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# Secure M-health system for enhancing a confidential access of HIV/AIDS healthcare information in Tanzania

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**SECURE M-HEALTH SYSTEM FOR ENHANCING A CONFIDENTIAL  
ACCESS OF HIV/AIDS HEALTHCARE INFORMATION IN  
TANZANIA**

**Ibrahim A. Mwammenywa**

**A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of  
Master's in Information and Communication Science and Engineering of the Nelson  
Mandela African Institution of Science and Technology**

**Arusha, Tanzania**

**February, 2019**

## **ABSTRACT**

For many years, stigma has been hindering people in the society from freely going to the Care and Treatment Centres (CTCs) to receive the HIV/AIDS healthcare information such as counselling, treatment and HIV/AIDS related education as well as other HIV/AIDS healthcare services. This research focuses on the development of a secure integrated m-health platform for enhancing the HIV/AIDS healthcare information delivery in Tanzania. With this platform, an easy, timely and secured access to relevant HIV/AIDS healthcare information can be achieved without people being disclosed, identified and subjected to the stigma.

The Rapid Application Development (RAD) model was adopted during the system development within this study. The system requirements were modelled into the Data Flow Diagram (DFD) in order to obtain the clear flow of the HIV/AIDS healthcare information between the clients and HIV/AIDS healthcare practitioners. With the use of different software development tools and environment such as Android studio, Symfony framework, and PostgreSQL Database; both android application and web-based system were developed.

This study developed a secure m-health platform for HIV/AIDS healthcare information delivery. The developed system was tested for individual module functioning as well as the functioning of the fully integrated system. The platform provides a confidential and anonymously one-to-one live communication between a client and an HIV/AIDS healthcare practitioner. Moreover, the system provides the clients with the HIV/AIDS healthcare tips, and nearest CTC among other useful features of the developed system in this research. Finally, the user acceptance survey concluded that the developed system was positively accepted by the users and commended the ministry of health to officially deploy the system for enhanced delivery of HIV/AIDS healthcare information.

## DECLARATION

I, **Ibrahim A. Mwammenywa**, do hereby declare to the Senate of Nelson Mandela African Institution of Science and Technology that this dissertation is my own original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

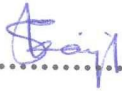


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The above declaration is confirmed by:



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**Supervisor**

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## CERTIFICATION

I, the undersigned certify that I have read and hereby recommends for acceptance by The Nelson Mandela African Institution of Science and Technology, a dissertation entitled, “Secure M-Health System for Enhancing a Confidential Access of HIV/AIDS Healthcare Information in Tanzania” in partial fulfilment of the requirements for award of the degree of “Master’s in Information and Communication Science and Engineering.”



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**Date**

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## **LIST OF ABBREVIATIONS**

<b>ACRONYM</b>	<b>DEFINITION</b>
AIDS	Acquired Immunodeficiency Syndrome
ART	Antiretroviral Therapy
ARV	Antiretroviral
CTC	Care and Treatment Centre
DBMS	Database Management System
DFD	Data Flow Diagrams
e-Health	Electronic Health
GUI	Graphical User Interface
HIV	Human Immunodeficiency Virus
HPHB	Healthy Pregnancy, Healthy Baby
HTTP	Hyper-Text Transfer Protocol
ICRW	International Centre for Research on Woman
ICT	Information and Communication Technologies
IDC	Infectious Diseases Centre
IT	Information Technology
JSON	JavaScript Object Notation
m-Health	Mobile Health
MAMA	Mobile Alliance for Maternal Action
NACOPHA	National Council for People living with HIV and AIDS
NBS	National Bureau of Statistics
NGO	Non-Government Organisation
ORDBMS	Object-oriented Relational Database Management System
PHP	Hypertext Pre-Processor
PLHIV	People Living with HIV
PMTCT	Prevention of Mother-To-Child Transmission
RAD	Rapid Application Development
SDLC	Software Development Life Cycle
SMS	Short Message Service
SQL	Structured Query Language
SSA	Sub-Saharan African

TACAIDS	Tanzania Commission for AIDS
TAYOA	Tanzania Youth Alliance
TCP	Transfer Control Protocol
TCRA	Tanzania Communications Regulatory Authority
UAT	User Acceptance Tests
UE	User Experience
UI	User Interface
UML	Unified Modelling Language
UNAIDS	Joint United Nations programme on HIV/AIDS
WHO	World Health Organisation
XML	eXtensible Markup Language

# CHAPTER ONE

## INTRODUCTION

### 1.1 Background of the Study

Human Immunodeficiency Virus infection and Acquired Immunodeficiency Syndrome (HIV/AIDS) has been one of the most killing global pandemics to date. Fighting the HIV/AIDS has been a very daunting challenge in the global health and particular Sub-Saharan African (SSA) countries. By 2015, almost 36.7 million people were living with HIV in the world, with more than two-third of them living in SSA (The Joint United Nations Programme on HIV/AIDS, 2016). Tanzania in particular, about 1.4 million people were living with HIV, and around 36 000 deaths which occurred in 2015 were due to HIV/AIDS (The Joint United Nations Programme on HIV/AIDS, 2016).

Most of the SSA governments, such as the Tanzanian government, have taken the socio-economic and political measures to tackle the HIV/AIDS pandemic by providing free HIV/AIDS medical services such as provision of the Antiretroviral therapy (ART) in the public hospitals. The increase usage of the ART has revealed that there is an increase in life expectancy of People Living with HIV (PLHIV) in some countries in the SSA thus it is more likely to turn the HIV/AIDS pandemic disease into a chronic infection (Bor *et al.*, 2013). Approximately, 10.3 million of PLHIV were accessing the ART in the eastern and southern SSA (The Joint United Nations Programme on HIV/AIDS, 2016).

Despite the of the socio-economic and political measures undertaken by the government in providing free HIV/AIDS medical services such as ART in the public hospitals, the fear of stigma and lack of awareness is still a handicap. The fear of stigma is still holding some people in the society from freely going to the Care and Treatment Centers (CTCs) and timely access to the HIV/AIDS related healthcare services such as counselling, treatment and HIV/AIDS healthcare related information as well as other associated HIV/AIDS services (Feyissa *et al.*, 2012; Mbonu *et al.*, 2009; Saki *et al.*, 2015).

The timely access to the relevant HIV/AIDS healthcare information can help people in making informed decisions of living a healthy life as well as to change their behavior, increase ability to self-care and more committed to treatment with more life hope and empowerment (Lwoga *et al.*, 2017; Zare-Farashbandi and Lalazaryan, 2014). Lwoga *et al.* (2017) further described that there is a considerably high effort by people to access to



internet-based HIV/AIDS healthcare information. However, there is a high need of proper and confidential access to timely and relevant HIV/AIDS healthcare information by people (both PLHIV and those who are not infected by HIV) which can enable them to have healthy life guidance.

Nevertheless, the Information and Communication Technologies (ICT) provides a great potential delivery of healthcare services. The ICT can be a useful weapon in fighting to eradicate pandemic diseases such as HIV/AIDS in the developing SSA countries such as Tanzania. So far, the usage of mobile technology has been of different forms such as mobile health (m-health), mobile money transactions (for example M-Pesa), and mobile banking. The m-health has integrated users in health associated activities, and thus improving availability of healthcare services, health information, and influencing healthy user behaviour (van Genuchten *et al.*, 2012).

This research study focused in assessing whether the use of ICT in form of integrated mobile application and a web portal can be a way forward for delivering the HIV/AIDS healthcare information for broader coverage (to many people with an easy access) without exposing them to stigma. Moreover, from the study we developed a secured m-Health system made up of an integrated mobile application and a web portal for enhancing the delivery of HIV/AIDS healthcare information. The developed m-health system is capable of establishing the anonymous health record and profile for the clients<sup>1</sup> while enabling them to directly communicate to the HIV/AIDS healthcare practitioners without revealing the physical identity of the person accessing the service.

## **1.2 Problem Statement**

Fear of stigma is still among the challenges in eradicating HIV/AIDS pandemic (Feyissa *et al.*, 2012; Mbonu *et al.*, 2009; Saki *et al.*, 2015). This fear is due to the lack of secured and confidential channel of communication between people and HIV practitioners. The people living with HIV (PLHIV) Stigma index shows that roughly one eighth of PLHIV are being deprived of healthcare service because of stigma and discrimination (Joint United Nations programme on HIV/AIDS, 2015). Feyissa *et al.* (2012) described that among different factors for fear of stigma among PLHIV, 37.4% of PLHIV fear for unethical treatment while 31.1% for unofficial disclosure of their health status.

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<sup>1</sup> Client – A person who is accessing the HIV/AIDS healthcare information and clinical services.

Despite a considerably people's high effort to access to internet-based HIV/AIDS related information, there is no any confidential integrated electronic platform for the HIV/AIDS public healthcare providers and the HIV/AIDS Care and Treatment Centres (CTCs) to provide a timely delivery of the relevant and correct HIV/AIDS healthcare information (Lwoga *et al.*, 2017). Moreover, Lwoga *et al.* (2017) made a call for the HIV/AIDS healthcare service provider to make use of internet and mobile phones to reach many people for broader coverage and impact.

Therefore, this research study aims to develop an integrated m-health platform for a timely delivery of HIV/AIDS healthcare information. The platform will be secure and provide the clients with a confidential access to the HIV/AIDS healthcare information services. Furthermore, clients will have access to the confidential, instant and direct communication to HIV/AIDS healthcare practitioners using the mobile applications in their mobile phones.

### **1.3 Research Objectives**

#### **1.3.1 General Objective**

The main objective of this research was to develop a secure integrated m-health platform for enhancing the access of HIV/AIDS healthcare information in Tanzania.

#### **1.3.2 Specific Objectives**

The specific objectives of this research were;

- (i) To identify and establish requirements for a secure integrated m-health platform for information linkage between people and HIV/AIDS healthcare practitioners in CTCs.
- (ii) To develop an integrated secure m-health system for linking people in the society to HIV/AIDS specialized counsellors/clinicians/practitioners.
- (iii) To validate the m-health system developed.

### **1.4 Research Questions**

- (i) Do people consider a secure m-health platform as a way forward towards enhancing the access of the HIV/AIDS healthcare information?
- (ii) What are the requirements for development of a secure integrated m-health platform for information linkage between people and HIV/AIDS practitioners?
- (iii) How can a secure integrated m-health platform be developed?

- (iv) Does the developed secure integrated m-health platform satisfy the users' requirements and meet the required ethical standards?

### **1.5 Significance of the Study**

With the developed secure integrated m-health platform, an easy, timely and secured access to relevant HIV/AIDS healthcare information can be achieved. The proper usage of the developed platform can significantly save the financial and time cost to clients. This is due to the fact that clients must not have to physically and frequently visit the HIV/AIDS CTCs for accessing the HIV/AIDS healthcare information such as HIV/AIDS health tips and clinical consultation which can also be accessible through the developed electronic platform. This is so essential in enabling people to access HIV/AIDS healthcare counselling and recommendations without being disclosed, identified and subjected to the stigma and hence, saving their lives.

The developed m-health platform provides people with the electronic profile and the consultation history for future references. This electronic consultation reference can be frequently reviewed by the particular client without frequently visiting the HIV/AIDS CTCs for similar cases. It hence provides a client with his/her specific HIV/AIDS healthcare recommendations as close as to his/her mobile phone.

Moreover, the developed platform will provide all other HIV/AIDS stakeholders such as the government, policy makers, HIV/AIDS related Non-Government Organisations (NGOs) and researcher with the instant HIV/AIDS statistical data. Using this computerized system, the real-time statistical data can be achieved, provided to the correct approved person for proper usage, and also be useful to the government in policy development related to the HIV/AIDS matters.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

The purpose of this chapter is to analyze different literatures related to this particular research study. These literatures have been collected from different sources such as books, journal and conference articles and official reports. Several literatures were reviewed to find out different information on this research study such as the HIV/AIDS situation in Tanzania, the usage of mobile technologies in delivering healthcare services as well as the other similar research works already done.

#### **2.2 HIV/AIDS Situation in Tanzania**

Currently, Tanzania has an HIV prevalence rate of 4.7% with around 1.4 million people living with HIV (Joint United Nations programme on HIV/AIDS, 2015). The HIV epidemic shows strong regional variation with Mbeya at 14%, Iringa at 13% and Dar es Salaam at 11% leading in HIV prevalence (Mutasingwa and Mbirigenda, 2017).

The HIV/AIDS healthcare services are freely offered at all CTCs across the country. The HIV/AIDS healthcare services range from provision of general public HIV/AIDS education, HIV testing, HIV counselling to HIV patient treatment and medications including the provision of antiretroviral (ARV) drugs. Despite the efforts put by the government, the fighting against HIV pandemic is facing a major problem which is stigma. Fear of being identified and/or stigmatized is still holding a lot of people in the society from freely going to CTCs for these HIV/AIDS healthcare services and information which can inspire the change of behaviour to strengthen HIV/AIDS prevention (Feyissa *et al.*, 2012; Mbonu *et al.*, 2009; Saki *et al.*, 2015).

The Joint United Nations programme on HIV/AIDS (2015) defines HIV-related stigma and discrimination as prejudice, negative attitudes and abuse directed at people living with HIV and AIDS. Discrimination and isolation of PLHIV have brought another epidemic of fear in people towards taking initiatives to HIV testing, consultation or medication leading to avoidable HIV related deaths. This hinders the efforts at halting the epidemic as well as it complicates personal decisions on HIV testing, disclosure of HIV status, and ability to get the medical guidelines and counselling to negotiate prevention behaviours (International Center

for Research on Woman, 2005). Moreover, the World Health Organisation (WHO) cites fear of stigma and discrimination as the main reason why people are reluctant to get tested, disclose their HIV status and take antiretroviral drugs (World Health Organisation, 2011). In 35% of countries with available data, over 50% of men and women reported to have been stigmatized; which is more of the same in Tanzania with about 39.4% of PLHIV to 49.7% cases of stigma in regions and Dar es Salaam respectively (Joint United Nations programme on HIV/AIDS, 2015; National Council for People living with HIV and AIDS, 2013).

This research study was to also assess whether the usage of mobile application platform can be a comfortable and acceptable way for people to access the HIV/AIDS healthcare information services. The usage of a confidential mobile application platform without actual regular visits to the CTCs may help people who want to access the HIV/AIDS healthcare information but do afraid of being identified and stigmatized.

HIV/AIDS healthcare information is any sort of HIV/AIDS related information which should be shared to the general public or a particular client. There are different types of healthcare information such as appointment and medication reminders, general health tips, diagnostic information, symptoms and vital signs (Serrano *et al.*, 2016). The important healthcare information which are provided in the HIV/AIDS CTCs are HIV/AIDS healthcare tips, HIV/AIDS healthcare recommendations, HIV/AIDS personal clinical counselling or consultation between the client and HIV/AIDS practitioner. These key HIV/AIDS healthcare information services are to be even when the HIV/AIDS healthcare information delivered through the m-health platform developed in this research study.

### **2.3 The Use of Mobile Technologies in Tanzania**

The ever-increasing developments in the field of Information and Communication Technologies (ICT) such as mobile technologies have transformed how people access, share and use information in our societies (Taghandiki *et al.*, 2016). The mobile technology is the technology of using cellular communication system for transferring of a specific information to the intended recipient(s). There has been a widespread usage of mobile technology as a vital medium for accessing and dissemination of information in various sectors such health, finance, and security and control systems. Mobile technology has become the powerful communication and behavioural change tool due to its extensive availability and coverage; and inexpensiveness of mobile gadgets (Muthee and Mhando, 2006).

The evolution of mobile technologies and mobile devices has been among the contributing factors in the transformation of how information is accessed, shared and used. The advancement of mobile devices such as mobile phones and tablets has been a global phenomenon with mobile phone ownership surpassing computer ownership in many countries (Global Statistics, 2018). The widespread of mobile phones especially the smartphones, has significantly led to an increase in development of advanced mobile applications. These mobile applications are so essential in provision of access to various important information that are needed by people in the society (Meier, 2010). Mobile application is a software which makes the use of the mobile technology, and it is used within mobile devices such as mobile phones. Mobile application allows mobile gadget users to interact with each other or with different online service providers (Muthee and Mhando, 2006; Meier, 2010).

In Tanzania, there is a diverse usage of mobile technologies such as mobile health (m-health), mobile money transactions (example M-Pesa), and mobile banking. Compared to the other media in the health sector, the mobile technology has been the fastest growing media recently (Michael *et al.*, 2010; Qiang *et al.*, 2012; Cole-Lewis and Kershaw, 2011). The use of the mobile technology in health sector has directly targeted the general public. There is a mounting evidence that reveals the potential of mobile communications to fundamentally improve healthcare services especially in remote as well as in resource-scarce areas (Vital Wave Consulting, 2009). This has been conducted through engaging all health stakeholders, and consequently improving the time and quality access to the health-related services and information as well as inspiring the change of behaviour to strengthen disease prevention (Muthee and Mhando, 2006; van Genuchten *et al.*, 2012).

There is a massive increase in usage of mobile communication and internet in Tanzania; Tanzania Communications Regulatory Authority (TCRA) provided their quarterly report of June 2017 showing that almost 40 million people (equivalent to 80% penetration) registered mobile subscribers as well as with about 20 million people with internet access as shown by figures 1 and 2 (Tanzania Communications Regulatory Authority, 2017).

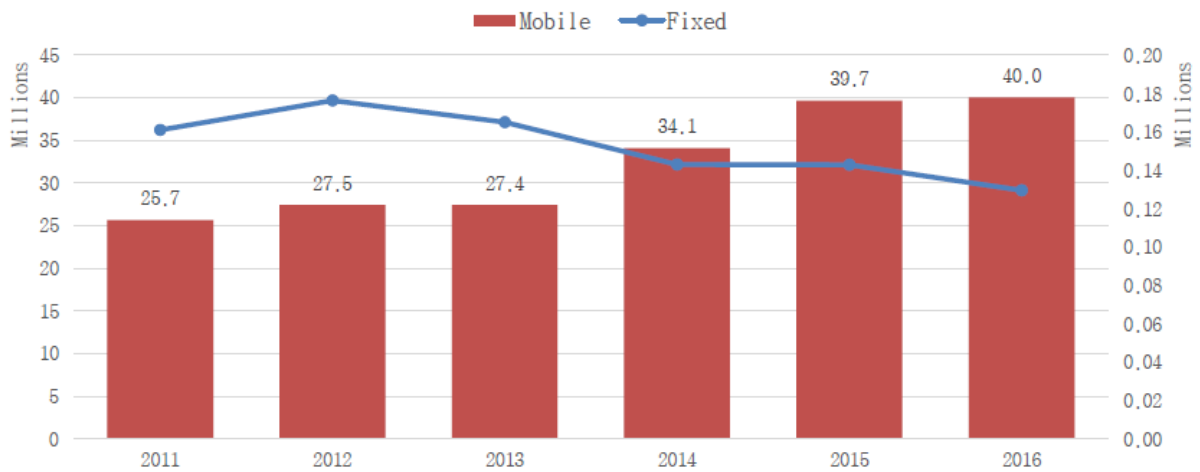


Figure 1: Mobile and fixed lines penetration in Tanzania (Tanzania Communications Regulatory Authority, 2017).

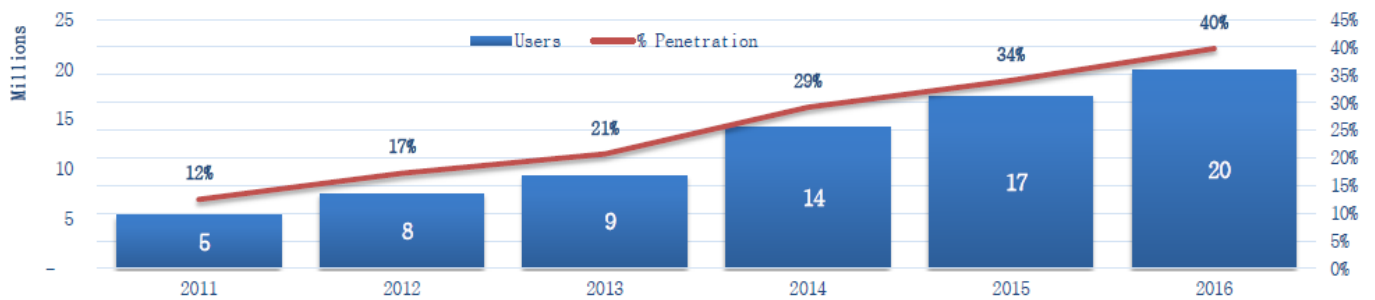


Figure 2: Internet penetration in Tanzania (Tanzania Communications Regulatory Authority, 2017).

There is a need of extending the use of the mobile technologies in fighting against the Human Immunodeficiency Virus infection and Acquired Immunodeficiency Syndrome (HIV/AIDS) in Tanzania. Lwoga *et al.* (2017) recommended that the HIV/AIDS public care providers, and the HIV/AIDS CTCs to use the electronic media to deliver the relevant and formal HIV/AIDS healthcare information. Particularly, healthcare information delivery for HIV/AIDS healthcare and treatment should make use of internet and mobile phones to reach many people for broader coverage and impact. This implies the usage of mobile and web-based application for enhancing the dissemination and delivery of HIV/AIDS healthcare information is the way forward.

## 2.4 Related m-Health Systems

The health sector has been actively employing the mobile technology in delivering health services to the public. The usage of the mobile technology applications for healthcare

provisions (such as exchange, transfer and delivery of the health information and services) is known as mobile health (or m-health) (Qiang *et al.*, 2012). M-health involves the transfer of healthcare resources including the delivery of healthcare information by using the mobile electronic means (World Health Organisation, 2011). During the past decade, the development of mobile health applications has been growing so fast, this is due to its contribution in shifting behavior to strengthen disease prevention at the low cost of acquiring a quality healthcare services (van Genuchten *et al.*, 2012; Qiang *et al.*, 2012; Cole-Lewis and Kershaw, 2011; Mechael *et al.*, 2010). The m-Health services have created a tremendous potential for improvement of health services delivery (Mechael *et al.*, 2010).

In Tanzania, like other African countries, there have been some initiatives of using m-Health services by different stakeholders in order to improve the health services delivery especially sharing health information and consultation. The number of mobile solutions using mobile applications for different healthcare services is growing very fast.

Moreover, different m-Health platforms have been developed in the bid to improve the health delivery; such as M-TIBA in Kenya, which is a digital platform that connects patients, healthcare providers, and payers such as health insurers. It enables people to have a mobile health wallet on their mobile phones with funds to only be spent on selected healthcare providers (PharmAccess Foundation, 2017).

There are some mobile applications which cover healthcare services such as dissemination of nutrition services and maternal healthcare with example of Mobile Alliance for Maternal Action (MAMA), NutriMobile and Healthy Pregnancy, Healthy Baby (HPHB) (Mobile Alliance for Maternal Action, 2012; Global System for Mobile Communications Associations, 2014; Mduma and Kalegele, 2015). These platforms use the cloud storage to connect multiple actors however they do not provide the secure and confidential mobile clinical communication channel between a person or a patient and health practitioners.

Moreover, in 2014, Vodacom Tanzania launched a service known as *Vodacom Simu Doctor* which provided the users with access to a panel of health specialists (available specialists including a Pediatrician, Cardiologist and OB/GYN) who shared their expertise with local communities and provided healthcare information including the impact of lifestyle changes on one's health and other health issues emphasizing in provision of free pregnancy and early childcare advise through our "healthy pregnancy, healthy baby" partnership programmes through Short Message Service (SMS) (Vodacom Tanzania, 2017). However, the *Vodacom*



*Simu Doctor* service has some drawbacks such that it is not only unidirectional, as a user only receives health tips messages (he/she cannot interact with the specialist to ask question or explain himself/herself) but also it provides the general medical information and not specializing in HIV counselling services.

