infectious Diseases as we expect it to embrace Home Based Care over Hospital Based Treatment that has been commonly used in the country and all around the world.

(ii) With this project, the government will have built capacity of its health sector to handle the biggest epidemics with ease and this will revolutionize the health sector for Uganda and Africa in general.

(iii) This system will simplify life for the population and reduce large expenses normally spent in hospital admissions as people will be able to have their patients treated in their localities especially in situations of out breaks of infectious diseases.

5.2 Recommendations

There have been many recommendations and suggestions made to this research project. Among them are more functionalities that can be added to the application. According to the scope of this dissertation, many of them are not included in this prototype. Some of the known future works will be to add an admin account which will be managing the application. This account will be able to oversee all the VHT officer accounts and will also be able to monitor the patient's progress. The admin account is very necessary for cases of new and dangerous infectious diseases where the only way we can confirm that a patient has healed is by visiting a health facility where tests can be carried out to ensure that the patient has healed. This admin interface could be on the application or could also have a web interface depending on what the using health institution would prefer or any other client would recommend. The admin will be able to do multiple functionalities such as updating data, deleting data as well as deleting the existing VHT officer accounts.

The other recommendation was with implementing local storage to cater for cases of poor or no internet connection especially in remote rural areas. This would best be implemented if it can synchronize with the data in the live database once the internet connection is restored. This will enable the VHTs to operate at full capacity in areas with little to no internet connection.

The other recommended future work is completing the design cycle which was suggested at the Infectious Disease Institute (IDI). The IDI envisioned this system to be integrated with their call for life system which interacts with patients offering them pill reminders and capturing symptom alerts. The Call for Life system at IDI is already used by the Ministry of Health in COVID-19 to offer call services to the patients. This system can be plugged into already existing HBC application as it will just need to pick data from the Junction Database where application deposits the data. In Fig. 32 is a diagram illustrating the envisioned system overview at IDI.

