

2020-02

# Enhancing maternal, newborn and child health support services using an interactive mobile application

Mramba, Bernard

NM-AIST

---

<http://doi.org/10.58694/20.500.12479/903>

*Provided with love from The Nelson Mandela African Institution of Science and Technology*

**ENHANCING MATERNAL, NEWBORN AND CHILD HEALTH  
SUPPORT SERVICES USING AN INTERACTIVE MOBILE  
APPLICATION**

**Bernard Patrice Mramba**

**A Dissertation Submitted in Partial Fulfilment 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 2020**

## ABSTRACT

Reducing maternal and infant deaths rates in developing countries, particularly in sub-Saharan Africa, remains a challenge. Among the interventions to address the challenge is mHealth. MHealth interventions are associated with positive healthcare outcomes such as in improving clinical attendance, skilled delivery and reducing mortality. However, there is slow adoption of mHealth applications in Tanzania. Factors hindering the use of mHealth are technology exposure and language barrier. This study provides a way to address the challenges by adopting interactive features in a mobile app solution which are successful in social networking and e-commerce apps. Such features may help a patient access services before reaching health facility, hence reducing the risk of maternal and infant deaths during emergency. We adopted a case study approach at Mwananyamala and Temeke hospitals. Respondents expressed readiness in appropriate mobile device ownership and willingness to use the mobile app. The mobile app was developed using the Rapid application development model. Different tools and languages such as Unified Modelling Language (UML), Java, XML, PHP programming language, and MySQL database management system were used. The app was tested colleagues at Nelson Mandela African Institution of Science and Technology, followed by user's validation at Temeke and Mwananyamala Hospitals. We, recommend enhancement and deployment of the app to users. Since users still view SMS as the preferred feature, future works may integrate this app with text messages. In addition, the government and other stakeholders should adopt innovative methods and efforts aimed at reducing maternal mortality and infant mortality, such as by providing smartphones pregnant women and infant mothers.

## DECLARATION

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

Bernard Patrice Mramba

---

**Name and Signature**

**Date**

I confirm the above declaration

Shubi Kaijage

---

**Name and Signature of Supervisor**

**Date**

## **COPYRIGHT**

This dissertation is copyright material protected under the Berne Convention, the Copyright Act of 1999 and other international and national enactments, in that behalf, on intellectual property. It must not be reproduced by any means, in full or in part, except for short extracts in fair dealing; for researcher private study, critical scholarly review or discourse with an acknowledgement, without a written permission of the Deputy Vice Chancellor for Academic, Research and Innovation, on behalf of both the author and the Nelson Mandela African Institution of Science and Technology.

## CERTIFICATION

We certify that we have read and found the dissertation acceptable by the Nelson Mandela African Institution of Science and Technology.

Shubi Kaijage

---

**Name and Signature of Supervisor**

**Date**

## ACKNOWLEDGEMENT

All Praise is to the Lord, God Almighty, for the strength of spirit and body, and protection throughout my academic journey at the Nelson Mandela African Institution of Science and Technology (NM-AIST). Also, I thank all my family members for your patience and prayers when I was away for my studies.

It was a great honour and privilege work under the guidance and support of my supervisor Dr. Shubi Kaijage. The experience was indeed useful and transformative for the journey ahead. I truly appreciate your constant reminders and encouragement throughout the study.

My sincere gratitude goes to my sponsors Mzumbe University and African Development Bank (AfDB) Programme at the Nelson Mandela African Institution of Science and Technology. I particularly thank Mzumbe University management for agreeing to pay for my second year of my studies.

The journey at NM-AIST was an exciting one, with lots of opportunities. My sincere gratitude for the opportunity to demonstrate the developed mobile app during this research at TCU and Nane Nane exhibitions. I was delighted to be part of the NM-AIST winning team during Nane Nane Exhibitions.

I further acknowledge the technical advice and mobile application development training received from Mr. Denis Minja of Mobile Boot Camp Initiative (MBI) during the development and testing phase of the mobile app. The training and the technical support was indeed useful and made possible the app to be available at the right time. Also, I acknowledge the support received during data collection and the app evaluation exercises from nursing officers at Temeke and Mwananyamala hospitals.

Words of encouragement and necessary assistance from my classmates, NM-AIST staff, and services received from members of the surrounding community made my journey at NM-AIST very memorable. I will always cherish the unique environment and culture at NM-AIST especially hard work and community engagement.

## **DEDICATION**

To the late mother Catherine C. Mramba. May her soul enjoy a happy abode.



## TABLE OF CONTENTS

<b>ABSTRACT</b> .....	<b>i</b>
<b>DECLARATION</b> .....	<b>ii</b>
<b>COPYRIGHT</b> .....	<b>iii</b>
<b>CERTIFICATION</b> .....	<b>iv</b>
<b>ACKNOWLEDGEMENT</b> .....	<b>v</b>
<b>DEDICATION</b> .....	<b>vi</b>
<b>LIST OF TABLES</b> .....	<b>xi</b>
<b>LIST OF FIGURES</b> .....	<b>xii</b>
<b>LIST OF APPENDICES</b> .....	<b>xiv</b>
<b>LIST OF ABBREVIATIONS</b> .....	<b>xv</b>
<b>CHAPTER ONE</b> .....	<b>1</b>
<b>INTRODUCTION</b> .....	<b>1</b>
1.1. Background of the Problem.....	1
1.2. Statement of the Problem.....	4
1.3. Rationale of the Study.....	4
1.4. Objectives.....	5
1.4.1. General Objective.....	5
1.4.2. Specific Objectives.....	5
1.5. Research Questions.....	5
1.6. Significant of the Study.....	6
1.7. Delineation of the Study.....	6
<b>CHAPTER TWO</b> .....	<b>7</b>
<b>LITERATURE REVIEW</b> .....	<b>7</b>
2.1. Maternal and Infant Mortality.....	7
2.2. State of Maternal, New-born and Child Health Support in Tanzania.....	7

2.3. Mobile Health Interventions for Maternal and Infant Mortality Reduction .....	9
2.4. Interactive Mobile Applications .....	10
2.5. Rapid Application Development Methodology.....	11
<b>CHAPTER THREE .....</b>	<b>12</b>
<b>MATERIALS AND METHODS .....</b>	<b>12</b>
3.1. Research Design and Study Area .....	12
3.2. Demographic Characteristics of Respondents .....	12
3.3. Data Collection Methods and Tools .....	13
3.4. Sample Size Determination and Sampling Technique .....	14
3.5. Statistical Analysis.....	14
3.6. Ethical Clearance and Consent .....	14
3.7. Software Development Approach.....	15
3.7.1. System Modelling .....	15
3.7.2. Mobile App Usability Testing and Validation .....	16
<b>CHAPTER FOUR.....</b>	<b>17</b>
<b>RESULTS AND DISCUSSION .....</b>	<b>17</b>
4.1. Currently Available Mobile Apps on Google Play Store .....	17
4.2. Mobile Phones Ownership and Mobile Internet Use.....	18
4.3. Mobile Apps for MNCH Support awareness and use .....	19
4.4. Mobile Apps for MNCH Support Features .....	22
4.5. System Modelling.....	23
4.5.1. Use Case Modelling .....	23
4.5.2. Data Flow Diagram .....	27
4.6. Requirements Analysis .....	31
4.6.1. Functional Requirements.....	31
4.6.2. Non-functional Requirements .....	31

4.7.	System Design .....	36
4.7.1.	Application Architecture .....	36
4.7.2.	Database Design .....	36
4.8.	System Implementation .....	39
4.8.1.	Android – Web application communication .....	39
4.8.2.	EXtensible Markup Language (XML) .....	39
4.8.3.	Java.....	39
4.8.4.	Hypertext Pre-processor (PHP) – Web Application .....	40
4.8.5.	MySQL.....	40
4.8.6.	Android App – MySQL Database Connectivity .....	40
4.8.7.	Smooch Platform for Instant Messaging (IM) .....	41
4.8.8.	Firebase .....	41
4.9.	Mobile Application Interfaces .....	42
4.9.1.	User Registration and Login .....	44
4.9.2.	Live Support Instant Messaging.....	47
4.9.3.	Latest News and Alerts .....	49
4.9.4.	Health Centres Directory.....	49
4.9.5.	Health Information Portal.....	51
4.9.6.	Application Settings .....	51
4.10.	System Testing.....	53
4.10.1.	Unit Testing, UI Testing and Integration Testing .....	53
4.10.2.	Usability Testing and Validation.....	54
<b>CHAPTER FIVE</b>	.....	<b>57</b>
<b>CONCLUSION AND RECOMMENDATIONS</b>	.....	<b>57</b>
5.1.	Conclusion .....	57
5.2.	Recommendations.....	58

<b>REFERENCES.....</b>	<b>59</b>
<b>APPENDICES.....</b>	<b>67</b>
<b>RESEARCH OUTPUT.....</b>	<b>100</b>

## LIST OF TABLES

Table 1: Demographic characteristics of respondents .....	13
Table 2: Android applications for health and fitness, and medical categories.....	17
Table 3: Mobile phones ownership and internet usage on mobile phones.....	18
Table 4: Functional requirements for an interactive MNCH support mobile app .....	32
Table 5: Non-functional requirement for an interactive MNCH support mobile app.....	35
Table 6: Mobile app testing report for key modules .....	54
Table 7: Mobile application evaluation results .....	55

## LIST OF FIGURES

Figure 1: Maternal mortality trends in Tanzania 1990 – 2015. ....	8
Figure 2: Infant mortality trend in Tanzania 1990 – 2015. ....	8
Figure 3: Rapid application development (RAD) model. ....	11
Figure 4: Respondents distribution by study area .....	12
Figure 5: Users awareness for MNCH support mobile application .....	20
Figure 6: Users experience in using MNCH support mobile applications.....	20
Figure 7: Users experience in receiving MNCH support through mobile app.....	21
Figure 8: Users likelihood of installing and using MNCH support mobile app .....	21
Figure 9: User’s preference for proposed features of MNCH support mobile application.....	22
Figure 10: Normal user use case diagram.....	25
Figure 11: Healthcare professional use case diagram .....	26
Figure 12: Administrator use case diagram .....	27
Figure 13: Context-Level data flow diagram for an interactive MNCH support mobile app...	29
Figure 14: Level-1 data flow diagram for an interactive MNCH support mobile app .....	30
Figure 15: The application architecture for an interactive NMCH support mobile app .....	37
Figure 16: ER diagram for MNCH support mobile application .....	38
Figure 17: Conceptual diagram for the mobile app and the web app data exchange .....	41
Figure 18: MNCH support mobile application main interfaces .....	43
Figure 19: User registration, login, and account activation interfaces in Kiswahili.....	45
Figure 20: User registration, login, and account activation interfaces.....	46
Figure 21: Live support (IM) interfaces.....	48
Figure 22: Latest news interfaces.....	49
Figure 23: Health centres directory and nearest health centres .....	50
Figure 24: Health information portal .....	51
Figure 25: Application settings interfaces.....	52

Figure 26: Poster presentation at the TCU and Farmers Day exhibitions 2018 .....102

## LIST OF APPENDICES

Appendix I-A: Research Questionnaire .....	86
Appendix I-B: Research Questionnaire Translated to Kiswahili.....	91
Appendix II: Usability Testing Questionnaire for MNCH Support Mobile App .....	98



## LIST OF ABBREVIATIONS

2G	Second Generation
3G	Third Generation
4G	Fourth Generation
ANC	Antenatal Care
API	Application Program Interface
APK	Android Package Kit
APP	Application
CDC	Center for Disease Control
CHW	Community Health Workers
DBMS	Database Management System
DFD	Data Flow Diagram
ER	Entity Relationship
GPRS	General Packet Radio Service
GPS	Global Positioning System
HMIS	Health Management Information System
HPHB	Healthy Pregnancy, Healthy Baby
HTTP	Hyper Text Transfer Protocol
ICT	Information and Communication Technology
IDE	Integrated Development Environment
IM	Instant Messaging
IMR	Infant Mortality Rate
ISP	Internet Services Provider
JSON	JavaScript Object Notation
MAMA	Mobile Alliance for Maternal Action
MBI	Mobile Bootcamp Initiative
MDG	Millennium Development Goals
MMR	Maternal Mortality Rate
MNCH	Maternal, New-born and Child Health
MSP	Mobile Services Provider
NBS	National Bureau of Statistics
NM-AIST	Nelson Mandela - African Institution of Science and Technology

OS	Operating System
PDA	Personal Digital Assistant
PHP	Personal Home Page
RAD	Rapid Application Development
SDK	Source Developing Kit
SMS	Short Message Service
SQL	Structured Query Language
TCRA	Tanzania Communications Regulation Authority
UML	Unified Modelling Language
URL	Uniform Resource Locator
USAID	United States Agency for International Development
USSD	Unstructured Supplementary Service Data
WHO	World Health Organization
XML	eXtensible Markup language

# CHAPTER ONE

## INTRODUCTION

### 1.1. Background of the Problem

Maternal mortality is defined as the death of women during pregnancy, delivery or within 42 days after birth. Maternal Mortality Rate (MMR) is maternal mortality per 100 thousand live births. On the other hand, infant mortality is defined as the death of infants of less than one year of age. Infant Mortality Rate (IMR) is infant mortality per one thousand live births. Maternal mortality and infant mortality remain among the significant healthcare challenges to the developing countries. For example, according to the World Health Organization (WHO) estimates, in 2015, the average MMR in developing countries was estimated at 239, versus 12 in the developed countries (WHO, 2015b). Furthermore, during the year 2016, an estimated 4.2 million infants died in the developing countries during their first year of life, accounting for 75% of deaths of all children aged less than five years worldwide (WHO, 2015a, pp. 71–98).

By the end of 2015, maternal mortality and infant mortality in three countries of the East Africa region stood at almost twice of the average maternal and infant mortalities of the developing countries. Based on recent nationally available data across East Africa, maternal mortalities per 100 thousand live births at the end of 2017 were 510 for Kenya, 556 for Tanzania and 343 for Uganda. These results are supported by other reports such as Tanzania demographic, health and malaria indicator survey of 2015-2016 (NBS, 2016), the 2016 Kenyan Demographic and Health (KNBS, 2015) and Uganda reference table of demographic indicators (UBOS, 2016).

Therefore, it is evident that number of maternal and infant deaths in Tanzania and across the East Africa region is much higher compared to other developing countries in other regions outside Sub-Saharan Africa. It is estimated that 99% of all maternal and infant deaths occur in low- and middle-income countries. However, due to recent economic advances in Asia, these figures do not necessarily reflect the current situation. Recent data show during the last decade maternal mortality and infant mortality have remained high in few countries located in Sub-Saharan Africa.

Many interventions have been used throughout the healthcare system to reduce maternal and infant deaths. Among them are electronic health (e-health) solutions (Piette *et al.*, 2012). E-health interventions are among the proposed potential interventions due to their accessibility by the majority of the population. One of the e-health solutions is mobile health (mHealth).

Skiba (2014) defined mHealth as a medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices. Mobile Health solutions use cellular phones' core functions of voice, text, and multimedia to exchange healthcare information. Besides, mHealth uses various telecommunications services, such as general packet radio services (GPRS), second, third and fourth generations of mobile telecommunication (2G, 3G, and 4G technology), global positioning systems (GPS) and Bluetooth. Mobile Health was found useful in improving patient-healthcare provider communication, managing healthcare information, and providing drug reminders to patients (Anshari & Almunawar, 2016). Beratarrechea *et al.* (2014) suggests that, by using mHealth healthcare providers can extend their services to more users, thereby attempting to achieve the main mHealth goal of making healthcare services accessible anywhere, anytime.

Mobile Health has received growing attention from researchers, academia, and industries worldwide. Several studies in the developed countries have shown positive impacts, such as in improving healthcare provider-patient communication and assisting in disease management (Berrouguet, Baca-García, Brandt, Walter & Courtet, 2016). Similar studies from developing countries have also shown positive outcomes. In one particular case in Zanzibar, an short message services (SMS) application was found to significantly reduce perinatal mortality (Lund *et al.*, 2014b) and improve antenatal care attendance (Lund *et al.*, 2014a). As a result, several mHealth projects were implemented in Tanzania and neighbouring countries. Some of these projects are: an e-health solution for monitoring malaria diagnostic tests in remote areas in Uganda (Lee *et al.*, 2011), mHealth solution for reducing delay in transferring HIV tests to remote health facilities in Zambia (Seidenberg *et al.*, 2012) and mHealth intervention for improving communication between community health workers in Malawi (Lemay, Sullivan, Jumbe & Perry, 2012).

Other mHealth projects were for improving clinical education, decision making, and patient adherence in Botswana (Littman-quinn *et al.*, 2011), monitoring pregnancy using SMS system in Rwanda (Ngabo *et al.*, 2012), and improving pregnancy and delivery skilled attendance using SMS reminders in Zanzibar (Lund *et al.*, 2012). Moreover, a desk review conducted by Barnett and Srivastava (2017), identified 31 active mHealth services in Tanzania dealing with maternal and child health. Some of the projects are Wired Mothers Initiative, Child Count++, and Healthy Pregnancy, Healthy Baby (HPHB). Wired Mothers Initiative and Child Count++

programmes were SMS programmes that aimed at linking mothers to healthcare providers and assist communities in improving child survival. The two projects targeted a single geographic area each. Healthy Pregnancy, Healthy Baby is an ongoing program funded by the Center for Disease Control (CDC), United States Agency for International Development (USAID), John Hopkins University, and other donors. Healthy Pregnancy, Healthy Baby runs the “*Wazazi Nipendeni*” campaign (Kiswahili meaning “*Parents love me*”), which provides free text messages in Swahili to pregnant women, mothers with newborns of up to 16 weeks old and their supporters.

MHealth initiatives for maternal, newborn and child health (MNCH) support in Tanzania have preferred SMS service over smartphone-based applications. Short messages services is a basic feature available to all mobile phones. Mobile telecommunication companies in Tanzania offer SMS service at little cost, thus making SMS based projects easy to launch and support. The absence of applications that have targeted smartphones owners may indicate that smartphones are still perceived as gadgets for the middle income and the rich. However, recently, smartphones prices have significantly dropped, making them affordable for the majority of the population, irrespective of their income. Studies by Neumann (2015) and Poushter (2016) show a growing smartphones ownership and internet penetration in Tanzania. Also, the Tanzania Communications Regulatory Authority (TCRA) estimated that around 19 million people accessed the internet through their mobile phones during the year 2017 (TCRA, 2017). Such growth of smartphones and internet penetration opens another opportunity for smartphones based mobile applications in Tanzania and other developing countries.

This study proposes an interactive mobile application for providing support for MNCH support in Tanzania. The application consists of six modules, namely live chat, directory, healthcare information portal, reminders, latest news, and discussion forum. This application aims to enhance support services using interactive features. It provides users with interactive features that allow healthcare providers to engage with patients before they arrive at a health facility, defines reminders of important events, discovers health centres nearby, and participate in discussions relevant to pregnancy, neonatal and infant care. Moreover, it allows users to choose a preferred language (Kiswahili or English) during the installation of the mobile application on their mobile phone.

## **1.2. Statement of the Problem**

Despite the rapid proliferation of mHealth mobile applications, only a few address healthcare challenges in the developing countries, such as for reducing maternal and infant deaths. The available mHealth applications have focused on healthcare information dissemination and SMS based reminders. Interactivity features that have been widely adopted in e-commerce, e-learning and online collaboration are rarely applied in mHealth (Blasco-Arcas, Hernandez-Ortega & Jimenez-Martinez, 2014; Chu & Yuan, 2013; Sun & Hsu, 2013). The review of mobile applications for maternal, newborn and child health (MNCH) support in Tanzania revealed the availability of several functionalities such as SMS based reminders, health information collection and dissemination. However, little is offered as of interactivity, for example, real-time communication between healthcare providers and patients.

Another barrier to slow adoption of mHealth applications in Tanzania is the language barrier. Majority of Tanzanians use Kiswahili as their medium of communication, while very few mHealth apps on google apps store have Swahili language support. As a result, the available English language mHealth mobile applications are accessible to only a few potential users (O' Connor & O' Donoghue, 2015). Avenue for higher levels of interactivity and personalisation are yet to be fully exploited. Due to this limited interactivity, the implemented mobile applications may not fully realise the potential benefits offered by the growing ownership of smartphones and mobile phones in Tanzania. Therefore, this study is aimed at developing an interactive mobile application for enhancing MNCH support services in Tanzania.

## **1.3. Rationale of the Study**

Maternal and infant mortalities in Tanzania are higher than the average mortality estimates of the other developing countries (NBS, 2016; WHO, 2015b). Technology intervention have been recognized as a way of improving healthcare services, therefore with a potential for reducing MMR and IMR. One of these technologies is the mobile phones based technologies. The increasing mobile phones ownership in Tanzania (TCRA, 2017) provides an important avenue for improving access to healthcare using mobile phones. A number of mobile phones based solutions such as information dissemination and SMS reminder applications have been implemented. Several studies have found these applications have an impact in improving health care (Lund *et al.*, 2014b). The assumption of this study is that the utility and viability of these applications as a means of reducing MMR and IMR can be enhanced by incorporating interactivity features. Such features can facilitate access to healthcare by increasing user control of the features of the technology, enabling user to

define preferences and linking users to health care professionals. Customization interactivity feature can help in addressing specific user needs of a user based on her preferences. Passive and active context awareness interactivity features can enable a healthcare professional respond to a patient and address patient needs in an active context and in real time.

## **1.4. Objectives**

### **1.4.1. General Objective**

The primary objective of this study is to develop an interactive mobile application that will provide support for maternal, newborn and child health support services in Tanzania.

### **1.4.2. Specific Objectives**

The specific objectives of this study are:

- (i) To review different mHealth interventions for providing MNCH support services in Tanzania.
- (ii) To assess the readiness of users to adopt mHealth applications for NMCH support services in Tanzania.
- (iii) To develop a mobile application for providing interactive support for MNCH support services in Tanzania.
- (iv) To validate the mobile app for MNCH support services at two selected health centres in Dar es Salaam Tanzania.

## **1.5. Research Questions**

How to improve MNCH support in Tanzania using smartphones based interactive mobile application?

- (i) What are mobile phones based health interventions aiming at providing MNCH support services in Tanzania?
- (ii) Are users ready to use smartphone-based mHealth applications in Tanzania?
- (iii) How can an interactive mobile application for providing MNCH support services be developed?
- (iv) How did the developed interactive mobile application for MNCH support services meet the end user's requirements?

## **1.6. Significant of the Study**

Maternal mortality and infant mortality in Tanzania remains high compared to the average mortality estimates of the developing countries (NBS, 2016; WHO, 2015b). Technology interventions, particularly mHealth, have been recognised as another way of improving MNCH support services, thereby reducing MMR and IMR. The increasing internet penetration and mobile phones ownership in Tanzania as reported by TCRA (2017) provides another avenue for improving access to healthcare. Several applications dealing with information dissemination and SMS reminders have been implemented (Lund *et al.*, 2014b). The utility of these applications as a viable intervention in reducing MMR and IMR can be further improved by incorporating interactivity features. Interactivity improves access to healthcare by increasing user control, enabling user to define preferences and by linking a user to health care providers. Interactivity features can help in addressing the specific needs of an individual based on her defined preferences. Passive and active context awareness interactivity features can enable a healthcare professional to respond to a patient and address problems in an active context and in real time.