However, there is no any mobile application platform for dissemination of HIV/AIDS healthcare information in Tanzania to date. Lwoga *et al.* (2017) made a call for online dissemination of HIV/AIDS healthcare information since there is a considerably people's high effort to try to access to internet-based HIV/AIDS information, HIV/AIDS clinical tips and recommendations.

#### **2.4.1 Similar m-health Platform for HIV/AIDS Healthcare Information Delivery**

In 2001, the National AIDS Helpline was launched and is being operated by Tanzania Youth Alliance (TAYOA) using a treatment toll free hotline (also known as 117 Afya Treatment) (Student Direct Stream Program, 2013; Tanzania Youth Alliance, 2017). The system delivers the HIV/AIDS healthcare information through phone calls by an Interactive Voice Responses (IVR). The Helpline has a comprehensive database with wide ranging information on HIV/AIDS topics including: voluntary counseling and testing, prevention of mother-to-child transmission (PMTCT), sexually transmitted infections, relationship guidance, gender-based violence, behavior change, and treatment opportunities (Tanzania Youth Alliance, 2017).

However, '117 Afya Treatment' system has encountered some challenges such as maintaining the user's confidential identity (or anonymity), since the use of the person mobile phone number risks to reveal his/her identity. Moreover, the system does not establish the client's medical profile with his/her clinical consultation history for future references by both HIV/AIDS practitioner and client himself/herself. It is normally uncomfortable for a person to start explaining himself/herself over and over again, it is also a wastage of time, while piling up a lot of people in the telephone line waiting queue and even other users are discouraged and terminate the phone lines.

Since the platform risks to reveal the client's identity through his/her registered phone number and considering how the HIV/AIDS is the complicated disease with a lot of people fear of being identified and then being stigmatized (Feyissa *et al.*, 2012; Mbonu *et al.*, 2009; Saki *et al.*, 2015) while using such platform. This research has developed a secure m-health platform which does not only use the particulars of the client but also maintain the client's

profile with his/her medical recommendation history for future reference.

## **2.5 Chapter Summary**

This chapter has portrayed how different literature material were reviewed. These literatures provided information on the HIV/AIDS situation in Tanzania and the increasing usage of ICTs particularly, mobile technologies in delivery of healthcare services. Furthermore, these literatures have shown the clear gap in provision of HIV/AIDS healthcare information through the available m-health platforms. These platforms seem not to be as confidential as required in fighting fear of stigma which hinders people from freely accessing HIV/AIDS healthcare services.

## **CHAPTER THREE**

### **MATERIALS AND METHODS**

#### **3.1 Introduction**

This chapter covers the different methods which have been employed to undertake this research study. It describes the study area, the data collection and analysis techniques used, as well as how the system have been developed and validated. The approach and techniques described here were used to ensure not only that the research was carried at the expected level but also the developed platform meet the stakeholders' expectations.

#### **3.2 Research Design**

Research design is an approach and structure of the study in order to find an answer for a research question. It covers an outline of everything the researcher has to do from the writing of a research question and their operational implication to the final analysis of the data (Davis, 1989).

The design of this research focused mainly in development of the m-health platform for enhancing the access of the HIV/AIDS healthcare information services. The research design involved following tasks: the evaluation of the peoples' acceptance and comfortability in existing practice of accessing all the HIV/AIDS services through visiting the HIV/AIDS practitioners in CTCs; collection and assessment of the requirements for the m-health platform; as well as development of the platform.

#### **3.3 Study Area**

This study was based in Dar es Salaam city in Tanzania. Dar es Salaam was chosen as it indicated high levels of stigma per PLHIV about 49.7% as compared to 39.4% from other regions (National Council for People living with HIV and AIDS, 2013); while having a high HIV prevalence of about 11% (Mutasingwa and Mbirigenda, 2017). Moreover, Dar es Salaam is the largest and most developed city as far as ICT infrastructures is concerned, in addition to the highest usage of internet and mobile services in the country (Ministry of Communications and Transport (The United Republic of Tanzania, 2003; Esselaar *et al.*, 2001).

The region contains four large district referral hospitals namely Mwananyamala Hospital, Temeke Hospital, Sinza-Palestina Hospital and Infectious Diseases Centre (IDC) each found

in Kinondoni, Temeke, Ubungo and Ilala districts respectively. These hospitals have special HIV/AIDS related clinics to offer HIV/AIDS healthcare clinical services such as general public HIV/AIDS healthcare information, counseling, testing and continued adherence counseling, medical treatment of PLHIV including treatment of opportunistic infections and provision of antiretroviral (ARV) drugs.

Both people getting HIV/AIDS healthcare clinical services and HIV/AIDS medical practitioners in these hospitals were involved in this study. The study was extended to involve the HIV/AIDS medical practitioners of a Non-Government Organization (NGO) dealing with HIV/AIDS services in remote areas within Dar es Salaam region, named Pastoral Activities and Services for people with AIDS in Dar es Salaam Archdiocese (PASADA).

### **3.4 Population and Sampling Technique**

The target population is the intended group of people that were researched on, for the information which was required to be ascertained (Saunders *et al.*, 2009; Banerjee and Chaudhury, 2010). The target population are the source of data, of which the research question is answered. In this study, all people were considered as everyone is entitled to access the HIV/AIDS healthcare information services.

Sampling is the process of selecting the suitable members of the population to represent the parameters and characteristics of the entire population (Haq and Shabbir, 2014). This study involved random sampling of both male and female, both HIV/AIDS healthcare services clients and HIV/AIDS practitioners. Each person who participated in this study, did so at his/her own consent.

The sample size was determined by using Kish formula for cross-sectional studies (Kish, 1965; Daniel, 1999). The calculation based on the HIV prevalence in Dar es Salaam of 11% and the entire population of the region of about 5 781 557 people at the precision of 5% and confidence level of 95% (Mutasingwa and Mbirigenda, 2017; National Bureau of Statistics, 2017). Therefore, the minimum sample size was found to be 151 people (calculated using the Kish formula shown in appendix I).

### **3.5 Data Collection**

In this study, both quantitative and qualitative approaches were employed for collecting both primary and secondary data. The quantitative study was done using a well-structured

questionnaire. The qualitative approach was implemented using unstructured interviews, casual talks and in-depth discussion (Silva, 2008).

The questionnaire guide for clients was made of three parts; demographic information (such as gender, age, education level and mobile phones ownership), comfortability and attendance to HIV/AIDS CTCs, and finally the perception towards accessing the HIV/AIDS healthcare information online (see appendix II). All of the questions in the mentioned parts were independent. The dependent variable evaluated whether respondents would want the mobile application platform for accessing HIV/AIDS healthcare information. These questionnaires were filled by sampled people at their consent, but under supervision.

The questionnaire guide for HIV/AIDS practitioners concentrated on understanding if there is a need for having m-health platform for HIV/AIDS healthcare information services; and if the CTCs and practitioners have capacity to offer those services online (see appendix III). Moreover, the Information Technology (IT) and data officers were interviewed on their consent, on the specific and general requirements for the m-health platform system to be developed.

Moreover, this research study employed a mixed research methodology during the collection of different relevant data for establishment of functional and non-functional requirements of the developed platform. Before requirements collection, the stakeholder analysis was conducted. This analysis was carried-out in order to gather substantive knowledge on the relevant actors so as to capture their specific requirements need on development of the m-health platform for delivery of HIV/AIDS healthcare information. Identification of the stakeholders was key in the data collection for establishment of the functional and non-functional requirements for the developed secure m-health platform.

During the stakeholder analysis, this study adopted the modified framework of Monko *et al.* (2017). This framework maps the typical rationale for stakeholder analysis, topology and respective methods. In analysing the stakeholders, the main emphasis was on identifying them and then identifies their roles in the HIV/AIDS healthcare information flow. The stakeholder identification was carried through analysing the official procedures by the authority, TACAIDS in handling the HIV/AIDS healthcare clinical information flow (Somi *et al.*, 2009; Kiwanuka *et al.*, 2015; Manda, 2007).

After the identification of all key actors, the system requirements were collected qualitatively using unstructured interviews. The identified actors were interviewed on the specific and general needs and requirements for the system. During the interview and discussion with them, the important system requirements were noted down for requirement specification.

Furthermore, direct observation was used in examining how different HIV/AIDS healthcare information services are offered. The direct observation provides a researcher with a clearer picture of a real situation which increases the validity and reliability of the research outcome (Rubin and Babbie, 2014).

Additionally, secondary data were from reviews of different related literatures. This study involved the documentary review from the published and unpublished documents such as reports, internet, statistics and journal and other grey literature from different sources such as UNAIDS, WHO and Government reports concerning m-health application and HIV/AIDS.

### **3.6 Data Analysis**

The data analysis process started by employing the data coding. Data coding prepared the information for easy entry into computer software as well as easy analysis. The collected data were analyzed by using Python; computer programming software for big data (McKinney, 2012). The study employed the hierarchical regression analysis which was performed by using data mining and analysis software, WEKA version 3.8.1 (Han *et al.*, 2011). Since the purpose of the questionnaire was to assess the acceptance of the current practice and determine the need of employing a m-health platform for HIV/AIDS healthcare information services; the frequencies and percentages were interpreted and inferences were drawn.

The hierarchical regression analysis was performed to examine the effect of different factors towards the need of mobile application platform for accessing HIV/AIDS healthcare information. This method was selected due to its suitability in investigating the impact of several independent variables sequentially (Petrocelli, 2003). Furthermore, Chong *et al.* (2012) proved that this appropriate technique for evaluating the influence of control independent factors to a dependent issue. This analysis involved four steps/models of regression analysis. In the first step, only the demographic attributes were examined towards the respondents' need of mobile application for accessing HIV/AIDS healthcare information. The second step added the respondents' mobile phones ownership, in third step the general awareness and attendance to CTCs were considered. Final stage examined if the prior access

of any health information through mobile and online media was to influence into the need of mobile application for accessing HIV/AIDS healthcare information.

For the information collected by using multiple questions to be valid, the reliability test was performed. The validity is the degree the collected data measure what it entitles to measure (Stake, 2010; Golafshani, 2003); where by the reliability is the degree of which the findings on the same issue are consistent from different members of the sample group (Golafshani, 2003). The internal-consistency (reliability) of the HIV/AIDS practitioners' readiness towards providing the HIV/AIDS healthcare information online were assessed using the Cronbach's alpha coefficient. Cronbach's alpha coefficient is used for examination of internal reliability and interrelation among the contributing items. The study showed the internal consistency by giving an alpha coefficient within accepted range of value above 0.7 (Cronbach, 1951; Tavakol and Dennick, 2011).

### 3.7 System Development Approach

In developing the m-health platform for HIV/AIDS healthcare information delivery, Software Development Life Cycle (SDLC) framework was employed. SDLC is a software development framework which outlines the tasks to be performed at every step in the software development process (Ragunath *et al.*, 2010). It describes the techniques for maintaining the quality of the developed software (Schwaber, 2001). It consists of a meticulous plan that is useful in developing, maintaining or altering software modules (Ragunath *et al.*, 2010). There are different system development models with different characteristics as portrayed in table 1 below.

Table 1: Comparison between different system development models

Model	Features		
	Financial Cost	Time	Functionality
Waterfall	High	Long	Static System
Incremental	High	Short	Static System
Spiral	High	Long	Dynamic System
Rapid Application Development (RAD)	Low	Short	Dynamic and Interactive System
Agile	Low	Short	Dynamic System

Source: Ismail, 2018; Hanafiah and Kasirun, 2007.

This study adopted the Rapid Application Development (RAD) model from the requirement acquisition to the system implementation and testing. It was adopted in order to hastily deliver the system within the given timeframe. It accentuates an extremely short development cycle by providing a top-quality system at a reduced development costs compared to other traditional models. Moreover, RAD provides the frequent developer-to-customer communication during the system development phases, hence it maintains the customer's satisfaction (Dawson *et al.*, 2010; Naz and Khan, 2015; Hirschberg, 2015). Rapid Application Development (RAD) is very appropriate for well-structured and defined requirements. Figure 3 below illustrates the RAD model used in this research study.

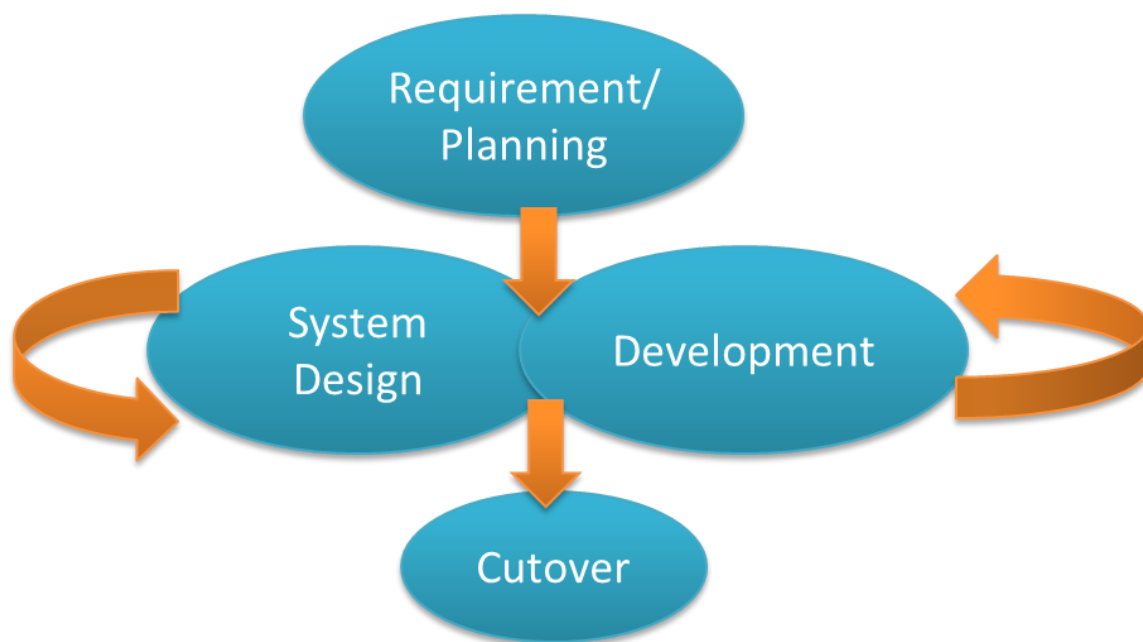


Figure 3: The system's Rapid Application Development (RAD) model (Daassnet, 2018).

### 3.8 System Modelling

In this study, the implementation of the integrated m-health platform was preceded by system modelling. The system modelling involved the process of mapping of the functional requirements into Data Flow Diagram (DFD). The captured m-health platform system's requirements were analyzed using graphical languages based on the Unified Modelling Language (UML) rules and artefacts. UML is the graphical language for specifying, visualizing, constructing, documenting and communicating the artefacts of a software system. It contains artefacts such as use case diagrams, system sequence diagrams, class diagrams and others (Booch, 2005).



The system modelling was done using a computer software, starUML. StarUML was used for mapping the collected requirements into the use case diagrams of subsystems. The establishment of the use case diagrams were useful in developing the information DFD and the conceptual framework of the developed m-health platform.

### **3.9 System Implementation**

During the implementation of this platform, different software development tools were employed. These tools vary from the computer programming languages, database to integrated development environment. The following is the description of system implementation tools used in this research study:

#### **3.9.1 PostgreSQL Database**

PostgreSQL is an object-oriented relational database management system (ORDBMS) which has been developed at the Berkeley Computer Science Department, University of California (PostgreSQL, 2018). It is an open-source DBMS which supports most of the SQL standard with additional features. It supports features such as complex queries, foreign keys, triggers, updatable views, transactional integrity, multi-version concurrency control. Furthermore, PostgreSQL allow developers to add some desired features such adding new data-types, functions, operators and procedural languages (Argyridis and Argialas, 2015). The PostgreSQL was employed in this study due to its ability to manage its internal security based on the user-roles, in additional to its support of external authentication mechanism such as password (supported by the HTTP authentication in Symfony framework).

'pgAdmin' is a Graphical User Interface (GUI) administrative tool for managing PostgreSQL which was used in this study. This tool is also an open-source which provides the graphical administrative support and built-in functions of the PostgreSQL. With the pgAdmin, the database was easily implemented and at the short time.

#### **3.9.2 Android Studio**

Android Studio is the developing tool for development of the android application. Android Studio is rich in multiple libraries that eases the implementation of an android application. In this study, the client application is developed based on the android operating system. Android was selected due to its high user penetration in Africa, and particularly in Tanzania. Android

is an open-source mobile operating system for smart mobile gadgets such as smart mobile phones and tablets (Reto, 2009).

Android Studio was employed in the implementation of the mobile application part of this study. It was used due to its built-in functionalities and libraries such as the mobile application web view, maps and locations which are essential requirements of this developed system.

### **3.9.3 Symfony Framework**

Symfony Framework is a free PHP web-application development framework with a set of PHP components and libraries (Porebski *et al.*, 2011; Radescu *et al.*, 2011). In this study, Symfony framework was used in order to speed up the implementation of the web-application. It also helped in maintenance of the code by replacing the repeated coding tasks.

Moreover, this framework provides the strong built-in security functions which not only provide the HTTP basic authentication, interactive form login and/or X.509 certificate login, but also allow the implementation of other authentication features. These authentication features include the use of double validation using both the in-system validation tool as well as by sending the validation code to the user through his/her personal email.

### **3.9.4 eXtensible Mark-up Language (XML)**

Extensible Markup Language (XML) is the programming language designed for information display, storage and transfer independently from other associated software and hardware (Marty and Larry, 2001). With XML, self-describing data formats and structures can be electronically shared by providing messaging systems' common syntax for information exchange between applications. Furthermore, it is an open-source software but well supported and full in technical information (Bray *et al.*, 2008).

In this study, XML was mainly employed for developing the user interfaces in android mobile application. This was due to it being inexpensive (free), easier in offloading and reloading of data to and from database while maintaining the desired information and user interface appearance. With the desired user interface, the user experience on the mobile application is improved.

### **3.9.5 Hypertext Pre-Processor (PHP)**

It is a server-side scripting language which is used for database connection and manipulation. PHP is commonly known for its ability of being compatible and not only supporting a wide range of databases but also it can concurrently connect to multiple databases as well as application and storage servers without compromising the database security (Supaartagorn, 2011). Furthermore, PHP is an open-source software, meaning is found for free. It also provides the dynamic functionality of the web application (Murach and Harris, 2010; Duckett, 2010).

During this study, PHP was used in scripting the connection between the web-based system and the PostgreSQL database. It provides the medium for database connection and database manipulation from the application point of view.

### **3.9.6 Java**

Java is an object-oriented computer programming language that is made for supporting and development of different features making of application software (Doug and Barry, 2007). It is normally favorable for software development since it runs on different operating software platforms such as Windows and UNIX varieties. It provides assurance in software development as it is always fast, secure, portable, stable and provides high performance while performing multiple tasks simultaneously (Eck, 2006; Saha, 2008).

In this study, Java was employed for its core libraries used in implementing the functionalities and some advanced User Interface (UI) features in implementing the android mobile application on the android studio. It simplified the development of some complex features of the developed mobile application in this research study.

### **3.9.7 JSON**

JavaScript Object Notation (JSON) is an open-standard and a programming language independent file format that employs human-readable text to convey data-objects containing attribute–value pairs and/or array data types (Bray, 2017; Crockford, 2006). It supports the basic data types such as number (such as integers, floats, double), string, boolean, array and null.

JSON was used in this system development for transmitting the array of data from the mobile application to the web application to the database. This simplifies the connection between the database and the mobile application.

### **3.9.8 WebSocket**

WebSocket is the communication protocol responsible for the full-duplex communication channels over a TCP connection. It enables the real-time interaction between a web-client and a web-server, doing so, it enables the real-time data transfer at low overheads. This is possible as WebSocket enables the streams of messages on top of TCP (Fette and Melnikov, 2011; Pimentel and Nickerson, 2012). It is currently supported by majority of the browsers such as Google Chrome, Microsoft Internet Explorer and Opera for both computers and smart mobile phones.

In this study, the WebSocket was employed during the development of real-time communication module. This module is to enable the real-time chatting communication between the service client and the HIV/AIDS healthcare practitioners.

### **3.10 System Testing and Validation**

In order to make sure that the implemented system satisfies the original specifications and requirements, series of tests were carried out. These tests were to ensure that all bugs have been removed and the final developed system is of top required quality and satisfies the clients' needs. The final implemented system was then validated by the identified stakeholders.

#### **3.10.1 System Testing**

The system testing was done stepwise, by firstly starting with unit testing and then the integration testing. Unit testing is the process of testing the functioning of the small independent module of the system in isolation from other modules. This type of testing was carried out during the implementation of each system feature. A single unit testing helps in elimination of bugs at the low level with easy. During the development of this system, each independent functioning module of the system was tested separately to uncover errors within its boundaries.

Integration testing is a systematic technique for conducting tests for uncovering errors associated with interfacing one functioning system's module to another. The integration

testing was done during the interfacing and/or connecting the unit-tested modules. The systematic integration led to the development of the required fully functioning system.

The final integrated system was then taken to the production environment to allow the User Acceptance Tests (UAT). The UAT was conducted by system users while validating the system against the earlier specified requirements. To enable UAT, the fully functioning system was hosted online with the mobile application installed to the clients who participated in the UAT.

### **3.10.2 System Validation**

The validation of the developed secure integrated system was conducted through the user experience (UE) survey. This was done by sampling few members of all identified actors (clients, HIV/AIDS healthcare practitioners and system administrators) of the system. This was done by providing them with the system for normal usage. After using it for 3 days, they were required to fill in the evaluation questionnaires (see appendix IV).

### **3.11 Ethical Consideration**

This research was given a permission from the Nelson Mandela – African Institution of Science and Technology (NM-AIST) before being undertaken. During the data collection in HIV/AIDS CTCs, there were a prior communication and permission from each of the CTC's supervisors.

This study maintained the ethical practices such as ensuring the privacy, integrity and confidentiality of the information given by the respondents. Berg (2004) insisted on ensuring the confidentiality during undertaking research so as to reduce the ambiguities and fear among the respondents. This in turn, it provides the truthful and meaning full data. Before the respondents being asked to fill in the questionnaires, they were briefly introduced on the purpose and the benefit of this research. Furthermore, this study considered only respondents whom with their consent were mentally and physically free and ready to participate.

## **CHAPTER FOUR**

### **RESULTS AND DISCUSSION**

#### **4.1 Introduction**

In the previous chapter, the materials and methods used in carrying out this research study from data collection, analysis and formulation of system requirements to system development and validation. This chapter presents results obtained after the analysis of the data collected, requirements formulation and system development; and in-depth discussions of the results in accordance to the research specific objectives. The first specific objective of this study was to assess whether a secure integrated m-health platform can be the way forward towards enhancing the access of HIV/AIDS healthcare information in Tanzania. The second specific objective was to identify and establish requirements for an integrated m-health system linking between people and HIV practitioners in CTCs. The third specific objective was to develop an integrated secure m-health system for linking people in the society to HIV/AIDS specialized counsellors/clinicians/practitioners. The final specific objective was to validate the m-health system developed. In order to have meaningful information in response to the research questions, total of 208 respondents, both male and female participated in this study, among them, 45 were HIV/AIDS practitioners.

#### **4.2 Findings from the Respondents**

##### **4.2.1 Demographic Characteristics of the Respondents**

Since the study focused on the human perception towards the access of the HIV/AIDS healthcare information services through both visiting the HIV/AIDS CTCs physically and using the m-health technology; it is important to look into demographic characteristics among the respondents. The demographic characteristics of respondents which were considered in this study were gender, age, education level attained. These characteristics are very significant in analyzing the trend of shifting from physical attendance to HIV/AIDS CTCs to the use of the m-health technology.