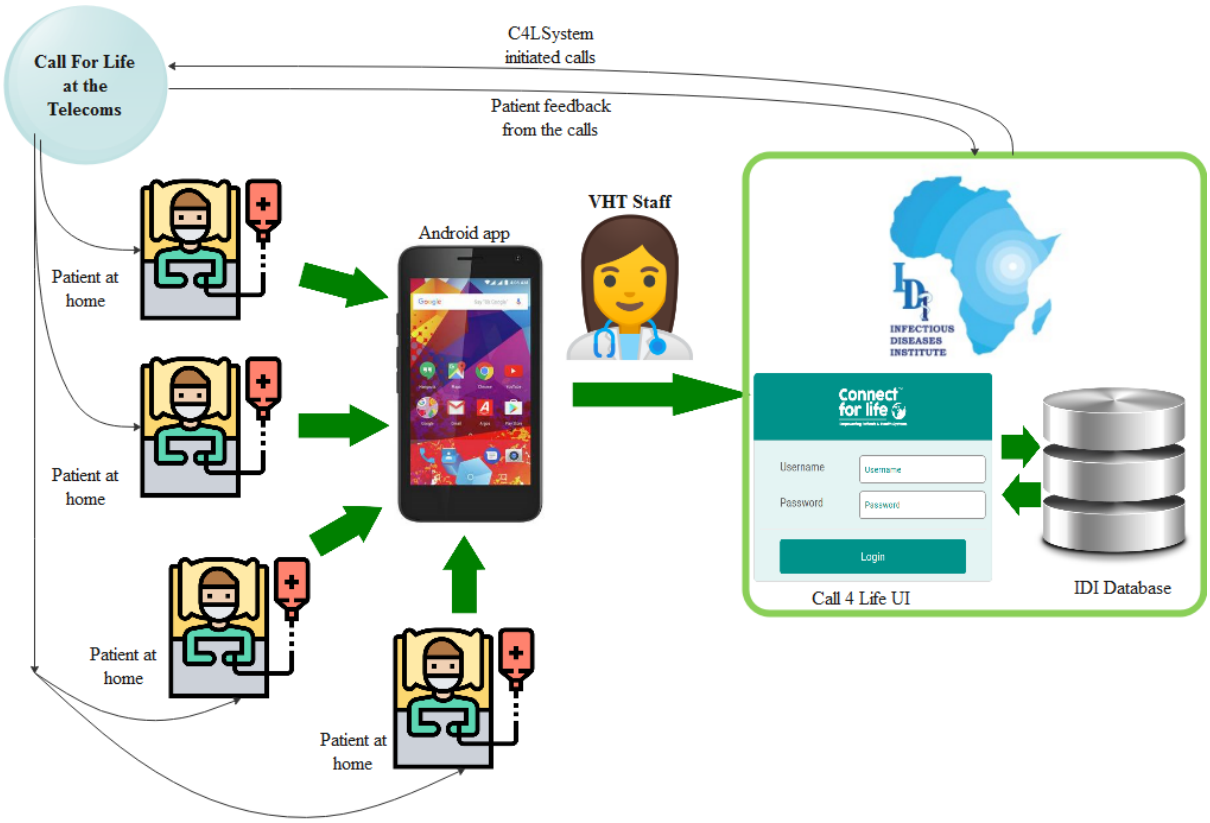

Figure 32: Infectious Disease Institute Envisioned System for HBC Application

The Other recommendations are from our survey and they included the following:

(i) Members of the Village Health Systems should be listed for security purposes when they visit a patient's home.

(ii) The HBC Mobile Application should be deployed on play store. And secondly the App should be available for both Android and Apple mobile users.

(iii) The application should be able to import patient profile from a central database once they present their ID number.

(iv) Including social authentication for instance using Google accounts so that the VHTs will be able to quickly log in without worries of forgetting their passwords.

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APPENDICES

Appendix 1: Ministry of Health COVID-19 Daily Self-Monitoring Form during Home Based Isolation and Care

Daily Self-Monitoring Form during Home Based Isolation and Care

Name:_____ **Date symptoms started (if applicable):** _____ **Self-monitoring start date:**___

* Avoid the use of fever-reducing medicines (e.g., Paracetamol, ibuprofen/Diclofenac) as much as possible. Fever-reducing medicines could hide early symptoms; if these must be taken, speak with your health care provider.

Self-monitoring day	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Date (MM/DD)														
Daily temperature*If thermometer is available (degrees Celsius)	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C
NO SYMPTOMS ✓														
Pay attention to your health. If you develop any symptoms write **YES** or **NO** below for each symptom daily.														
Chills														
new chest pain														
Headache														
Cough														
Short of breath or difficulty breathing														
Fatigue (tired)														
Runny nose														
Diarrhea (loose stool)														
Sore throat														
Other (add in notes) Conjunctivitis loss of appetite, loss of taste or sense of smell, nausea & vomiting, muscle aches, etc.														

NOTES:
If you develop any new or worsening symptoms, call ..... to speak with a health care provider or dial *206# and follow the prompts to help determine if you need further assessment and evacuation

Appendix 2: Survey Questionnaire on the Research and the Product

IDI Home Based Care App Survey

With the outbreak of COVID 19, the world has been faced with a lot of health challenges due to the increased demand for health services. As a result, there is need for alternative methods to offer health services and among them is Home Based Care (HBC). Home Based Care is a health system where patients are offered treatment in their localities or homes.

The problem we are trying to solve is the enormous pressure built on the health systems as a result of crowding in facilities which comes from reallocation of health resources, the rate of spread of the disease exceeding what the health systems can handle, among others.

The goal/solution we are suggesting is the mobile application for implementing Home Based Care to handle pandemics like COVID 19 and the app is designed to be used by VHTs (Village health Teams). Village Health Teams (VHTs) were established by the Ministry of Health to empower communities to take part in the decisions that affect their health; mobilize communities for health programs, and strengthen the delivery of health services at house-hold level. The main justification for this approach is that majority of the patients infected have mild symptoms and don't need hospitalization and there is an already existing VHT health system in Uganda.

In this survey, we asses the validity, usability of the application and also get suggestions from the public on what they think the application should work like to achieve its goal.

Kindly note that the data captured is anonymous therefore feel free to give your honest opinion.