## **1.7. Delineation of the Study**

This study considered users with Android smartphones. The choice is based on the trends for internet usage and mobile subscription which show that smartphones ownership rapidly increasing in rural areas (Neumann, 2015; Poushter, 2016). Majority of user in rural areas either do not have smartphones or cannot afford the costs of internet service offered by mobile phones operators. However, the recent data show that smartphones ownership and internet access using mobile devices is increasing. This research considers the potential of smartphones in reducing MMR and IMR in urban areas, while considering the trends in mobile phones ownership across the country.



## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1. Maternal and Infant Mortality**

Maternal Mortality is the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and size of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes (Alkema *et al.*, 2016) Maternal Mortality Ratio (MMR) is the ratio of maternal mortality per 100 thousand live births. Infant mortality is defined as the death of an infant baby during the first year of its birth. The infant mortality rate (IMR) is the number of infant deaths per one thousand live births (WHO, 2006).

Statistics of IMR and MMR are essential in the determination of the general health of a population at national, regional, or ethnic/racial groupings levels. For example, IMR is often used as an indicator of the health and wellbeing of a nation because of the interrelationship between factors that impact the health of entire populations and those that impact the health of infants (Kronenfeld, 2016). Following the global interventions, such as the worldwide initiatives aimed at reducing maternal and infant deaths, and requirements from the millennium development goals (MDG), IMR and MMR have declined significantly worldwide since the 1990s (WHO, 2015b). The trend has similarly declined in Tanzania because of various interventions by many stakeholders, including the government.

#### **2.2. State of Maternal, New-born and Child Health Support in Tanzania**

Maternal mortality and infant mortality in Tanzania have been slowly declining from the past one and a half decade. However, when compared to the MDGs targets, the rate of decrease is still insufficient. For example, the MDGs four and five required countries to reduce IMR and MMR by 67% and 75% respectively between 1990 and 2015 (UNDP, 2010). The decline is recorded in Tanzania is evidently slower compared to other developing countries decline rates. Figures 1 and 2 below show the trend for MMR and IMR in Tanzania from 1990 to 2015 (WHO, 2015b).

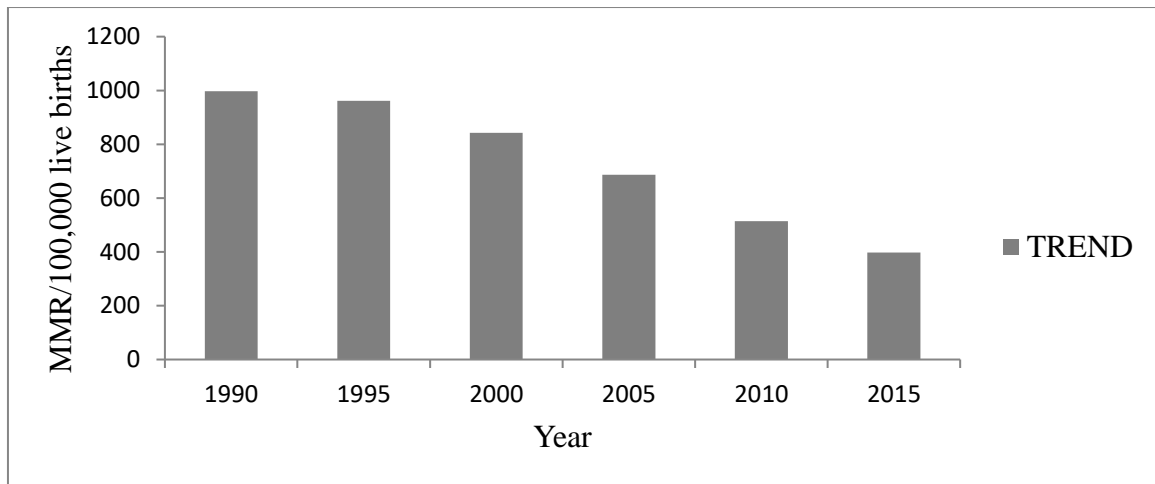


Figure 1: Maternal mortality trends in Tanzania 1990 - 2015. Source: (WHO, 2015)

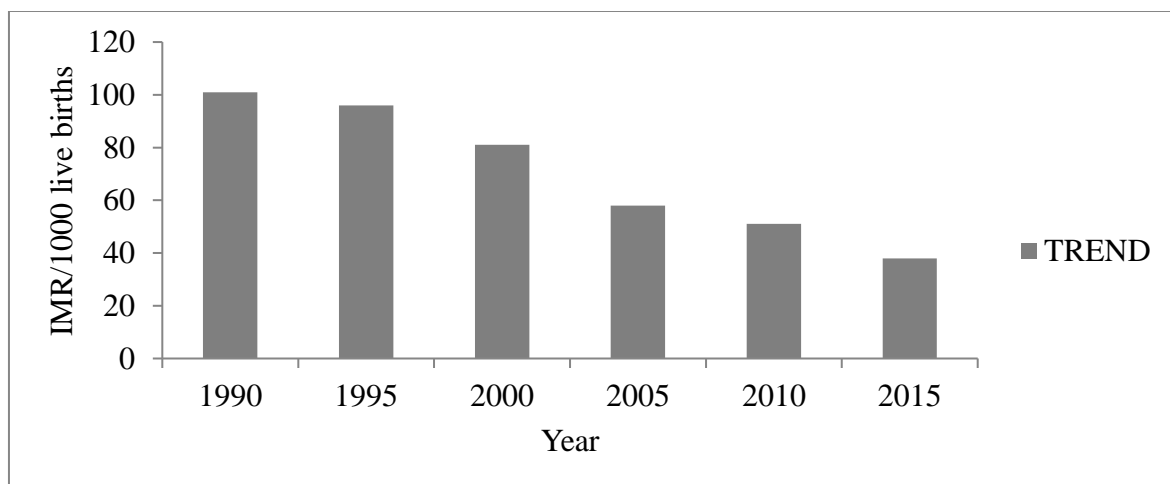


Figure 2: Infant mortality trend in Tanzania 1990 – 2015. Source (UNICEF, 2016)

Figures 1 and 2 above show that MMR and IMR in Tanzania declined significantly. However, the decrease did not meet the targets set by the MDGs. In addition, recent data from the 2012 nationwide census shows that Tanzania has IMR of 51 and MMR of 398 (NBS, 2016) which are still high compared to the other developing countries.

Empirical evidence shows that the major contributing factors to the high MMR is the failure for pregnant women to access health facility promptly when care is needed. This delay, may be due to inability to recognize the need for health care and making decision to seek care, delay to arrive at a health facility, or receiving inappropriate and inadequate care at the health facility (Noordam, Kuepper, Stekelenburg & Milen, 2011). Other factors are unequitable access to

healthcare, persistent poverty and inadequate healthcare staff capacity (Shoo, Mboera, Ndeki & Munishi, 2017), poor access to and low utilization of skilled birth attendance during pregnancy, childbirth, and the postnatal period; limited availability of basic emergency obstetric care, which can save women's lives in the event of serious medical complications; delay in seeking skilled care; and limited national commitment of resources for maternal health (Shija, Msovela & Mboera, 2011).

Therefore, using the above statistics, it is evident that more efforts are needed in different fronts especially in addressing infrastructural and health systems related challenges in order to reduce infants and mothers deaths. One potential technological intervention is mobile phone supported mHealth applications. are among the promising interventions along with other efforts from different stakeholders and policy improvements by the government.

### **2.3. Mobile Health Interventions for Maternal and Infant Mortality Reduction**

With the advancement of information and communication technology (ICT) and the widespread use of mobile phones, several solutions based on mobile phones have been developed. Nyamawe and Seif (2014), reviewed several projects and mobile applications developed and used in Tanzania. Among the reviewed applications is "Wired-mothers". This project used mobile phones to send reminders for clinical attendance text messages to pregnant women and mothers in Zanzibar. Another application is "HPHB text messaging service", which was launched by Mobile Alliance for Maternal Action (MAMA) in collaboration with several other development partners in Tanzania. This project aimed at delivering high quality antenatal care (ANC) information during pregnancy and 16 weeks after delivery. In addition, a mobile phone-based tool used by Community Health Workers (CHWs) in Singida districts was found. The tool was launched and sponsored by D-Tree International and World Vision Tanzania. It helped community health workers provide preventive care and proactive monitoring of pregnancy related threatening signs to pregnant women (Nyamawe & Seif, 2014). Several other mobile phone-based solutions and tools have focused on gathering, collecting, and exchanging health information, as well as in delivering community-based healthcare services.

The proliferation of mobile applications for healthcare has been nearly exponential. For example, a simple search on the Apple's iTunes Apps Store on 15 January 2014 for the keyword "weight loss," in the research by Boudreaux *et al.* (2014) generated 3800 applications. The

number of healthcare apps in the categories of health, fitness and medical on Google Play Store and Apple's iTunes reached 325 thousand by the end of 2017 (Research2Guidance, 2017). Despite this rapid proliferation of mHealth mobile applications, very few of these apps are in actual use in Tanzania. Majority of these applications are developed, maintained and updated according to the needs of consumers in developed and developing countries that differ in several aspects from Tanzania.

Causes of slow adoption of mobile applications for health in Tanzania are related to customary practice of generally using Kiswahili in daily activities, limited practice of the English language and low technological exposure. For example, most Tanzanians generally communicate fluently in Kiswahili language, while the available applications with Kiswahili language support in the leading apps repository (Google Apps Store) are just a few. As a result, accessibility of apps becomes limited to a few individuals (O' Connor & O' Donoghue, 2015). Another barrier to the uptake of the smartphones based mobile applications is limited interactive features. Interactivity enables users to engage in real- or delayed-time communication, allowing sharing of text or several multimedia formats. Other features in an interactive application may include a discussion forum, mLearning with questions and answers, context awareness such as location context and nearby hospitals discovery (Blasco-Arcas *et al.*, 2014). Interactive features make it easier for patients to communicate with healthcare professionals in real or delayed time, discover nearby hospitals and get to know services offered at hospitals before arrival, set reminders, and interact with other users through the discussion forum and questions and answers.

#### **2.4. Interactive Mobile Applications**

Rice (1984) defines interactivity as the capability of a computer-enabled communication system to permit the exchange of roles between sender and receiver in real or delayed time so that communicators have more control over the structure, pace, and content of the communication. Recent research show that interactivity is an essential component in web and mobile applications. For example, a large number of mobile applications have used interactive features in e-commerce (Cyr, Head & Ivanov, 2009; Jiang, Chan, Tan & Chua, 2010; Sun & Hsu, 2013), eLearning and online collaboration (Blasco-Arcas *et al.*, 2014; Sun & Hsu, 2013). In addition, recent studies show that interactive features are increasingly being recognised as a useful in many industries, particularly in healthcare. More evidences emanate from studies such as Hashim (2016), which proposed taxonomy for interactive health applications, and Heffernan *et*

al. (2016) which proposed guidelines and recommendations for the development of interactive eHealth applications.

## 2.5. Rapid Application Development Methodology

The objectives of rapid application development (RAD) are to obtain high-quality software systems much faster and at a lower cost (Pawar, 2015). Rapid application development uses incremental and prototyping approach to generate phased deliverables. Prototyping allows development of system iteratively. Developers after initial investigation develop a working prototype of the system and then discuss it with the users for further enhancement. The process is repeated several times until users are satisfied with the system. Figure 3 below shows the rapid application development model.

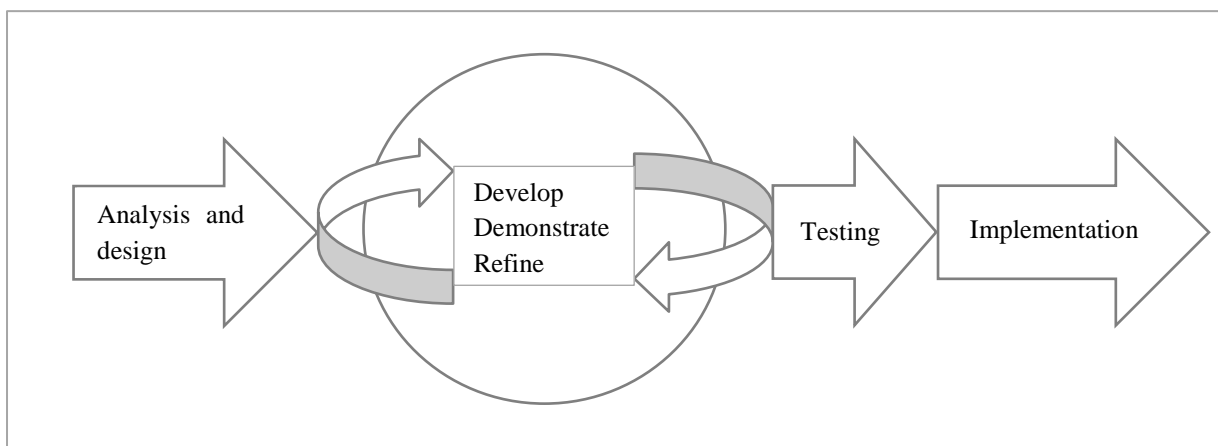


Figure 3: Rapid application development (RAD) model. Source (Rosenblatt, 2012)

## CHAPTER THREE

### MATERIALS AND METHODS

#### 3.1. Research Design and Study Area

In this research, an assessment of users' awareness and readiness to install eHealth interactive mobile applications using a case study was conducted at Temeke and Mwananyamala Municipal referral hospitals, in Dar es Salaam Tanzania between March and April 2018. Internal data communicated to the researcher from the patient log at the Mwananyamala Municipal referral hospital shows that there is an average daily inflow of women seeking maternal, newborn and child healthcare of 200, while Temeke Municipal referral hospital has an average of 150. This makes an average total of 350 attendees per day and a five days week average of 1750 attendees. In this study, pregnant women and mothers with infants of less than one year of age were eligible for the study. Patients present at the hospitals for one week of five days, receiving various maternal and infant care services were the respondents. Respondents were asked about their willingness to participate in the study. Every participant voluntarily consented verbally after being informed about the purpose and benefits of the study. Figure 4 shows the distribution of the respondents to the study areas.

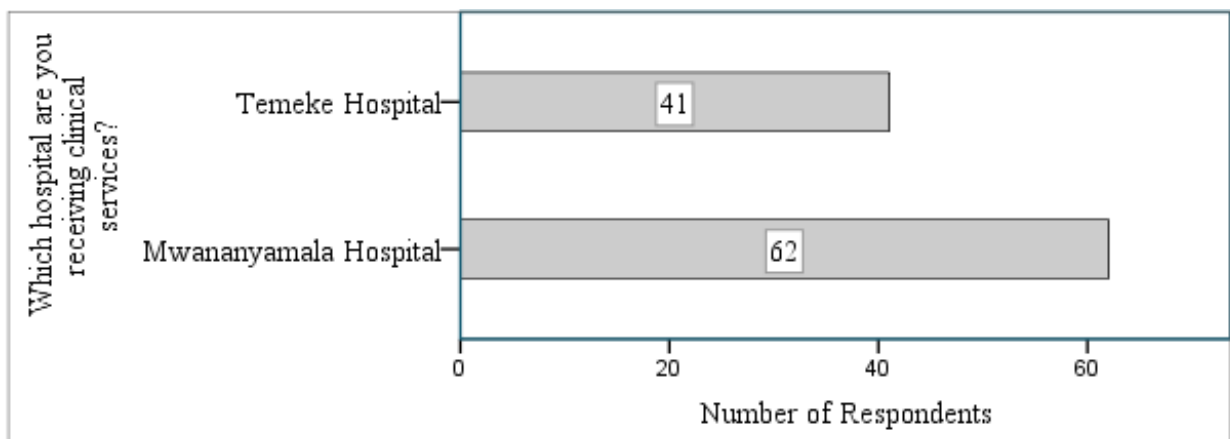


Figure 4: Respondents distribution by study area

#### 3.2. Demographic Characteristics of Respondents

While all 150 administered questionnaires were returned, only 103 were completed correctly, of which 42 were returned from Temeke and 61 from Mwananyamala Municipal Referral Hospitals. Demographic characteristics of the respondents included age group, marital status, (pregnant or infant-mother), and highest education level. The age groups were below 20 years, between 20 and 34 years, and above 34 years. The age groups were adapted from related studies

by Kowalcek and Hainer (2012) and Sim *et al.* (2015). The maternal status included pregnant women and infant mothers. The marital status contained unmarried, married, divorced and widowed. Education levels were primary education, secondary education, certificate or tertiary education, and higher education. Table 1 below shows the results of the demographic characteristics of the respondents.

Table 1: Demographic characteristics of respondents

<b>Question</b>	<b>N (%)</b>
<b>Age group:</b> How old are you?	
Less than 20 years	19 (18%)
20 – 34 years	67 (65%)
Greater than 34 years	17 (17%)
<b>Marital status:</b> What is your marital status?	
Unmarried	36 (35%)
Married	55 (53%)
Divorced	8 (8%)
Widowed	4 (4%)
<b>Maternal status:</b> What is your maternal status?	
Pregnant	49 (48%)
Infant-mother	54 (52%)
<b>Highest education level:</b> What is your highest level of education?	
Primary education	47 (46%)
Secondary education	47 (46%)
Tertiary (Certificate/Diploma)	8 (7%)
Higher education	1 (1%)

### 3.3. Data Collection Methods and Tools

Questionnaires were used to collect the data. For this study, questionnaires were chosen due to the amount of information. The questionnaires were translated into the Swahili language for respondents to understand. Areas covered by these questionnaires were demographic characteristics, mobile phones ownership and internet use, mobile phone-based applications awareness, and readiness to use interactive features of mobile applications for MNCH support. One midwife and three nurses at each hospital were trained to administer the questionnaires.

The researchers assisted in clarification of the questions to the respondents during the whole period of data collection. Nurses provide daily clinical, maternal and infant care, therefore familiar with respondents enough to administer the questionnaires effectively.

### **3.4. Sample Size Determination and Sampling Technique**

Determining sample size in quantitative approach refers to the technique of electing the number of observations to include in a sample (Singh & Masuku, 2013). Selecting a sample is based on the cost of data collection and the statistical power. The formula adopted in this study to determine the sample size was that proposed by Yamane as follows

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size, N is the population size, and e is the level of precision. Applying the information from this study with N = 1750 attendees the hospitals per week e=0.08 and 95% confidence level, the sample size is found to be 143 responses. Adding 10% to 30% for compensation of any uncertainties, the collection sample size was set at 150 respondents.

### **3.5. Statistical Analysis**

The questionnaires were coded and the data was entered into a comma separated values (CSV) formatted file. The data was analyzed using Python programming language. A variety of charts and descriptive statistics were generated using the Python programming language and Python libraries available on the Anaconda platform.

### **3.6. Ethical Clearance and Consent**

Ethical clearance was obtained from relevant authorities at Temeke and Kinondoni municipal councils. Permission to do the research was received from District Medical Officers at the municipal councils head offices, then submitted to Temeke and Mwananyamala hospitals. Respondents were requested to consent to participate in the research before the onset of data collection exercise. A prepared statement was read to the respondents, stating the aim of the research, and the usage, limitations and confidentiality of respondent's personal information.



### **3.7. Software Development Approach**

Rapid Application Development (RAD) model was used to implement the MNCH support mobile app. The model is an agile based software development methodology which emphasises on creating a working prototype of the software or module and using it to obtain user feedback instead of strict planning of requirements used in Waterfall model variants of software development.

Brainstorming was used to specify requirements for the initial prototype of the mobile app. Brainstorming leads to better problem understanding and feeling of shared ownership (Paetsch, Eberlein & Maurer, 2003). The initial user's preferences were obtained from the data gathered from Temeke and Mwananyamala hospitals in Dar es Salaam, Tanzania. Prospective users were asked to choose from a list of thirteen proposed features to be included in the mobile application. Based on the data, the software developers further discussed and arranged into possible modules of the initial prototype.

Eleven modules were initially generated, which were user accounts, live chat, directory, map navigation, mLearning, reminders, latest news and alerts, discussion forum, personalisation, and settings. After consultation with selected healthcare professionals, these modules were re-arranged into eight modules as described in the functional requirements in the next sections of this dissertation.

Several technologies and tools were used to develop the MNCH support mobile application. These include extended markup language (XML), Java and PHP programming languages, MySQL database management system, Smooch instant messaging platform, Firebase for app users' invites and testing, and Slack communication and collaboration platform.

#### **3.7.1. System Modelling**

Unified Modelling Language (UML) as proposed by Gomaa (2011) was used to present the conceptual use cases for the MNCH support mobile application. Unified Modelling Language provides different language tools that can facilitate communication with stakeholders, describe the relationship between various components of software, elicitation of requirements, representation of software requirements, and automatic code generation (Petre, 2013). For this mobile application, Visual Paradigm 15.1<sup>©</sup> Community Edition was used to generate the modelling diagrams.

### **3.7.2. Mobile App Usability Testing and Validation**

The researchers used an experimental strategy to test and validate the mobile application. In testing the mobile application, the International Organization for Standardization (ISO) software quality model was adopted. The usability metric of software which refers to effectiveness, efficiency and satisfaction (Alturki & Gay, 2017) was used to generate a set of 15 questions, which were used to infer on the overall usability of the mobile application. A set of five questions for each of the three metric measures were selected. Respondents chose on a Likert scale their experience for each question.

To validate the MNCH support mobile app, a group of 15 volunteers each from Mwananyamala and Temeke Hospitals were selected. From among pregnant women and infant mothers attending at Temeke District Hospital and Mwananyamala Hospital, 14 and 13 volunteers respectively were requested for their consent to participate in the testing of the mobile application. In addition three nurses participated in the testing. The volunteers' mobile phones were checked to ensure they meet the minimum specifications of Android 4.1 or higher. The volunteers' connected their mobile phones to a mobile hotspot with pre-loaded 10 Gigabytes of internet data to perform the validation. The MNCH support mobile app was installed to the volunteer's smartphone using an Android Package Kit (APK) file generated from the Android Studio development environment. Before interacting with the mobile application, the volunteers were shown a demo of how the application works. Then every user was given time to interact independently with at least one feature of their choice. The volunteers were then given the questionnaires to provide their experience on the usability of the mobile application.

**CHAPTER FOUR**  
**RESULTS AND DISCUSSION**

**4.1. Currently Available Mobile Apps on Google Play Store**

Two leading repositories for mobile applications were identified, namely Google’s Play Store and Apple’s iTunes. According to an analysis by the sole reseller premium iPhones in the Tanzania market, as of December 2018, out of the 40 million mobile phones owners, less than one a million had iPhones (IPP Media, 2018). The larger percentage of the 20 million users of mobile phones with internet access had other types of mobile phones, of which about 90 percent used Google’s Android Operating Systems. Therefore, for this research, Google Play Store which accounts for about 90 percent of the smartphones owners in Tanzania was purposely selected for analysis. A search on Google Play Store repository performed in October, 2019 using the app market explorer available at 42 Matters website provided the results in table 2 below.