Out of 163 respondents who were not HIV/AIDS practitioners, number of male respondents were slightly higher (51.5%) than female respondents. Within this group of respondents, majority were aged between 20 – 29 years (about 46%), at the mean age. Majority of the respondent who were willing to participate in this study had the tertiary education (36.2 %). Table 2 shows demographic characteristics of all respondents.

Table 2: Demographic Characteristics of Respondents

Demographic Characteristic		Respondents	Percentage (%)
Gender	Male	84	51.5
	Female	79	48.5
Age (in Years)	15-19	14	8.6
	20-29	75	46.0
	30-39	31	19.0
	40-49	26	16.0
	50-59	14	8.6
	60 and above	3	1.8
Education	Non-formal education	9	5.5
	Primary education	41	25.2
	Secondary education	54	33.1
	Tertiary education	59	36.2

#### 4.2.2 Mobile Phones Ownership

Among the respondents, only 9.2% do not own any mobile phone, while 23.3% possess two or more mobile phones each. Moreover, a total of 60.8% of all respondents had at least smart-phones with internet capabilities. Detailed information on the ownership distribution of mobile phones among the respondents is depicted in Fig. 4 below.

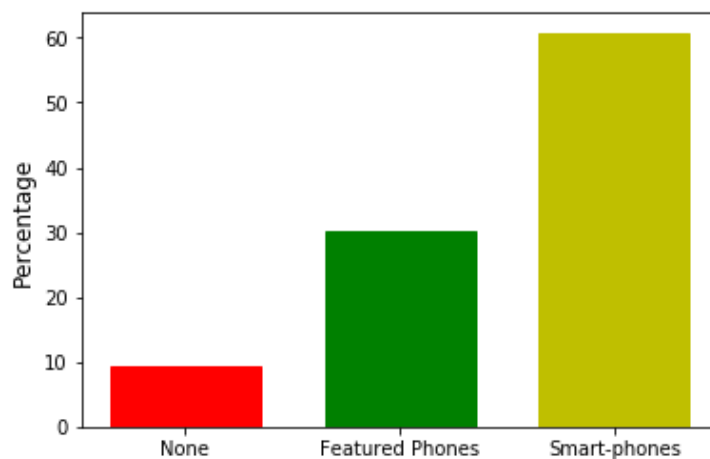


Figure 4: Mobile phones ownership among respondents

### 4.2.3 Respondents' Awareness and Comfortability towards Attending HIV/AIDS CTCs

Only 88.3% of respondents are aware of the existence of HIV/AIDS CTCs. Furthermore, even fewer respondents (60.7%) had at least once visited the HIV/AIDS CTCs, among them majority (about 35%) went to seek for HIV/AIDS healthcare information. 24.5% of the respondents were not comfortable going to HIV/AIDS CTCs indicating that they were afraid of being exposed and stigmatized. This situation is well summarized in table 3 and Fig. 5 below.

Table 3: Respondents' awareness and comfortability towards attending HIV/AIDS CTCs

		<b>Respondents</b>	<b>Percentage (%)</b>
I am aware of existence of HIV/AIDS CTCs		144	88.3
I have visited HIV/AIDS CTCs at least once		99	60.7
Reason for going	HIV/AIDS patient under clinical care.	26	16
HIV/AIDS CTCs	HIV/AIDS healthcare information seeking only.	57	35
	Forced by situations (e.g. marriage, travel, job requirements).	16	9.8
Frequency of going to CTCs in the past year	Never	76	46.6
	Once	23	14.1
	Twice	10	6.1
	More than twice	54	33.1
I am comfortable to visit HIV CTCs		123	75.5



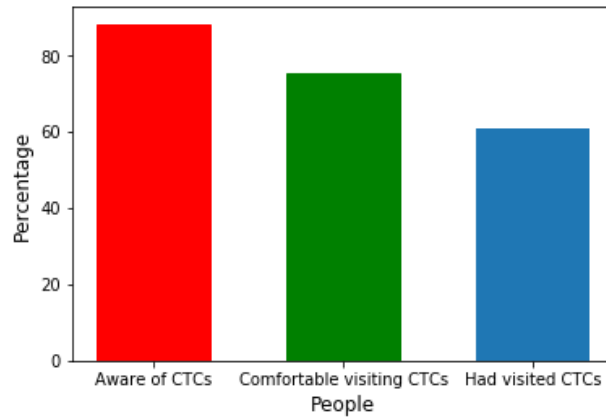


Figure 5: Comparison of peoples’ awareness, comfortability and actual visiting HIV/AIDS CTCs

#### 4.2.4 HIV/AIDS Healthcare Information Seeking Pattern

Almost one-third (31.3%) of respondents prefer to seek HIV/AIDS related information from online media (via internet). However, 33.7% of the respondents claimed to get the HIV/AIDS healthcare information through visiting to HIV/AIDS CTCs. Figure 6 provides HIV/AIDS healthcare information seeking pattern as analysed from the respondents.

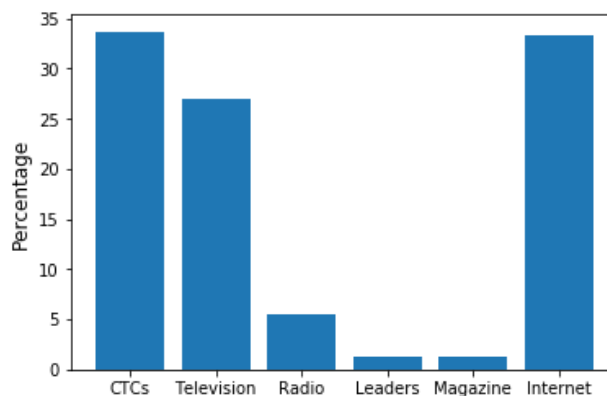


Figure 6: HIV/AIDS healthcare information access pattern

#### 4.2.5 Towards Accessing HIV/AIDS Healthcare Information Online

Almost two-third of the respondents (66.3%) had the tendency of accessing and searching of different health information through online media sources. Furthermore, 79.1.4% of respondents believed that they could access reliable HIV/AIDS healthcare information if there is an online platform while 78.5% went even further by suggesting that they wanted the mobile application platform. This information is summarized in table 4 below.

Table 4: Response towards accessing online HIV/AIDS healthcare information

	<b>Respondents</b>	<b>Percentage (%)</b>
I access and search for different healthcare information through online sources	99	66.3
I believe that I can access reliable HIV/AIDS healthcare information in online platform	129	79.1
I would like to have a mobile application for accessing the HIV/AIDS healthcare information	128	78.5

#### **4.2.6 Factors Contributing to the need of Mobile Application Platform for HIV/AIDS Healthcare Information Access**

In examining why respondents asked for the mobile application platform for accessing the HIV/AIDS healthcare information, different factors were put into consideration. The study employed the hierarchical regression analysis to assess the proportional contribution of different factors towards the need of mobile application platform for accessing HIV/AIDS healthcare information. The findings showed that demographic factor contributed 3.25% in need of mobile application platform for accessing HIV/AIDS healthcare information. The ownership of mobile phone contributed further to 7.28% for respondents to need this mobile application platform. The general awareness and attendance to CTCs as well as experience of using any other health-related mobile application proved to have almost negligible contribution to the respondents need for mobile application platform for accessing HIV/AIDS healthcare information. Table 5 narrates hierarchical regression analysis to factors affecting contribution to the need of the mobile application for accessing HIV/AIDS healthcare information.

Table 5: Hierarchical regression analysis on the factors contributing to the need of the mobile platform for HIV/AIDS healthcare information access

Factors	Model 1	Model 2	Model 3	Model 4
Gender	0.0002	0.0002	~0.0001	~0.0001
Increasing Age	0.0004	0.0003	-0.0001	0.0001
Increasing Education Level	0.0882	0.0621	0.0601	0.0502
Having a Mobile Phone		0.2962	0.2752	0.2762
Having a Smart Phone		0.0003	0.0002	0.0002
Knowing HIV CTCs			-0.0052	-0.0032
Going to CTCs			-0.0102	-0.0022
Frequency of going to CTCs			-0.0091	-0.0065
Comfortability going to CTCs			-0.0105	-0.0102
Experience on m-health applications				~0.0001
<i>Df</i> <sup>2</sup>	3	5	9	10
<i>Adjusted R-squared</i> <sup>3</sup>	0.0325	0.0728	0.0726	0.0726

*Notes: All figures were round off to 4 decimal places and P<0.05*

### 4.3 Findings from the HIV/AIDS Healthcare Practitioners

The study also collected information from among 45 HIV/AIDS practitioners. Majority of them, almost one-fifth (22.2%) were from Infectious Diseases Centre (IDC) which is a special Care and Treatment Center for people living with HIV (PLHIV) in Dar es Salaam. Majority (71.1%) were serving more than 30 people per day on more or less same kind of clinical services. Table 6 shows the distribution of HIV/AIDS healthcare practitioners who were involved in this study.

<sup>2</sup>*Df*: Degree of Freedom – number of independent variables in the statistical analysis.

<sup>3</sup>*Adjusted R-squared*: It calculates R-square values (how much variance is in a model) from significant independent variables in the model

Table 6: HIV/AIDS healthcare practitioners

		<b>Practitioners</b>	<b>Percentage (%)</b>
HIV/AIDS CTC	Temeke Hospital	8	17.8
	Mwananyamala Hospital	8	17.8
	Sinza Hospital	7	15.6
	IDC	10	22.2
	Kairuki Hospital	7	15.6
	PASADA	5	11.1
Number of People served per day by each practitioner	Less than 5	1	2.2
	5 to 10	5	11.1
	10 to 20	4	8.9
	20 to 30	3	6.7
	More than 30	32	71.1

#### **4.3.1 HIV/AIDS Practitioners' Perspectives on Provision of HIV/AIDS Healthcare Information**

Table 7 narrates that out of 45 HIV/AIDS practitioners, 91.1% insisted that it is important to always provide the HIV/AIDS healthcare information to people in the society. About three-fifth (62.2%) acknowledged the existing effort of disseminating the HIV related information to the society but insisted on more effort should be employed. Surprisingly, more than half (55.6%) of HIV/AIDS practitioners cited that they did not disseminate the HIV related healthcare information. Four-fifth of the respondents in this category agreed that the said healthcare information can be transacted via electronic means, while 64.4% went further by showing there is a need for having a mobile application for delivering the HIV/AIDS healthcare information.

Table 7: HIV/AIDS healthcare practitioners' perspectives on provision of HIV/AIDS healthcare information

	<b>Practitioners</b>	<b>Percentage (%)</b>
It is important to disseminate HIV/AIDS healthcare information to society	41	91.1
Is HIV/AIDS healthcare information reaching community?	8	17.8
Not at all	9	20
Somehow	28	62.2
Yes, but more effort is required	0	0
Yes, no need for more improvement	36	80
I can provide the HIV/AIDS healthcare information using online platform	29	64.4
There is a need of having a mobile application platform for delivering HIV/AIDS healthcare information		

#### 4.3.2 HIV/AIDS Practitioners' Readiness towards Online Delivery of HIV/AIDS Healthcare Information

Two-third of the HIV/AIDS practitioners said that they are computer literate and even have the internet access at their offices at the CTCs. However, only one-third of them are supplied with the working computers in their offices. Cronbach's alpha coefficient of 0.7012 shows that there is an internal reliability and interrelation for them to be ready to offer the HIV/AIDS services online.

Table 8: HIV/AIDS healthcare practitioners' readiness towards online delivery of HIV/AIDS healthcare information

	<b>Practitioners</b>	<b>Percentage (%)</b>	<b>Cronbach's alpha</b>
HIV/AIDS Practitioners' Readiness			0.7012
Do you have computer knowledge?	35	77.8	
Does your Office have Working Computer?	15	33.3	
Does your Office have Internet Access?	33	73.3	

## 4.4 Requirement Definitions

### 4.4.1 HIV/AIDS Healthcare Information Types

There are different types of healthcare information such as appointment and medication reminders, general health tips, diagnostic information, symptoms and vital signs (Serrano *et al.*, 2016). This study captured the key types of healthcare information which are provided or delivered by the HIV/AIDS CTCs. These healthcare information types include the provision of HIV/AIDS health tips, HIV/AIDS healthcare recommendations, HIV/AIDS clinical face-to-face counselling or consultation between the client and HIV/AIDS healthcare practitioner, and HIV/AIDS statistical reports. These services are to remain as the key services even when the HIV/AIDS healthcare information delivery is through the mobile application and web-based system. The key items for each of information type are as shown in the tables 9 to 12.

- (i) **HIV/AIDS Health Tip:** Set of HIV/AIDS healthcare related information given by the qualified HIV/AIDS healthcare practitioners to the clients. Table 9 below shows the key items forming HIV/AIDS health tip and their respective data types.

Table 9: Key items of an HIV/AIDS healthcare tip

Key Item	Data Type
Title/Subject	Text
Detail	Text
Category	Text
Date Posted	Date/Time (Timestamp)
Author ID or Name	Integer/Text

- (ii) **HIV/AIDS Healthcare Recommendation:** Set of HIV/AIDS related information that is advised or proposed by an HIV/AIDS practitioner to a specific person/service client based on his/her previously described information. The key items forming an HIV/AIDS healthcare recommendation are shown in the Table 10 below.

Table 10: Key items of an HIV/AIDS healthcare recommendation

Key Item	Data Type
Title/Subject	Text
Detail	Text
Category	Text
Requester/Client ID	Integer
Date Requested	Date/Time (Timestamp)
Recommender (Practitioner) ID/Name	Integer/Text
Date Recommended	Date/Time (Timestamp)

- (iii) **HIV/AIDS Clinical Counselling:** An HIV/AIDS clinical counselling or consultation involves the to-and-fro exchange of information between the client and HIV/AIDS healthcare practitioner. This has been done by directly face-to-face conversation between the client and healthcare practitioner in the consultation room. In developing the mobile application and web-based system, this should be implemented via the real-time message exchange.

Table 11: Key items of an HIV/AIDS clinical counselling/consultation chatroom

Key Item	Data Type
Client ID	Integer
Practitioner ID/Name	Integer/Text
Message	Text
Date and Time	Date/Time (Timestamp)

- (iv) **HIV/AIDS Statistical Reports:** These are reports of different statistical data based on the HIV/AIDS healthcare services. These reports are for providing information to help researchers, investigators and even the policy makers in making some critical decisions regarding the HIV/AIDS (Bailar and Mosteller, 1988).

Table 12: Key items of an HIV/AIDS statistical report

Key Item	Data Type
Title/Subject	Text
Detail	Text
Category	Text
Generation Date	Date/Time (Timestamp)

#### 4.4.2 Functional and Non-functional Requirements

In this study, the gathered system requirements were grouped into functional and non-functional requirements. These are providing the guidelines for the implementation of the information system (Ebert, 1997). The tables 13 and 14 show the functional and non-functional requirements respectively.

Table 13: Functional requirements for m-health platform for HIV/AIDS healthcare information delivery

Requirement	Description	Actor
Users Registration and Users' Accounts Management	All system clients must register themselves into the system, each of them must create his/her own user profile; with the system providing each of them with both username and password	Client
	All the HIV/AIDS healthcare practitioners must be registered in the system based on the qualifications and roles; the system should provide each of them with username and password	System Administrator
	The system should provide the system administrator with ability of deleting or suspending HIV/AIDS practitioner's account	System Administrator
Document Gallery Management	System administrator should manage the uploading, editing, and/or removing of documents such as announcements, guidelines and other documents in documents gallery	System Administrator



	The system should allow all registered and authorized users to view the posted system management related and/or HIV/AIDS related posted documents in the document gallery	All System's Users
Reports Generation	The system should be able to generate different reports for other stakeholders such as researchers and policymakers	System Administrator
Online HIV/AIDS Clinical Consultation	System should allow the clients to get into an online consultation chatroom <sup>4</sup> and request for clinical attention from HIV/AIDS healthcare practitioners System should allow the HIV/AIDS healthcare practitioners to interact and/or respond to consultation requests	Clients HIV/AIDS Practitioners
HIV/AIDS Healthcare Tips	System should allow the HIV/AIDS healthcare practitioners to upload, add, edit and/or remove the HIV/AIDS related healthcare tips System should all the registered clients to receive and view the HIV/AIDS Healthcare tips	HIV/AIDS Practitioners Clients
HIV/AIDS Healthcare Recommendations and Reminders	System should allow the HIV/AIDS healthcare practitioner to set, edit and/or remove recommendation and/or reminders for a particular client based on his/her health status System should all the registered and authorized clients to receive and view the HIV/AIDS healthcare recommendations, the recommendation history and/or timely reminders	HIV/AIDS Practitioners Clients
Systems' Technical and User Support	System should allow all users to request and receive the system usage support in case of any difficulties System should all the system administrators to support others users	All user System Administrator

<sup>4</sup> A consultation chatroom for real-time end-to-end conversation between a client and an HIV/AIDS healthcare practitioner through text messages.

Table 14: Non-functional requirements for m-health platform for HIV/AIDS healthcare information delivery

Requirement	Description
Security	<ul style="list-style-type: none"> <li>• System should authenticate all users before allowing them to interact with the system functionalities.</li> <li>• System should maintain password best practices such as maintaining maximum and minimum password age, password history, containing character mixing complexity of a predefined minimum length and employing encryption for password storage (Ginsberg, 2014).</li> </ul>
Maintainability	The system should be easy maintained, i.e. the system should be able to add new functionality/features without any major redesign.
Responsiveness	Short response time is required by the system.
Scalability	The system should be easy scalable, i.e. increased depending on the demand.
Robustness	The system should have ability to continue function accurately if the something wrong happens or multiple requests are received at the same time.
Operating System	Mobile application based on Android platform. The web-based system should be cross-platform of all browsers.
Language	The system should be implemented in both English and Swahili

## 4.5 System Modelling

### 4.5.1 Conceptual Use Case

Table 12 above, of functional requirements has shown how the different actors (system administrator, HIV/AIDS practitioner and client) interact. The interaction can further be analysed using the use case diagram. Use case diagram designates the anticipated functionality of the system on the system user's point of view; and interactions between users (external actors) and the system under consideration (Gries and Schneider, 2010; Sparx Systems, 2004). At a high level of abstraction, Fig. 7 and Fig. 8 show the complete functionality of the mobile application system for the HIV/AIDS healthcare information delivery. Figures 7 and 8 show the use case diagram for the system administration and mobile healthcare clinic subsystems respectively.

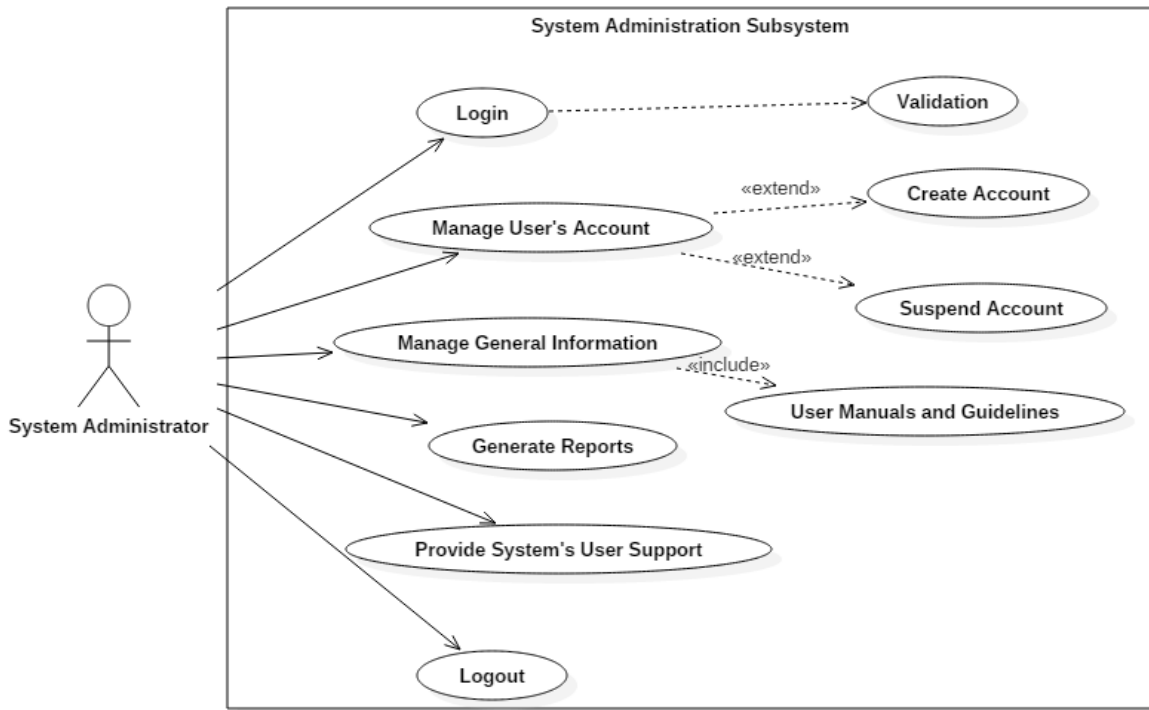


Figure 7: Use case diagram for the system administration subsystem

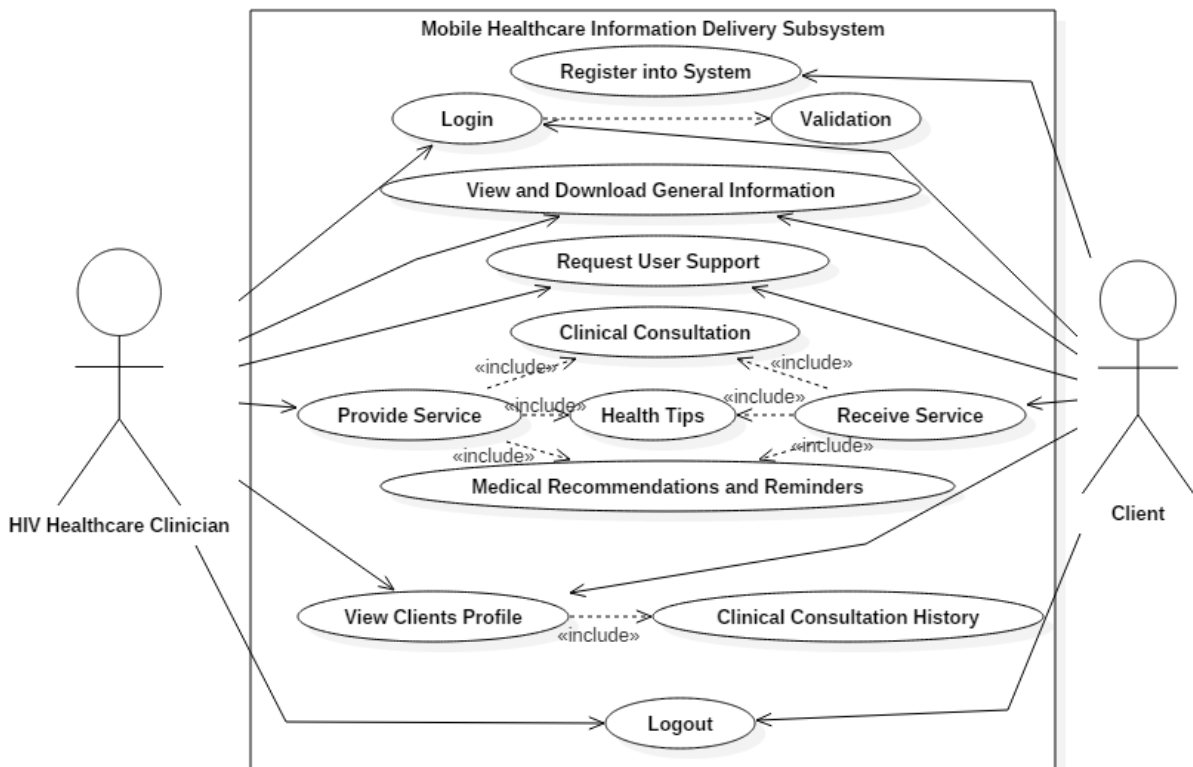


Figure 8: Use case diagram for mobile HIV/AIDS healthcare information delivery subsystem

### 4.5.2 Data Flow Diagram (DFD)

The following DFD diagram (Fig. 9 below) shows how the information will be flowing from one actor to another. The registered client will just use mobile application to have the HIV/AIDS healthcare tips and recommendation while being able to have interactive communication with the HIV/AIDS healthcare practitioners.