*Required

Kindly select your Gender? *

- ◯ Male
- ◯ Female

To which age bracket do you belong to? *

Choose ▾

What is your education level? *

Choose ▾

To what Professsional Career Field do you belong to?

Choose ▾

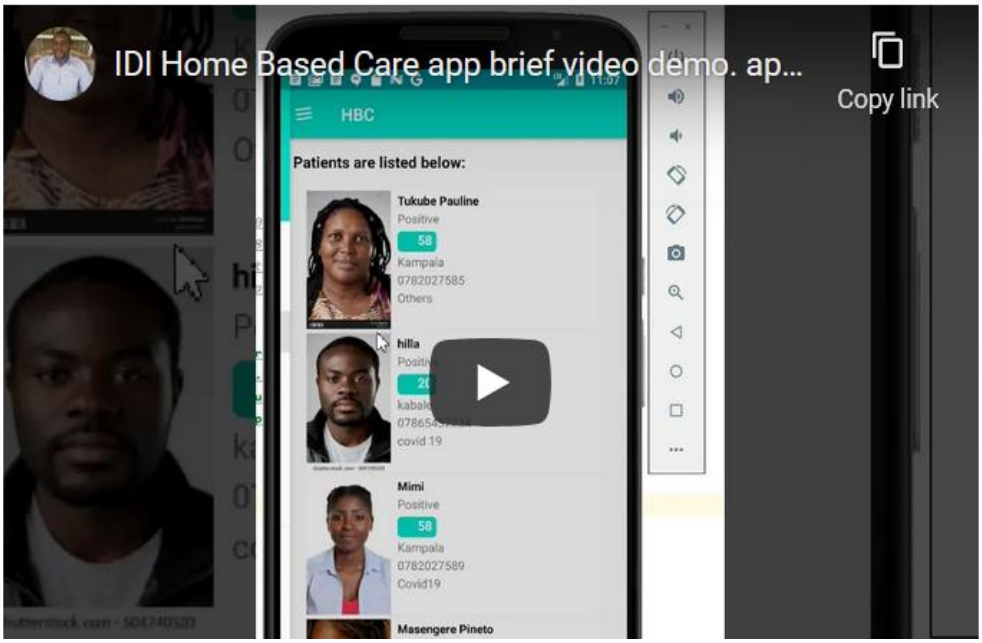
Do you have access to a smart phone? *

- ◯ Yes
- ◯ No

Application Demo, testing and User Acceptance Tests (UATs)

In this section of the survey we present a link to a demo of the application to give you a feel of how it works. Kindly take some time to watch it and give feedback on it.

A brief Demo of the HBC Application. (Takes only 8 minutes). If the youtube video is not working for you, try using a network where youtube is not blocked.



	Strongly Agree	Agree	Neutral	Disagree	Strongly disagree
The application is easy to use.	○	○	○	○	○
The application will impress health staff to use it such as the VHTs	○	○	○	○	○
The mobile app enables the users to access the captured patient information.	○	○	○	○	○

The mobile application submits its information into a database hosted on a live server. In operation, those two components will be hosted at the MOH. Do you feel the application will quicken the time it takes for the ministry to have updated information on the patients that have been visited by the VHTs. *

- ○ Yes
- ◉ No
- ○ Maybe

To what extent do you think this application could be of use to frontline workers like VHTs considering all the functionalities it has. *

	1	2	3	4	5	
Totally of no use	○	○	○	○	○	Surely of so much use.

This application was designed to enable VHTs carry out daily check ups for patients in this case of COVID 19 in Home Based Care. To what extent do you feel the app will enable this? *

	1	2	3	4	5	
It will not enable at all	○	○	○	○	○	It will surely enable that

Do you think the application will enable the implementation of HBC as an alternative means of offering health care when handling pandemics like COVID 19 *

	1	2	3	4	5	
Not at all	○	○	○	○	○	Surely it will

Do you think the suggested solution of a mobile application for implementing HBC will reduce or solve the specified problem of increasing stress / pressure on the health system in situations of pandemics like COVID 19? *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Give reasons if any for your choice of response in the previous question.

Your answer

Would you recommend this app for use by the VHTs *

	1	2	3	4	5	
I strongly discourage	○	○	○	○	○	I strongly recommend

In your own words, what other functionalities or improvements would you suggest to be added to the Mobile application or the system at large, if you have any.