Table 2: Android applications for health and fitness, and medical categories.

<b>Application category</b>	<b>Number of apps</b>
Health and Fitness	102 247
Medical	46 497
Health and Fitness + “Swahili   Kiswahili”	Not Listed
Medical + “Swahili   Kiswahili”	Not Listed

From “Launchpad to your favourite features” by 42matters.com from  
<https://42matters.com/launchpad>

However, further search using keyword “*afya*”, “*lishe*”, “*mama na mtoto*”, and “*mama mjamzito*” which were deliberately chosen as they closely relate to this study, revealed few applications in the “*health and fitness*” category. Among the identified apps were “*Lishe360*”, TanzMed, “*LisheBora*” or “*HeA*”, “*Afya Yako*”, and “*Afya PAP*”. Lishe360 provides dietary information for child of up to 6 months old and during pregnancy in Kiswahili language. “*Lishe Bora*” app provides information and dietary advice to combat infertility. TanzMed and AfyaPAP provide several functionalities such as for managing children vaccinations and clinical dates, information on children growth, and question and answers from doctors. All the apps are freely available on Google Apps store for anyone to download and use.

#### 4.2. Mobile Phones Ownership and Mobile Internet Use

Respondents were asked whether they own a mobile phone or not and the type of mobile phone as either feature-phone or smartphone. Internet use on mobile phones was obtained by asking users if they use the internet, the frequency of use and an average number of hours per day. Table 3 below shows the results of mobile phones ownership and internet use on mobile phones.

Table 3: Mobile phones ownership and internet usage on mobile phones

<b>Question</b>	<b>N (%)</b>
<b>Owned a mobile phone: Do you own a mobile phone?</b>	
Yes	97 (94%)
No	6 (6%)
<b>Type of mobile phone: What type of mobile phone are you using?</b>	
Smartphone	58 (60%)
Feature-phone	39 (40%)
<b>Internet usage on the mobile phone: Are you using internet on your mobile phone?</b>	
Yes	59 (61%)
No	38 (39%)
<b>Internet use per day: What is your daily average internet usage on your mobile phone?</b>	
Less than one hour	21 (34%)
1 – 2 hours	19 (30%)
2 – 3 hours	15 (24%)
3 – 4 hours	4 (7%)
More than 4 hours	3 (5%)
<b>Internet use frequency: How frequent are you using internet on your mobile phone?</b>	
At least once every day	40 (68%)
At least once every week	16 (27%)
At least once every month	3 (5%)

This study shows that mobile phone penetration is very high (94.2%) among pregnant women and infant mothers receiving maternal and infant care services at Temeke and Mwananyamala hospitals. This number is consistent with the mobile phone subscription statistics provided by Tanzania Communications Regulation Agency (TCRA), which show mobile phones

subscription approaching 40 million at the end of 2017 (TCRA, 2017). The study further shows that smartphone ownership among the respondents was significantly high with 59.8% of the respondents owning a smartphone. The large percentage of smartphones ownership may be attributed to the fact that the research was done at hospitals in the urban environment, which is the commercial capital of Tanzania. Also, the prices of smartphones for the Tanzania market are rapidly decreasing, making them available to a broader population.

Similarly, internet usage among the respondents is significant and precisely matches the ownership of smartphones. This study reveals that the majority of respondents spend a considerable amount of time on the internet using their mobile phones, with the majority (68%) accessing the internet every day (see table 2). This implies that internet dependent mobile applications for MNCH support are feasible to users without facing the challenge of internet connectivity in a similar environment.

#### **4.3. Mobile Apps for MNCH Support awareness and use**

Despite the existence of several mobile apps in the two leading app repositories, namely Google's Play store and Apple's iTunes, many of the respondents 90.7% (n=88) were unaware of any mobile application used to provide support for maternal, newborn and child health support. A similar number of respondents had never installed a mobile app for the same purpose on their mobile phones. Only a few respondents were aware of mobile apps that can be used to support them during pregnancy, delivery and childcare. The mobile applications mentioned by respondents who recalled receiving any support on their mobile phones were Facebook, WhatsApp group, and Text Messages. Specific types of support received were nutritional information, HIV awareness, breastfeeding, and infant vaccination. None of the respondents was aware of any specialised mobile application for smartphones available on Google Play Store, iPhone's iTunes or Windows Phone Apps, used for MNCH support.

This study revealed that there is a general lack of awareness among users of MNCH support mobile applications. Despite the presence of several mobile apps on Google Play Store and Apples iTunes Apps Store for MNCH support, most of the respondents were unaware of these applications. The low user awareness is unsurprising finding because the demographics of the respondents reveal education limitations, which relates to limited fluency and use of English language and computer literacy. The finding is further supported by other researchers such as O'Connor and Donoghue (2015). Furthermore, a search on Google Play Store at the time of

writing this dissertation found very few and functionally limited MMNCH support mobile applications in the Kiswahili language. Respondents of better education and higher income levels were unlikely to be found in these hospitals due to the presence of privately-run hospitals, which are more convenient due to the presence of fewer patients. Mobile apps for MNCH support awareness and use are shown by Fig. 5, Fig. 6 and Fig. 7 below:

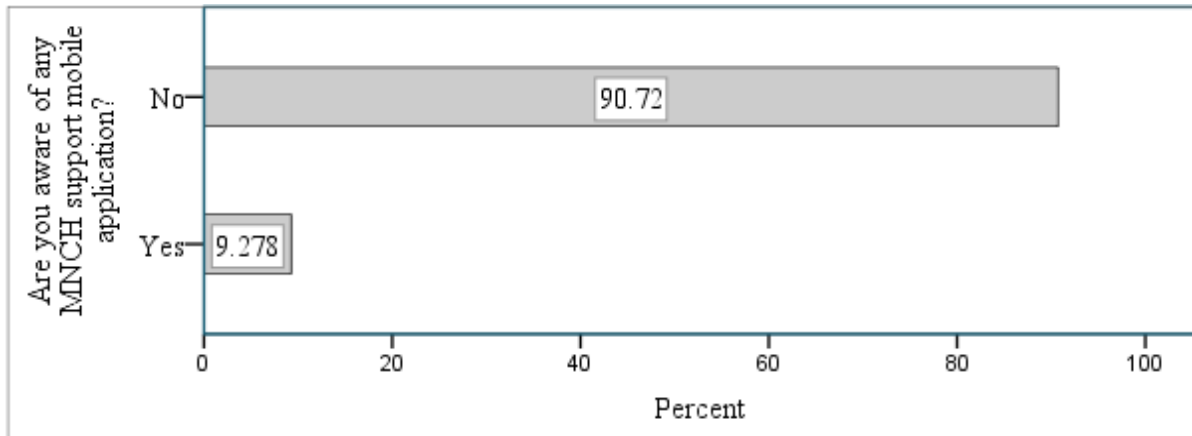


Figure 5: Users awareness for MNCH support mobile application

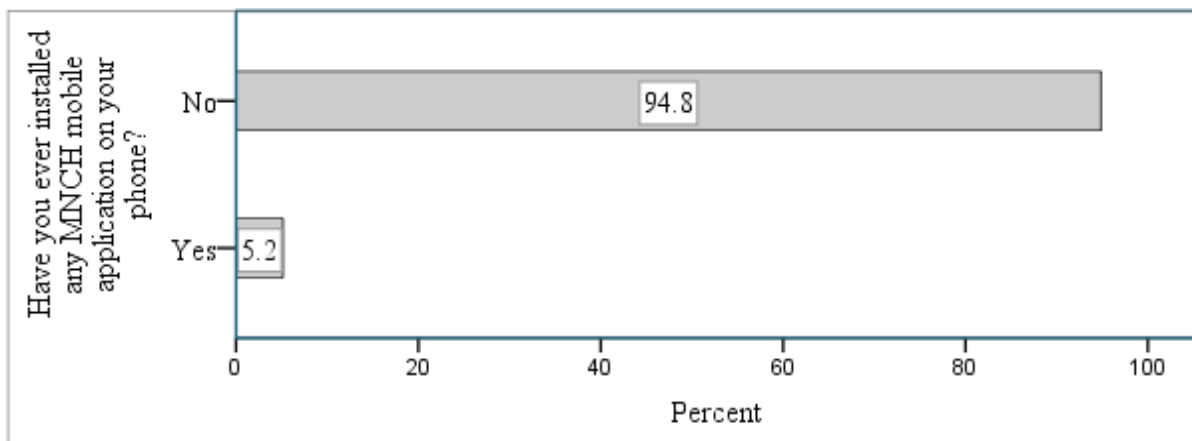


Figure 6: Users experience in using MNCH support mobile applications

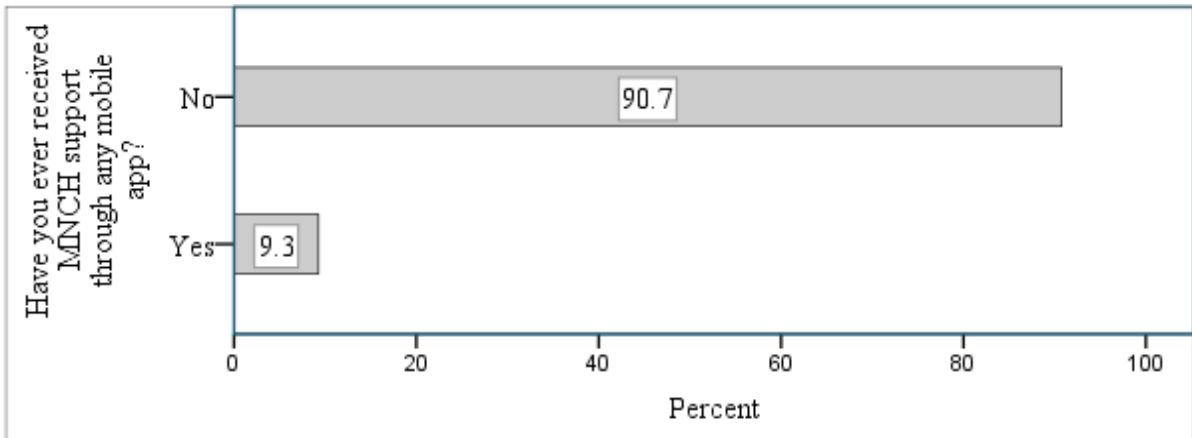


Figure 7: Users experience in receiving MNCH support through mobile app

The readiness of users to install a mobile application for maternal and infant care support on their smartphones was determined using a Likert scale of user’s willingness to install such an app when it is available. Figure 8 shows the number of users with the corresponding responses on the question asked, “*Will you install a mobile app for maternal and infant care support?*” The results show that out of 103 respondents, 6.80% (n=7) indicated that they would be “*very happy to install the app*”, 25.24% (n=26) indicated that they would “*like to install the app*”, 25.24% (n=26) indicated they would “*like to install the app*”, 29.13% (n=30) indicated that they “*will think about it*”, and 13.59% (n=14) indicated that they “*will not install the app*”.

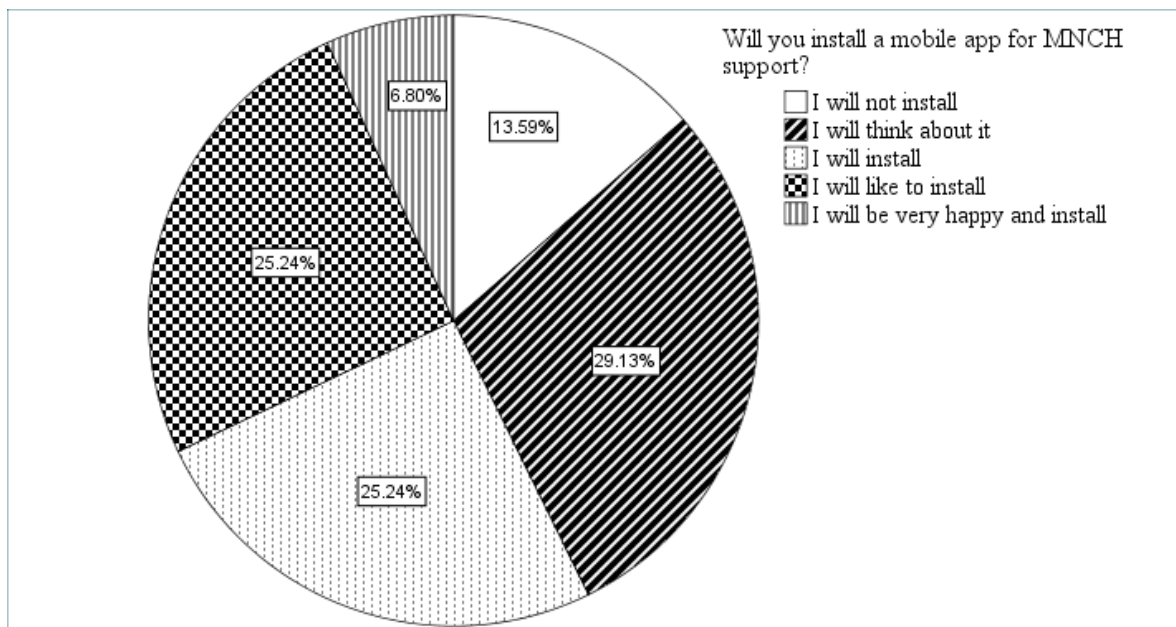


Figure 8: Users likelihood of installing and using MNCH support mobile app

The results above revealed users’ willingness to install the MNCH support mobile application. It was found that 57.3% of potential users are very likely to install the MNCH support mobile app immediately when available, as recorded by respondents who answered “*I will install*”, “*I*

*will like to install*”, and *“I will be pleased to install”* the application. The remaining (42.7%) are not likely to install such an application immediately when available. Some of the likely reasons as of the negative response might be non-possession a smartphone or unawareness of the benefits of such an application. Only a few respondents (13.6%) said they would not install such an application. These findings exhibit common characteristics of innovation adoption models where almost 50% are likely to embrace innovation in the early stages, while the remaining embrace the innovation late (Lai, 2017; Rogers, 1995).

#### 4.4. Mobile Apps for MNCH Support Features

Preferences for MNCH support interactive mobile application features were determined using thirteen (13) proposed features that perform different functions on a mobile phone. Figure 9 provides the percentage of the features preferred in such a proposed MNCH support mobile application. The most preferred features were general SMS messages (64.1%), SMS reminders message (56.3%), Chatting (56.3%), a discussion forum (51.5%), real-time voice call (43.7%), question and answers (43.7%), and feedback (41.7%).

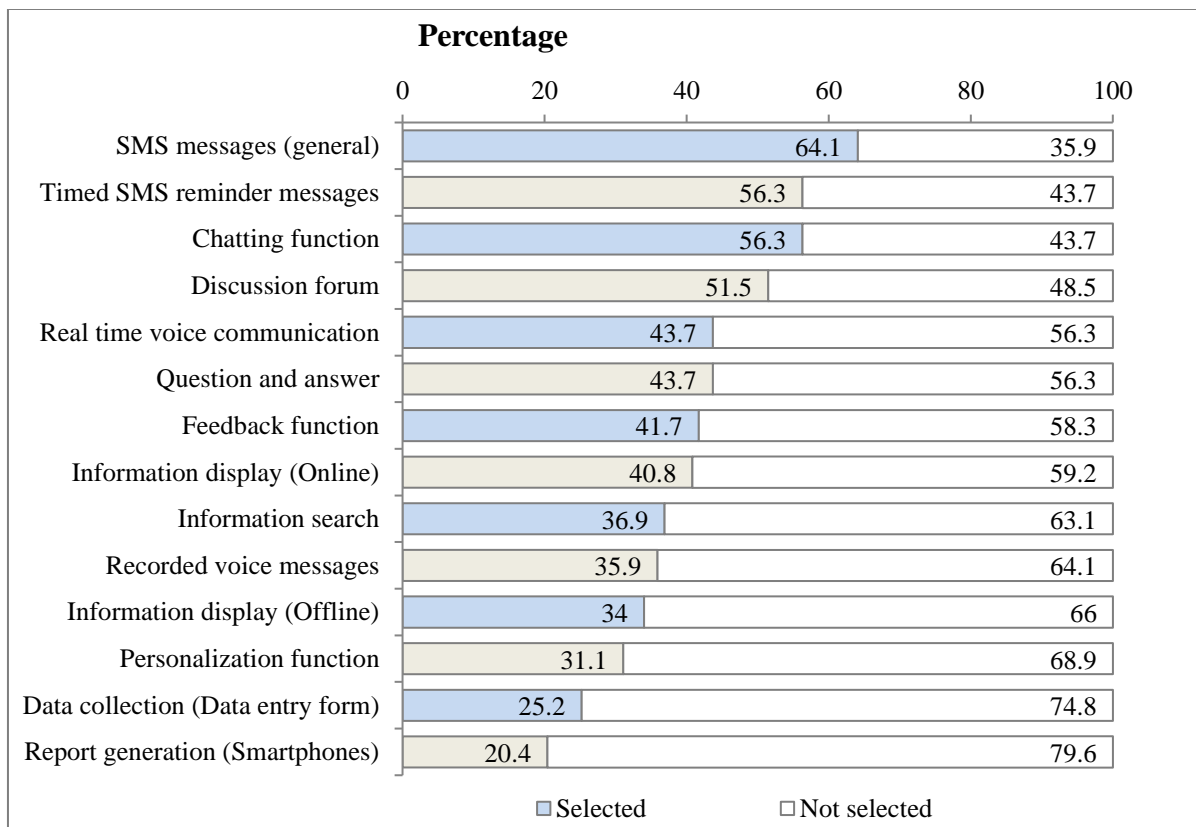


Figure 9: User’s preference for proposed features of MNCH support mobile application



The preferences for features of MNCH interactive mobile application were generated using proposed 13 functions on a mobile phone. These are the functions available on both on feature-phones and smartphones. The findings from this study show that general SMS was preferred by 64.1% of the respondents, while reminder SMS was preferred by 56.3% of the respondents. SMS is a common feature available in all types of mobile phones and provides the cheapest and reliable mechanism of exchanging text messages. Text messages (SMS) was found to be a preferred mobile application in learning (Chinnery, 2006; Stone, Briggs & Smith, 2002). These results indicate the limitations of MNCH support mobile app functions that depend on internet availability.

Chatting and discussion forum features were preferred by 56.3% and 51.5% respectively. The high preference can be explained based on the availability of similar features on popular social media applications such as Facebook, WhatsApp, Twitter, and Instagram, where users can interact by responding to message by writing their comments. Chatting either as a group or one-to-one provide a reliable mechanism where users can interact. Discussion forum provides a platform where users interact via forum posts online. Both chatting and discussion forum require an internet connection.

#### **4.5. System Modelling**

System modelling is a process of creating abstract models of the system. Each model is used to present a view of a software system according to some perspective (Sommerville, 2016). System modelling for this study used context and interaction models represented graphically using Unified Modeling Language (UML). These models were used to clarify the requirements to users and explain the MNCH support mobile application to other stakeholders. In addition, the UML design was used to generate partial tables of the database tables. System models can also be used to auto-generate full or partial classes of the system and database tables.

##### **4.5.1. Use Case Modelling**

Use cases diagrams explain how one or more actors interact with the system. Use cases describe what the system does, i.e. its functional requirements in response to user inputs (Gomaa, 2011). To generate the use cases, first, different actors on the mobile application were identified. An actor represents a role played by someone who interacts with the system. Any actor of the mobile app has some access rights on some functions. Based on the access rights, three types of actors, namely administrators, healthcare professionals, and ordinary users were identified.

These actors were then categorised according to the expected functions they might needs from the mobile application.

Typically, any user will wish to accesses the mobile application's essential features, namely chatting, health information portal, discussion forums, and healthcare directory. However, some features require the user to have an account and log in to the app. Any person shall have the ability to create an account. The app administrator shall be able to modify the user type from a user to a healthcare professional. A user with healthcare professional privileges can access more app features than those available to a user. Healthcare professionals create the contents for discussion forums and health information portal. The app administrator exercises overall control on the working of the app. An administrator has access rights to perform critical system functions, thereby making the mobile application convenient to use by other users. An administrator mainly performs management of mobile application's modules. Figures 10, 11 and 12 show use case diagrams for a user, healthcare professional, and administrator respectively.