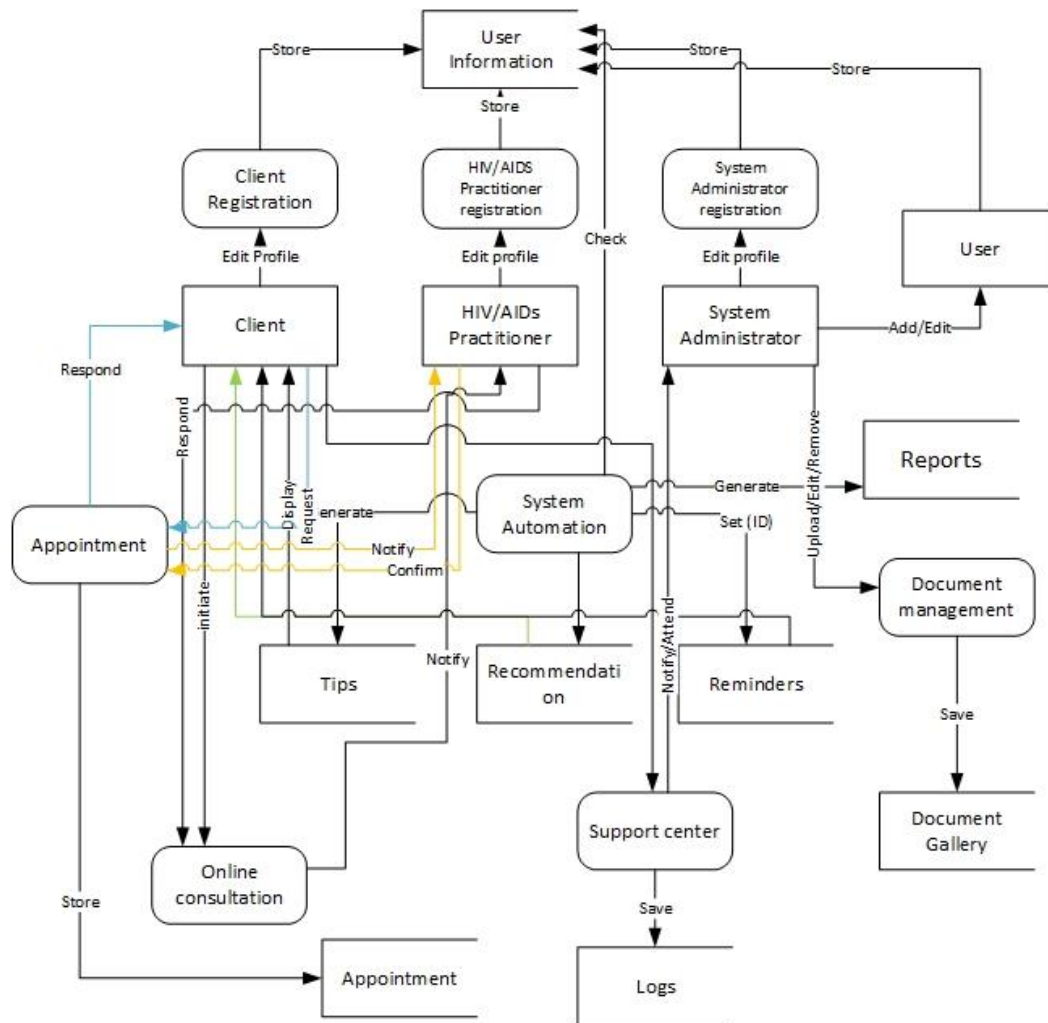


Figure 9: Data flow diagram for a secure m-health platform for HIV/AIDS healthcare information delivery

### 4.5.3 Conceptual System's Framework

From the gathered and analyzed requirements above, the conceptual system diagram has been developed as seen in Fig. 10 below. The complete system will contain the application and database servers, client's user-end mobile application and/or the practitioner's web-based system and the internet connectivity infrastructure.

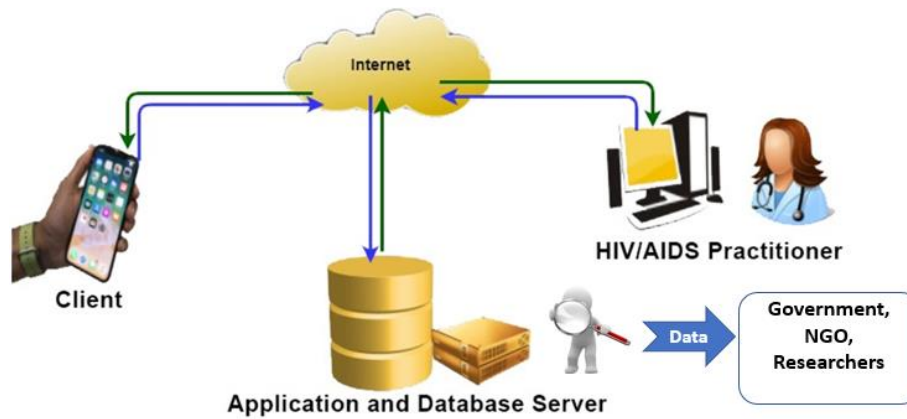


Figure 10: The Conceptual system's framework

## 4.6 System Implementation

### 4.6.1 Database Implementation

The mobile and web applications in this system are supported by the PostgreSQL database management system. A number of JSON and PHP scripts have been used in connecting the database with the client's application to allow smooth and consistency data manipulation (including data insertion, updating, retrieval and deletion). The database schema contains 14 tables and their relation is displayed in the Fig. 11 below.

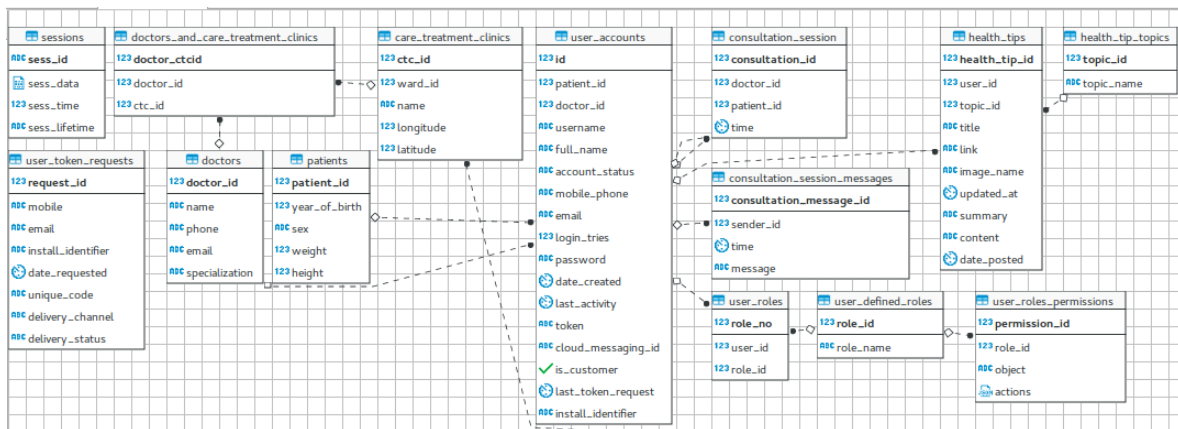


Figure 11: Entity relational schema

### 4.6.2 Mobile Application Implementation

The mobile application was developed based on android platform. It contains the simple and easy to use user-interfaces to provide the interaction between user and application. This application is only for HIV/AIDS healthcare services clients. It is based on both English and Swahili languages; whereby a user can select the language of his/her preference before

logging into the system as shown in Fig. 12(a) below. Figure 12(b) shows the Swahili UI once the user switches the language to Swahili.

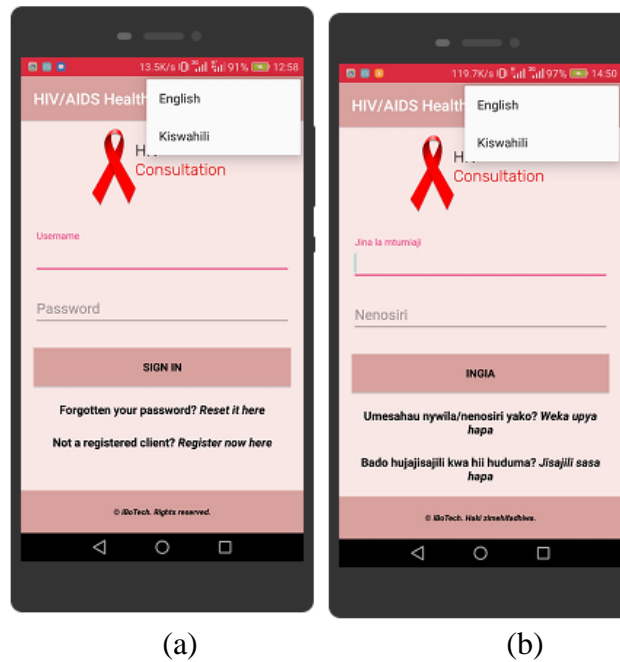


Figure 12: Mobile application's login UIs in both English and Swahili languages

Before logging into the system, user must have an activated and registered account. During registration, the client will have to submit personal particulars which are useful for HIV/AIDS healthcare practitioners in delivering healthcare services. Some of these particulars such as gender, age, weight and height are shown in the Fig. 13 below.

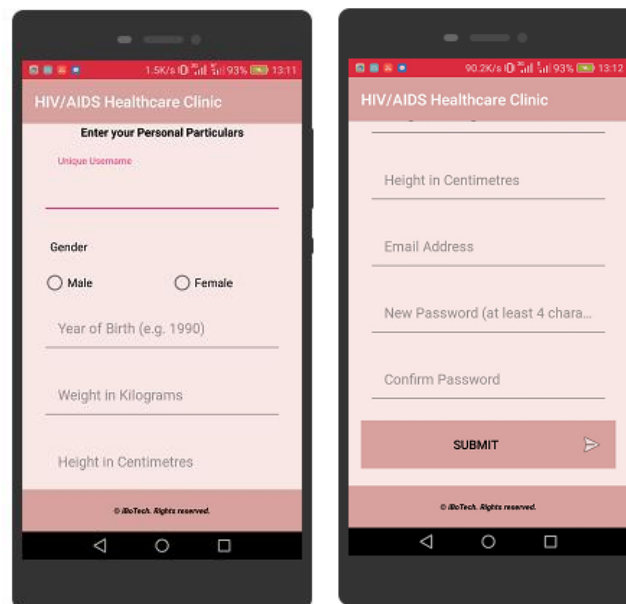


Figure 13: Mobile application's client's registration UI

After successfully registration, the client will be prompted to use his/her unique display name (not a real name for the sake of maintaining anonymity) and password to log into the system. After a successfully logging into the system, the client will be presented with the menu containing all the HIV/AIDS healthcare information services provided by this platform. Figure 14 below shows the menu UI.

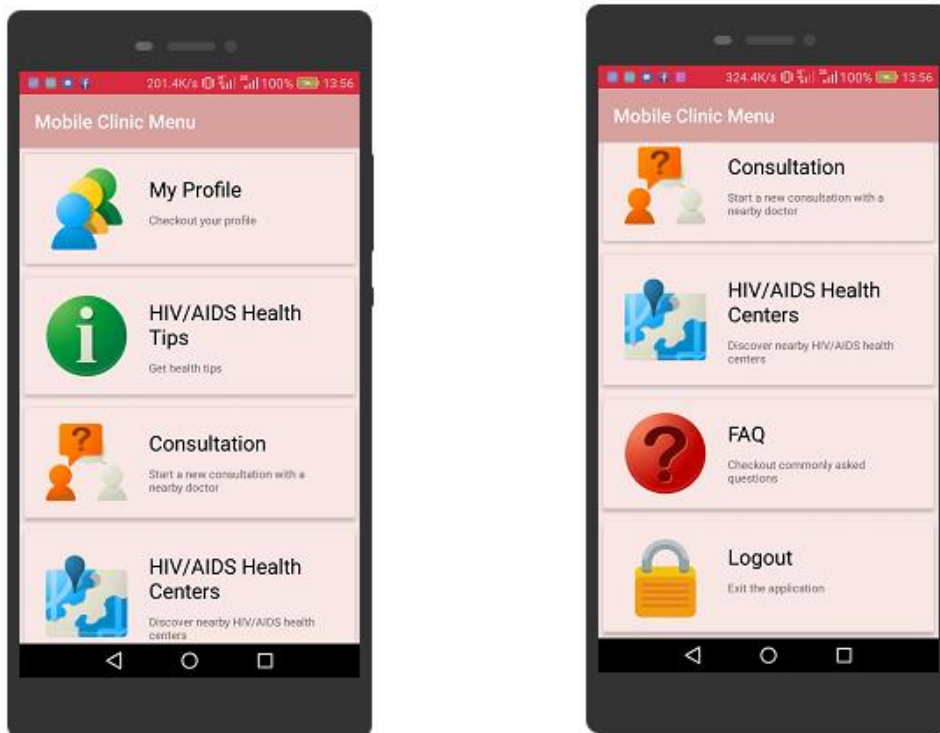


Figure 14: Mobile application's main menu UI

- (i) **HIV/AIDS Healthcare Tips:** The client can view different HIV/AIDS healthcare tips as they are posted by the qualified and registered HIV/AIDS healthcare practitioners. These tips are arranged in the order of time they are posted, with the newest at the top as shown by Fig. 15(a) below. Once the tip is clicked, it provides the client with more details on itself as shown in Fig.15(b).



(a)



(b)

Figure 15: Mobile application's HIV/AIDS healthcare tips UI

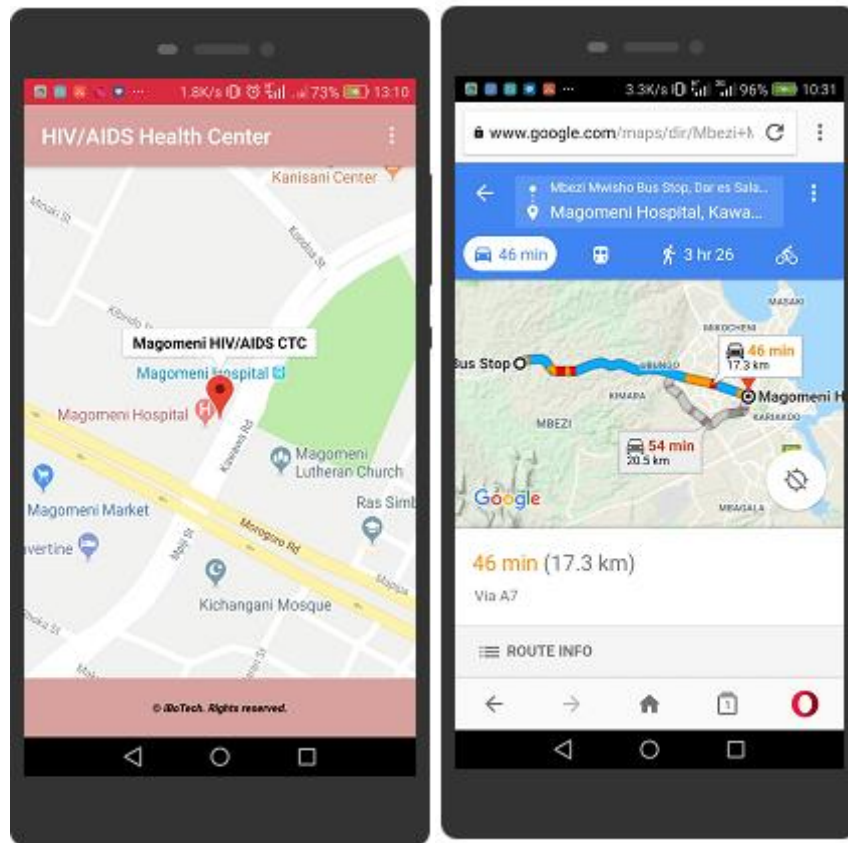
- (ii) **Consultation:** This is the chat space for the mobile application's client to real-time interact to the HIV/AIDS healthcare practitioner. Figure 16 shows how the client can interact with the HIV/AIDS healthcare practitioner for counselling and healthcare recommendations.





Figure 16: Mobile application's HIV/AIDS consultation live chat UI

- (iii) **HIV/AIDS Health Centers:** In order for the system to help the client who needs a physical healthcare from the physician, the mobile application provides the client with the map showing the route to the nearest HIV/AIDS CTC. Figure 17(a) below shows the nearest CTC. With the help of the google map services, the shortest route to the nearest CTC can be achieved either by car, or by foot as depicted in Fig. 17(b).

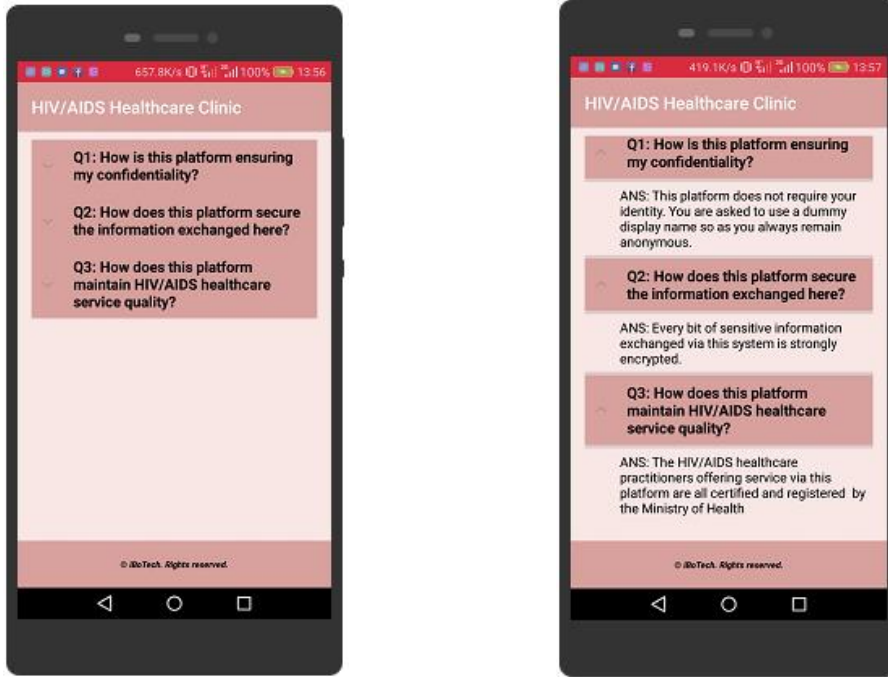


(a)

(b)

Figure 17: Mobile applications nearest HIV/AIDS CTC locator UI

- (iv) **Frequently Asked Questions (FAQ):** The mobile application also provides the answers for the frequently asked questions. These questions are answered by the system administrators with consultation to the HIV/AIDS healthcare practitioners. Figure 18(a) shows the questions, and when the question is clicked, it displays its answer as shown in Fig. 18(b)



(a)

(b)

Figure 18: Mobile application's FAQ UI

- (v) **Client Profile:** The client is able to view his/her profile and even update his/her personal information. At this UI, the client can change his/her password to enforce his/her account's security. During the password reset, the system will send the verification code to the clients email for confirmation before allowing the password reset. Figure 19 shows how the particulars are displayed and how to update them.

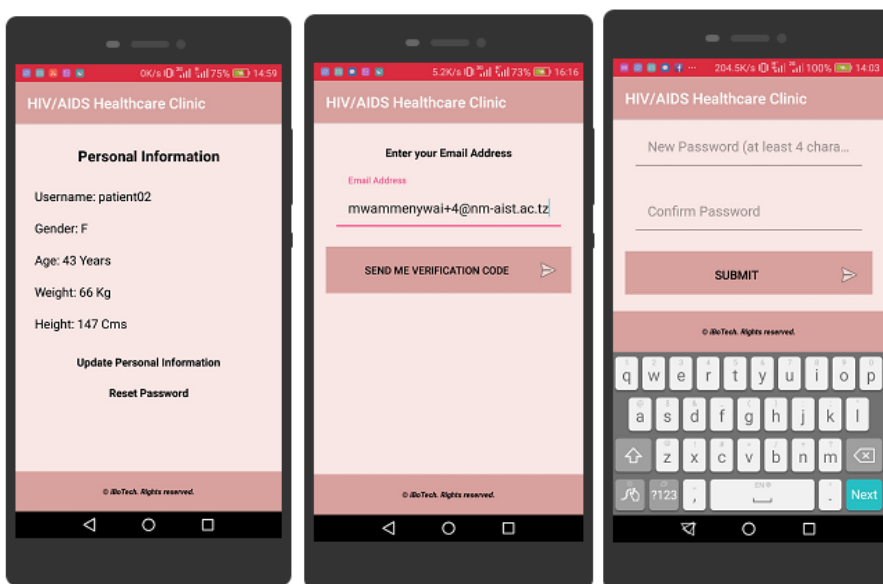


Figure 19: Mobile application's client profile UI

(vi) **Logout:** To maintain the client’s confidentiality and anonymity, the mobile application provides the client with the logout option. This option will terminate the communication session between his/her profile and the system. Hence, none can be able to use his/her account.

### 4.6.3 Web Application Implementation

The web system was developed as a cross-platform of all web browsers. It provides the interfaces for HIV/AIDS healthcare practitioners as well as the system administrators working in the CTCs. These web application interfaces help them in offering services such as uploading healthcare tips and answering the frequently asked questions.

Both the HIV/AIDS healthcare practitioners and system administrators must be registered into the system and have to log into the system with the unique username and password. Figures 21 and 22 show the login page for HIV/AIDS practitioner and system administrator respectively. For each kind of user, his/her account is associated with some specific roles.