Your answer

Submit

Page 1 of 1

Never submit passwords through Google Forms.

POSTER PRESENTATION

Implementation of Home Based Care for COVID 19 using a Mobile Application

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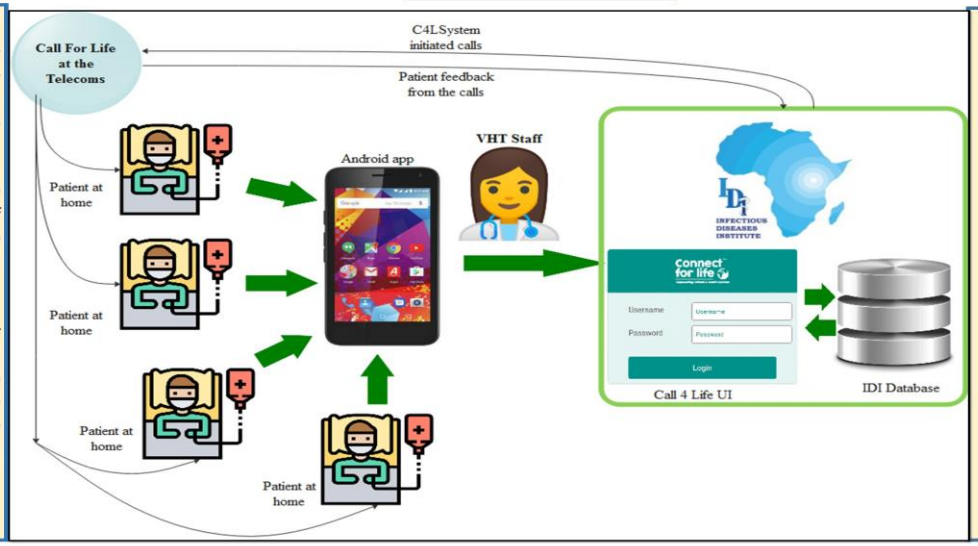
INTRODUCTION

COVID-19 is an infectious disease caused by the corona virus SARS-CoV-2 which is a respiratory pathogen. COVID-19 stands for Corona Virus Disease of 2019.

With the outbreak of COVID 19, the world has been faced with a lot of health challenges as a result to the increased demand for health services.

There has been increasing need for alternative methods to offer health services and among them is Home Based Care (HBC). Home Based Care (HBC) is a health system where patients are offered treatment in their localities or homes.

WORKFLOW



PROBMEM STATEMENT

With reduced resources and the rate of spread of the disease exceeding what the health centers can handle there is need come up with alternative means to care for the sick using the existing resources such as the HBC with can use the existing VHT system in Uganda.

There has also been crowding in the existing health facilities which has created the demand for more facilities and has constituted an insurmountable obstacle for preventing further spread of COVID-19.

As a result, pressure/stress is built on the health systems especially in the health centers and this is worse in Africa where the health systems are already fragile.

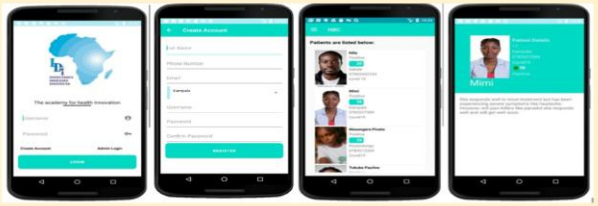
OBJECTIVES

- **THE MAIN OBJECTIVE**: To develop a mobile application to facilitate and support monitoring of patients in Home Based Care for COVID-19.

SPECIFIC OBJECTIVE:

- To review and analyse the requirements for developing a mobile application.
- To design and implement the proposed system by programming the interface, scripts and database.
- To validate and deploy the developed system.

RESULTS



EXPECTED BENEFITS

- Transform the way the government deals with the infectious Diseases as we expect it to embrace Home Based Care over the hospital Based Treatment.
- Built capacity of health sector to handle the biggest epidemics with ease and this will revolutionize the health sector for Uganda and Africa in general.
- This system will reduce large expenses normally spent in hospital admissions.