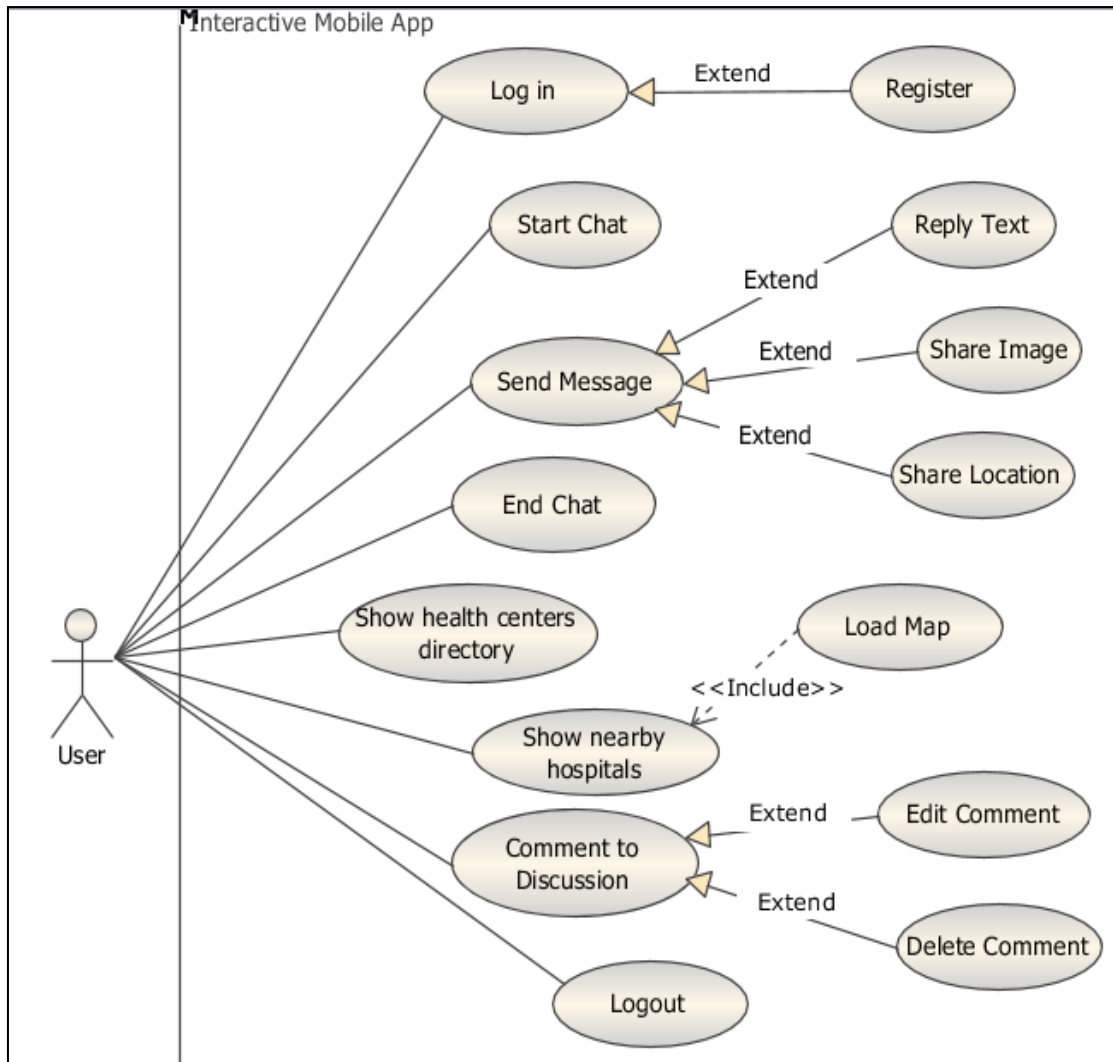


Figure 10: Normal user use case diagram

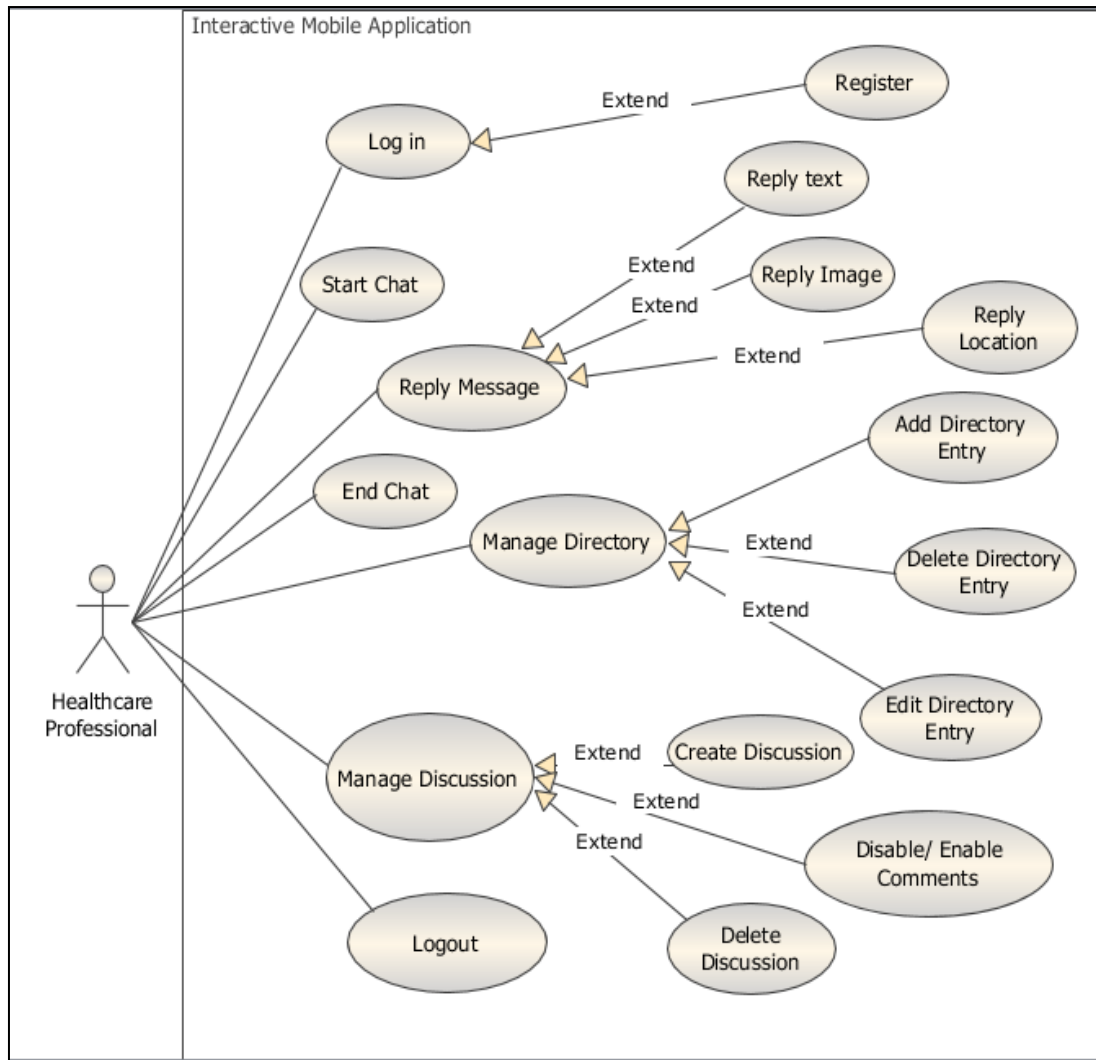


Figure 11: Healthcare professional use case diagram

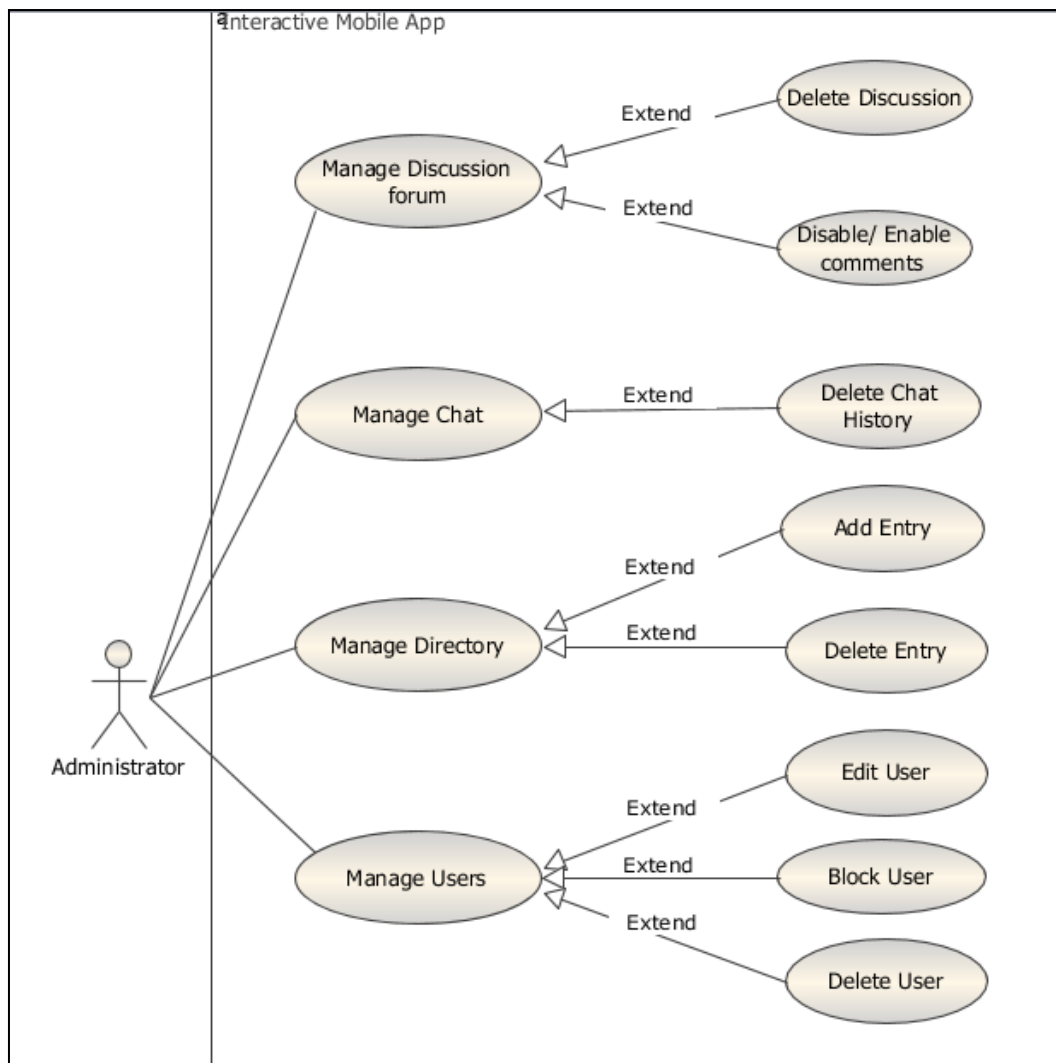


Figure 12: Administrator use case diagram

#### 4.5.2. Data Flow Diagram

Data flow diagram (DFD) is a graphical system-modelling tool used to depict the flow of information between actors in an information system (Braude & Bernstein, 2010). Data flow diagram can be presented in several levels, namely context level, level one, level two, or more, until enough details are revealed. Context level DFD shows the communication of information between the entire system and external entities. Context-level DFD is further expanded to show more details as of the application and its components, thus generating DFD levels 1, 2, or more, until enough details of the system are revealed. For this mobile app, the context level and level one DFDs, focusing on the flow of information between three user-categories, namely users, healthcare professionals, and administrator are presented.

The details for users and healthcare professionals are created when a user inserts them in the application using the “User Registration” module. A user is registered by filling a registration form with necessary details to create an account. After registration, any user may log in to the system using the “Login” functionality. After registration, an administrator may elevate the privilege of a user to a healthcare professional. An administrator can control the way other users interact with the mobile app.

Any person can install the application and get access to the general information available on the mobile app. However, registered users and healthcare professional can interact with other registered users through main modules, namely “*Live Chat*”, “*Discussion forum*” and “*Health centres directory*”. The interaction, which is the primary objective of this study, empowers users to get specific and timely responses from healthcare professionals based on their needs. Live chat, apart from text and images, enables a user to share his/her location, which may further improve the way healthcare providers handle emergency cases for patients.

Discussion forum enables healthcare professionals to share useful information related to pregnancy and childcare using the application. Healthcare centres directory adds to the interactivity of the application by allowing users to locate nearby health centres and the services offered at these centres on an interactive map. This function may improve decision making on which centre to go for a particular service by the patient. Figures 13 and 14 show the context-level and level-1 data flow diagrams for the mobile application respectively.

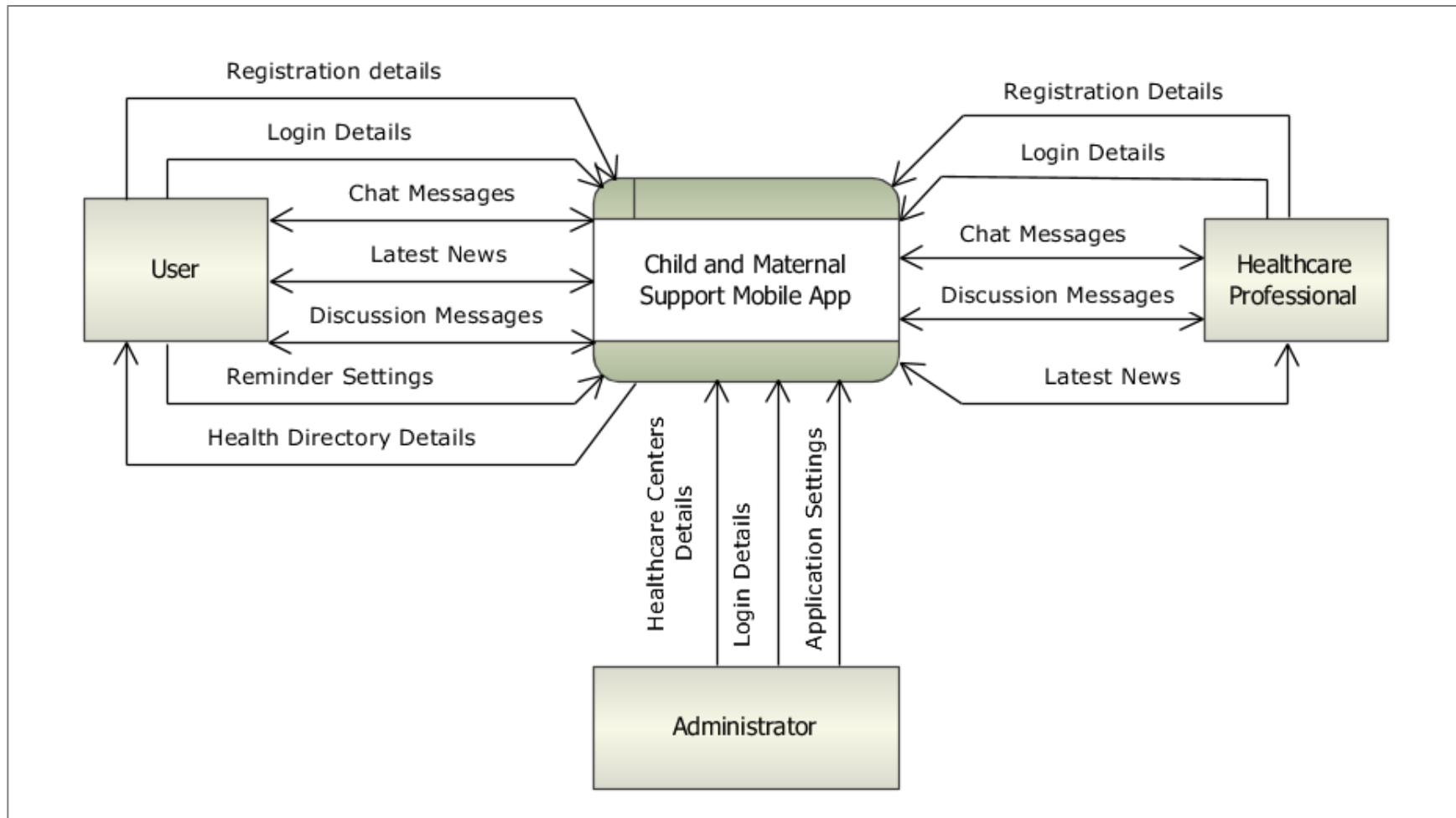


Figure 13: Context-Level data flow diagram for an interactive MNCH support mobile app

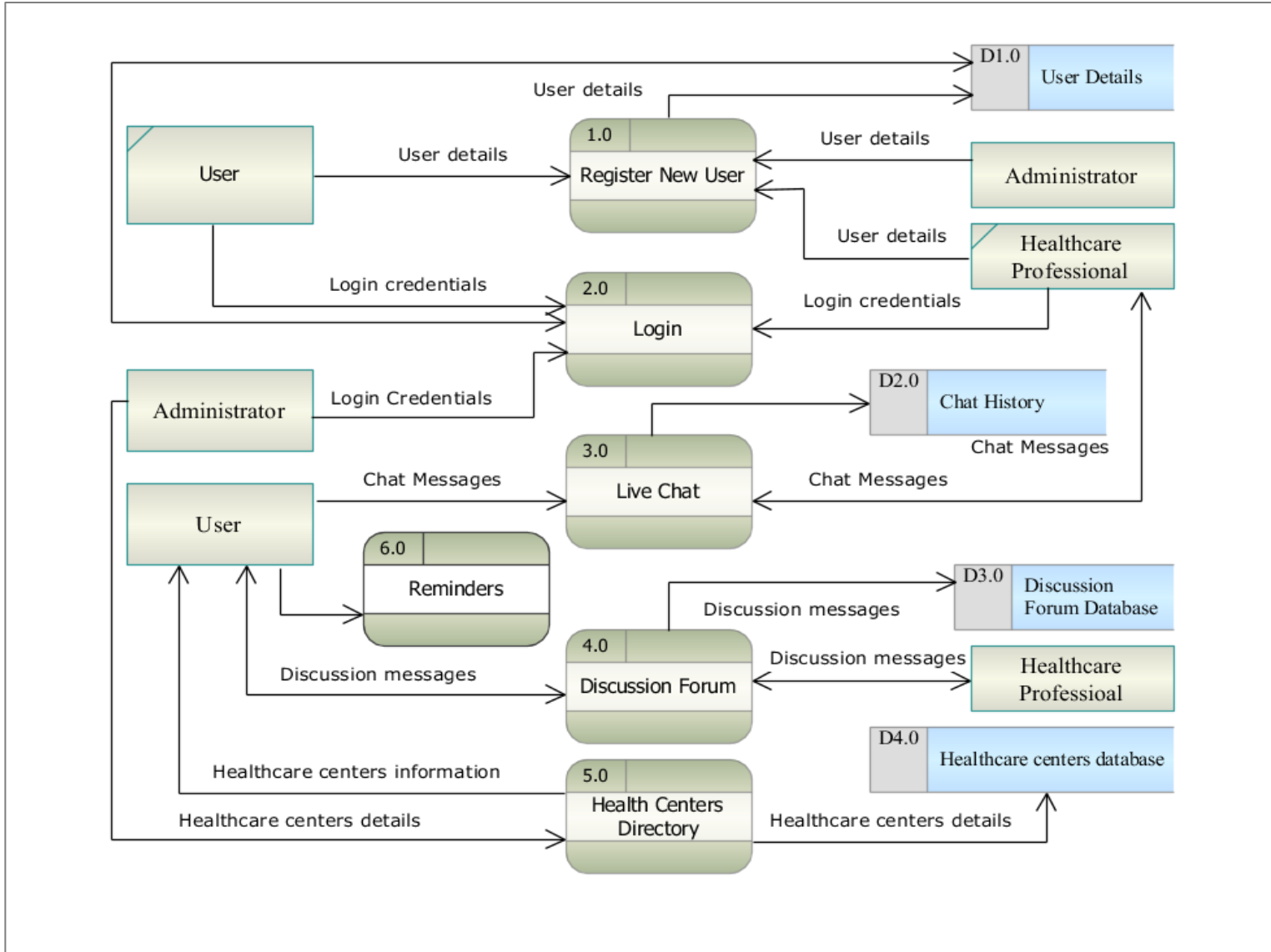


Figure 14: Level-1 data flow diagram for an interactive MNCH support mobile app



## **4.6. Requirements Analysis**

Requirements of a system are the descriptions of the services that the system should provide and the constraints on its operations. Generally, requirements are grouped into user requirements and system requirements. User requirements are the high-level abstract user statements in natural language or diagrams of the services expected from the system by a user. On the other hand, system requirements are a detailed description of the software's functionalities, services, and constraints (Sommerville, 2016).

Requirements analysis specifications involve functional and non-functional requirements. Functional requirements state the expected system behaviour in particular situations, system response to specific inputs, and form of services, tasks or functions of the system. On the other hand, non-functional requirements capture the required properties and constraints of the system that apply to the entire system rather than any individual system feature. Most of the non-functional requirements constraints are imposed by standards that are relevant to a particular industry (Sommerville, 2016). For example, information in the healthcare industry may require unique ways of capturing, processing, storage, and retrieval in order to comply with laws and regulations governing the healthcare industry.

### **4.6.1. Functional Requirements**

In this study, eight modules, namely User Accounts, Live Chat (Instant Messaging – IM), Directory, Health Information, Latest News, Discussion Forum, and Settings were generated. Table 4 provides the functional requirements for the modules of an interactive mobile application for maternal and infant care support.

### **4.6.2. Non-functional Requirements**

In this study, the non-function requirements of the mobile app include security, privacy, scalability, operational requirements, robustness, performance, and compliance with local standards. Table 4 provides non-functional requirements.

Table 4: Functional requirements for an interactive MNCH support mobile app

ID: Requirement	Requirement description
<i>Module1: User Accounts (Provides basic user management functions)</i>	
<b>FR001:</b> Create Account	<p>This app must allow a user to create an account. The user must be able to register for the application by creating an account using a name, valid phone number, username, and password.</p> <p>The username must be alphanumeric and must not be already used by another user.</p> <p>The password shall be any characters including numbers and special characters, with a minimum length of six symbols. The user’s username shall be the unique identifier of his/her account on the application.</p>
<b>FR002:</b> Login	<p>A user must be able to login to the application using the created username and password.</p> <p>A login interface appears when a user touches the login link or attempts to open a function that requires the user to log in.</p> <p>Errors will be displayed if a field is left blank, or the supplied username and password do not exist in the system.</p> <p>If the supplied username and password are correct, the application shall give permissions to use more features of the system such as sending a message to live chat, discussion forum, setting reminders.</p>
<b>FR003:</b> Show online users	<p>A user may be able to see healthcare professionals who are online.</p>
<b>FR004:</b> Update Profile	<p>A user must be able to update his/her profile information, such as password and mobile number.</p>
<b>FR005:</b> Reset password	<p>A user must be able to reset the password. A registered user shall reset the password by entering his/her mobile number.</p> <p>A verification code shall be sent to the mobile number. The user shall use the verification code as a new password.</p>
<b>FR006:</b> Logout	<p>A user must be able to log out of the application when they want to end a session. When a user logs out, restricted functions are no longer accessible.</p>
<b>FR007:</b> Change Language	<p>A user must be able to change language between at least two languages English and Swahili.</p>

ID: Requirement	Requirement description
<i>Module2: Live Chat (provides users with the ability to interact with healthcare providers using IM messaging)</i>	
<b>FR008:</b> Send Message	Users must be able to initiate a chat session where he/she can send text, image or location. A healthcare professional shall be able to respond to messages from users.
<b>FR009:</b> Share attachments	<p>A user should be able to send images and documents as attachments.</p> <p>The application should support jpg, png, and pdf.</p> <p>File size must not exceed 2MB per message.</p>
<b>FR010:</b> Share location	<p>A user should be able to share location on a map showing the active location of the user as a Google Maps.</p> <p>The screen capture can be opened for more details.</p>
<b>FR011:</b> Show direction	Healthcare provider from a hospital may be able to see the directions on a map to the user's active location.
<i>Module3: Directory (Provides a list of healthcare directories, and map navigation)</i>	
<b>FR012:</b> List Directory	<p>A user must be able to view a list of all hospitals, in alphabetical order.</p> <p>A user may filter hospitals based on location (region, district or ward).</p>
<b>FR013:</b> Show hospital details	A user must be able to display hospital details such as name, physical address, mobile/phone numbers, website URL, and services offered by selecting it on the list.
<b>FR014:</b> Nearby Hospitals	<p>A user must be able to view nearby hospitals relative to his active location.</p> <p>The nearby hospitals shall be shown as points on Google Maps on which a user can open to reveal details of the hospital.</p>
<i>Module4: Discussion Forum (A discussion forum platform for users of the app to interact)</i>	
<b>FR015:</b> Create a discussion	<p>A logged in user must be able to create a discussion.</p> <p>A user shall select among the categories such as pregnancy, delivery or childcare, to which the discussion is about, the title and content of the discussion.</p> <p>Discussions created by users other than healthcare professionals and administrators must be approved by the administrator or by a healthcare professional to be visible to all users.</p>

ID: Requirement	Requirement description
<b>FR016:</b> Contribute to discussion	<p>A registered user must be able to contribute to a discussion.</p> <p>Only logged in user will be able to contribute to a discussion.</p> <p>Administrators and healthcare professionals will be able to see all contributions.</p> <p>Contributions created by users other than healthcare professionals and administrators must be approved by the administrator or by a healthcare professional to be visible to all users.</p>
<b>FR017:</b> Delete a discussion or comment	<p>A user who created a discussion post must be able to delete a post.</p> <p>When a user deletes a discussion, all associated comments are also deleted.</p> <p>In addition, the administrator may delete or make a discussion invisible.</p>
<b>FR018:</b> Make a discussion post public or private	<p>A user must be able to change a discussion post from the public to private or vice versa.</p> <p>A private post shall be visible to the post creator, and administrators only while a public post shall be visible to all logged in users.</p>
<b>Module5: Healthcare Information Portal</b> ( <i>A health information portal also used as a learning platform</i> )	
<b>FR019:</b> Show all health information topics	<p>A user must be able to see the health information topics on a list of all topics arranged in the order of creation starting with the most recent topic.</p>
<b>FR020:</b> Show health information topic details	<p>A user must be able to view health information related to a topic. This information shall be shown when a user selects a specific topic.</p>
<b>Module6: Reminders</b> ( <i>Provides users with functions to manage reminders of important events</i> )	
<b>FR021:</b> Configure a reminder	<p>A user must be able to set a reminder.</p> <p>A reminder is set by specifying reminder date, time and reminder text.</p>
<b>FR022:</b> Automate reminder	<p>When a pregnant woman registers or an infant is born, some reminders can be automated such as vaccinations and clinic visits.</p>
<b>FR032:</b> Delete Reminder	<p>User must be able to delete a reminder</p>
<b>Module7: Latest News</b> ( <i>Gives users the latest news and relevant information</i> )	

<b>ID: Requirement</b>	<b>Requirement description</b>
<b>FR021:</b> Show all latest news	A user must be able to see the latest news on a list arranged in the order of creation starting with the most recent news item.
<b>FR022:</b> Open the latest news item	A user must be able to view news details for a selected news item.