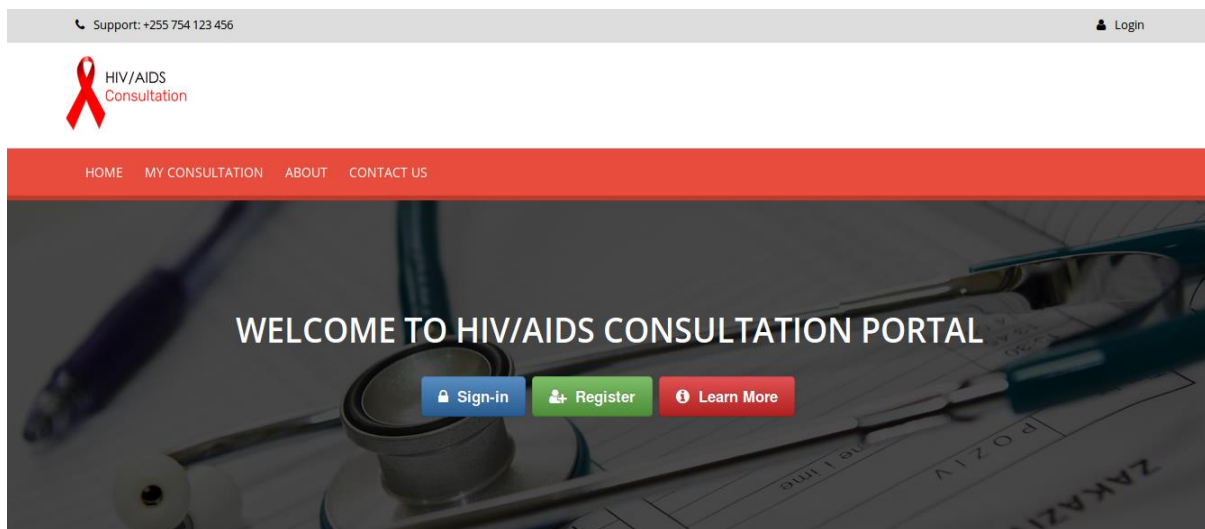


Figure 20: Web application's welcoming page

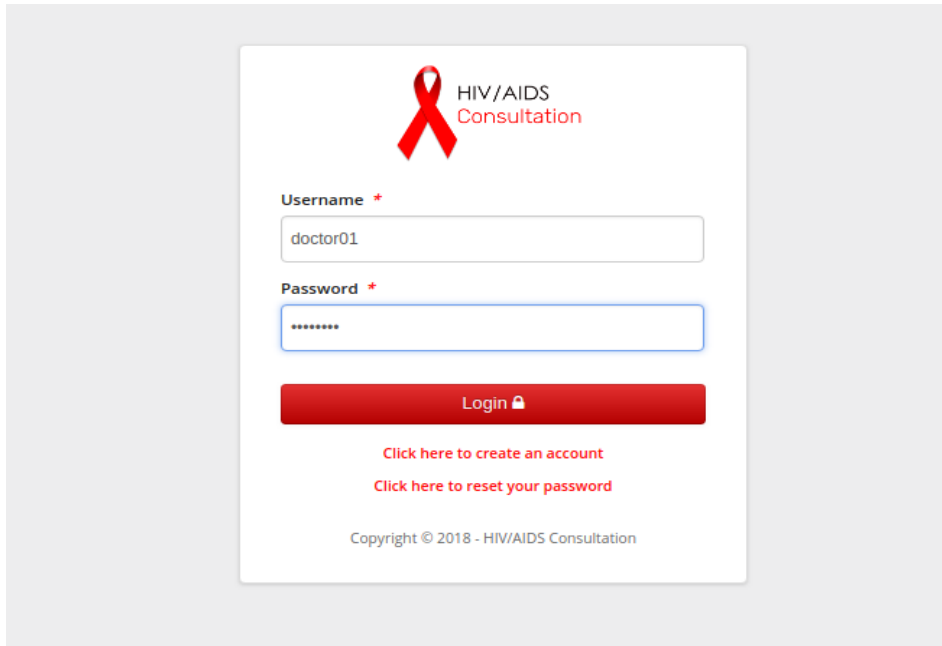


Figure 21: Web application's login page for HIV/AIDS healthcare practitioners

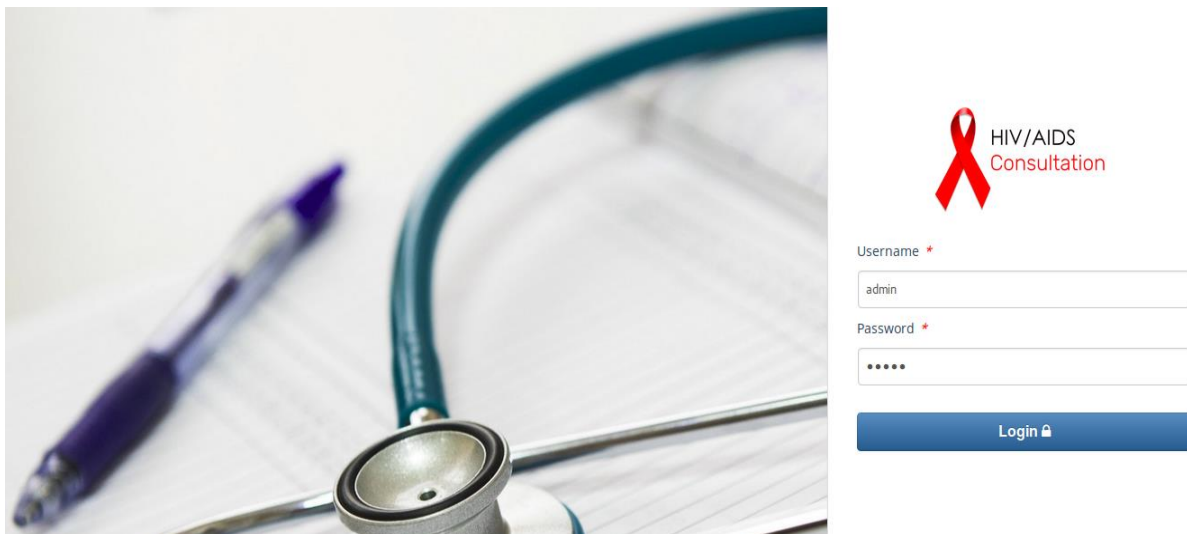


Figure 22: Web application's login page for the system administrators

Once the HIV/AIDS healthcare practitioner has logged into the system, he will be provided with the list of clients who are line into the system seeking for the consultation session. The practitioner will select one client and start the live chat consultation with him/her, as shown in Fig. 23 below.

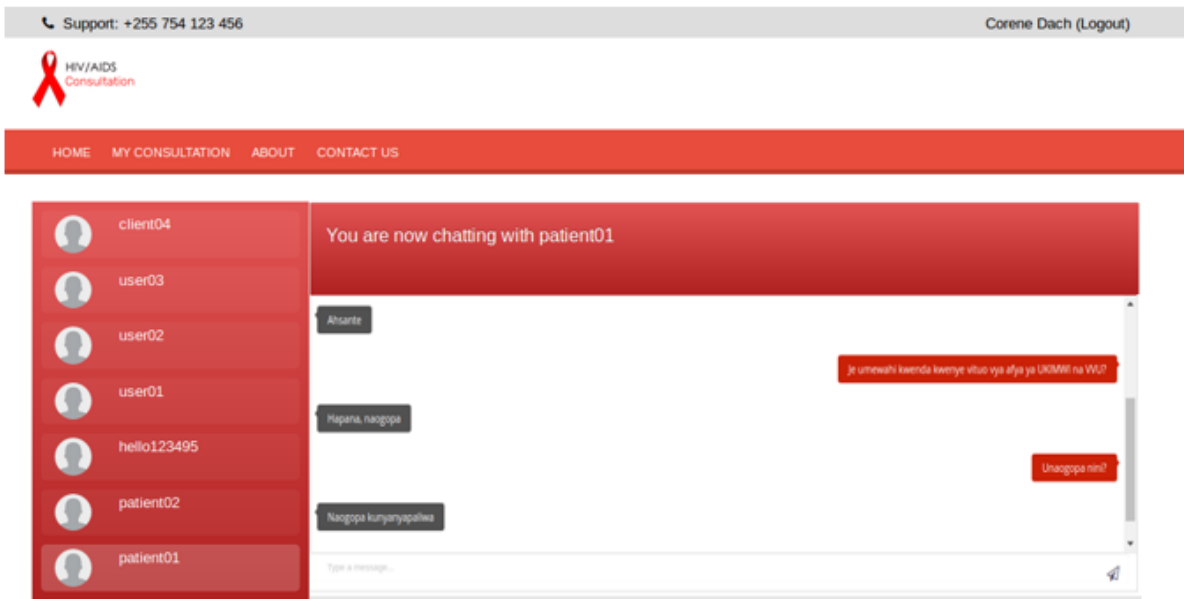


Figure 23: Web application's consultation live chat web page for HIV/AIDS healthcare practitioner

Furthermore, the system administration web page provides the system administrators with different roles such as managing users, health tips, providing support and others. Figure 24 below shows an example of the system administrator's web page when managing users.

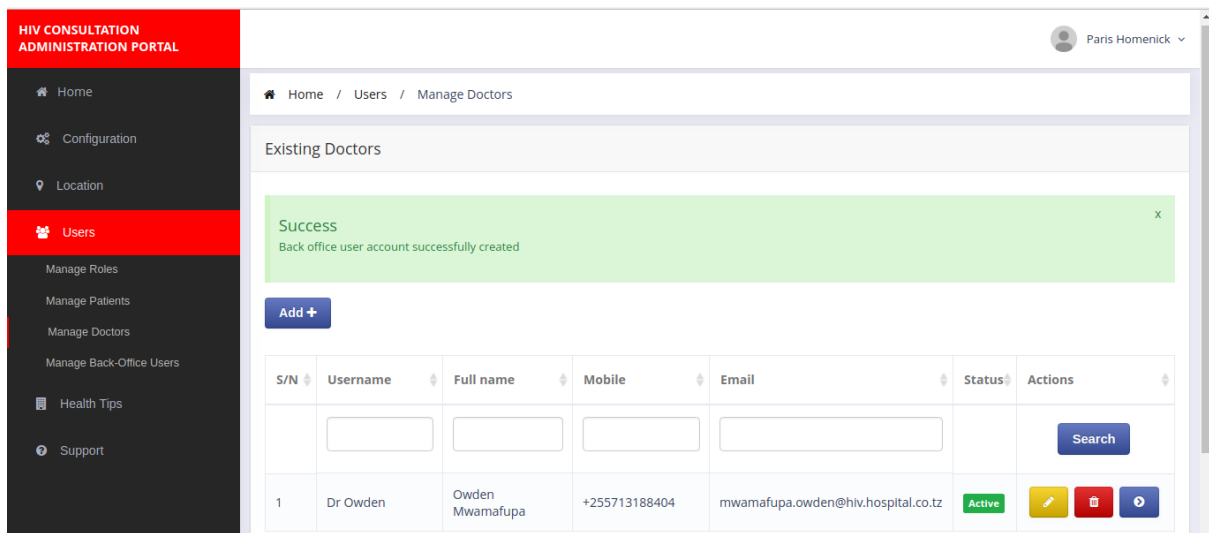


Figure 24: A web application's page for the system administrator managing users' accounts

## 4.7 System Validation

### 4.7.1 System Testing

The system's modules were tested to determine if they are working as per defined system's requirements. Table 15 below shows the test results for different tested modules.

Table 15: System's modules testing results

<b>System Requirement</b>	<b>Test Result</b>
The web system should be compatible with all browsers and mobile application should work on the android OS	PASS
The mobile application should enable user to switch languages from English to Swahili	PASS
The system must allow registered user to login and logout	PASS
The system must allow unregistered client to register himself/herself with a unique username	PASS
The system must allow the system administrator to create, suspend or remove a user account for the HIV/AIDS healthcare practitioners	PASS
The system should allow the system administrator to upload and/or remove HIV/AIDS health tips and other healthcare information	PASS
The system should provide the live chat capability between the client and HIV/AIDS healthcare practitioner; the healthcare practitioners to use this module for provision of healthcare recommendations	PASS
The system should allow all successfully logged users to view the HIV/AIDS health tips and other healthcare information	PASS
The system should produce different reports as requested by the system administrator	PASS

### 4.7.2 Users' Acceptance Validation

With the system fully developed, it was taken into the practical environment for user's acceptance validation. Fifteen people participated in this system validation survey, among

them, 10 clients who installed the mobile application in their mobile smart phones, 3 HIV/AIDS healthcare practitioners and 2 system administrators. All participants were given 3 days to use the system and after then, they filled in the survey questionnaires. The survey results were computed on the mean score based on a five-point Likert scale (5 = Strongly Agree; 4 = Agree; 3 = Not Sure; 2 = Disagree and 1 Strongly Disagree) as displayed in the table16 below.

From the study, the mean score for each validated aspect was above 3.5 showing that the majority of the sampled respondents strongly agreed with the quality and ability of the developed m-health system. The sampled users of the system even recommended that the ministry of health (and other related healthcare stakeholder) should employ this developed system for delivery of HIV/AIDS healthcare information.

Table 16: The system’s user acceptance validation response

Validation Aspect	Number of Respondents					Mean Score
	Strongly Disagree	Disagree	Note Sure	Agree	Strongly Agree	
The system’s interfaces are attractive and interactive	0	0	1	5	9	4.53
The system’s contents are easy to learn and understand	0	1	1	3	10	4.47
No compatibility problems between the system and your mobile phone and/or computer’s web-browser	0	0	0	3	12	4.80
I need further training and/or technical assistance for fully exploit this system	8	4	2	1	0	1.73
The system is useful and helpful in accessing the HIV/AIDS healthcare services	0	0	3	7	5	4.13
The system provides an easy and confidential interactive between a client and HIV/AIDS healthcare practitioner	0	0	3	5	7	4.27
I will use this system for accessing or delivering HIV/AIDS healthcare information	0	0	0	4	11	4.73
I am generally satisfied with this system	0	0	1	4	10	4.60
I will recommend others to use this system	0	0	0	5	10	4.67



## 4.8 Discussion

The findings of this study show that currently majority of people still rely on accessing HIV healthcare information through having direct personal contacts with HIV/AIDS practitioners by visiting HIV/AIDS CTCs. In the same way, previous different studies revealed that PLHIV mostly relied on direct contact with HIV/AIDS healthcare practitioners to access the HIV/AIDS health information (Rumisha *et al.*, 2006; Mboera *et al.*, 2007; Mwaiswelo and Masalu, 2008). Surprisingly, this study shows that the usage of the tradition ICT such as radio for accessing the HIV/AIDS health information has sharply diminished. This is in contrary to previous studies, which indicated the majority of people depended on the healthcare information from personal contacts at the HIV/AIDS CTCs and through radio programs (Chilimo and Nawe, 2004; Montez, 2011; Moshia and Sulemani, 2012; Rumisha *et al.*, 2006).

The study reveals that majority of people are aware of existence of HIV/AIDS CTCs found in different public and private hospitals. However, not all people who are aware of these HIV/AIDS CTCs are comfortable and ready to visit them for accessing the HIV/AIDS related information. A significant portion of people indicated that they are not comfortable visiting them, citing that they are scared of being exposed and/or stigmatized. These findings support a number of previous studies which showed that fear of stigma is still among the challenges in delivery of HIV/AIDS healthcare information (Feyissa *et al.*, 2012; Mbonu *et al.*, 2009; Saki *et al.*, 2015). Furthermore, Feyissa *et al.* (2012) described that among different factors for fear of stigma among PLHIV, 37.4% fear for unethical treatment of PLHIV and 31.1% for unofficial disclosure of their health status.

Furthermore, this study finds that there is a massive increase in number of people who seek the HIV/AIDS related information from the internet sources. Lwoga *et al.* (2017) stipulated that there is a considerably people's high effort to access to internet-based HIV information. Some previous studies indicated that Internet technologies improvements have vastly increased access of healthcare information (Kalichman *et al.*, 2002, 2005; Boot and Meijman, 2010; Chang and Im, 2014). Moreover, the study reveals that majority of people believed that they could access reliable HIV/AIDS healthcare information through the mobile application platform. Moreover, the study reveals that the education level and ownership of mobile phones have played a significant role in influencing people's need for mobile application platform. The need of having a mobile application for HIV/AIDS healthcare information delivery was even supported by the HIV/AIDS healthcare practitioners during this study. In

addition, the study findings have particularly shown that majority of the HIV/AIDS healthcare practitioners have the capacity to provide the HIV/AIDS healthcare information through online means. However, the lack of computer facilities in some of their healthcare centres is still a challenge.

Additionally, this study evidently shows that majority of people own mobile phones and in particular at least one smart phone. These findings are in line with the communication statistics report of December 2017 report which shows a massive increase in usage of mobile communication and internet access penetration of equivalent to 80% and 40% respectively (Tanzania Communications Regulatory Authority, 2017; Internet World Statistics, 2017).

#### **4.9 Chapter Summary**

In this chapter, the findings from the data collected have been discussed. These findings led to the need of the secure m-health platform for enhancing the delivery of HIV/AIDS healthcare information. Furthermore, in this chapter, the system requirements have been drawn, leading to the system modelling and implementation. The implemented system was then tested and validated by the identified actors or users. Moreover, in this chapter, the detailed discussion has been drawn in answering the questions associated with this research.

## CHAPTER FIVE

### CONCLUSION AND RECOMMENDATIONS

#### 5.1 Conclusion

This research study was conducted in order to develop the secured and integrated m-health platform system for enhancing the access of HIV/AIDS healthcare information access in Tanzania. The study evaluated the peoples' acceptance and comfortability on the existing HIV/AIDS healthcare information access situation; and whether there is a need of mobile platform. Furthermore, not only the study identified and established functional and non-functional requirements for the proposed mobile platform, but also the study came out with the developed m-health platform (made up of an android mobile application and a web-based system) for HIV/AIDS healthcare information access.

This research study has found that the ever-growing usage of mobile communications technologies and particularly internet can be useful for HIV/AIDS healthcare information delivery. Majority of people who participated in this study suggested that there is a need of having a mobile application platform for the HIV/AIDS healthcare information delivery. This need was even supported by the HIV/AIDS healthcare practitioners with this very study. The HIV/AIDS healthcare practitioners also implied there is a need for having a mobile application platform for disseminating HIV/AIDS healthcare information; and even suggesting that they were ready to offer this service online.

The study findings imply that usage of the ICT, especially the mobile technology is essential in provision of the HIV/AIDS healthcare information. The mobile application platform will consequently help people to confidentially access the HIV/AIDS healthcare information in their mobile electronic gadgets frequently without fear of being exposed as compared to when they would frequently visit the CTCs. This would subsequently improve the time and quality access to the healthcare information; and inspiring the change of behavior to strengthen disease prevention. Specifically, dissemination of the HIV/AIDS healthcare information must line up the use of internet and mobile phones for broader coverage and impact. The usage of mobile health (m-health) technology is important especially in this well-established communication era where by the majority own mobile gadgets with internet access capabilities.

## 5.2 Recommendations

Healthcare providers, the ministry of health and all other stakeholders in fighting against the HIV/AIDS should work on these findings and therefore start using the developed m-health platform for HIV/AIDS healthcare information delivery. This is because of the present findings has shown that the number of people who tend to attempt to find the HIV/AIDS healthcare information on the online sources has increased but there is no any official electronic mobile clinic for delivery of HIV/AIDS healthcare information.

The mobile application platform developed should be made aware to the public in order to easy their hustle of seeking the HIV/AIDS healthcare information. People should be made aware that the developed mobile application platform is simple, user friendly and available in both local languages, Kiswahili and English. Healthcare providers, public-health educationists, as wee as the information providers should sponsor, promote and encourage people on the timely accessing of the HIV/AIDS healthcare information. This should be done by promoting the benefits of accessing online HIV/AIDS healthcare information. Since the personal medical information is very sensitive data, this research recommends that the clients of this HIV/AIDS m-health platform should handle their personal information such as usernames and passwords and other healthcare information with maximum confidentiality.

The government, policy makers and other stakeholders such as internet service providers should improve the access to the HIV/AIDS' m-health platform at the affordable prices. Furthermore, the HIV/AIDS practitioners should be empowered with both technological know-how as well as with the technical facilities so as they can swiftly serve people online.

The future studies should also extend further this research from the access of HIV/AIDS healthcare information only to the delivery of other HIV/AIDS healthcare services such as testing. Moreover, the future studies should also find out means of dealing with other opportunistic diseases associated with HIV/AIDS using the mobile technologies.

This research recommends the future studies to put emphasize on assessment of the impact of the online provision of the HIV/AIDS healthcare information; and make the comparison with the impact of accessing the same information through visiting the traditional HIV/AIDS CTCs. The future studies can also consider to have a modified research design that can comprise of both qualitative and quantitative methods in order to have a concrete description of study and their findings.

### **5.3 Study Limitations**

This study considered only respondents whom with their consent were mentally and physically free and ready to participate. The study excluded people who were hesitant and those who indicated negative attitude towards this kind of studies, this was done purposely to avoid responses which are not genuine. The study also excluded the critically sick people whom might have been influenced by their health situations.

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## APPENDICES

### Appendix I: Kish Formula for Cross-Sectional Studies

Formula with Finite Population Correction:

$$n' = \frac{NZ^2P(1-P)}{d^2(N-1) + Z^2P(1-P)}$$

Where  $n'$  = Sample size with finite population correction,

$N$  = Population size,

$Z$  = Z Statistic for a level of confidence,

$P$  = Expected proportion (prevalence),

$d$  = Precision



## Appendix II: Questionnaire for HIV/AIDS Healthcare Clients

### NELSON MANDELA – TAASISI YA AFRIKA YA SAYANSI NA TEKNOLOJIA

#### HOJAJI YA UTAFITI

Ndugu,

Hojaji hii ni lengo la kujifunza haja na mahitaji ya kutengeneza njia/chombo cha TEHAMA ili kuwezesha mawasiliano salama, ya simu/intanet kati ya watu na watoa huduma za kitaalamu na ushauri nasaha wa maswala ya UKIMWI katika vituo vya matibabu/ushauri.

Hojaji hii haitachukua utambulisho wako, na kwa hivyo, hudumisha usiri wako. Tafadhali kuwa huru kutoa majibu ya uaminifu.

#### SEHEMU A: Tabia ya Kidemografia

1. Jinsia yako ni ipi?

- a) Kiume
- b) Kike

2. Una umri wa miaka mingapi?

- a) 15-19
- b) 20-29
- c) 30-39
- d) 40-49
- e) 50-59
- f) 60 na zaidi

3. Umefikia kiwango kipi cha elimu?

- a) Elimu isiyo rasmi
- b) Elimu ya msingi
- c) Elimu ya sekondari
- d) Elimu ya juu ya juu zaidi ya sekondari

4. Ndugu unajibu hapa, wewe ni nani?

- a) Mtoa huduma ya matibabu/ushauri nasaha wa maswala ya UKIMWI
- b) Daktari wa matibabu
- c) Mtu/mteja wa kawaida
- d) Mengineyo (Tafadhali kutaja.....)

#### SEHEMU B: Umiliki wa Simu ya Mkononi

5. Unamiliki simu ngapi za mkononi?

- a) Sina
- b) Moja
- c) Mbili

d) Zaidi ya mbili

6. Kama unamiliki simu ya mkononi, aina gani ya simu unayomiliki?
- a) Simu ya kawaida (isiyokuwa na huduma za intaneti)
  - b) Simu ya kisasa (yenye huduma za intaneti)
  - c) Zote

**SEHEMU C: Taarifa ya jumla ya upatikanaji wa huduma za matibabu na ushauri nasaha**

7. Je unakijua kituo chochote kinachotoa huduma ya matibabu/ushauri nasaha juu ya UKIMWI?
- a) Ndio
  - b) Hapana
8. Je umewahi kutembelea kituo chochote cha huduma za matibabu na ushauri nasaha juu ya UKIMWI?
- a) Ndio
  - b) Hapana
9. Kama NDIO, katika swali la juu, ipi ilikua ndiyo sababu kuu kukufanya wewe utembelee kituo cha huduma za matibabu na ushauri nasaha juu ya UKIMWI?
- a) Mgonjwa wa UKIMWI chini ya kliniki ya matibabu
  - b) Kwenda kutafuta taarifa na ushauri juu ya Afya
  - c) Kulazimishwa na mazingira au hali (mfano: kufunga ndoa, mahitaji ya usafiri, mahitaji ya kazi, kliniki ya ujauzito)
10. Je, unaona ni vizuri na ungependa kutembelea kituo chochote cha huduma za matibabu na ushauri nasaha juu ya UKIMWI?
- a) Ndio, hakuna tatizo
  - b) Hapana, naona aibu na ninaogopa kunyanyapaliwa
11. Ni kwa mara ngapi ndani ya mwaka umewahi kutembelea kituo chochote cha huduma za matibabu na ushauri nasaha juu ya UKIMWI?
- a) Kamwe (sijawahi hata mara moja)
  - b) Mara moja
  - c) Mara mbili
  - d) Zaidi ya mara mbili
12. Jinsi gani huwa unapata taarifa juu ya maswala yahasuyo UKIMWI?
- a) Kwenda kituo chochote cha huduma za matibabu na ushauri nasaha juu ya UKIMWI?
  - b) Runinga (Television - TV)
  - c) Redio,
  - d) Viongozi wa kijamii,

- e) Magazeti,
- f) Intaneti (mitandao ya kijamii)

13. Je huwa unajifunza taarifa yoyote ya afya kupitia mtandao ya intaneti?

- a) Ndio
- b) Hapana

14. Je unafikiri unaweza kupata habari/taarifa/ushauri na matibabu kuhusu UKIMWI kupitia intaneti ya simu ya mkononi?

- a) Ndio
- b) Hapana

15. Je, unaujua/umewahi kutumia mfumo wa TEHAMA (wavuti) wowote rasmi wa simu za mkononi kwa ajili ya huduma za taarifa juu ya UKIMWI?