Table 5: Non-functional requirement for an interactive MNCH support mobile app

<b>ID: Requirement</b>	<b>Requirement description</b>
<b>NFR001:</b> Security	<p>The application should define a way for private access, for example, using usernames and passwords.</p> <p>The application must ensure privacy and compliance with regulations on patients' data sharing.</p> <p>The application should be secure from various security challenges such as hacking, and denial of service attacks.</p>
<b>NFR002:</b> Scalability	The application must be able to provide services to at least 1000 users concurrently.
<b>NFR003:</b> Privacy	<p>The application must be able to ensure the privacy of user information.</p> <p>The application must provide for the protection of user information such that only the intended recipients may access user information.</p>
<b>NFR004:</b> Robustness	In the case of a user changing a device or device malfunction, the user must be able to obtain their history of created contents such as chat history and reminders.
<b>NFR005:</b> Performance	The application must be lightweight and must allow delivering messages instantly
<b>NFR006:</b> Operability	<p>The mobile application shall support Android OS version 4.0 (API 14) and above.</p> <p>The web application shall be written using PHP Programming language.</p> <p>The web application shall interface with the database and shall be able to connect to an external HMIS database.</p>

## **4.7. System Design**

System design is a technical translation of the output of the analysis phase aiming to produce a more technically elaborate concept of the software product or solution. Mainly the functional requirements and constraints form significant inputs to the system design phase of the software. The design phase of this mobile application was done on three components, which are system architecture, database, and user interfaces as further explained in the next sections of this chapter.

### **4.7.1. Application Architecture**

Application architecture defines the interactions between different components of the mobile application. The main components of our architecture are the mobile application, the database server, and web services, users and access devices. Information such as user's details, hospitals directory details, and healthcare professionals are stored in the databases. Information such as healthcare professionals may be obtained from an external hospital management information system (HMIS) database. The system has two major functional components, namely the mobile application and a web application. The mobile application provides different interfaces for users to interact with the entire system.

Moreover, the mobile app connects users at health centres and hospitals to users who may be located far away from the health facility. Web services are used to transfer data between the mobile application and web application. Figure 15 describes the high-level architecture of the mobile application for maternal, newborn and child health support services.

### **4.7.2. Database Design**

Database design for this mobile application followed the Entity-Relationship (ER) model. Entity-Relationship model shows how entities are related to each other within a database or an information system. An entity represents things of interest that may have one or more attributes. A relationship is an association between these entities. The ER model is a graphical representation of the database of a system also called the ER diagram (Earp & Bagui, 2012). Relational databases are represented graphically using Entity-Relationship diagrams. The ER diagram is also a communication tool used to clarify requirements to the clients by the database designers. Figure 16 below shows the ER diagram of the database for MNCH support interactive mobile application.

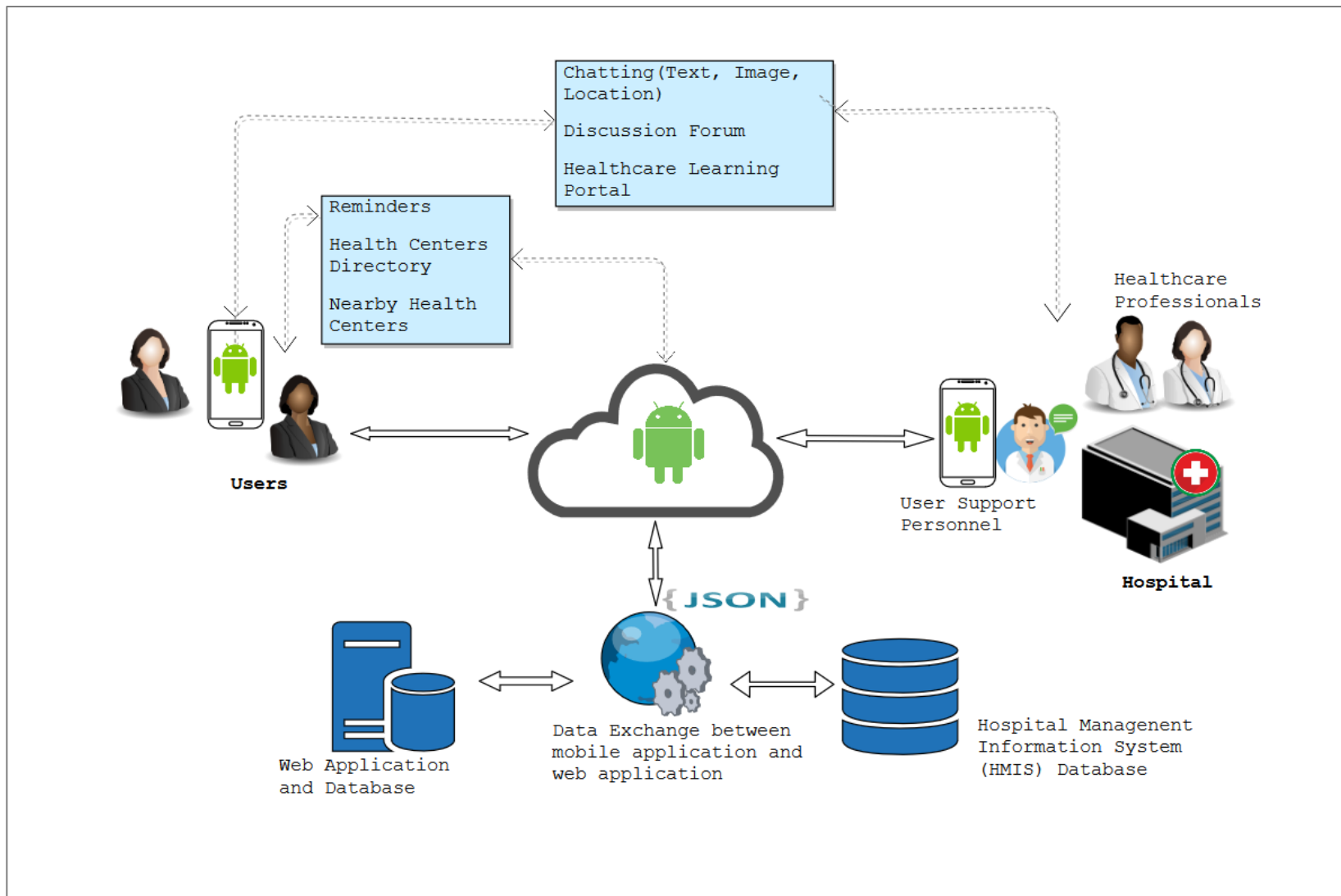


Figure 15: The application architecture for an interactive NMCH support mobile app

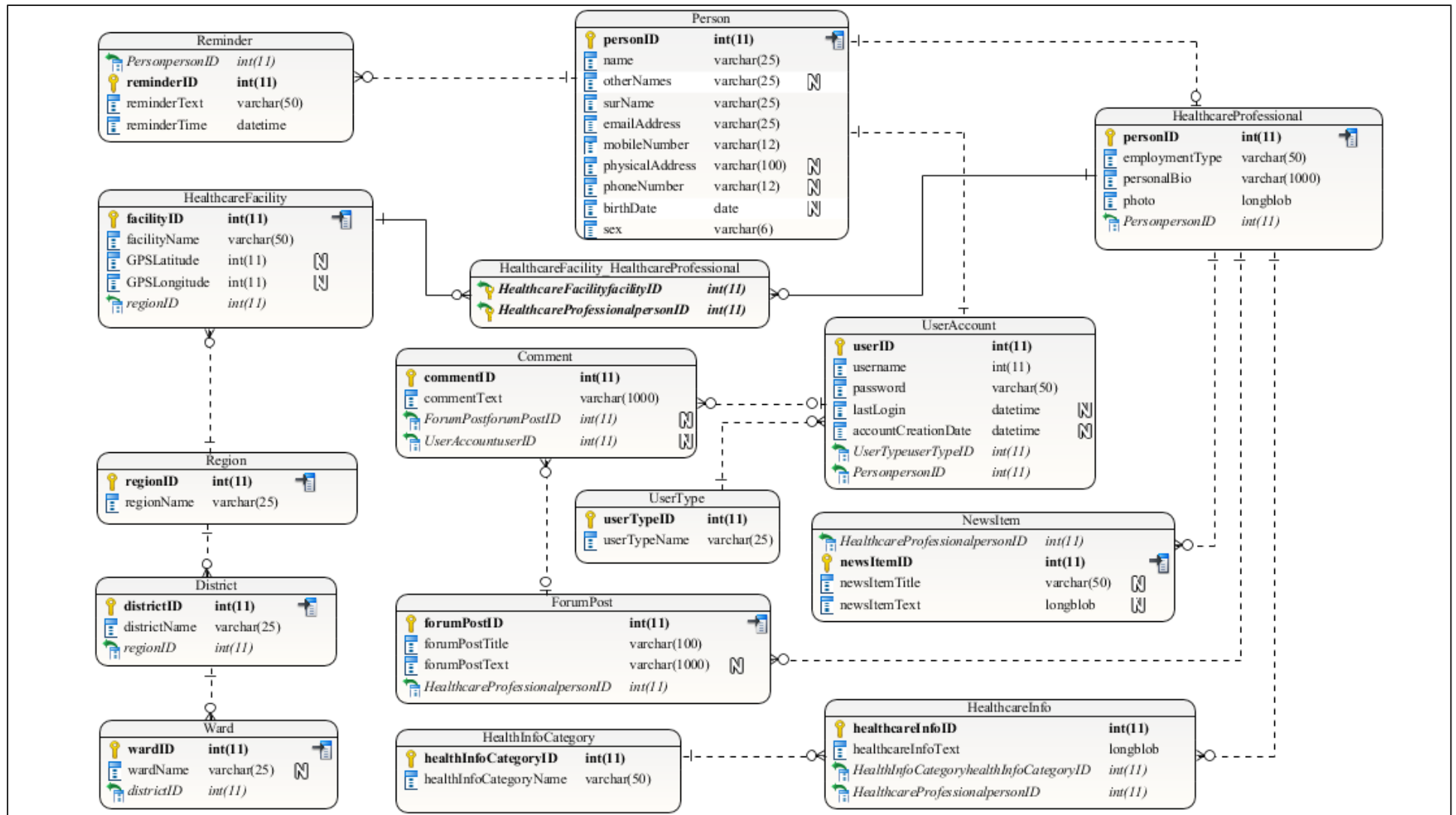


Figure 16: ER diagram for MNCH support mobile application



## **4.8. System Implementation**

Android has been the leading Operating System (OS) for smartphone devices worldwide since 2011. Android market share surpassed 70% of the mobile phones market share as of 2017 (Giachetti & Marchi, 2017). Android is the most powerful and flexible open source platforms for smartphones, tablets and other mobile devices (Meier, 2008). Android has been preferred by mobile phones manufacturers primarily because it is free and open source. As a result, cheaper mobile phones are becoming increasingly available in many markets worldwide. In addition, Android creators provided a free platform for developers to quickly write their mobile apps and make them available for users on the Google Play Store apps repository. Currently, millions of applications are available for Android smartphones. Android applications use XML and Java programming languages.

### **4.8.1. Android – Web application communication**

Communication between the mobile application and the web application is implemented using JavaScript Object Notation (JSON) data formatting and exchange technology, which represents text data using key-value pairs of ordered list (Bray, 2017). JavaScript object notation is supported by all major programming languages and is the preferred information exchange format between web clients and servers. Java's AsyncTask class is used to perform data exchange between a mobile application and a remote web server where the data is present.

### **4.8.2. EXtensible Markup Language (XML)**

Extensible Markup Language (XML) is a text formatting standard for storage and exchange of data over the World Wide Web, Intranets and elsewhere (Bray, Paoli, Sperberg-McQueen, Maler & Yergeau, 1998). This study adopted XML as the primary UI implementation language available in Android Integrated Development Environment (IDE). Android IDE uses XML as the primary user interface design language with all features and controls needed for designing a mobile application.

### **4.8.3. Java**

Android provides a platform for developers to use Java and XML programming languages to develop mobile applications. Java is an object-oriented programming language, widely versatile and compatible with multiple platforms and devices. Its simplicity, security, portability, dynamic,

and performance has made Java the preferred language for Android developers (Saha, 2012). After the user interface (UI) design was completed, Java programming language was used to implement the business logic of the mobile app. The rationale for using Java programming language is because it contains many libraries already packaged in Android IDE, eliminating any need for extra efforts in finding libraries for software development. Also, Java programming language has the necessary classes for connectivity between the app and web server.

#### **4.8.4. Hypertext Pre-processor (PHP) – Web Application**

The web application part is implemented using PHP programming language which is the most widely used programming language for web applications. Being an open source programming language, PHP is freely available for use by web based applications developers (PHP Group, 2017). It supports all popular databases such as Oracle, PostgreSQL and MySQL. To develop the mobile application for this study, MySQL database management system was used.

#### **4.8.5. MySQL**

MySQL is a robust, free and reliable Database Management System (DBMS). Despite its acquisition by Oracle, MySQL has maintained a community edition, which supports all major features available in other modern DBMS. It uses the standard Structured Query Language (SQL). It enables developers to deploy high performance and cost-effective database driven systems. MySQL provides developers with the flexibility to implement many features for high system performance such as replication, clustering, and indexing. In addition, MySQL gives users the ability to define role-based access restrictions and outstanding security features on their database (Reese, Yarger, King & Williams, 2002).

#### **4.8.6. Android App – MySQL Database Connectivity**

The MNCH android app installed on a user's mobile phone communicates and exchanges data with the MySQL database using HTTP client. The mobile app uses Java libraries and Java AsyncTask to connect and exchange data between the app and MySQL server through the web server. After establishing a connection, JSON formatted data is processed by PHP functions on the web server and Java classes in the mobile app. The simplified procedure for the exchange of data between the mobile app and the web application is explained by Fig. 17 below.

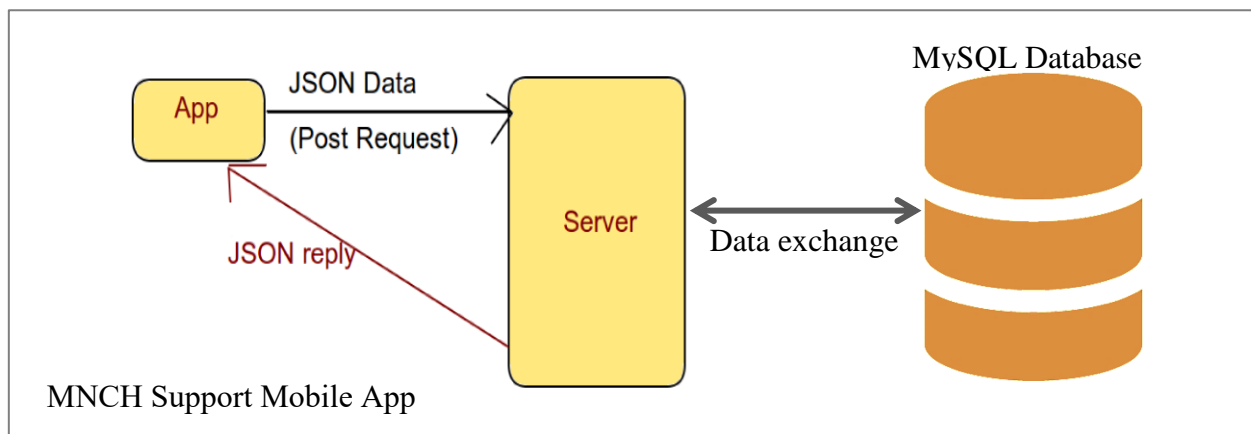


Figure 17: Conceptual diagram for the mobile app and the web app data exchange

#### 4.8.7. Smooch Platform for Instant Messaging (IM)

Smooch provides a multichannel messaging and communication platform that can be integrated into enterprise software for customer engagement. Smooch offers developers a rich set of channels, such as web messaging, Android messaging, Telegram messaging, email, and more (Smooch Technologies Inc, n.d.). By adding Smooch messenger in an app, an organisation can allow users to send queries using email, web messaging, or an existing messaging application on user's mobile device. For this study, Smooch API was used to enable users to communicate with healthcare providers and professionals using instant messaging (chatting) feature.

#### 4.8.8. Firebase

Firebase provides an extensive set of solutions for mobile and web applications development. Firebase was founded as Firebase Inc. in 2011, then acquired by Google in 2014 (Lardinois, 2014). Firebase offers a wide range of services and products, including real-time databases, cloud storage, remote configurations, test lab for Android apps, crash reporting, hosting, performance monitoring, Google analytics, dynamic links, App invites, AdMob, user notification, Application Indexing, and AdWords (Stonehem, 2016). Firebase reduces development time by offering ready tools for users to develop, test, host, advertise, and monitor their applications. Firebase was used in the development of the MNCH support app for cloud storage, messaging, user invites and test lab for the mobile app.

#### **4.9. Mobile Application Interfaces**

User interfaces of software seek to promote productive and engaging interactions between users and the software. The mobile application provides users with interfaces that make it usable. These interfaces enable users to navigate different functions of the application intuitively. Figure 18 shows the MNCH support mobile application main interfaces.

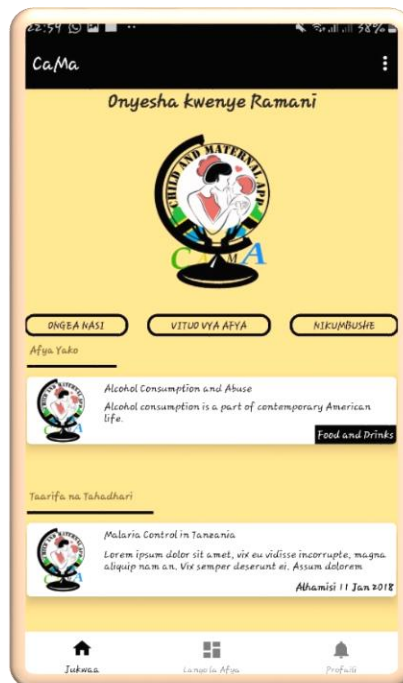
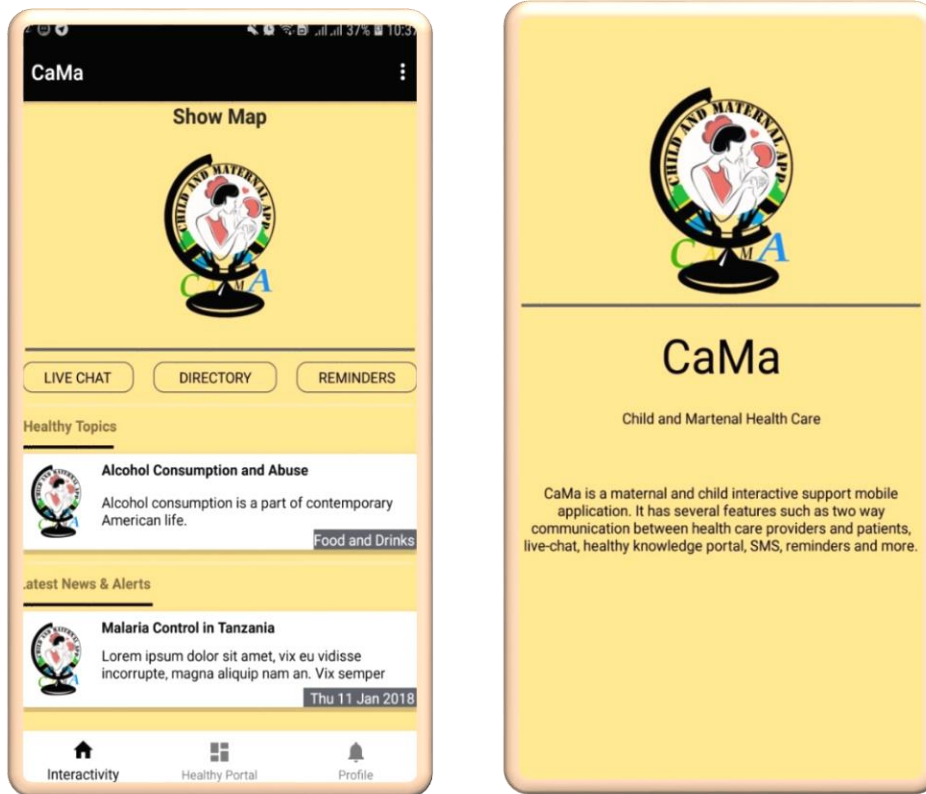


Figure 18: MNCH support mobile application main interfaces

#### **4.9.1. User Registration and Login**

This module provides users with functionalities to create an account, log in, and reset passwords. Any user can create an account by opening the account creation form and filling in necessary details such as full name, mobile number, username and password. A user can recover a forgotten password by supplying the mobile number used during initial registration. An activation code is sent to the number, and the user can set a new password. Figure 19 below shows the interfaces for user registration, and log in and password recovery.

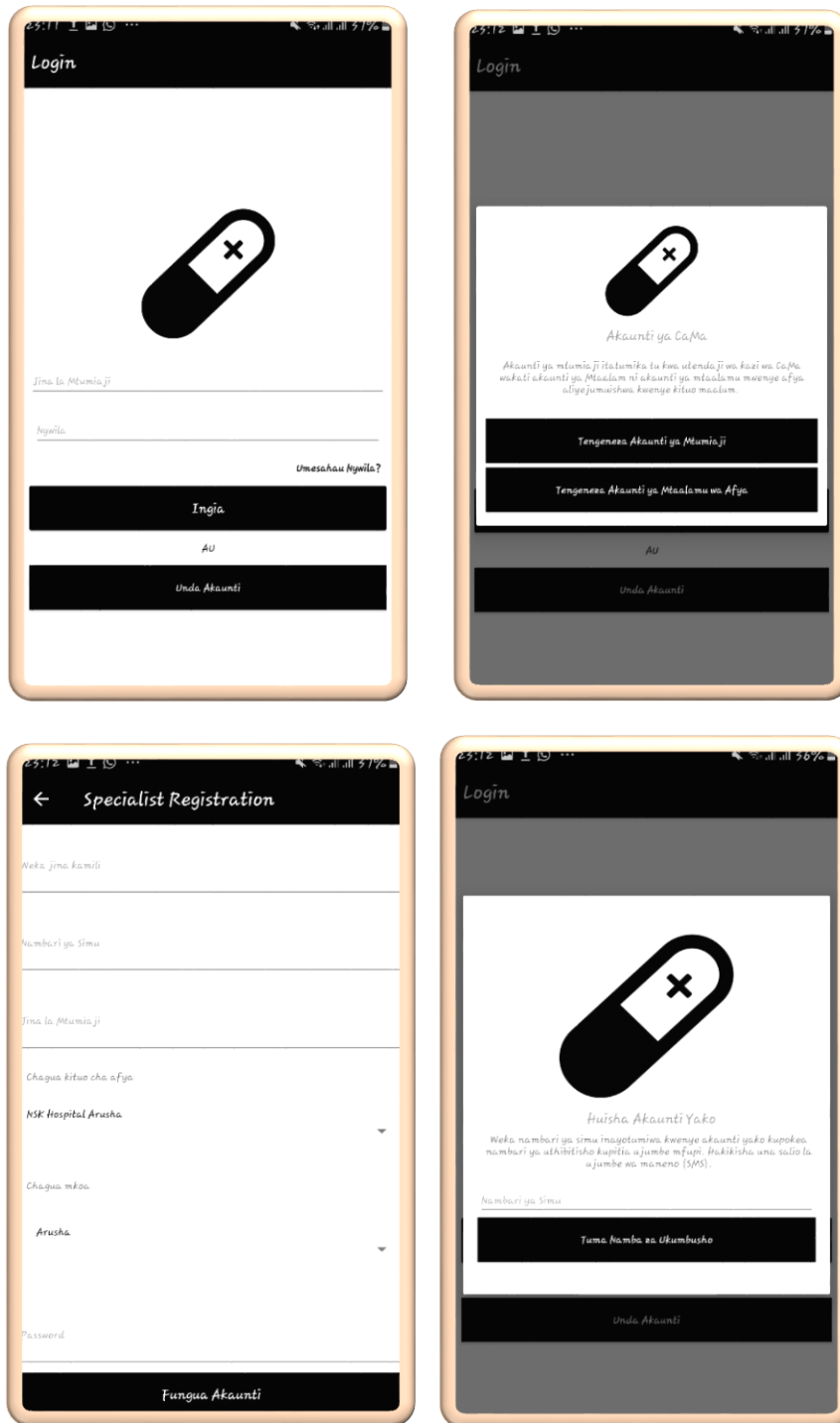


Figure 19: User registration, login, and account activation interfaces in Kiswahili

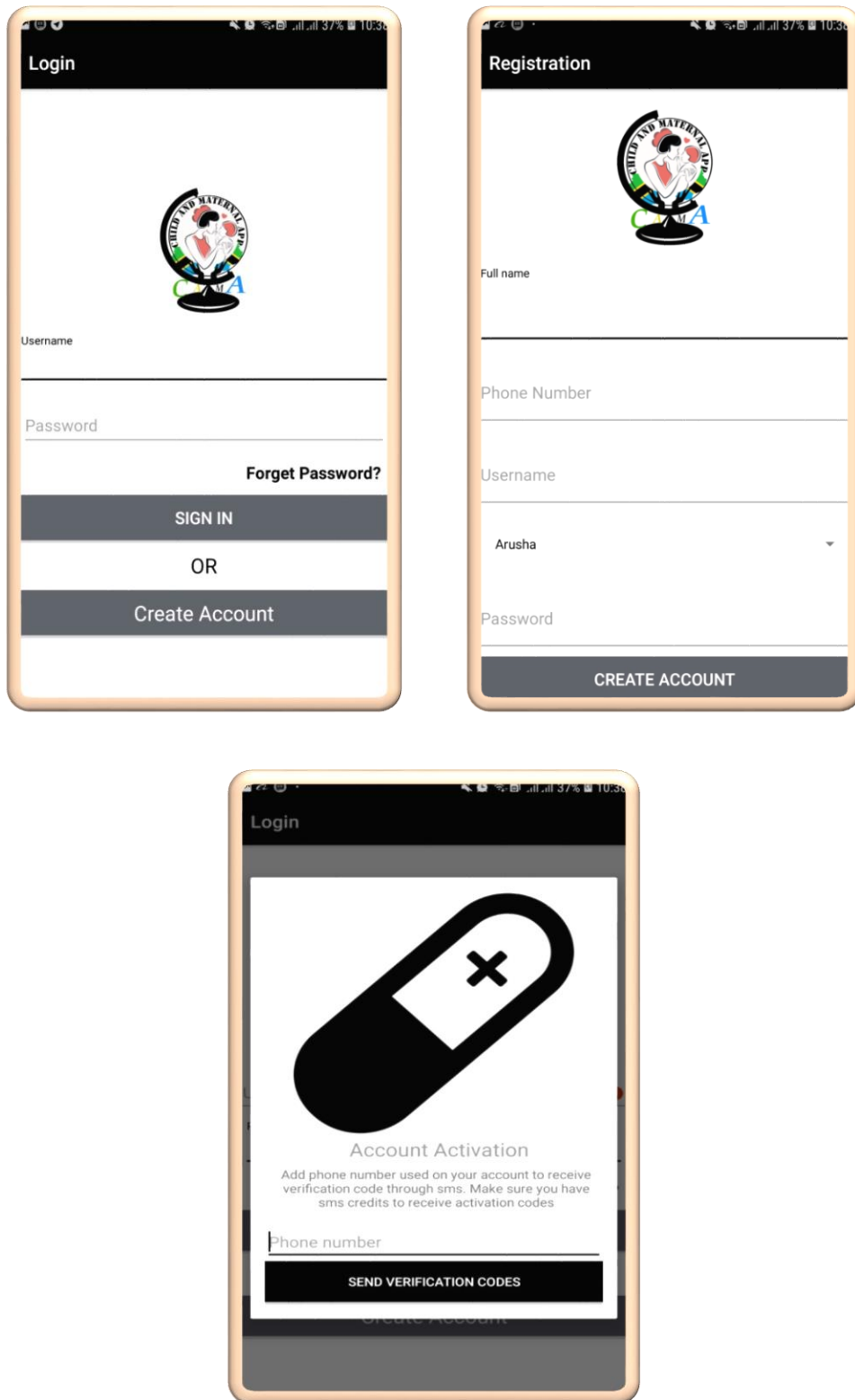


Figure 20: User registration, login, and account activation interfaces



#### **4.9.2. Live Support Instant Messaging**

A user can interact with healthcare providers and professionals using the live support function of the MNCH support app. A user can send text, images and her location on a chat screen. Healthcare providers and professionals can use this feature to communicate and instruct the patient in real time. The location of the patient can be seen on the chat screen when the patient is under emergency. Figure 20 shows live support interfaces.

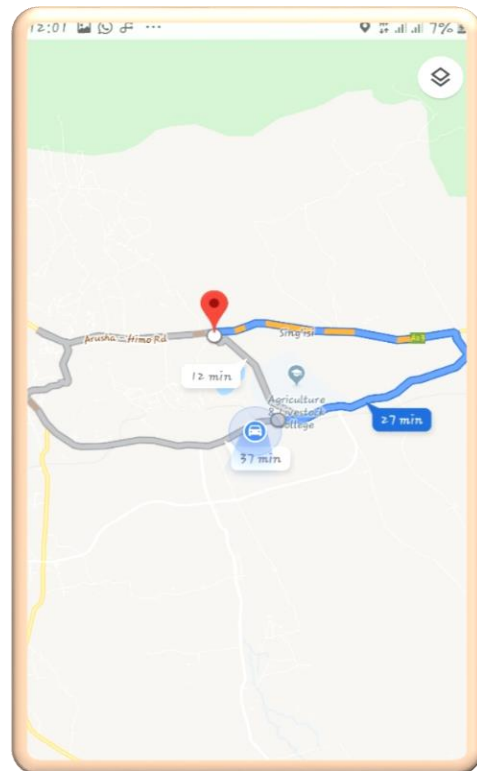
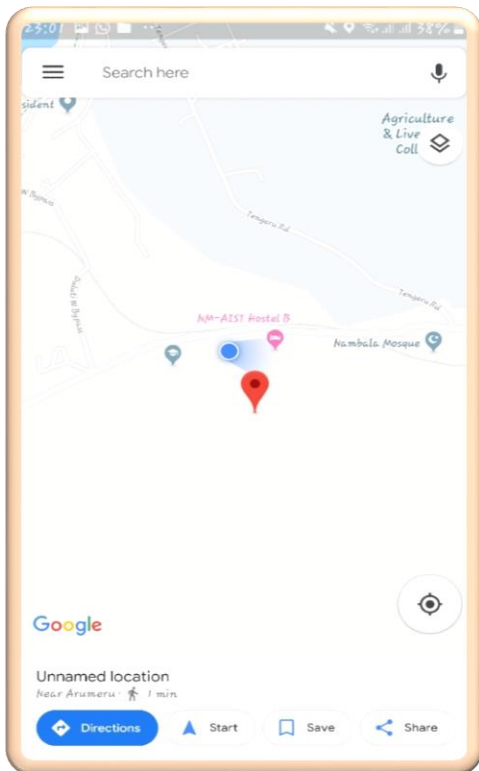
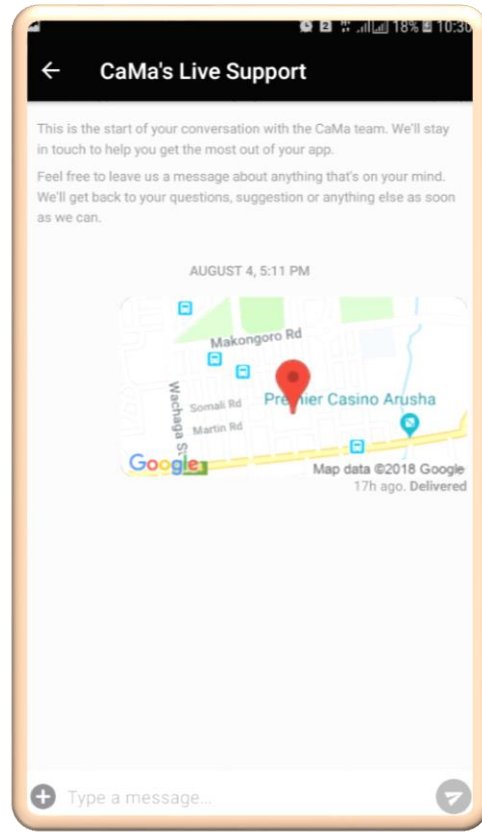


Figure 21: Live support (IM) interfaces

### 4.9.3. Latest News and Alerts

Users can get the latest news and alerts on the front page of the mobile application. News and alerts are useful especially to convey information to the general public. Latest news and alerts was used to convey relevant information to the public, such as informing the public about outbreaks of diseases and convey other health-related concerns to the general public. Latest news and alerts may also be used to conduct campaigns and to announce health-related events to the public. Figure 21 shows the latest news and alerts interfaces.

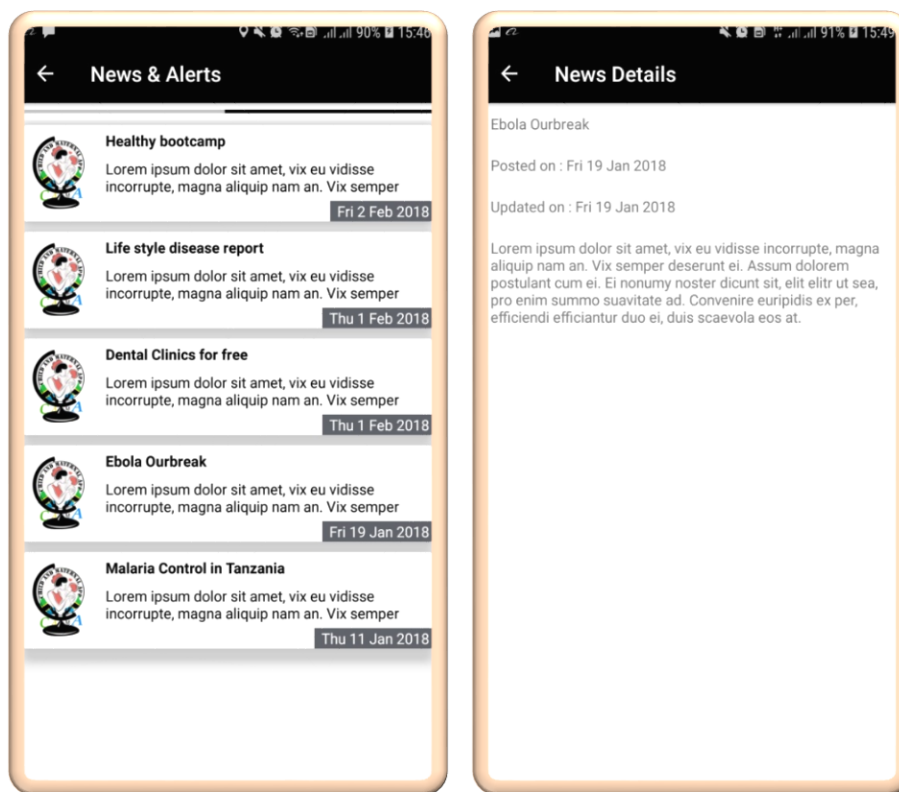


Figure 22: Latest news interfaces

### 4.9.4. Health Centres Directory

Users can view the health centres directory on the MNCH mobile app. The directory contains essential information for all health centres in Tanzania. A user can view a centre and get more details such as location, contact information and services offered. Such information may help a patient in making important decisions before arriving at the health centre. The user can also view the nearest health centres on a map using the user-specific location obtained from her mobile phone. Figure 22 below shows the health centres directory interfaces.

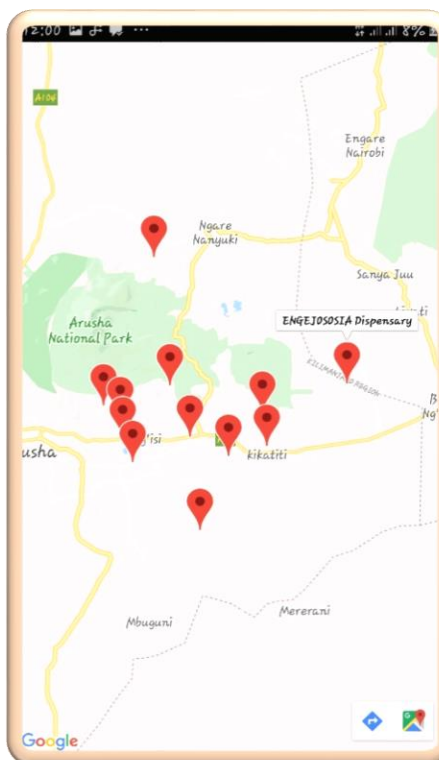
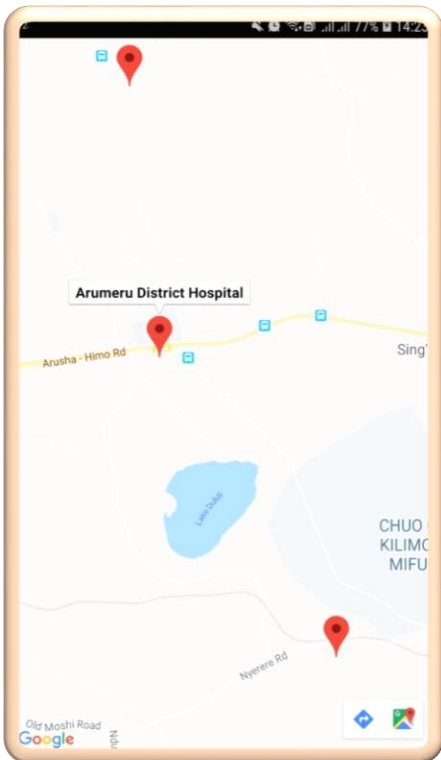
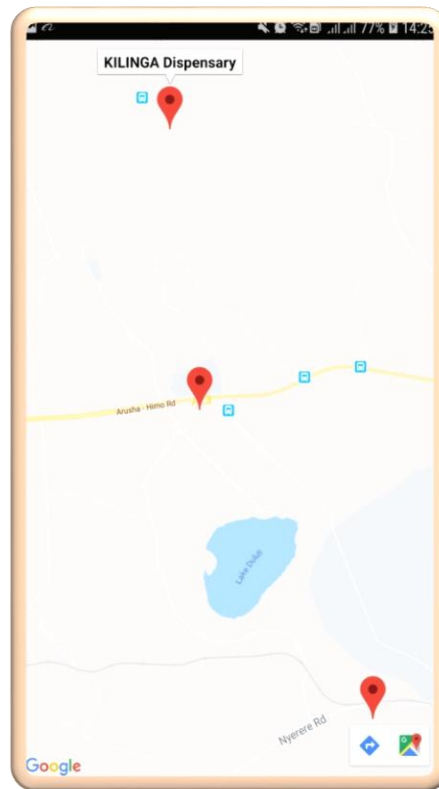
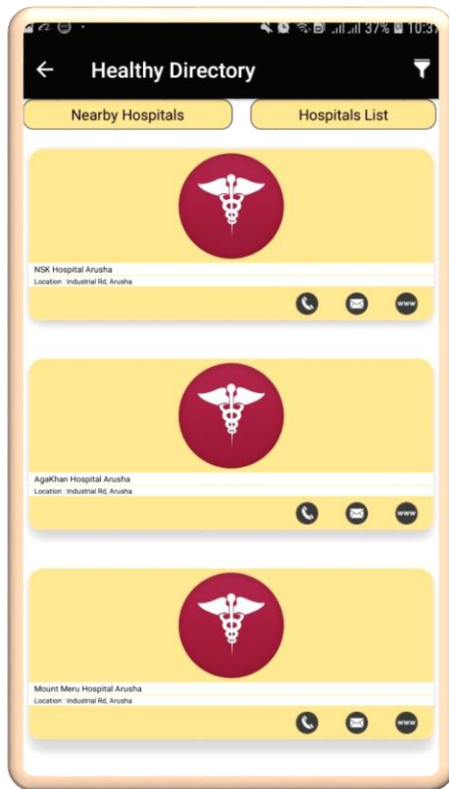


Figure 23: Health centres directory and nearest health centres

#### 4.9.5. Health Information Portal

The MNCH support mobile app also contains a health information portal. The portal is a learning platform for users. Healthcare professionals upload different topics related to MNCH. Figure 23 shows the health information portal interfaces.

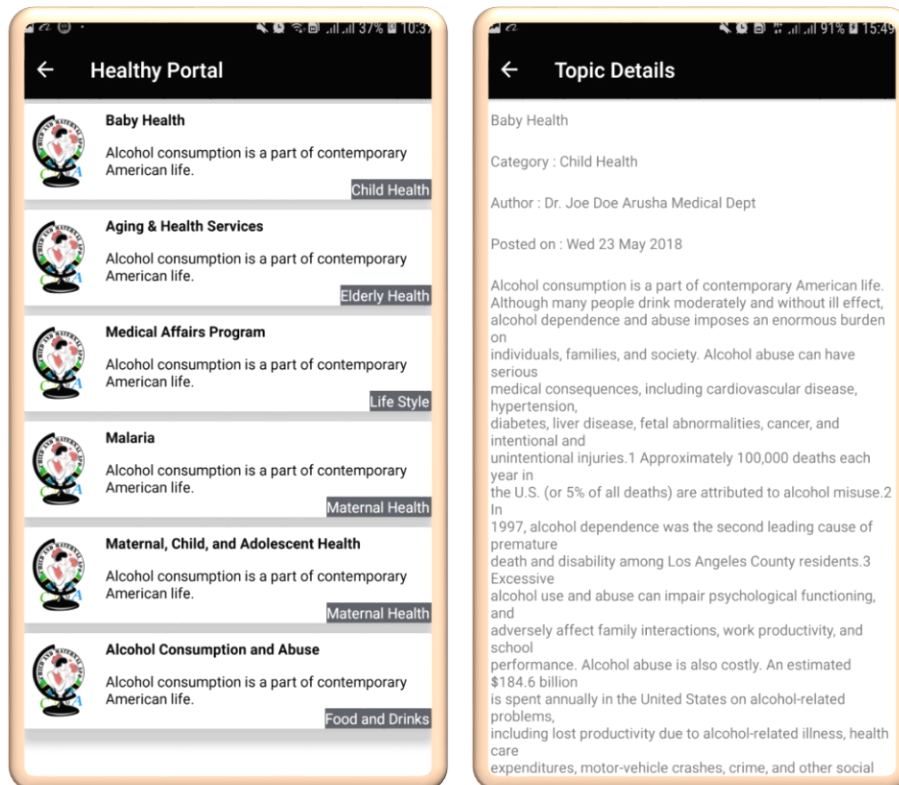


Figure 24: Health information portal

#### 4.9.6. Application Settings

The MNCH support mobile app provides features for the user to configure several settings on the app. Some of the settings which are performed by the user are language settings, user account settings, and personal reminders. Also, a user can perform other related actions on the app such as inviting new users and subscribing to an email list for news and updates information. Figure 24 below shows the essential app settings.