- a) Ndio
- b) Hapana

Kama NDIO, tafadhali naomba utaje jina la mfumo huo (kama unakumbuka baadhi, itaje) .....

16. Kama umejibu NDIO katika swali la 15 hapo juu, je huwa unapata taarifa za muhimu na za kuaminika (kutoka chanzo rasmi) kwa njia ya intaneti?

- a) Ndio
- b) Hapana

17. Kama umejibu HAPANA, katika swali la 16 hapo juu, je ungependa kuwa na mfumo wa TEHAMA (wavuti) rasmi wa simu za mkononi ili kuwezesha mawasiliano salama kati ya watu na watoa hudumu za UKIMWI?

- a) Ndio
- b) Hapana

18. Kama umejibu NDIO katika swali hapo juu, Je ni yapi mahitaji yako ya msingi au matarajio juu ya mfumo (wavuti) ya intaneti ya simu za mkononi kwa ajili ya taarifa za UKIMWI na mawasiliano rasmi na salama (usiri) kati ya watoa huduma za ukimwi na watu?

- a) .....
- b) .....
- c) .....
- d) .....
- e) .....

## **Appendix III: Questionnaire for HIV/AIDS Healthcare Practitioner**

### **NELSON MANDELA – TAASISI YA AFRIKA YA SAYANSI NA TEKNOLOJIA**

#### **HOJAJI YA UTAFITI**

Ndugu,

Hojaji hii ni lengo la kujifunza haja na mahitaji ya kutengeneza njia/chombo cha TEHAMA ili kuwezesha mawasiliano salama, ya simu/intanet kati ya watu na watoa huduma za kitaalamu na ushauri nasaha wa maswala ya UKIMWI katika vituo vya matibabu/ushauri.

Hojaji hii haitachukua utambulisho wako, na kwa hivyo, hudumisha usiri wako. Tafadhali kuwa huru kutoa majibu ya uaminifu.

#### **KWA MADAKTARI/WASHAURI NASAHA WA UKIMWI TU**

1. Unatoa huduma katika hospital au kituo gani cha afya?.....  
.....
2. Unahudumia watu wangapi (wanaohusiana na mambo ya UKIMWI) kwa siku?
  - a) Chini ya watano
  - b) 5 hadi 10
  - c) 10 hadi 20
  - d) 20 hadi 30
  - e) Zaidi ya 30
3. Je, muitikio wa watu kuja kwenye vituo vya matibabu na ushauri nasaha wa UKIMWI unaridhisha?
  - a) Ndio
  - b) Hapana
4. Je, ni huduma gani inayohusiana na UKIMWI unaitoa mara nyingi kwa watu wanaokutembelea katika kituo chako?
  - a) Dawa za wagonjwa wa UKIMWI
  - b) Mafunzo juu ya afya na UKIMWI
  - c) Mashauriano juu ya afya na UKIMWI
5. Je, taarifa na elimu sahihi juu ya UKIMWI huifikia jamii kwa wakati?
  - a) Si wakati wote
  - b) Kwa namna fulani
  - c) Ndio, lakini juhudi zaidi inahitajika
  - d) Ndio, hakuna haja ya kuboresha zaidi

6. Je, kuna umuhimu wa watu katika jamii kupata taarifa rasmi zinazohusiana na UKIMWI?  
a) Ndio  
d) Hapana
7. Kama NDIO, katika swali hapo juu, toa sababu, ni kwa nini?  
.....
8. Je, inawezaka kutumika njia za mitandao na intaneti katika simu za mikononi kusambaza taarifa na elimu ihusuyo UKIMWI?  
a) Ndio  
b) Hapana
9. Je, mnaziweka taarifa na mafunzo yenu kuhusu UKIMWI katika njia za mfumo ya kompyuta na TEHAMA?  
a) Ndio  
b) Hapana
10. Je, huwa mnasambaza taarifa na elimu ya ushauri juu ya UKIMWI kupitia aina gani ya vyombo vya habari?  
a) Hapana hatusambazi taarifa  
b) tovuti maalumu katika intaneti  
b) maombi maalum ya simu  
c) mitandao ya kijamii  
d) televisheni/runinga  
e) redio  
f) njia zote
11. Je, unatumia kompyuta ukiwa unatoa huduma kwa wagonjwa ukiwa ofisini?  
a) Ndio  
b) Hapana
12. Je! Ofisi yako imeunganishwa na huduma ya intaneti?  
a) Ndio  
b) Hapana
13. Una ujuzi wa msingi juu ya matumizi ya kompyuta/tarakilishi?  
a) Ndio  
b) Hapana
14. Je! Ungependa kuwa na wavuti (mfumo) rasmi wa kompyuta wa kukuwezesha kuwahudumia na kuwasiliana na watu wanaohitaji huduma za UKIMWI kwa njia za mtandao bila kuja ofisini kwako?  
a) Ndio  
b) Hapana

15. Kama NDIO, yapi ni mahitaji/matarajio yako kwa ajili ya matumizi ya mfumo wa kompyuta na simu kwa mawasiliano pamoja na utoaji wa taarifa za UKIMWI?

- a) .....
- b) .....
- c) .....
- d) .....
- e) .....

## Appendix IV: Questionnaire for the System's Validation

### NELSON MANDELA – TAASISI YA AFRIKA YA SAYANSI NA TEKNOLOJIA

#### HOJAJI YA UTAFITI

Ndugu,

Hojaji hii ni lengo la kuhakiki na kuthibitisha mfumo wa TEHAMA wa kuwezesha mawasiliano salama, ya simu/intanet kati ya watu na watoa huduma za kitaalamu na ushauri nasaha wa maswala ya UKIMWI katika vituo vya matibabu/ushauri.

#### SEHEMU A: UTAMBULISHO

Ndugu unayejibu hapa, wewe ni nani?

- Mtoa huduma ya matibabu/ushauri nasaha wa maswala ya UKIMWI
- Ofisa wa TEHAMA wa kituo cha afya ya UKIMWI
- Mtu/mteja wa kawaida wa Huduma ya afya ya UKIMWI

#### SEHEMU B: MAONI YA UTHIBITISHAJI MFUMO

Tiki kwenye chumba kinachoonesha uhalisia wa hisia zako juu ya huu mfumo wa mawasiliano ya afya ya UKIMWI

	Ninakataa Kabisa	Ninakataa	Sina Uhakika	Nimekubali	Nimekubali Kabisa
Violesura vya mfumo huu vinavutia na rahisi kutumia					
Maudhui ya mfumo huu ni rahisi kujifunza na kuelewa					
Hakuna matatizo ya utangamano kati ya mfumo na simu yako ya mkononi au tarakilishi-kivinjari					
Nahitaji zaidi mafunzo na msaada wa ufundi wa kikamilifu ili kuweza kutumia mfumo huu					
Mfumo ni muhimu na husaidia katika kufikisha huduma ya afya ya UKIMWI kwa watu					
Mfumo hutoa huduma rahisi na ya usiri kati ya mteja na mhudumu wa afya wa UKIMWI					
Mimi hutumia mfumo huu kwa kupokea au kutoa taarifa ya afya ya UKIMWI					
Nimeridhika kwa ujumla na mfumo huu					
Nitapendekeza wengine kutumia mfumo huu					

## Appendix V: Sample Python Codes for Data Analysis

```
%matplotlib inline

import numpy as np

import matplotlib.pyplot as plt

import pandas as pd

#load data file

data_file = pd.read_excel('Field Data - Respondents.xlsx')

from pandas import Series, DataFrame

gender = Series(data_file['Gender'])

male = 0

female = 0

error = 0

for gnd in gender:

    if gnd == 1:

        male +=1

    elif gnd == 2:

        female +=1

    else:

        error +=1

total = male+female+error

male_percent = male/total

female_percent = female/total

print (male)
```



```

print (female)

print (error)

print (total)

print (male_percent)

print (female_percent)

import matplotlib.pyplot as plt

import numpy as np

know = 88.3

gone = 60.7

comfortable = 75.5

height = [know, comfortable, gone]

lable = ['Aware of CTCs', 'Comfortable visiting CTCs', 'Had visited CTCs']

x = np.arange(3)

barlist = plt.bar(x, height, width=0.6)

plt.xticks(x, lable, fontsize=10);

plt.xlabel('People', fontsize=12)

plt.ylabel('Percentage', fontsize=12)

#plt.suptitle(r'Sup title')

#plt.title('Situation related to knowing, and comfortability of attending the CTCs', fontsize=20)

barlist[0].set_color('r')

barlist[1].set_color('g')

plt.show()

```

```

ctc = 33.7

tv = 27

radio = 5.5

leaders = 1.2

magazine = 1.2

internet = 33.3

height = [ctc, tv, radio, leaders, magazine,internet]

lable = ['CTCs', 'Television', 'Radio','Leaders', 'Magazine','Internet']

x = np.arange(6)

barlist = plt.bar(x, height, width=0.8)

plt.xticks(x, lable, fontsize=10);

plt.xlabel('People', fontsize=12)

plt.ylabel('Percentage', fontsize=12)

#plt.suptitle(r'Sup title')

#plt.title('HIV/AIDS Clinical Information Access ', fontsize=20)

#barlist[0].set_color('r')

#barlist[1].set_color('g')

plt.show()

```

## Appendix VI: The Sample XML and Java Codes used in Mobile Application Development

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
package="com.ibotech.mobileclinic">

<application
android:allowBackup="true"
android:icon="@drawable/app_logo42"
android:label="@string/app_name"
android:supportsRtl="true"
android:theme="@style/AppTheme">

<activity android:name=".MainActivity">
<intent-filter>
<action android:name="android.intent.action.MAIN" />
<category android:name="android.intent.category.LAUNCHER" />
</intent-filter>
</activity>

<activity android:name=".LoginActivity"
android:label="@string/app_name">
<meta-data
android:name="android.support.PARENT_ACTIVITY"
android:value=".LoginActivity">
</meta-data>
</activity>

<activity android:name=".RegisterActivity"
android:label="User Registration">
<meta-data
android:name="android.support.PARENT_ACTIVITY"
android:value=".RegisterActivity">
</meta-data>
</activity>

<activity android:name=".PasswordResetActivity"
android:label="Reset Your Password">
<meta-data
android:name="android.support.PARENT_ACTIVITY"
android:value=".PasswordResetActivity">
</meta-data>
</activity>

<activity android:name=".ConsultationActivity"
android:label="Clinic Room">
<meta-data
android:name="android.support.PARENT_ACTIVITY"
android:value=".ConsultationActivity">
</meta-data>
</activity>

<activity android:name=".MyProfileActivity"
android:label="My Profile">
<meta-data
android:name="android.support.PARENT_ACTIVITY"
android:value=".MyProfileActivity">
</meta-data>
</activity>

<activity android:name=".HealthTipsActivity"
android:label="HIV/AIDS Health Tips">
<meta-data
android:name="android.support.PARENT_ACTIVITY"
```

```

    android:value=".HealthTipsActivity">
</meta-data>
</activity>

<activity android:name=".HealthCenterActivity"
android:label="HIV/AIDS Health Center">
<meta-data
android:name="android.support.PARENT_ACTIVITY"
android:value=".HealthCenterActivity">
</meta-data>
</activity>

<activity android:name=".FAQActivity"
android:label="Frequent Asked Questions">
<meta-data
android:name="android.support.PARENT_ACTIVITY"
android:value=".FAQActivity">
</meta-data>
</activity>

</application>

</manifest>

<?xml version="1.0" encoding="utf-8"?>
<RelativeLayout
xmlns:android="http://schemas.android.com/apk/res/android"
xmlns:app="http://schemas.android.com/apk/res-auto"
xmlns:tools="http://schemas.android.com/tools"
android:orientation="vertical"
android:id="@+id/activity_main"
android:layout_width="match_parent"
android:layout_height="match_parent"
android:background="#fae7e7"
tools:context="com.ibotech.mobileclinic.MainActivity">

<include
android:id="@+id/tool_bar"
layout="@layout/app_bar"
/>

<ScrollView
android:layout_width="match_parent"
android:layout_height="match_parent"
android:paddingBottom="16dp"
android:paddingLeft="16dp"
android:paddingRight="16dp"
android:paddingTop="16dp"
android:layout_marginBottom="60dp">

<LinearLayout
android:orientation="vertical"
android:layout_width="match_parent"
android:layout_height="match_parent">

<TextView
android:text="@string/login_note"
android:layout_width="match_parent"
android:layout_height="wrap_content"
android:textColor="#000"
android:gravity="center_horizontal|center_vertical"

```

```

android:textSize="15sp"
android:padding="20dp"
android:layout_marginTop="100dp"
android:id="@+id/loginNote"
android:layout_weight="2" />

<EditText
android:layout_width="match_parent"
android:layout_height="wrap_content"
android:inputType="textEmailAddress"
android:hint="Username"
android:ems="10"
android:padding="20dp"
android:layout_marginTop="10dp"
android:layout_weight="2"
android:id="@+id/username" />

<EditText
android:layout_width="match_parent"
android:layout_height="wrap_content"
android:inputType="textPassword"
android:hint="Password"
android:ems="10"
android:padding="20dp"
android:layout_marginTop="10dp"
android:layout_weight="2"
android:id="@+id/password" />

<Button
android:text="login"
android:textAllCaps="true"
android:textSize="16sp"
android:layout_width="match_parent"
android:layout_height="wrap_content"
android:padding="20dp"
android:background="@color/colorPrimary"
android:layout_marginTop="10dp"
android:onClick="button_clicked"
android:layout_weight="2"
android:id="@+id/login_button" />

<TextView
android:text="@string/password_reset"
android:layout_width="match_parent"
android:layout_height="wrap_content"
android:textColor="#000"
android:gravity="center_horizontal|center_vertical"
android:textSize="15sp"
android:layout_marginTop="10dp"
android:padding="20dp"
android:id="@+id/passwordReset"
android:layout_weight="2" />

</LinearLayout>

</ScrollView>

<LinearLayout
android:layout_width="match_parent"
android:layout_height="wrap_content"
android:layout_alignParentBottom="true">

<TextView
android:text="@string/copyright"
android:textSize="10sp"
android:textStyle="bold"
android:textColor="#000"

```

```

android:gravity="center_horizontal|center_vertical"
android:padding="20dp"
android:layout_width="match_parent"
android:layout_height="wrap_content"
android:background="#daa19f"
android:id="@+id/textView"
android:layout_weight"1" />

```

```
</LinearLayout>
```

```
</RelativeLayout>
```

```
package com.ibotech.mobileclinic;
```

```

import android.os.Bundle;
import android.support.v7.widget.Toolbar;
import android.view.Menu;
import android.view.MenuItem;
import android.widget.Button;
import android.widget.EditText;
import android.widget.TextView;
import android.support.v7.app.AppCompatActivity;
import android.content.Intent;
import android.view.View;

```

```

/**
 * Created by Admin on 20/04/2018.
 */

```

```
public class LoginActivityextends AppCompatActivity {
```

```
private Toolbar myToolbar;
```

```
@Override
```

```

protected void onCreate(Bundle savedInstanceState) {
super.onCreate(savedInstanceState);
setContentView(R.layout.activity_login);

```

```

myToolbar= (Toolbar) findViewById(R.id.tool_bar);
setSupportActionBar(myToolbar);

```

```

TextViewmyRegister = (TextView) findViewById(R.id.loginNote);
myRegister.setOnClickListener(new View.OnClickListener() {
@Override
public void onClick(View v) {
startActivity(new Intent(getApplicationContext(),RegisterActivity.class));
}
});

```

```

TextViewmyPasswordReset = (TextView) findViewById(R.id.passwordReset);
myPasswordReset.setOnClickListener(new View.OnClickListener() {
@Override
public void onClick(View v) {
startActivity(new Intent(getApplicationContext(),PasswordResetActivity.class));
}
});

```

```

final EditText myUsername = (EditText) findViewById(R.id.username);
final EditText myPassword = (EditText) findViewById(R.id.password);
    Button myLogin = (Button) findViewById(R.id.login_button);
myLogin.setOnClickListener(new View.OnClickListener() {

```

```

@Override
public void onClick(View v) {
    startActivity(new Intent(getApplicationContext(), ConsultationActivity.class));
    });
}

@Override
public boolean onCreateOptionsMenu(Menu menu) {
    getMenuInflater().inflate(R.menu.login_menu, menu);
    return true;
}

@Override
public boolean onOptionsItemSelected(MenuItem item) {
    int id = item.getItemId();
    if (id==R.id.about_us) {
        startActivity(new Intent(getApplicationContext(), AboutUsActivity.class));
        return true;
    }
    return super.onOptionsItemSelected(item);
}
}

```

## Appendix VII: The Sample PHP Codes used in Web Application Development

```
{% extends 'public.base.html.twig' %}

{% block title %}{{ app_name }} | {{ title }}{% endblock %}

{% block stylesheets %}
    {{ parent() }}
{% endblock %}

{% block body %}

    {{ parent() }}
    {% if app.user %}
        <div class="space-20 col12"></div>
        <div class="section-inner">
            <h1 class="lighter">Dashboard</h1>
            <div class="space-10"></div>
            <div class="divider"></div>
            <div class="menu-icon col4">
                <a href="{{ path('patient_consultation') }}" class="btn">
                    <imgsrc="{{ asset('images/icons/iv_stethoscope_45400.png') }}" />
                    Start a new consultation
                </a>
            </div>

            <div class="menu-icon col4">
                <a href="#" class="btn">
                    <imgsrc="{{ asset('images/icons/hourglass.png') }}" />
                    View previous consultation
                </a>
            </div>

            <div class="menu-icon col4 last">
                <a href="#" class="btn">
                    <imgsrc="{{ asset('images/icons/help.png') }}" />
                    Get Some Help
                </a>
            </div>
        </div>
        <div class="space col12"></div>
    {% else %}
        <div class="col12 intro">
            <div class="background-overlay grid-overlay-70">
                <div class="section-inner">
                    <div class="col12 intro-text">
                        <h1 class="styled-header">Welcome To HIV/AIDS Consultation
                        Portal</h1>
                    </div>
                </div>
            </div>
        </div>
    {% endif %}

```



```
    <a href="{{ path('consumer_login') }}" class="btnbtn-blue"><span
class="icon-spacer-right"><i class="fa fa-lock" aria-hidden="true"></i></span>Sign-in
</a>
```

```
    <a href="{{ path('consumer_registration') }}" class="btnbtn-
green"><span class="icon-spacer-right"><i class="fa fa-user-plus" aria-
hidden="true"></i></span>Register</a>
```

```
    <a href="#" class="btnbtn-red"><span class="icon-spacer-right"><i
class="fa fa-info-circle" aria-hidden="true"></i></span>Learn More</a>
```

```
    </div>
```

```
  </div>
```

```
</div>
```

```
</div>
```

```
<div class="col12 space"></div>
```

```
<div class="col12 align-center">
```

```
  <div class="section-inner">
```

```
    <h1>How to use this service</h1>
```

```
    <div class="divider"></div>
```

```
  </div>
```

```
  <div class="col12 space"></div>
```

```
  <div class="col12 space"></div>
```

```
  <div class="col12 space"></div>
```

```
  <div class="col12 space"></div>
```

```
  <div class="col12 space"></div>
```

```
</div>
```

```
{% endif %}
```

```
{% endblock %}
```

```
{% block javascripts %}
```

```
  {{ parent() }}
```

```
{% endblock %}
```


# RESEARCH OUTPUTS

## Journal Articles

Ibrahim A. Mwammenywa, Shubi F. Kaijage, "Towards Enhancing Access of HIV/AIDS Healthcare Information in Tanzania: Is a Mobile Application Platform a Way Forward?", *International Journal of Information Technology and Computer Science (IJITCS)*, Vol.10, No.7, pp.31-38, 2018. DOI: 10.5815/ijitcs.2018.07.04


Ibrahim A. Mwammenywa, Shubi F. Kaijage, "HIV/AIDS Healthcare Information Delivery in Tanzania using Integrated Mobile Application and Web-based System: System's Functional and Non-functional Requirements", *International Journal of Information Technology and Computer Science (IJITCS)*, Vol.10, No.11, pp.30-38, 2018. DOI: 10.5815/ijitcs.2018.11.03

## Poster Presentation



### SECURE M-HEALTH SYSTEM FOR ENHANCEMENT OF HIV/AIDS HEALTHCARE INFORMATION DELIVERY IN TANZANIA

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#### BACKGROUND

- HIV/AIDS has been one of the most killing global pandemics to date

By 2016, in Tanzania, HIV prevalence rate was 4.7%; 1.4 Million People were living with HIV/AIDS; 36,000 People died of HIV/AIDS (UNAIDS, 2015; The Joint United Nations Programme on HIV/AIDS, 2016)

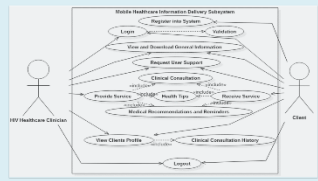
#### PROPOSED SOLUTION

- Secure and confidential integrated m-health system for enhancement of HIV/AIDS healthcare information access as well as communication-linkage between people and HIV Practitioners in Care and Treatment Centres (CTCs).




#### FUNCTIONAL REQUIREMENTS

- Functional requirements for Online Delivery of HIV/AIDS Healthcare Information between Practitioner and Client




#### PROBLEM STATEMENT

- Fear of Stigma is holding back people from openly going to HIV/AIDS CTCs for accessing healthcare services



#### DEVELOPED SYSTEM

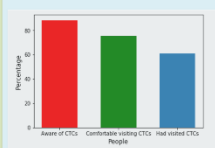
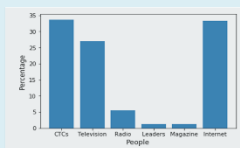


#### OBJECTIVES

- To assess peoples' acceptance and comfortability on going to HIV/AIDS CTCs for HIV/AIDS Healthcare Information
- To identify and establish requirements for an integrated secure m-health system linking between people and HIV practitioners in CTCs.
- To develop an integrated secure m-health system for linking people in the society to HIV practitioners.

#### RESEARCH FINDINGS

- Peoples' Awareness and Comfortability towards Attending HIV/AIDS CTCs
- HIV/AIDS Healthcare Information Seeking Pattern
- HIV/AIDS Practitioners' Readiness towards Online HIV/AIDS Clinic

HIV/AIDS Practitioners' Readiness	Percentage (%)	Cronbach's alpha
Having a computer knowledge	77.8	0.7312
Having a good working computer in my office	33.3	
Having internet connectivity in my office	73.3	

#### VALUE PROPOSITION

- Provides a secure and stigma-free HIV/AIDS mobile clinic and healthcare information services
- Maintains the client confidentiality: No tracing ID through the App as compared to a phone call
- Time saving: No need of waiting in a queue as by going to CTCs
- Client can access and review his/her previous HIV/AIDS healthcare recommendations
- Easy access to HIV/AIDS Health Tips
- Easy access to Map Location of the nearest HIV/AIDS CTC
- Use of both Swahili and English languages
- Providing accurate HIV/AIDS related data/information

# Towards Enhancing Access of HIV/AIDS Healthcare Information in Tanzania: Is a Mobile Application Platform a Way Forward?

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**Abstract**—This survey study evaluates the peoples' acceptance and comfortability on accessing the HIV/AIDS healthcare information through visiting HIV/AIDS Care and Treatment Centers (CTCs). Furthermore, the survey examines whether a mobile application platform can be the way forward towards enhancing HIV/AIDS healthcare information delivery in Tanzania. This study was conducted in Dar es Salaam city in Tanzania. The structured questionnaire-based survey was carried-out involving a total of 208 respondents, among them, 45 were the HIV/AIDS healthcare practitioners. The collected data were analyzed by using WEKA and Python computer programming software. The study findings indicated that: 24.5% of the respondents claimed that they were not comfortable going to HIV/AIDS CTCs indicating that they were afraid of being exposed and stigmatized; almost one-third (31.3%) of respondents prefer to seek HIV/AIDS related information from online sources; 78.5% of respondents preferred to have an official mobile application for access the HIV/AIDS healthcare information; 64.4% of HIV/AIDS practitioners indicated the need of having a mobile application platform for HIV/AIDS healthcare information delivery; and more than two-third of HIV/AIDS practitioners claimed to be able to serve people with HIV/AIDS healthcare information online. It is concluded that there is a need for the HIV/AIDS healthcare providers to have a mobile application platform for HIV/AIDS healthcare information delivery. The mobile application platform will consequently help people to confidentially access the HIV/AIDS healthcare information in their mobile electronic gadgets frequently without fear of being exposed as if they would frequently visit CTCs.

**Index Terms**—HIV/AIDS, Mobile Health (m-health), Mobile Application, HIV/AIDS Healthcare Information, Online HIV/AIDS Healthcare Information.

## I. INTRODUCTION

Since being discovered, Human Immunodeficiency Virus infection and Acquired Immunodeficiency Syndrome (HIV/AIDS) has been one of the most killing global pandemics to date. Fighting the HIV/AIDS has been a very daunting challenge in the global health and particular Sub-Saharan African (SSA) countries. Approximately of 36.7 million people were living with HIV worldwide by 2015, with more than two-third of them living in SSA. Tanzania in particular, there were about 1.4 million people living with HIV (PLHIV), and around 36,000 deaths which occurred in 2015 were due to HIV/AIDS [1]. The most of SSA governments, such as the Tanzanian government, have taken the socio-political and economic measures to tackle the HIV pandemic by providing free HIV medical services such as provision of the Antiretroviral therapy (ART) in the public hospitals [2]. Approximately, 10.3 million (about 54%) of PLHIV were accessing ART in eastern and southern SSA [1].

Despite these measures undertaken by the government in providing free HIV medical services such as ART in the public hospitals, the fear of stigma and lack of awareness is still a handicap. The fear of stigma is still holding some people in the society from freely going to the HIV/AIDS Care and Treatment Centers (CTCs) to receive the HIV/AIDS healthcare clinical services including HIV/AIDS healthcare information [3-5]. [3] described that among different factors for fear of stigma among PLHIV, 37.4% fear for unethical treatment of PLHIV and 31.1% for unofficial disclosure of their health status. The timely access to the relevant HIV/AIDS healthcare information can help people in making informed decisions of living a healthy life [6, 7]. The living of healthy life includes the change behavior, increase ability to self-care and more committed to treatment with more life hope and empowerment.



However, the Information and Communication Technologies (ICT) provides a great potential in delivery of health services. The usage of mobile technology has been of different forms such as mobile health (m-health), mobile money transactions (for example M-Pesa), and mobile banking. The m-health has integrated users in health associated activities, and thus improving availability of healthcare services, health information, and influencing healthy user behavior [8]. There is a massive increase in usage of mobile communication and internet in Tanzania showing 80% mobile phones penetration as well 40% internet penetration [9].

This paper reports the assessment on the people's general awareness and comfortability towards physically attending HIV/AIDS CTCs for accessing the HIV/AIDS healthcare information. Moreover, this study assesses whether the use of ICT in form of mobile application can be a way forward for delivering the HIV/AIDS healthcare information for broader coverage (to many people with an easy access) without exposing them.

The rest of this paper is organized as follows: the second section explains the background information on the currently situation in provision of HIV/AIDS healthcare information and the fear of stigma as its major challenge. The third section talks about related works of which the mobile technologies have been applied to facilitate the delivery of healthcare information. The detailed research study design and methods used from the data collection, data analysis to results presentation have been explained in section four. Sections five and six provide the detailed explanation of results and discussion respectively. The conclusion has been drawn in section seven. Finally, the limitations of this study were given in section eight.

## II. BACKGROUND

Currently in Tanzania, all of the HIV/AIDS healthcare service are offered at the CTCs across the country. The HIV/AIDS healthcare services ranges from provision of general public HIV/AIDS education, HIV testing, HIV counselling to HIV patient treatment and medications (including the provision of antiretroviral, ARV drugs). However, fear of being identified and/or stigmatized is still holding a lot of people in the society from freely going to CTCs for these HIV/AIDS healthcare services [3-5].

This research study is trying to assess whether the usage of mobile application platform can be a comfortable and acceptable way for people to access the HIV/AIDS healthcare information services. The usage of a confidential mobile application platform without actual regular visits to the CTCs may help people who want to access the HIV/AIDS healthcare information but do afraid of being identified and stigmatized.

HIV/AIDS healthcare information is any sort of HIV/AIDS related information which should be shared to

the general public or a particular client<sup>1</sup>. There are different types of healthcare information such as appointment and medication reminders, general health tips, diagnostic information, symptoms and vital signs [10]. The important healthcare information which are provided in the HIV/AIDS CTCs are HIV/AIDS healthcare tips, HIV/AIDS healthcare recommendations, HIV/AIDS personal clinical counselling or consultation between the client and HIV/AIDS practitioner. These services are to remain as the key services even when the HIV/AIDS healthcare information delivery is through the mobile application platform.

## III. RELATED WORKS

In ICT, the mobile technology is the technology used for transferring of a specific information from one part to the intended recipient (or recipients) by using the cellular communication system. Currently, the mobile technology has been widely used for accessing and dissemination of information in various sectors such health, finance, and security and control systems. Mobile application is a software which makes the use of the mobile technology, and it is used within mobile devices such as mobile phones. Mobile application allows mobile gadget users to interact with each other or with different online service providers [11, 12].

The health sector has been actively employing the mobile technology in delivering health services to the public. The usage of the mobile technology applications for healthcare provisions is known as mobile health (or m-health) [13]. M-health involves the transfer of healthcare resources including the delivery of healthcare information by using the mobile electronic means [14]. Mobile health applications have been growing so fast recently, this is due to its contribution in shifting behavior to strengthen disease prevention at the low cost of acquiring a quality healthcare services [8, 13, 15, 16].

In Tanzania, like other African countries, the number of mobile solutions using mobile applications for different healthcare services is growing very fast. These mobile applications cover healthcare services such as dissemination of nutrition services and maternal healthcare with example of Mobile Alliance for Maternal Action (MAMA), NutriMobile and Healthy Pregnancy, Healthy Baby (HPHB) [17-19]. However, there is no any mobile application platform for dissemination of HIV/AIDS healthcare information in Tanzania to date. [6] made a call for online dissemination of HIV/AIDS healthcare information since there is a considerably people's high effort to try to access to internet-based HIV information, HIV/AIDS clinical tips and recommendations.

## IV. METHODOLOGY

The questionnaire-based study was conducted among

<sup>1</sup> Client – A person who is accessing the HIV/AIDS health care services such as healthcare tips, recommendations, and/or clinical conversation.



different groups of people, involving people living with HIV (PLHIV), and those without HIV along with the HIV medical practitioners. This study was based in Dar es Salaam city in Tanzania. Dar es Salaam was chosen as it indicated high levels of stigma per PLHIV about 49.7 percent as compared to 39.4 percent from other regions [20]; while having a high HIV prevalence of about 11 percent [21]. Moreover, Dar es Salaam is the largest and most developed city as far as ICT infrastructures is concerned, in addition to the highest usage of internet and mobile services in the country [22, 23]. The region contains four large district referral hospitals namely Mwananyamala Hospital, Temeke Hospital, Sinza-Palestina Hospital and Infectious Diseases Centre (IDC) each found in Kinondoni, Temeke, Ubungo and Ilala districts respectively. These hospitals have special HIV/AIDS related clinics to offer HIV/AIDS healthcare clinical services such as general public HIV/AIDS healthcare information, counseling, testing and continued adherence counseling, medical treatment of PLHIV including treatment of opportunistic infections and provision of antiretroviral (ARV) drugs.

Due to complexity of this study, both people getting HIV/AIDS healthcare clinical services and HIV/AIDS medical practitioners in these hospitals were involved in this study. The study was extended to involve the HIV/AIDS medical practitioners of a Non-Government Organization (NGO) dealing with HIV/AIDS services in remote areas within Dar es Salaam region, named Pastoral Activities and Services for people with AIDS in Dar es Salaam Archdiocese (PASADA). The data from respondents were used to assess the need of mobile application for accessing HIV/AIDS healthcare information. The data from HIV/AIDS medical practitioners were used in assessment of capacity and readiness of the HIV practitioners to serve people with the HIV/AIDS healthcare information online.

The sample size was determined by using Kish formula for cross-sectional studies [24, 25]. The calculation based on the HIV prevalence in Dar es Salaam of 11 percent and the entire population of the region of about 5,781,557 people at the precision of 5 percent and confidence level of 95 percent [21, 26]. Therefore, the minimum sample size was found to be 151 people. The study involved random sampling of both male and female who filled in questionnaire on their consent. The questionnaires were made of three parts; demographic information (such as gender, age, education level and mobile phones ownership), comfortability and attendance to HIV/AIDS CTCs, and finally the perception towards accessing the HIV/AIDS healthcare information online. All of the questions in the mentioned parts were independent. The dependent variable evaluated whether respondents would want the mobile application platform for accessing HIV/AIDS healthcare information.

The internal-consistency of the HIV/AIDS practitioners' readiness towards providing the HIV/AIDS healthcare information online were assessed using the Cronbach's alpha coefficient. Cronbach's alpha coefficient is used for examination of internal reliability

and interrelation among the contributing items. The study had an alpha coefficient within accepted range of value is above 0.7 [27, 28].

The collected data were analyzed by using Python, computer programming software for big data [29]. The study employed the hierarchical regression analysis which was performed by using data mining and analysis software, WEKA version 3.8.1 [30]. The hierarchical regression analysis was performed to examine the effect of different factors towards the need of mobile application platform for accessing HIV/AIDS healthcare information. This method was selected due to its suitability in investigating the impact of several independent variables sequentially [31]. Furthermore, [32] proved that this is an appropriate technique for evaluating the influence of control independent factors to a dependent issue. This analysis involved four steps/models of regression analysis. In the first step, only the demographic attributes were examined towards the respondents' need of mobile application for accessing HIV/AIDS healthcare information. The second step added the respondents' mobile phones ownership, in third step the general awareness and attendance to CTCs were considered. Final stage examined if the prior access of any health information through mobile and online media was to influence into the need of mobile application for accessing HIV/AIDS healthcare information.

## V. RESULTS

In this study, total of 208 people participated, among them, 45 were HIV/AIDS practitioners.

### A. Demographic Characteristics of Respondents.

Out of 163 respondents who were not HIV/AIDS practitioners, number of male respondents were slightly higher (51.5%) than female respondents. Within this group of respondents, majority were aged between 20 – 29 years (about 46%). Majority of the respondent who were willing to participate in this study had the tertiary education (36.2 %). Table 1 shows demographic characteristics of all respondents.

Table 1. Demographic Characteristics of Respondents

Demographic Characteristics	Respondents	Percentage (%)	
Gender	Male	84	51.5
	Female	79	48.5
Age (in Years)	15-19	14	8.6
	20-29	75	46.0
	30-39	31	19.0
	40-49	26	16.0
	50-59	14	8.6
	60 and above	3	1.8
Education	Non-formal education	9	5.5
	Primary education	41	25.2
	Secondary education	54	33.1
	Tertiary education	59	36.2

### B. Mobile Phones Ownership

Among the respondents, only 9.2% do not own any mobile phone, while a total of 60.8% of all respondents had at least one smart-phone with internet capabilities. Detailed information on the ownership distribution of mobile phones among the respondents is depicted in Fig. 1 below.

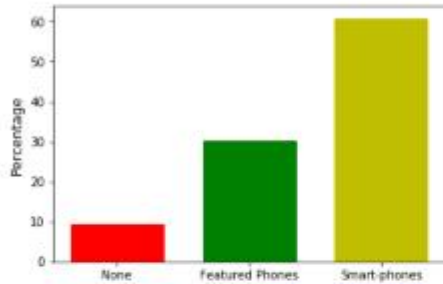


Fig.1. Mobile Phones Ownership Distribution

### C. Respondents' Awareness and Comfortability towards Attending HIV/AIDS CTCs

Only 88.3% of respondents are aware of the existence of HIV/AIDS CTCs. Furthermore, even fewer respondents (60.7%) had at least once visited the HIV/AIDS CTCs to seek for HIV/AIDS healthcare information. 24.5% of the respondents were not comfortable going to HIV/AIDS CTCs indicating that they were afraid of being exposed and stigmatized. This situation is well summarized by Fig. 2 below.

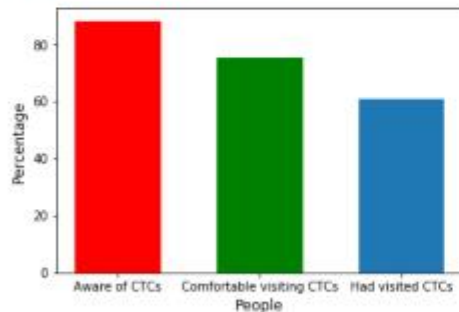


Fig.2. Comparison of peoples' awareness, comfortability and actual visiting HIV/AIDS CTCs

### D. HIV/AIDS Healthcare Information Seeking Pattern

Almost one-third (31.3%) of respondents prefer to seek HIV/AIDS related information from online media (via internet). However, 33.7% of the respondents claimed to get the HIV/AIDS healthcare information through visiting to HIV/AIDS CTCs. Fig. 3 below provides HIV/AIDS healthcare information seeking pattern as

analyzed from the respondents.

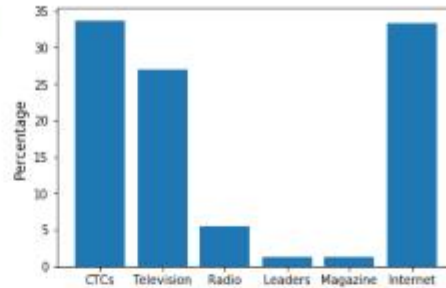


Fig.3. HIV/AIDS Healthcare Information Access Pattern

### E. Towards Accessing HIV/AIDS Healthcare Information Online

Almost two-third of the respondents (66.3%) had the tendency of accessing and searching of different health information through online media sources. Furthermore, 79.1% of respondents believed that they could access reliable HIV/AIDS healthcare information if there is an online platform while 78.5% went even further by suggesting that they wanted the mobile application platform. This information is summarized in table 2 below.

Table 2. Towards Accessing HIV/AIDS Healthcare Information Online

	Respon dents	Percentage (%)
I access and search for different healthcare information through online sources	99	66.3
I believe that I can access reliable HIV/AIDS healthcare information in online platform	129	79.1
I would like to have a mobile application for accessing the HIV/AIDS healthcare information	128	78.5

### F. Factors Contributing to the need of Mobile Application Platform for HIV/AIDS Healthcare Information Access

In examining why respondents asked for the mobile application platform for accessing the HIV/AIDS healthcare information, different factors were put into consideration. The study employed the hierarchical regression analysis to assess the proportional contribution of different factors towards the need of mobile application platform for accessing HIV/AIDS healthcare information. The findings showed that demographic factor contributed 3.25% in need of mobile application platform for accessing HIV/AIDS healthcare information. The ownership of mobile phone contributed further to 7.28% for respondents to need this mobile application platform. However, the general awareness and attendance to CTCs had a very small negative influence towards the need of the mobile application platform, reducing the overall contribution to 7.26% as shown in model 3.



Moreover, the experience of using other health-related mobile application proved to have almost negligible contribution to the respondents need for mobile application platform for accessing HIV/AIDS healthcare information. Table 3 below narrates hierarchical regression analysis of factors affecting contribution to the need of the mobile application for accessing HIV/AIDS healthcare information.

Table 3. Hierarchical Regression Analysis

Factors	Model 1	Model 2	Model 3	Model 4
Gender	0.0002	0.0002	-0.0001	-0.0001
Increasing Age	0.0004	0.0003	-0.0001	0.0001
Increasing Education Level	0.0882	0.0621	0.0601	0.0502
Having a Mobile Phone		0.2962	0.2752	0.2762
Having a Smart Phone		0.0003	0.0002	0.0002
Knowing HIV CTCs			-0.0052	-0.0032
Going to CTCs			-0.0102	-0.0022
Frequency of going to CTCs			-0.0091	-0.0065
Comfortability going to CTCs			-0.0105	-0.0102
Experience of using m-Health applications				-0.0001
<i>Df</i> <sup>2</sup>	3	5	9	10
<i>Adjusted R-squared</i> <sup>3</sup>	0.0325	0.0728	0.0726	0.0726

Notes: All figures were round off to 4 decimal places and P<0.05

#### G. HIV/AIDS Practitioners

The study also collected information from among 45 HIV/AIDS practitioners. Majority of them, almost one-fifth (22.2%) were from Infectious Diseases Centre (IDC) which is a special Care and Treatment Center for people living with HIV (PLHIV) in Dar es Salaam. Majority (71.1%) were serving more than 30 people per day on more or less same kind of clinical services. Table 4 shows the distribution of HIV/AIDS healthcare practitioners who were involved in this study.

Table 4. HIV/AIDS Healthcare Practitioners

		Practitioners	Percentage (%)
HIV/AIDS CTC	Temeke Hospital	8	17.8
	Mwananyamala Hospital	8	17.8
	Sinza Hospital	7	15.6
	IDC	10	22.2
	Kairaki Hospital	7	15.6
	PASADA	5	11.1
Number of People served per day by each practitioner	Less than 5	1	2.2
	5 to 10	5	11.1
	10 to 20	4	8.9
	20 to 30	3	6.7
	More than 30	32	71.1

<sup>2</sup> *Df*: Degree of Freedom – number of independent variables in the statistical analysis.

<sup>3</sup> *Adjusted R-squared*: It calculates R-square values (how much variance is in a model) from significant independent variables in the model

#### H. HIV/AIDS Practitioners' Perspectives on Provision of HIV/AIDS Healthcare Information

Table 5 narrates that out of 45 HIV/AIDS practitioners, 91.1% insisted that it is important to always provide the HIV/AIDS healthcare information to people in the society. About three-fifth (62.2%) acknowledged the existing effort of disseminating the HIV related information to the society but insisted on more effort should be employed. Surprisingly, more than half (55.6%) of HIV/AIDS practitioners cited that they did not disseminate the HIV related healthcare information. Four-fifth of the respondents in this category agreed that the said healthcare information can be transacted via electronic means, while 64.4% went further by showing there is a need for having a mobile application platform for delivering the HIV/AIDS healthcare information.

Table 5. HIV/AIDS Practitioners' Perspectives on Provision of HIV/AIDS Healthcare Information

	Practitioners	Percentage (%)
It is important to disseminate HIV/AIDS healthcare information to society	41	91.1
Is HIV/AIDS healthcare information reaching community?	Not at all.	8
	Somehow.	9
I can provide the HIV/AIDS healthcare information using online platform	Yes, but more effort is required.	28
	Yes, no need for more improvement.	0
There is a need of having a mobile application platform for delivering HIV/AIDS healthcare information	36	80
	29	64.4

#### I. HIV/AIDS Practitioners' Readiness towards Online Delivery of HIV/AIDS Healthcare Information

Two-third of the HIV/AIDS practitioners said that they are computer literate and even have the internet access at their offices at the CTCs. However, only one-third of them are supplied with the working computers in their offices. Cronbach's alpha coefficient of 0.7012 shows that there is an internal reliability and interrelation for them to be ready to offer the HIV/AIDS services online.

Table 6. HIV/AIDS Practitioners' Readiness towards Online Delivery of HIV/AIDS Healthcare Information

	Practitioners	Percentage (%)	Cronbach's alpha
HIV/AIDS Practitioners' Readiness			0.7012
Do you have computer knowledge?	35	77.8	
Does your Office have Working Computer?	15	33.3	
Does your Office have Internet Access?	33	73.3	

## VI. DISCUSSION

The findings of this study show that currently majority of people still rely on accessing HIV healthcare information through having direct personal contacts with HIV/AIDS practitioners by visiting HIV/AIDS CTCs. In the same way, previous different studies revealed that PLHIV mostly relied on direct contact with HIV/AIDS healthcare practitioners to access the HIV/AIDS health information [33-35].

The study reveals that majority of people are aware of existence of HIV/AIDS CTCs found in different public and private hospitals. However, not all people who are aware of these HIV/AIDS CTCs are comfortable and ready to visit them for accessing the HIV/AIDS related information. A significant portion of people indicated that they are not comfortable visiting them, citing that they are scared of being exposed and/or stigmatized. These findings support a number of previous studies which showed that fear of stigma is still among the challenges in delivery of HIV/AIDS healthcare information [3-5]. Furthermore, [3] described that among different factors for fear of stigma among PLHIV, 37.4 percent fear for unethical treatment of PLHIV and 31.1 percent for unofficial disclosure of their health status.

Moreover, this study finds that there is a massive increase in number of people who seek the HIV/AIDS related information from the internet sources. [6] stipulated that there is a considerably people's high effort to access to internet-based HIV information. Some previous studies indicated that Internet technologies improvements have vastly increased access of healthcare information [36-39]. This could be highly contributed by the massive increase in penetration and usage of Internet services, and mobile phones as well [9, 40]. Additionally, this study evidently shows that majority of people own mobile phones and in particular at least one smart phone. These findings are in line with the communication statistical report of December 2017, which shows a massive increase in usage of mobile communication and internet access penetration of equivalent to 80 percent and 40 percent respectively [9, 40]. Surprisingly, this study shows that the usage of the tradition ICT such as radio for accessing the HIV/AIDS health information has sharply diminished. This is in contrary to previous studies, which indicated the majority of people depended on the healthcare information from personal contacts at the HIV/AIDS CTCs and through radio programs [33, 41-43].

Furthermore, the study reveals that majority of people believed that they could access reliable HIV/AIDS healthcare information through the mobile application platform. The study reveals that the education level and ownership of mobile phones have played a significant role in influencing people's need for mobile application platform. The need of having a mobile application platform for HIV/AIDS healthcare information delivery was even supported by the HIV/AIDS healthcare practitioners during this study. In additional, the study findings have particularly shown that majority of the HIV/AIDS healthcare practitioners have the capacity to