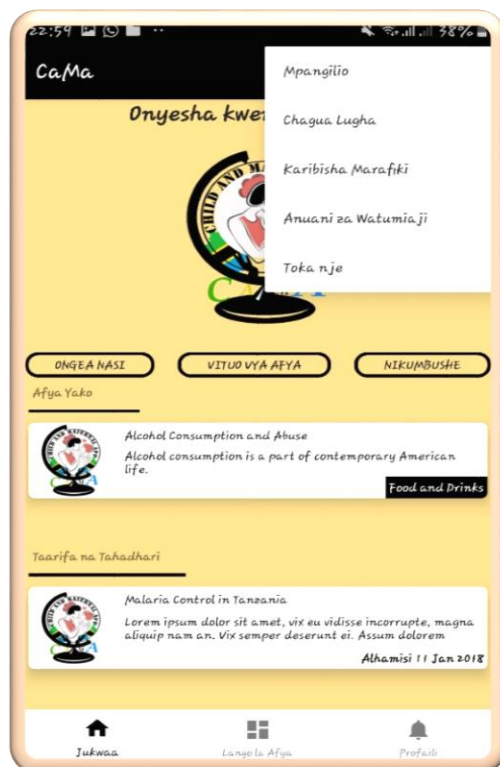
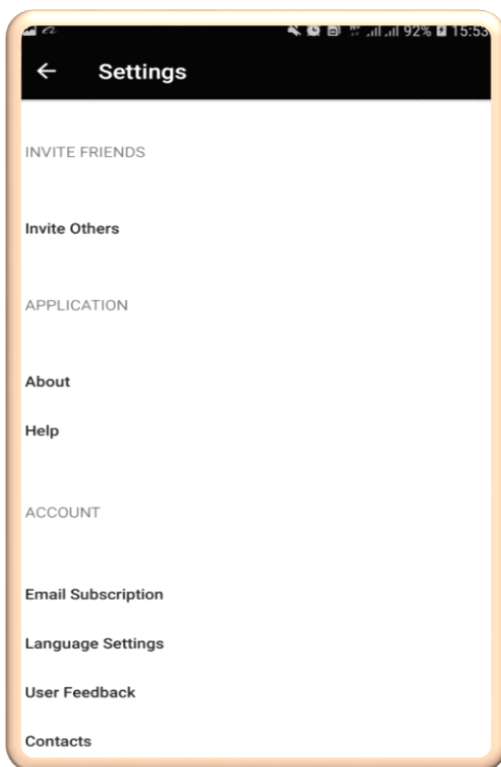
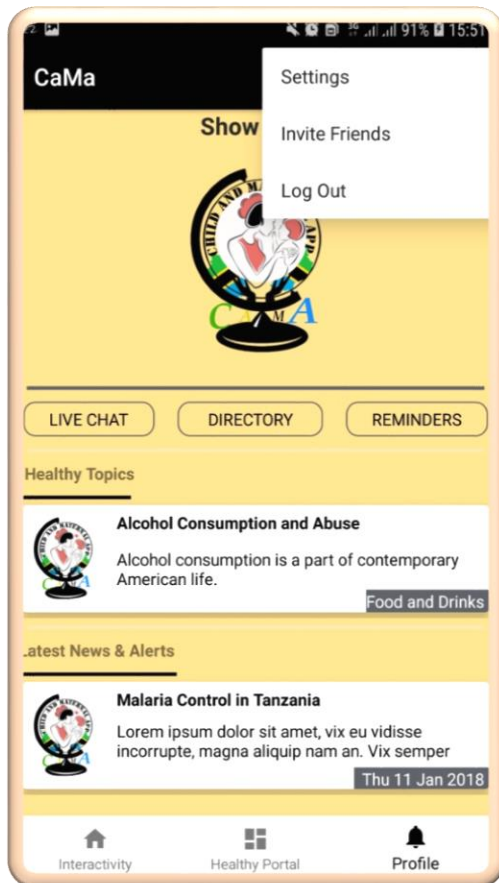


Figure 25: Application settings interfaces

## **4.10. System Testing**

### **4.10.1. Unit Testing, UI Testing and Integration Testing**

The MNCH mobile application went through three tests, namely unit testing, integration testing, and user interface (UI) testing whereby both manual and automated testing techniques were employed.

Functional testing technique was used to perform unit testing of the mobile application throughout the project during the implementation of each module. Using the testing methods mentioned, every part of the software was verified to conform to the requirements specification. For this application, testing was done using a combination of manual tests and using automated test scripts generated using JUnit available on Android Studio as provided in Nolan (2015).

Integration testing was used to test the collective working of the modules of the mobile application. User interface testing was also done using various test cases on the graphical user interface such as login screen, chatting interface, discussion forum and reminders.

While testing was done throughout the development of the mobile application, formal testing was done by selected ICT Masters students' volunteers at NM-AIST. Table 6 shows the details of the conducted formal testing of the MNCH support the mobile app.

Table 6: Mobile app testing report for key modules

Function	Test Description	Result
User Registration	User can enter personal details and register	PASS
	The app shows appropriate error messages for incorrect details	PASS
User Login	A user can log in to the mobile app after registration	PASS
	The app denies user login when details are incorrect	PASS
Live Chat	A user can send text, image and location on a chat screen	PASS
	A healthcare professional can see the user message and reply	PASS
	A healthcare professional can identify user's location on a map	PASS
Latest News	Latest news and alerts are displayed on the app	PASS
	A user can open and read the latest news and alerts	PASS
Discussion Forum	A user can see the list of discussion topics	PASS
	A user can open a discussion topic	PASS
	A user can comment on a discussion topic	PASS
Directory	A user can see the list of available health centres	PASS
	A user can view the nearest health centre on a map	PASS
	A user can view health centre contact details	PASS
Information Portal	A user can see the list of health information portal topics	PASS
	A user can open a health information topic	PASS
Reminders	A user can set a reminder	PASS
	A user can delete a reminder	PASS
	A user can modify a reminder	PASS

#### 4.10.2. Usability Testing and Validation

Survey was used to validate the MNCH support mobile app. Participants of the validation were pregnant women and infant mothers' volunteers selected at Mwananyamala and Temeke hospitals. Only volunteers who had smartphones with internet working on their mobile phones were admitted for this evaluation. The composition of the evaluation participants were nurses (n=3), mothers with infants (n=14), and pregnant women (n=13). The evaluation was done for two days in December 2018, one day at Temeke Hospital and another day at Mwananyamala Hospital. All participants were given an opportunity for a demo session, followed by interaction with at least



one module of the MNCH support mobile app for a duration of time and then filling of the app evaluation questionnaire.

The validation results confirm the research findings in the previous sections. Users accepted the MNCH mobile application as easy to install, learn and use. Majority of the users agree with the assertion that the contents of the app are meaningful and useful. From the design point of view, users accepted the placing of buttons, labels, text content, and font sizes. Moreover, the app was found to be compatible with the mobile phones of most of the users. The app further functions well with internet connectivity.

The survey shows that users agreed with perceived advantages of the app notably helping in communication with healthcare providers and interaction with other users. As a result, most of the users would recommend such an app to other users. The results of the responses are shown in table 7 below.

Table 7: Mobile application evaluation results

#	Question	Strongly agree	Agree	Disagree	Strongly disagree	Not sure
		%	%	%	%	%
1	The mobile app is easy to install, learn and use	50	37	3	3	7
2	The mobile app interactive	50	33	3	0	13
3	The contents and features of the app meaningful	33	23	33	7	3
4	I did not get any compatibility problem with my phone	40	33	17	3	7
5	Internet connectivity works perfectly with the mobile app	67	27	3	0	3
6	I will need technical assistance in using the mobile app	3	10	63	10	13
7	The labels and buttons text clear and concise	47	50	0	3	0
8	The font size and spacing are suitable for readability of information	83	7	3	3	3

#	Question	Strongly agree	Agree	Disagree	Strongly disagree	Not sure
		%	%	%	%	%
9	The mobile app provides a confirmation option when deleting	17	7	0	0	77
10	Error messages clearly explain how to correct the problem	50	10	33	3	3
11	The information is useful and could be helpful	87	3	3	7	0
12	I think that I would like to use the Application	90	3	3	0	3
13	The application helps to communicate with healthcare providers	57	7	3	0	33
14	The application helps to interact with other users	10	17	33	0	40
15	I will recommend this mobile application for other users	93	0	0	0	7

## CHAPTER FIVE

### CONCLUSION AND RECOMMENDATIONS

#### 5.1. Conclusion

The findings of the survey reveal that the majority of pregnant women and mothers with infants exhibit readiness to install and use mobile application for providing support during pregnancy and infant care. Significantly, an increasing number of users possesses smartphones, and the majority of these smartphones' owners use internet on their mobile phones. Thus, these users are the potential users of the MNCH support mobile application.

Moreover, the respondents' preference for mobile application features that enhance interaction between healthcare providers such as instant messaging, discussion forums, online learning materials and information, and personalisation is significant. There is a clear indication that a mobile application for providing interactive support during pregnancy, delivery and childcare will likely be useful. Since this research was done in urban hospitals, further research is needed for rural areas where there are limited smartphones ownership and internet penetration.

The mobile app for maternal, newborn and child health support provide pregnant women and infant mothers with a range of interactive features, which address the challenges of inadequate support they receive before they physically arrive at a health facility. The application takes advantage of the rapid growth of smartphones ownership and internet penetration in Tanzania. It gives users the ability to communicate with healthcare professionals, access knowledge portal, set reminders of important events such as infant vaccination and clinical attendances, discover healthcare directory on an interactive map and engages in discussion forums.

Therefore, the mobile app adds to other interventions especially mHealth related interventions aimed at reducing the high maternal and infant deaths in Tanzania. It is developed by considering the local environment and challenges. These challenges are such as language barrier, which is addressed by the ability to switch language, and local content ownership, where doctors and healthcare professionals in Tanzania hospitals and health centres are the primary content creators in the Swahili. The mobile app links healthcare service providers and patients in both real and

delayed times. It also allows patients to learn and communicate using interactive features available on the app.

## **5.2. Recommendations**

The app evaluation survey shows that the app is an appropriate solution to the end users. Majority of the respondents indicated their willingness to use the app. Users agreed with the foreseen advantages of the app such as the ability to communicate with healthcare providers and other users. From the above assessment, we recommend the following: -

- (i) Taking into consideration that reducing MMR and IMR in the developing countries requires efforts in multiple fronts, the government should continue with efforts improve quality of healthcare service delivery, reduce income inequalities, extend similar healthcare incentives to private hospitals as in government hospitals, address infrastructural challenges in rural areas and reduce the unequitable access to healthcare, particularly MNCH support services.
- (ii) The developed MNCH support mobile application should be made available on the Google Play store for users and healthcare professionals while encouraging hospitals to use the features of the app to enhance communication and support for MNCH.
- (iii) Education and awareness on how to use MNCH support mobile application should be provided to users.
- (iv) Government and other stakeholders should continue with efforts to reduce MMR and IMR in Tanzania by considering other approaches such as providing mobile devices to most vulnerable pregnant women and infant mothers as well as reduced prices for internet connectivity on their mobile phones.

## REFERENCES

- Alkema, L., Chou, D., Hogan, D., Zhang, S., Moller, A.-B., Gemmill, A., ... Mathers, C. (2016). Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030. *Obstetric Anesthesia Digest*, 36(4). [https://doi.org/10.1016/S0140-6736\(15\)00838-7](https://doi.org/10.1016/S0140-6736(15)00838-7)
- Alturki, R., & Gay, V. (2017). Usability testing of fitness mobile application : methodology and quantitative results. *Computer Science & Information Technology (CS & IT)*, 97–114. <https://doi.org/10.5121/csit.2017.71108>
- Anshari, M., & Almunawar, M. N. (2016). Mobile health (mHealth) services and online health educators. *Biomedical Informatics Insights*, 8, 19–27. <https://doi.org/10.4137/BII.S35388>
- Barnett, I., & Srivastava, S. (2017). *Desk-review: Determinants of undernutrition and existing m-Health services in Tanzania*. Retrieved from <https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/13124>
- Beratarrechea, A., Lee, A. G., Willner, J. M., Jahangir, E., Ciapponi, A., & Rubinstein, A. (2014). The impact of mobile health interventions on chronic disease outcomes in developing countries: A systematic review. *Telemedicine and E-Health*, 20(1), 75–82. <https://doi.org/10.1089/tmj.2012.0328>
- Berrouiguet, S., Baca-García, E., Brandt, S., Walter, M., & Courtet, P. (2016). Fundamentals for future mobile-health (mHealth): A systematic review of mobile phone and web-based text messaging in mental health. *Journal of Medical Internet Research*, 18(6), 135. <https://doi.org/10.2196/jmir.5066>
- Blasco-Arcas, L., Hernandez-Ortega, B. I., & Jimenez-Martinez, J. (2014). Collaborating online: The roles of interactivity and personalization. *Service Industries Journal*, 34(8), 677–698. <https://doi.org/10.1080/02642069.2014.886190>

- Boudreaux, E. D., Waring, M. E., Hayes, R. B., Sadasivam, R. S., Mullen, S., & Pagoto, S. (2014). Evaluating and selecting mobile health apps: strategies for healthcare providers and healthcare organizations. *Translational Behavioral Medicine*, 4(4), 363–371. <https://doi.org/10.1007/s13142-014-0293-9>
- Braude, E. J., & Bernstein, M. E. (2010). *Software Engineering: Modern Approaches*. 53(9), 376.
- Bray, T. (2017). The JavaScript Object Notation (JSON) Data Interchange Format. *RFC*, 8259, 1-16.
- Bray, T., Paoli, J., Sperberg-McQueen, C. M., Maler, E., & Yergeau, F. (1998). Extensible Markup Language (XML). In *World Wide Web Journal*. <https://doi.org/10.1111/j.1467-937X.2009.00537.x>
- Chinnery, G. M. (2006). Going to the MALL : Mobile Assisted Language Learning. *Language Learning & Technology*, 10(1), 9–16. <https://doi.org/ISSN 1094-3501>
- Chu, K. M., & Yuan, B. J. C. (2013). The Effects of Perceived Interactivity on E-Trust and E-Consumer Behaviors: The Application of Fuzzy Linguistic Scale. *Journal of Electronic Commerce Research*, 14(1), 124–137.
- Cyr, D., Head, M., & Ivanov, A. (2009). Perceived interactivity leading to e-loyalty: Development of a model for cognitive-affective user responses. *International Journal of Human Computer Studies*, 67(10), 850–869. <https://doi.org/10.1016/j.ijhcs.2009.07.004>
- Earp, R., & Bagui, S. (2012). Database Design Using Entity-Relationship Diagrams. In *Library*. <https://doi.org/10.1201/9780203486054>
- Giachetti, C., & Marchi, G. (2017). Successive changes in leadership in the worldwide mobile phone industry: The role of windows of opportunity and firms' competitive action. *Research Policy*, 46(2), 352–364. <https://doi.org/10.1016/j.respol.2016.09.003>
- Gomaa, H. (2011). Software modelling and design: UML, use cases, patterns, and software architectures. In *Software Modelling and Design: UML, Use Cases, Patterns, and Software Architectures* (Vol. 9780521764). <https://doi.org/10.1017/CBO9780511779183>

- Hashim, M. J. (2016). User interactivity in eHealth applications: A novel taxonomy. *2016 Twelfth International Conference on Innovations in Information Technology (IIT)*, 1–4. IEEE.
- Heffernan, K. J., Chang, S., Maclean, S. T., Callegari, E. T., Garland, S. M., Reavley, N. J., ... Wark, J. D. (2016). Guidelines and Recommendations for Developing Interactive eHealth Apps for Complex Messaging in Health Promotion. *Journal of Medical Internet Research: MHealth and UHealth*, 4(1), e14. <https://doi.org/10.2196/mhealth.4423>
- IPP Media. (2018). Challenge of making the iPhone more “affordable” in Tanzania. Retrieved October 30, 2019, from <https://www.ippmedia.com/en/business/challenge-making-iphone-more-affordable-tanzania>
- Jiang, Z., Chan, J., Tan, B. C., & Chua, W. S. (2010). Effects of Interactivity on Website Involvement and Purchase Intention. *Journal of the Association for Information Systems*, 11(1), 34–59. <https://doi.org/Article>
- KNBS. (2015). *Republic of Kenya Kenya Demographic and Health Survey 2014 Kenya National Bureau of Statistics*. Retrieved from [www.DHSprogram.com](http://www.DHSprogram.com).
- Kowalcek, I., & Hainer, F. (2012). Is There a Relation Between Maternal Age and Preferred Mode of Delivery? *Journal of Clinical Gynecology and Obstetrics*, 1(1), 4–9. <https://doi.org/10.4021/JCGO.VIII.8>
- Kronenfeld, J. J. (2016). Infant Mortality Rates. In *Encyclopedia of Family Studies*. <https://doi.org/10.1002/9781119085621.wbef018>
- Lai, P. (2017). Literature Review of Technology Adoption Models and Theories for the Novelty Technology. *Journal of Information Systems and Technology Management*, 14(1), 21–38. <https://doi.org/10.4301/S1807-17752017000100002>
- Lardinois, F. (2014). Google Acquires Firebase To Help Developers Build Better Real-Time Apps TechCrunch. *Tech Crunch*.

- Lee, E., Asiimwe, C., Sundaram, L., Amor, Y. B., Quinto, E., Gelvin, D., ... Katureebe, C. (2011). Use of an Innovative, Affordable, and Open-Source Short Message Service–Based Tool to Monitor Malaria in Remote Areas of Uganda. *The American Journal of Tropical Medicine and Hygiene*, *85*(1), 26–33. <https://doi.org/10.4269/ajtmh.2011.10-0528>
- Lemay, N. V., Sullivan, T., Jumbe, B., & Perry, C. P. (2012). Reaching remote health workers in Malawi: Baseline assessment of a pilot mhealth intervention. *Journal of Health Communication*. <https://doi.org/10.1080/10810730.2011.649106>
- Littman-quinn, R., Chandra, A., Schwartz, A., Chang, A. Y., Fadlelmola, F. M., Ghose, S., ... Bewlay, L. (2011). mHealth Applications for Clinical Education , Decision Making , and Patient Adherence in Botswana. *IST-Africa 2011 Conference Proceedings*.
- Lund, S., Hemed, M., Nielsen, B. B., Said, A., Said, K., Makungu, M. H., & Rasch, V. (2012). Mobile phones as a health communication tool to improve skilled attendance at delivery in Zanzibar: A cluster-randomised controlled trial. *An International Journal of Obstetrics and Gynaecology*, *119*(10), 1256–1264. <https://doi.org/10.1111/j.1471-0528.2012.03413.x>
- Lund, S., Nielsen, B. B., Hemed, M., Boas, I. M., Said, A., Said, K., ... Rasch, V. (2014a). Mobile phones improve antenatal care attendance in Zanzibar: A cluster randomized controlled trial. *BMC Pregnancy and Childbirth*, *14*(1), 29. <https://doi.org/10.1186/1471-2393-14-29>
- Lund, S., Nielsen, B. B., Hemed, M., Boas, I. M., Said, A., Said, K., ... Rasch, V. (2014b). Mobile phone intervention reduces perinatal mortality in Zanzibar: Secondary outcomes of a cluster randomized controlled trial. *Journal of Medical Internet Research*, *16*(3), e15. <https://doi.org/10.2196/mhealth.2941>
- Meier, R. (2008). Professional Android Application Development. In *Framework*. <https://doi.org/10.1007/9781118102275>
- NBS. (2016). Tanzania Demographic and Health Survey 2016. In *National Bureau of Statistics Dar es Salaam, Tanzania ICF Macro Calverton, Maryland, USA*. [https://doi.org/10.1007/SpringerReference\\_187125](https://doi.org/10.1007/SpringerReference_187125)



- Neumann, M. (2015). Relative Smartphone Penetration in Tanzania. Retrieved March 10, 2017, from <http://www.tetea.org/relative-smartphone-penetration-in-tanzania/>
- Ngabo, F., Nguimfack, J., Nwaigwe, F., Mugeni, C., Muhoza, D., Wilson, D. R., ... Binagwaho, A. (2012). Designing and implementing an innovative SMS-based alert system (RapidSMS-MCH) to monitor pregnancy and reduce maternal and child deaths in Rwanda. *Pan African Medical Journal*, 13. <https://doi.org/10.11604/pamj.2012.13.31.1864>
- Nolan, G. (2015). Android Unit Testing. In *Agile Android* (pp. 15–24). Springer.
- Noordam, A. C., Kuepper, B. M., Stekelenburg, J., & Milen, A. (2011). Improvement of maternal health services through the use of mobile phones. *Tropical Medicine and International Health*, 16. <https://doi.org/10.1111/j.1365-3156.2011.02747.x>
- Nyamawe, A. S., & Seif, H. (2014). The role of ICT in reducing maternal and neonatal mortality rate in Tanzania. *International Journal of Computer Applications*, 95(13).
- O' Connor, Y., & O' Donoghue, J. (2015). Contextual Barriers to Mobile Health Technology in African Countries: A Perspective Piece. *Journal of Mobile Technology in Medicine*, 4(1), 31–34. <https://doi.org/10.7309/jmtm.4.1.7>
- Paetsch, F., Eberlein, A., & Maurer, F. (2003). Requirements engineering and agile software development. *WET ICE 2003 Proceedings: Twelfth IEEE International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises.*, 308–313. IEEE.
- Pawar, R. P. (2015). A Comparative study of Agile Software Development Methodology and traditional waterfall model. *IOSR Journal of Computer Engineering*, 01–08. Retrieved from <http://www.iosrjournals.org/iosr-jce/papers/NCIEST/Volume 2/01.01-08.pdf>
- Petre, M. (2013). UML in practice. *2013 35th International Conference on Software Engineering*, 722–731. IEEE.
- PHP Group. (2017). PHP Manual: What is PHP? Retrieved October 20, 2018, from <https://www.php.net/manual/en/intro-what-is.php>

- Piette, J., Lun, K., Moura, L., Fraser, H., Mechael, P., Powell, J., & Khoja, S. (2012). Impacts of e-health on the outcomes of care in low- and middle-income countries: where do we go from here? *Bulletin of the World Health Organization*. <https://doi.org/10.2471/BLT.11.099069>
- Poushter, J. (2016). Smartphone ownership and internet usage continue to climb in emerging economies. *Pew Research Center*, 22, 1–44.
- Reese, G., Yarger, R. J., King, T., & Williams, H. E. (2002). Managing and using MySQL. In *Book*.
- Research2Guidance. (2017). *mHealth App Economics 2017: Current Status and Future Trends in Mobile Health*. Retrieved from <https://research2guidance.com/product/mhealth-economics-2017-current-status-and-future-trends-in-mobile-health/>
- Rice, R. E. (1984). New media technology: Growth and integration. *The New Media: Communication, Research, and Technology*, 33–54.
- Rogers, E. M. (1995). Diffusion of innovations. In *Macmillian Publishing Co*. <https://doi.org/citeulike-article-id:126680>
- Rosenblatt, H. J. & Shelly, G. B. (2012). Rapid Application Development. In *Systems Analysis and Design*. <https://doi.org/10.1017/CBO9781107415324.004>
- Saha, A. K. (2012). A Developer's Frst Look At Android. *ICCSE 2012 - Proceedings of 2012 7th International Conference on Computer Science and Education*. <https://doi.org/10.1109/ICCSE.2012.6295176>
- Seidenberg, P., Nicholson, S., Schaefer, M., Semrau, K., Bweupe, M., Masese, N., ... Thea, D. (2012). Early infant diagnosis of HIV infection in Zambia through mobile phone texting of blood test results. *Bulletin of the World Health Organization*, 90(5), 348–356. <https://doi.org/10.2471/BLT.11.100032>
- Shija, A. E., Msovela, J., & Mboera, L. E. G. (2011). Maternal health in fifty years of Tanzania independence: Challenges and opportunities of reducing maternal mortality. *Tanzania Journal of Health Research*. <https://doi.org/10.4314/thrb.v13i5.5>