provide the HIV/AIDS healthcare information through online means. However, the lack of computer facilities in some of their healthcare centers is still a challenge.

## VII. CONCLUSION

This study has found that the ever-growing usage of mobile telephony and particularly internet can be useful for HIV/AIDS healthcare information delivery. Majority of people who participated in this study suggested that there is a need of having a mobile application platform for HIV/AIDS healthcare information delivery. This need was even supported by the HIV/AIDS healthcare practitioners with this very study. The HIV/AIDS healthcare practitioners also implied there is a need for having a mobile application platform for disseminating HIV/AIDS healthcare information; and even suggesting that they were ready to offer this service online.

The study findings imply that the usage of ICT, especially the mobile technology is essential in providing the healthcare information. The mobile application platform will consequently help people to confidentially access the HIV/AIDS healthcare information in their mobile electronic gadgets frequently without fear of being exposed as if they would frequently visit CTCs. This subsequently improve the time and quality access to the healthcare information; and inspiring the change of behavior to strengthen disease prevention. Specifically, dissemination of HIV/AIDS healthcare information must line up the use of internet and mobile phones for broader coverage and impact. This usage of mobile health (m-health) technology is important especially in this communication era where by the majority own mobile gadgets with internet capabilities.

Healthcare providers, the ministry of health and all other stakeholders in fighting against HIV/AIDS should work on these findings and therefore develop a mobile application for HIV/AIDS healthcare information delivery. The mobile application platform developed should be made aware to the public in order to easy their hustle of seeking HIV/AIDS healthcare information. The developed mobile application platform should be simple, user friendly and available in local language, such as Kiswahili in Tanzania. Since the personal medical information is very sensitive data, this research recommends that the developed mobile application platform should handle the personal healthcare and healthcare information with maximum confidentiality.

## VIII. STUDY LIMITATIONS

This study considered only respondents whom with their consent were mentally and physically free and ready to participate. The study excluded people who were hesitant and those who indicated negative attitude towards this kind of studies, this was done to avoid responses which are not genuine. The study also excluded the critically sick people whom might be influenced by the health situations. Future studies should emphasize on



assessment of the impact of the online provision of the HIV/AIDS healthcare information; and make the comparison with the impact of accessing the same information through visiting the traditional HIV/AIDS CTCs. The future studies can also consider to have a modified research design that can comprise of both qualitative and quantitative methods in order to have a concrete description of study and their findings.

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# HIV/AIDS Healthcare Information Delivery in Tanzania using Integrated Mobile Application and Web-based System: System's Functional and Non-functional Requirements

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**Abstract**—This study examines the functional requirements (FR) and non-functional requirements (NFR) for development of an integrated mobile application and a web-based system for enhancement of HIV/AIDS healthcare information delivery in Tanzania. The study was conducted in Dar es Salaam city in Tanzania. The unstructured interview was carried-out involving 45 people, among them, there were selected relevant users of the proposed system, Information Technologists, System Administrators and HIV/AIDS healthcare practitioners from the HIV/AIDS Care and Treatment Centers (CTCs) in district referral hospitals in Dar es Salaam. The captured requirements were classified into functional and non-functional requirements, the functional requirements were then graphically analyzed using the use case diagram, which was done by using starUML computer software. These findings can be used as the foundation's building block for the development of a mobile application and web-based system for HIV/AIDS healthcare information delivery services.

**Index Terms**—Mobile Health (m-health), HIV/AIDS Healthcare Information, Online HIV/AIDS Healthcare Information, Functional Requirements, Non-functional Requirements.

## I. INTRODUCTION

The ever-increasing developments in the field of Information and Communication Technologies (ICT) such as mobile technologies have transformed how people access, share and use information in our societies [1]. The mobile technology is the technology of using cellular communication system for transferring of a specific information to the intended recipient(s). There has been a widespread usage of mobile technology as a

vital medium for accessing and dissemination of information in various sectors such health, finance, and security and control systems. Mobile Technology has become the powerful communication and behavioral change tool due to its extensive availability and coverage; and inexpensiveness of mobile gadgets [2]. The ever-increasing development in the field of ICT have transformed how people access, share and use information in our societies [1]. The evolution of mobile technologies and mobile devices has been among the contributing factors in the transformation of how information is accessed, shared and used. The advancement of mobile devices such as mobile phones and tablets has been a global phenomenon with mobile phone ownership surpassing computer ownership in many countries [3]. The widespread of mobile phones especially the smart-phones, has significantly led to an increase in advanced mobile applications for providing access to various information that are needed by the community [4].

In Tanzania, there is a diverse usage of mobile technologies such as mobile health (m-health), mobile money transactions (example M-Pesa), and mobile banking. Compared to the other media in the health sector, the mobile technology has been the fastest growing media recently [5-7]. The use of the mobile technology in health sector has directly targeted the general public. There is a mounting evidence that reveals the potential of mobile communications to fundamentally improve healthcare services especially in remote as well as in resource-scarce areas [8]. This has been conducted through engaging all health stakeholders, and consequently improving the time and quality access to the health-related services and information as well as inspiring the change of behavior to strengthen disease prevention [2, 9].

There is a need of extending the use of the mobile

technologies in fighting against the Human Immunodeficiency Virus infection and Acquired Immunodeficiency Syndrome (HIV/AIDS) in Tanzania. [10] recommended that the HIV/AIDS public care providers, and the HIV/AIDS Care and Treatment Centers (CTCs) to use the electronic media to provide access to relevant and formal HIV/AIDS healthcare information. Particularly, healthcare information delivery for HIV care and treatment should make use of internet and mobile phones to reach many people for broader coverage and impact. This implies the usage of mobile and web-based application for enhancing the dissemination and delivery of HIV/AIDS healthcare information is the way forward.

When developing the mobile and/or web-based application for the delivery of HIV/AIDS healthcare information, the first stage in the system development is to well analyze, generate and document the desired specifications or requirements. System requirements are description or statements of a function, features or conditions that a user seeks to have implemented in a system and so the developer has to implement into his/her system [11]. The requirements specification process highly rests on the information flow to allow the communication between all sets of users and system developer so as to implement the right system [12]. The system requirements specification serves as the foundation for designing, implementation, testing and maintenance of the developed system [13]. In system development, the requirements are generally categorized into functional and non-functional requirements [11].

The functional requirements (FR) are requirements and/or services that a system should provide to the users and how the system should react to particular inputs from the users. Non-functional requirements (NFR) of the system are certain attributes which are the desired characteristics of the system [14, 15]. NFR is what systems users call the generic quality attributes of the system [13].

This paper assesses the functional requirements and non-functional requirements for development of the mobile application and web-based system for delivery of the HIV/AIDS healthcare information. Moreover, this study maps the specific requirements into the use case diagram and going further to suggest the conceptual framework for the mobile application and web-based system for HIV/AIDS healthcare information delivery.

The rest of this paper is arranged as follows: the second section describes the background information on the current situation of HIV/AIDS pandemic, healthcare information delivery and the fear of stigma as a major problem. The third section talks about related works of which the mobile technologies have been applied to facilitate the delivery of HIV/AIDS healthcare information. The detailed research study design and methods used from the data collection, data analysis to results presentation have been explained in section four. Sections five provides the detailed explanation of the findings and discussion. Finally, the conclusion has been drawn in section six.

## II. BACKGROUND

HIV/AIDS has been one of the most killing global pandemics to date, with approximately of 36.7 million people were living with HIV worldwide by 2015. Tanzania in particular, there were about 1.4 million people living with HIV (PLHIV), and around 36,000 deaths which occurred in 2015 were due to HIV/AIDS [16]. Tanzania currently has an HIV prevalence rate of 4.7 percent with statistics showing strong regional variation in Tanzania with Mbeya at 14 percent, Iringa at 13 percent and Dar Es Salaam at 11 percent leading in HIV prevalence [17,18].

Currently, all of the HIV/AIDS healthcare service including the healthcare information delivery are offered at the CTCs across the country. However, fear of stigma is still holding some people in the society from freely going to the Care and Treatment Centers (CTCs) to receive the HIV/AIDS related health services such as counselling, treatment and HIV/AIDS related information which can inspire the change of behavior to strengthen HIV/AIDS prevention [19-21]. The People Living with HIV Stigma Index indicates that roughly one in every eight-people living with HIV is being denied health services because of stigma and discrimination [17]. [19] described that among different factors for fear of stigma among PLHIV, 37.4% fear for unethical treatment of PLHIV and 31.1% for unofficial disclosure of their health status. This fear is due to the lack of a secured platform for accessing the HIV/AIDS healthcare information services. [10] recommended that the HIV/AIDS public healthcare providers, and the HIV/AIDS CTCs to use the electronic platform to provide a confidential access to relevant and formal HIV/AIDS healthcare information. Despite the need for the m-health platform for enhancement of HIV/AIDS healthcare delivery, there is no any m-health platform for dissemination of HIV/AIDS healthcare information in Tanzania to date. The electronic systems' developers seem to not have the system's requirements as the foundation to build the m-health system for HIV/AIDS healthcare information delivery.

This research study assesses the important requirements; both functional and non-functional requirements for developing a mobile application and web-based system platform for delivery of HIV/AIDS healthcare information. System requirement engineering is a critical stage of software development cycles that defines the services that the system is to provide and its operational constraints [22].

## III. RELATED WORKS

In this section, the review of the similar platform for delivery of HIV/AIDS healthcare information is conducted. Furthermore, this paper also reviews a similar study on the system requirements for development of health information delivery system.



#### A. Similar Platform for HIV/AIDS Healthcare Information Delivery

In 2001, the National AIDS Helpline was launched and is being operated by Tanzania Youth Alliance (TAYOA) using a Treatment toll free Hotline (also known as *117 Afya Treatment*) [23-24]. The system delivers the HIV/AIDS healthcare information through phone calls. However, '*117 Afya Treatment*' system has encountered some challenges such as maintaining the user's confidential identity (or anonymity), since the use of the person mobile phone number risks to reveal his/her identity. Moreover, the system does not establish the client's medical profile with his/her clinical consultation history for future references by both HIV/AIDS practitioner and client himself/herself.

Since the platform risks to reveal the client's identity through his/her registered phone number and considering how the HIV/AIDS is the complicated disease with a lot of people fear of being identified and then being stigmatized [19-21] while using such platform. Therefore, this paper stipulates the functional and non-functional system requirements for development of the secure online platform for delivery of HIV/AIDS healthcare information.

#### B. Similar Study on the Requirements for Health Information Delivery System

[25] provides the similar study by examining the system requirements for the delivery of nutrition information to both prenatal and postnatal mothers. These requirements are used for delivering nutrition tips and nutrition specific recommendations to the system's clients. [26] used those requirements in implementation of the NutriMobile system for delivery of nutrition information to both prenatal and postnatal mothers.

Moreover, there some other online platforms for healthcare services such as Mobile Alliance for Maternal Action (MAMA) and Healthy Pregnancy, Healthy Baby (HPHB) [27, 28]. However, there is no any online platform for delivery of HIV/AIDS healthcare information in Tanzania up to the present moment. [6, 29] show the need for online delivery of HIV/AIDS healthcare information as their studies show that majority of people tend to try to access the internet-based HIV information, HIV/AIDS clinical tips and recommendations.

## IV. METHODOLOGY

The gathering of requirements was conducted in the Dar es Salaam city in Tanzania. For gathering and collection of system requirements for the development of a mobile application, this region was suitable since it indicates the highest usage of internet and mobile services and platforms in the country (Ministry of Communications and Transport [30, 31]. Moreover, statistically, Dar es Salaam is the region which statistically indicated a high HIV prevalence of about 11% percent [18], as well as high levels of stigma per

PLHIV about 49.7% percent as compared to 39.4% percent from other regions [32].

This research employed a mixed research methodology during the collection of different relevant data for establishment of the functional and non-functional requirements. Before data collection, the stakeholder analysis was conducted. This analysis was carried-out in order to gather substantive knowledge on the relevant actors so as to capture their specific requirements need on the proposed online platform for delivery of HIV/AIDS healthcare information. Identification of the stakeholders was key in the data collection for establishment of the functional and non-functional requirements for the proposed online platform.

During the stakeholder analysis, this study adopted the modified framework of [33]. This framework maps the typical rationale for stakeholder analysis, topology and respective methods. In analyzing the stakeholders, the main emphasis was on identifying them and then identify their roles in the HIV/AIDS healthcare information flow. The stakeholder identification was carried through analyzing the official procedures by the authority, TACAIDS in handling the HIV/AIDS healthcare clinical information flow [34-36].

After the identification of all key actors, the system requirements were collected qualitatively. Qualitative data collection method was utilized, which consists of investigation for particular information using unstructured interview, casual talks and in-depth discussion [37]. This was conducted in the district referral hospitals in the city. The region is currently having four large district referral hospitals namely Mwananyamala Hospital, Temeke Hospital, Sinza-Palestina Hospital and Infectious Diseases Centre (IDC) each found in Kinondoni, Temeke, Ubungo and Ilala districts respectively. 45 people were interviewed on their consent, among them, there were relevant users of the proposed system, Information Technologists, System Administrators and HIV/AIDS healthcare practitioners in CTCs. These people were interviewed on the specific and general needs and requirements for the system. During the interview and discussion with them, the important system requirements were noted down for requirement specification. The collected information was then analyzed using the qualitative data analysis software, NVivo 11.

The captured requirements were analyzed using graphical languages based on the Unified Modelling Language (UML) rules and artefacts [38-40]. This was done using a computer software, starUML. StarUML was used for mapping the collected requirements into the use case diagrams of subsystems. The establishment of the use case diagrams were useful in developing the conceptual framework of the system.

## V. FINDINGS

#### A. Key players or actors.

The study established the key players or actors who are

involved in the process of dissemination of all kinds of HIV/AIDS healthcare information. The study came up with three different groups of actors such as clients who are ordinary people in need of accessing the HIV/AIDS healthcare clinical information for their health benefits; second group is the HIV/AIDS healthcare practitioners who are responsible for provision of all HIV/AIDS clinical information, consultations, recommendation and HIV/AIDS health tips; and the last group is made up of researchers, policy makers and other associated HIV/AIDS healthcare stakeholders who are in need of the accurate HIV/AIDS related data for further researching, further planning, and policy making and implementation.

**B. HIV/AIDS Healthcare Information Types**

There are different types of healthcare information such as appointment and medication reminders, general health tips, diagnostic information, symptoms and vital signs [41]. This study captured the key types of healthcare information which are provided or delivered by the HIV/AIDS CTCs. These healthcare information types include the provision of HIV/AIDS health tips, HIV/AIDS healthcare recommendations, HIV/AIDS clinical face-to-face counselling or consultation between the client and HIV/AIDS healthcare practitioner, and HIV/AIDS statistical reports. These services are to remain as the key services even when the HIV/AIDS healthcare information delivery is through the mobile application and web-based system. The key items for each of information type are as shown in the tables 1 to 4.

*HIV/AIDS Health Tip:* An HIV/AIDS health tip is a set of HIV/AIDS healthcare related information. These tips should be given by the qualified HIV/AIDS healthcare practitioners to the clients. Table 1 below shows the key items forming HIV/AIDS health tip and their respective data types.

Table 1. Key Items of an HIV/AIDS Healthcare Tip

Key Item	Data Type
Title/Subject	Text
Detail	Text
Category	Text
Date Posted	Date/Time (Timestamp)
Author ID or Name	Integer/Text

*HIV/AIDS Healthcare Recommendation:* An HIV/AIDS recommendation is a set of HIV/AIDS related information that is advised or proposed by an HIV/AIDS practitioner to a specific person/service client based on his/her previously described information. The key items forming an HIV/AIDS healthcare recommendation are shown in the table 2 below.

Table 2. Key Items of an HIV/AIDS Healthcare Recommendation

Key Item	Data Type
Title/Subject	Text
Detail	Text
Category	Text
Requester/Client ID	Integer
Date Requested	Date/Time (Timestamp)
Recommender (Practitioner) ID/Name	Integer/Text
Date Recommended	Date/Time (Timestamp)

*HIV/AIDS Clinical Counselling:* An HIV/AIDS clinical counselling or consultation involves the to-and-fro exchange of information between the client and HIV/AIDS healthcare practitioner. This has been done by directly face-to-face conversation between the client and healthcare practitioner in the consultation room. In developing the mobile application and web-based system, this should be implemented via the real-time message exchange.

Table 3. Key Items of an HIV/AIDS Clinical Counselling/Consultation Chatroom

Key Item	Data Type
Client ID	Integer
Practitioner ID/Name	Integer/Text
Message	Text
Date and Time	Date/Time (Timestamp)

*HIV/AIDS Statistical Reports:* These are reports of different statistical data based on the HIV/AIDS healthcare services. These reports are for providing information to help researchers, investigators and even the policy makers in making some critical decisions regarding the HIV/AIDS [42].

Table 4. Key Items of an HIV/AIDS Statistical Report

Key Item	Data Type
Title/Subject	Text
Detail	Text
Category	Text
Generation Date	Date/Time (Timestamp)

**C. Requirements Specification**

In this study, the gathered system requirements were grouped into functional and non-functional requirements. These are providing the guidelines for the implementation of the information system [13]. The tables 5 and 6 show the functional and non-functional requirements respectively.



#### D. Conceptual Use Case

Table 5 above, of functional requirements has shown how the different actors (system administrator, HIV/AIDS practitioner and client) interact. The interaction can further be analyzed using the use case diagram. Use case diagram designates the anticipated functionality of the system on the system user's point of

view; and interactions between users (external actors) and the system under consideration [39, 44]. At a high level of abstraction, Fig.1 and 2 show the complete functionality of the mobile application system for the HIV/AIDS healthcare information delivery. Fig.1 and 2 show the use case diagram for the system administration and mobile healthcare clinic subsystems respectively.

Table 5. Functional Requirements

Requirement	Description	Actor
Users Registration and Users' Accounts Management	All system clients must register themselves into the system, each of them must create his/her own user profile; with the system providing each of them with both username and password	Client
	All the HIV/AIDS healthcare practitioners must be registered in the system based on the qualifications and roles; the system should provide each of them with username and password	System Administrator
	The system should provide the system administrator with ability of deleting or suspending HIV/AIDS practitioner's account	System Administrator
Document Gallery Management	System administrator should manage the uploading, editing, and/or removing of documents such as announcements, guidelines and other documents in documents gallery	System Administrator
	The system should allow all registered and authorized users to view the posted system management related and/or HIV/AIDS related posted documents in the document gallery	All System's Users
Reports Generation	The system should be able to generate different reports for other stakeholders such as researchers and policymakers	System Administrator
Online HIV/AIDS Clinical Consultation	The system should allow the clients to get into an online consultation chatroom <sup>1</sup> and request for clinical attention from HIV/AIDS healthcare practitioners	Clients
	The system should allow the HIV/AIDS healthcare practitioners to interact and/or respond to consultation requests	HIV/AIDS Practitioners
HIV/AIDS Healthcare Tips	The system should allow the HIV/AIDS healthcare practitioners to upload, add, edit and/or remove the HIV/AIDS related healthcare tips	HIV/AIDS Practitioners
	The system should allow all the registered clients to receive and view the HIV/AIDS Healthcare tips	Clients
HIV/AIDS Healthcare Recommendations and Reminders	The system should allow the HIV/AIDS healthcare practitioner to set, edit and/or remove recommendation and/or reminders for a particular client based on his/her health status	HIV/AIDS Practitioners
	The system should allow all the registered and authorized clients to receive and view the HIV/AIDS healthcare recommendations, the recommendation history and/or timely reminders	Clients
Systems' Technical and User Support	The system should allow all users to request and receive the system usage support in case of any difficulties	All user
	The system should allow all the system administrators to support others users	System Administrator

<sup>1</sup> A consultation chatroom for real-time end-to-end conversation between a client and an HIV/AIDS healthcare practitioner through text messages.

Table 6. Non-functional Requirements

Requirement	Description
Security	<ul style="list-style-type: none"> <li>The system should authenticate all users before allowing them to interact with the system functionalities.</li> <li>The system should maintain password best practices such as maintaining maximum and minimum password age, password history, containing character mixing complexity of a predefined minimum length and employing encryption for password storage [43].</li> </ul>
Maintainability	The system should be easy maintained, i.e. the system should be able to add new functionality/features without any major redesign.
Responsiveness	Short response time is required by the system.
Scalability	The system should be easy scalable, i.e. increased depending on the demand.
Robustness	The system should have ability to continue function accurately if the something wrong happens or multiple requests are received at the same time.
Operating System	Mobile application based on Android platform. The web-based system should be cross-platform of all browsers.
Language	The system should be implemented in both English and Swahili (for local clients in Tanzania)

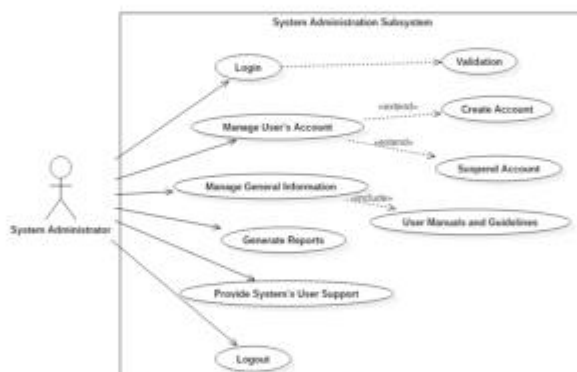


Fig.1. Use case diagram for the system administration subsystem

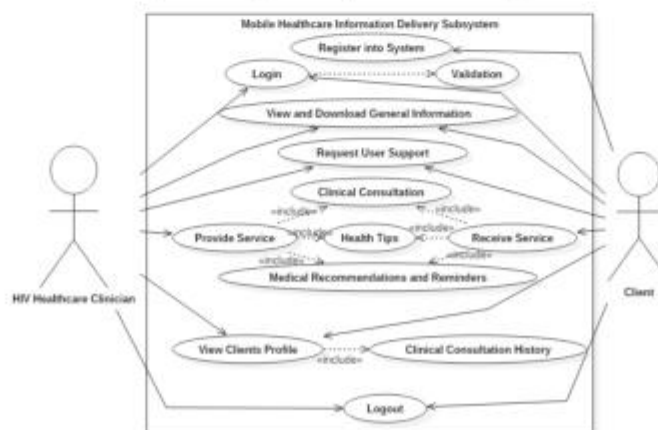


Fig.2. Use case diagram for mobile HIV/AIDS healthcare information delivery subsystem



### E. Conceptual System Framework

From the gathered and analyzed requirements above, the conceptual system diagram has been developed as seen in Fig. 3 below. The complete system will contain the application and database servers, client's user-end mobile application and/or the practitioner's web-based system and the internet connectivity infrastructure.

In Fig. 3 below shows that when the system platform is fully developed and hosted for online access then all the actors can use the system depending on their roles. The client is able to access the HIV/AIDS healthcare information through the developed mobile application via his/her mobile gadgets with internet capability. On the

other hand, the HIV/AIDS practitioners in the HIV/AIDS CTCs are providing the HIV/AIDS healthcare clinical information service through the online system using the computers in their workstations. Furthermore, the other HIV/AIDS healthcare stakeholders such as the Government, researchers, HIV/AIDS related Non-Government Organizations (NGO) who need the timely and relevant HIV/AIDS statistical data for fund raising, further researches, and policy making and implementation. These HIV/AIDS stakeholders can access these data through different reports which are generated by the system under the control of the system administrators.

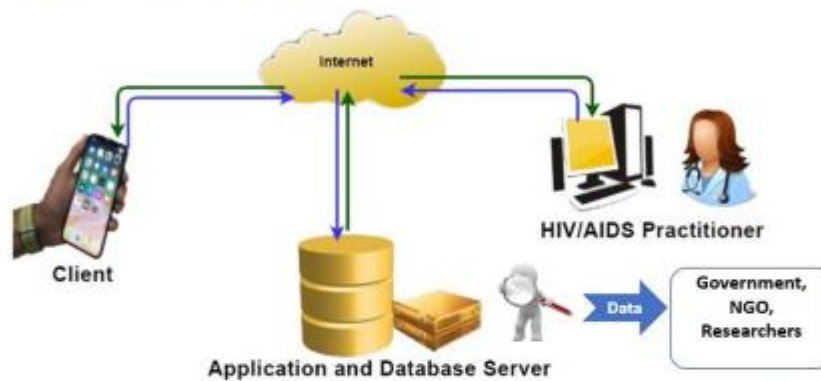


Fig.3. The Conceptual System Framework

### VI. CONCLUSION

This study was to identify the functional and non-functional requirements for the development of the mobile application and the web-based-system for the HIV/AIDS healthcare information delivery. These requirements were collected from the identified HIV/AIDS stakeholders. From the stakeholders, the functional and non-functional requirements were collected using the unstructured interviews, the collected qualitative information was analyzed using NVivo and modelled into use cases and conceptual framework using the starUML. These findings are essential to help the system developers in developing the secure m-health system for delivery of HIV/AIDS healthcare information.

HIV/AIDS healthcare providers, the ministry of health and all other stakeholders in fighting against HIV/AIDS can work on these findings as they provide the foundation for the development of a mobile application and web-based system for HIV/AIDS healthcare information delivery services. These online platforms planned to be developed can be made aware to the public in order to ease their hustle of seeking HIV/AIDS healthcare information.

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