- Shoo, R. S., Mboera, L. E. G., Ndeki, S., & Munishi, G. (2017). Stagnating maternal mortality in Tanzania: What went wrong and what can be done. *Tanzania Journal of Health Research*. <https://doi.org/10.4314/thrb.v19i2.6>
- Sim, J. H., Chung, D., Lim, J. S., Lee, M. Y., Chung, C. H., Shin, J. Y., & Huh, J. H. (2015). Maternal age at first delivery is associated with the risk of metabolic syndrome in postmenopausal women: from 2008-2010 Korean National Health and Nutrition Examination Survey. *PloS One*, *10*(5), e0127860. <https://doi.org/10.1371/journal.pone.0127860>
- Singh, A. S., & Masuku, M. B. (2013). Fundamentals of Applied Research and Sampling Techniques. *International Journal of Medical and Applied Sciences*.
- Skiba, D. J. (2014). The Connected Age: Mobile Apps and Consumer Engagement. *Nursing Education Perspectives*. <https://doi.org/10.1377/hlthaff.2012.1216>
- Smooch Technologies Inc. (n.d.). Smooch Docs. Retrieved October 12, 2018, from <https://docs.smooch.io/guide/>
- Sommerville, I. (2016). *Software Engineering*. Pearson Education Limited.
- Stone, A., Briggs, J., & Smith, C. (2002). SMS and interactivity-some results from the field, and its implications on the effective uses of mobile technologies in education. *Proceedings - IEEE International Workshop on Wireless and Mobile Technologies in Education, WMTE 2002*. <https://doi.org/10.1109/WMTE.2002.1039238>
- Stonehem, B. (2016). *Google Android Firebase: Learning the Basics* (Vol. 1). First Rank Publishing.
- Sun, J. N., & Hsu, Y. C. (2013). Effect of interactivity on learner perceptions in Web-based instruction. *Computers in Human Behavior*, Vol. 29, pp. 171–184. <https://doi.org/10.1016/j.chb.2012.08.002>
- TCRA. (2017). *Quarterly communications statistics report: October - December 2017 operator returns*. Retrieved from <https://www.tcra.go.tz/images/documents/telecommunication/>

- UBOS. (2016). *Uganda Demographic and Health Survey 2016: Key Indicators Report*. Retrieved from [www.DHSprogram.com](http://www.DHSprogram.com)
- UNDP. (2010). The Millennium Development Goals Report. *Development*, 17(1 Suppl), 80. <https://doi.org/10.1177/1757975909358250>
- WHO. (2006). *Indicator definitions and metadata*. Retrieved from <http://www.who.int/whosis/whostat2006DefinitionsAndMetadata.pdf?ua=1>
- WHO. (2015a). Health in 2015: from MDGs, Millennium Development Goals to SDGs, Sustainable Development Goals. *World Health Organisation*, 204. [https://doi.org/978 92 4 156511 0](https://doi.org/978_92_4_156511_0)
- WHO. (2015b). *Trends in maternal mortality: 1990-2015: Estimates from WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division*. Retrieved from World Health Organization website: [http://apps.who.int/iris/bitstream/10665/194254/1/9789241565141\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/194254/1/9789241565141_eng.pdf)

## APPENDICES

### Appendix I: AndroidManifest.xml File for the Mobile Application

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

    <uses-permission android:name="android.permission.ACCESS_NETWORK_STATE" />
    <uses-permission android:name="android.permission.INTERNET" />
    <uses-permission android:name="android.permission.ACCESS_WIFI_STATE" />
    <uses-permission android:name="android.permission.CALL_PHONE" />

    <application
        android:name=".CaMaSmoochie"
        android:allowBackup="true"
        android:icon="@mipmap/ic_launcher"
        android:label="@string/app_name"
        android:roundIcon="@mipmap/ic_launcher_round"
        android:supportsRtl="true"
        android:usesCleartextTraffic="true"
        android:theme="@style/AppTheme">

        <meta-data
            android:name="com.google.android.gms.version"
            android:value="@integer/google_play_services_version" />
        <meta-data
            android:name="com.google.android.geo.API_KEY"
            android:value="AIzaSyCUGo_p3MMkHLjMym_0wvw46Kp0JNRQmBU" />

        <activity
            android:name=".SplashActivity"
            android:label="@string/app_name"
            android:screenOrientation="sensor"
            android:theme="@android:style/Theme.Holo.Light.NoActionBar.Fullscreen">
            <intent-filter>
                <action android:name="android.intent.action.MAIN" />

                <category android:name="android.intent.category.LAUNCHER" />
            </intent-filter>
        </activity>
        <uses-library
            android:name="org.apache.http.legacy"
            android:required="false" />

        <activity
            android:name=".AppTourActivity"
            android:screenOrientation="sensor"
            android:theme="@style/Theme.AppCompat.Light.NoActionBar" />
        <activity
            android:name=".MainActivity"
            android:label="@string/app_name"
            android:screenOrientation="sensor" />
        <activity
            android:name=".DirectoryActivity"
            android:label="Healthy Directory"
            android:parentActivityName=".MainActivity"
            android:screenOrientation="sensor" />
        <activity
            android:name=".ContactsActivity"
            android:label="Forum Contacts"
```

```

        android:parentActivityName=".MainActivity"
        android:screenOrientation="sensor" />
<activity
    android:name=".HealthTopicsActivity"
    android:label="Healthy Portal"
    android:parentActivityName=".MainActivity"
    android:screenOrientation="portrait" />
<activity
    android:name=".NewsAlertsActivity"
    android:label="News & Alerts"
    android:parentActivityName=".MainActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".RegisterActivity"
    android:label="Registration"
    android:screenOrientation="portrait" />
<activity
    android:name=".LoginActivity"
    android:label="Login"
    android:screenOrientation="sensor" />
<activity
    android:name=".ProfileActivity"
    android:label="Profile"
    android:parentActivityName=".MainActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".InteractivityPostsActivity"
    android:label="Healthy Discussions"
    android:parentActivityName=".MainActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".InteractivityFormActivity"
    android:label="Add Posts"
    android:parentActivityName=".InteractivityPostsActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".SettingsActivity"
    android:label="Settings"
    android:parentActivityName=".MainActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".AboutActivity"
    android:label="About"
    android:parentActivityName=".SettingsActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".HelpActivity"
    android:label="Help"
    android:parentActivityName=".SettingsActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".FeedbackActivity"
    android:label="Feedback"
    android:parentActivityName=".SettingsActivity"
    android:screenOrientation="sensor" />

<service android:name=".FirebaseMessagingService">
    <intent-filter>
        <action android:name="com.google.firebase.MESSAGING_EVENT" />
    </intent-filter>
</service>
<service android:name=".FirebaseInstanceIdService">
    <intent-filter>

```

```

        <action android:name="com.google.firebase.INSTANCE_ID_EVENT" />
    </intent-filter>
</service>

<activity
    android:name=".RemindersActivity"
    android:label="Reminders"
    android:parentActivityName=".MainActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".AddRemindersActivity"
    android:label="Add Reminder"
    android:parentActivityName=".RemindersActivity"
    android:screenOrientation="sensor" />
<!-- Register the Alarm Receiver -->
<receiver android:name=".AlarmReciever" />

<activity
    android:name=".PostsRepliesActivity"
    android:label="Post Replies"
    android:parentActivityName=".InteractivityPostsActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".PostsDetailsActivity"
    android:label="Post Details"
    android:parentActivityName=".InteractivityPostsActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".LanguageSettingsActivity"
    android:label="Language Settings"
    android:parentActivityName=".InteractivityPostsActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".DirectoryDetailsActivity"
    android:label="Directory Details"
    android:parentActivityName=".DirectoryActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".NewsDetailsActivity"
    android:label="News Details"
    android:parentActivityName=".NewsAlertsActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".HealthTopicDetailsActivity"
    android:label="Topic Details"
    android:parentActivityName=".HealthTopicsActivity"
    android:screenOrientation="sensor" />
<activity
    android:name=".ForumContactsActivity"
    android:label="Forum Contacts"
    android:parentActivityName=".MainActivity" />
<activity
    android:name=".RemindersDetailsActivity"
    android:label="Reminder Details"
    android:parentActivityName=".RemindersActivity" />
<activity
    android:name=".RegisterSpecialistActivity"
    android:label="Specialist Registration"
    android:parentActivityName=".LoginActivity"></activity>

<activity android:name=".GoogleMapActivity"
    android:label="Show Health Centers Map"
    android:parentActivityName=".MainActivity"

```

```
    />  
  </application>  
</manifest>
```



## Appendix II: Java Source Code for the Main Menu of the Mobile Application

```
package com.tanzania.nmaist.bernard.cama;

//import static
com.tanzania.nmaist.bernard.cama.GoogleMapActivity.LOCATION_PERMISSION_REQUEST_CODE;

public class MainActivity extends AppCompatActivity {

    /**
     * This URL should be the domain hosting the application's PHP files
     */
    private static String URL_NEWS =
"http://www.makumbushofc.com/cama_php_files/get_news.php";
    private static String URL_TOPICS =
"http://makumbushofc.com/cama_php_files/get_topics.php";
    private List<ProductGetter_News> customList_news;
    private List<ProductGetter_Topics> customList_topics;
    private String id;
    private String news_title;
    private String details;
    private String posted_date;
    private String updated_on;

    private RecyclerView recyclerView;
    private RecyclerView recyclerViewListTopics;
    private RecyclerViewAdapter_News recyclerViewAdapterNews;
    private RecyclerViewAdapter_Topics recyclerViewAdapterTopics;
    SwipeRefreshLayout swipeRefreshLayout;
    SwipeRefreshLayout swipeRefreshLayoutTopics;

    private MyTask_News taskNews;
    private MyTask_Topics taskTopics;
    private java.net.URL url;
    private HttpURLConnection urlConnection;
    String receivedstate;
    Snackbar snack;
    ProgressBar progressBar;
    private static final int LOCATION_PERMISSION_REQUEST_CODE = 200;
    SharedPreferences sharedPreferences;
    SharedPreferences mySharedPreferences;
    public static final String MYPREFERENCES = "MyPreferences_001";

    private BottomNavigationView.OnNavigationItemSelectedListener
mOnNavigationItemSelectedListener
        = new BottomNavigationView.OnNavigationItemSelectedListener() {

        @Override
        public boolean onNavigationItemSelectedListener(@NonNull MenuItem item) {
            switch (item.getItemId()) {
                case R.id.navigation_interactivity:
                    sharedPreferences = getSharedPreferences(MYPREFERENCES,
Context.MODE_PRIVATE);
                    if (sharedPreferences.contains("username")) {
                        mySharedPreferences = getSharedPreferences(MYPREFERENCES, 0);
                        startActivity(new Intent(getApplicationContext(),
InteractivityPostsActivity.class));
                    } else {
                        startActivity(new Intent(getApplicationContext(),
LoginActivity.class));
                    }
            }
        }
    }
}
```

```

        return true;
    case R.id.navigation_healthy_portal:
        startActivity(new Intent(getApplicationContext(),
HealthTopicsActivity.class));
        return true;
    case R.id.navigation_profile:

        sharedPreferences = getSharedPreferences(MYPREFERENCES,
Context.MODE_PRIVATE);
        if (sharedPreferences.contains("username")) {
            mySharedPreferences = getSharedPreferences(MYPREFERENCES, 0);
            startActivity(new Intent(getApplicationContext(),
ProfileActivity.class));
        } else {
            startActivity(new Intent(getApplicationContext(),
LoginActivity.class));
        }
        return true;
    }
    return false;
}
};

@Override
protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);

    //      FirebaseMessaging.getInstance().subscribeToTopic("eventsbased");
    //      FirebaseInstanceId.getInstance().getToken();

    loadLocale();
    ActionBar actionBar = getSupportActionBar();
    actionBar.setTitle(getResources().getString(R.string.app_name));

    SharedPreferences preferences =
MainActivity.this.getSharedPreferences("MyPreferences_001", Context.MODE_PRIVATE);
    String region = preferences.getString("region_selected", null);
    //      Log.e("regionooo", region);

    BottomNavigationView navigation = (BottomNavigationView)
findViewById(R.id.navigation);

navigation.setOnNavigationItemSelectedListener(mOnNavigationItemSelectedListener);

    progressBar = (ProgressBar) findViewById(R.id.my_progressBar);
    progressBar.setVisibility(View.VISIBLE);

    recyclerView = (RecyclerView) findViewById(R.id.recyclerList);
    recyclerView.setHasFixedSize(true);
    swipeRefreshLayout = (SwipeRefreshLayout) findViewById(R.id.swipe);

    LinearLayoutManager layoutManager = new
LinearLayoutManager(MainActivity.this);
    layoutManager.setOrientation(LinearLayoutManager.HORIZONTAL);
    layoutManager.setStackFromEnd(true);

    recyclerView.setLayoutManager(layoutManager);
    SnapHelper helper = new LinearSnapHelper();
    helper.attachToRecyclerView(recyclerView);

    recyclerView.addOnItemTouchListener(new

```

```

RecyclerViewClickListener(MainActivity.this, new
RecyclerViewClickListener.OnItemClickListener() {
    @Override
    public void onItemClick(View view, int position) {
        Intent intent = new Intent(getApplicationContext(),
NewsAlertsActivity.class);
        startActivity(intent);
    }
}));
if (haveNetworkConnection()) {

    accessWebService_news();
    swipeRefreshLayout.setOnRefreshListener(new
SwipeRefreshLayout.OnRefreshListener() {
    @Override
    public void onRefresh() {
        progressBar.setVisibility(View.VISIBLE);
        progressBar.setIndeterminate(true);
        accessWebService_news();
        swipeRefreshLayout.setRefreshing(false);
    }
});
} else {
    progressBar.setIndeterminate(false);
    progressBar.setVisibility(View.GONE);
    snack =
Snackbar.make(MainActivity.this.findViewById(android.R.id.content), "No internet.
Check Network Settings!", Snackbar.LENGTH_LONG).setAction("RETRY", new
View.OnClickListener() {
    @Override
    public void onClick(View view) {
        snack.dismiss();
        startActivity(new Intent(MainActivity.this, MainActivity.class));
    }
});
View v = snack.getView();
v.setBackgroundColor(getResources().getColor(R.color.colorPrimary));
((TextView)
v.findViewById(android.support.design.R.id.snackbar_text)).setTextColor(Color.WHITE);
((TextView)
v.findViewById(android.support.design.R.id.snackbar_action)).setTextColor(Color.WHITE);
;
    snack.setDuration(Snackbar.LENGTH_INDEFINITE);
    snack.show();
}

recyclerViewTopics = (RecyclerView) findViewById(R.id.recyclerViewTopics);
recyclerViewTopics.setHasFixedSize(true);
swipeRefreshLayoutTopics = (SwipeRefreshLayout)
findViewById(R.id.swipeTopics);

LinearLayoutManager layoutManager1 = new
LinearLayoutManager(MainActivity.this);
layoutManager1.setOrientation(LinearLayoutManager.HORIZONTAL);
layoutManager1.setStackFromEnd(true);

recyclerViewTopics.setLayoutManager(layoutManager1);
SnapHelper helper1 = new LinearSnapHelper();
helper1.attachToRecyclerView(recyclerViewTopics);
if (haveNetworkConnection()) {
    accessWebService_Topics();
    swipeRefreshLayoutTopics.setOnRefreshListener(new

```

```

SwipeRefreshLayout.OnRefreshListener() {
    @Override
    public void onRefresh() {
        accessWebService_Topics();
        swipeRefreshLayoutTopics.setRefreshing(false);
    }
});
} else {
    Toast.makeText(getApplicationContext(), "Check your Network Connection!",
Toast.LENGTH_LONG).show();
}

recyclerListTopics.setOnItemClickListener(new
RecyclerViewClickListener(MainActivity.this, new
RecyclerViewClickListener.OnItemClickListener() {
    @Override
    public void onItemClick(View view, int position) {
        Intent intent = new Intent(getApplicationContext(),
HealthTopicsActivity.class);
        startActivity(intent);
    }
}));

}

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

@Override
public boolean onOptionsItemSelected(MenuItem item) {
    switch (item.getItemId()) {
        case R.id.menuInvite:
            break;
        case R.id.menuLogout:
            SharedPreferences sharedPreferences =
getSharedPreferences(LoginActivity.MYPREFERENCES, Context.MODE_PRIVATE);
            SharedPreferences.Editor editor = sharedPreferences.edit();
            editor.clear();
            editor.commit();
            moveTaskToBack(true);
            finish();
            startActivity(new Intent(getApplicationContext(),
LoginActivity.class));
            break;
        case R.id.menuForumContacts:
            startActivity(new Intent(getApplicationContext(),
ForumContactsActivity.class));
            break;
        case R.id.menuSettings:
            startActivity(new Intent(getApplicationContext(),
SettingsActivity.class));
            break;
        case R.id.langSettings:
            showchangelangDialog();
            break;
    }
    return super.onOptionsItemSelected(item);
}

```

```

}

@RequiresApi(api = Build.VERSION_CODES.M)
public void widgetClicked(View view) {
    switch (view.getId()) {
        case R.id.textviewLiveChat:
            ConversationActivity.show(MainActivity.this);
            break;
        case R.id.textviewDirectory:
            startActivity(new Intent(getApplicationContext(),
DirectoryActivity.class));
            break;
        case R.id.textViewReminders:
            sharedPreferences = getSharedPreferences(MYPREFERENCES,
Context.MODE_PRIVATE);
            if (sharedPreferences.contains("username")) {
                mySharedPreferences = getSharedPreferences(MYPREFERENCES, 0);
                startActivity(new Intent(getApplicationContext(),
RemindersActivity.class));
            } else {
                startActivity(new Intent(getApplicationContext(),
LoginActivity.class));
            }
            break;
        case R.id.textviewHealthTopics:
            startActivity(new Intent(getApplicationContext(),
HealthTopicsActivity.class));
            break;
        case R.id.textviewNewsandAlerts:
            startActivity(new Intent(getApplicationContext(),
NewsAlertsActivity.class));
            break;
        case R.id.show_map:
            if (hasPermission())
                startActivity(new Intent(getApplicationContext(),
GoogleMapActivity.class));
            else
                requestPermission();
            break;
    }
}

@RequiresApi(api = Build.VERSION_CODES.M)
private boolean hasPermission() {
    int res = 0;
    String[] permissions = new
String[]{android.Manifest.permission.ACCESS_FINE_LOCATION};

    for (String perms : permissions) {
        res = checkSelfPermission(perms);
        if (!(res == PackageManager.PERMISSION_GRANTED))
            //request the permission
            return false;
    }
    return true;
}

private void requestPermission () {
    String[] permissions = new String[]{Manifest.permission.ACCESS_FINE_LOCATION};
    if (Build.VERSION.SDK_INT >= Build.VERSION_CODES.M) {
        requestPermissions(permissions, LOCATION_PERMISSION_REQUEST_CODE);
    }
}

```

```

    }
}
private class MyTask_News extends AsyncTask<String, Void, List> {

    @Override
    protected List doInBackground(String... params) {
        try {
            url = new URL(params[0]);
            urlConnection = (HttpURLConnection) url.openConnection();
            urlConnection.connect();
            urlConnection.setConnectTimeout(5000);

            InputStream in = new
BufferedInputStream(urlConnection.getInputStream());
            StringBuilder jsonResult = inputStreamToString(in);
            customList_news = new ArrayList<>();
            JSONObject jsonResponse = new JSONObject(jsonResult.toString());
            JSONArray jsonMainNode = jsonResponse.optJSONArray("news_jsondata");
            for (int i = 0; i < jsonMainNode.length(); i++) {
                JSONObject jsonChildNode = jsonMainNode.getJSONObject(i);
                id = jsonChildNode.optString("id");
                news_title = jsonChildNode.optString("news_title");
                details = jsonChildNode.optString("details");
                posted_date = jsonChildNode.optString("posted_date");
                updated_on = jsonChildNode.optString("updated_on");

                customList_news.add(new ProductGetter_News(id, news_title,
details, posted_date, updated_on));
            }
        } catch (MalformedURLException e) {
            e.printStackTrace();
        } catch (IOException e) {
            e.printStackTrace();
        } catch (JSONException e) {
            e.printStackTrace();
        }
        return customList_news;
    }

    private StringBuilder inputStreamToString(InputStream is) {
        String rLine = "";
        StringBuilder answer = new StringBuilder();
        BufferedReader rd = new BufferedReader(new InputStreamReader(is));
        try {
            while ((rLine = rd.readLine()) != null) {
                answer.append(rLine);
            }
        } catch (Exception e) {
            finish();
        }
        return answer;
    }

    @Override
    protected void onPostExecute(List list) {
        ListDrawer_News(list);
        progressBar.setIndeterminate(false);
        progressBar.setVisibility(View.GONE);
    }
}

private void accessWebService_news() {
    Random rand = new Random();
}

```

```

        int n = rand.nextInt(50000000) + 1;
        String randomstamp = "70timestamp" + n;
        URL_NEWS = "http://www.makumbushofc.com/cama_php_files/get_news.php?tmps=" +
randomstamp;
        URL_NEWS = URL_NEWS.replaceAll("\\s+", "%20");
        taskNews = new MyTask_News();
        taskNews.execute(new String[]{URL_NEWS});
    }

    public void ListDrawer_News(List<ProductGetter_News> customList) {
        recyclerViewAdapterNews = new RecyclerViewAdapter_News(customList);
        recyclerViewAdapterNews.notifyDataSetChanged();
        recyclerView.setAdapter(recyclerViewAdapterNews);
    }

    private class MyTask_Topics extends AsyncTask<String, Void, List> {

        @Override
        protected List doInBackground(String... params) {
            try {
                url = new URL(params[0]);
                urlConnection = (URLConnection) url.openConnection();
                urlConnection.connect();
                urlConnection.setConnectTimeout(5000);

                InputStream in = new
BufferedInputStream(urlConnection.getInputStream());
                StringBuilder jsonResult = inputStreamToString(in);
                customList_topics = new ArrayList<>();
                JSONObject jsonResponse = new JSONObject(jsonResult.toString());
                JSONArray jsonMainNode = jsonResponse.optJSONArray("topics_jsondata");
                for (int i = 0; i < jsonMainNode.length(); i++) {
                    JSONObject jsonChildNode = jsonMainNode.getJSONObject(i);
                    String id = jsonChildNode.optString("id");
                    String topic = jsonChildNode.optString("topic");
                    String details = jsonChildNode.optString("details");
                    String category = jsonChildNode.optString("category");
                    String author = jsonChildNode.optString("author");
                    String posted_on = jsonChildNode.optString("posted_on");
                    customList_topics.add(new ProductGetter_Topics(id, topic, details,
category, author, posted_on));
                }
            } catch (MalformedURLException e) {
                e.printStackTrace();
            } catch (IOException e) {
                e.printStackTrace();
            } catch (JSONException e) {
                e.printStackTrace();
            }
            return customList_topics;
        }
    }

    private StringBuilder inputStreamToString(InputStream is) {
        String rLine = "";
        StringBuilder answer = new StringBuilder();
        BufferedReader rd = new BufferedReader(new InputStreamReader(is));
        try {
            while ((rLine = rd.readLine()) != null) {
                answer.append(rLine);
            }
        } catch (Exception e) {
            finish();
        }
    }

```

```

        }
        return answer;
    }

    @Override
    protected void onPostExecute(List list) {
        ListDrawer_Topics(list);
        progressBar.setIndeterminate(false);
        progressBar.setVisibility(View.GONE);
    }
}

private void accessWebService_Topics() {

    Random rand = new Random();
    int n = rand.nextInt(50000000) + 1;
    String randomstamp = "70timestamp" + n;
    URL_TOPICS = "http://makumbushofc.com/cama_php_files/get_topics.php?tmps=" +
randomstamp;
    URL_TOPICS = URL_TOPICS.replaceAll("\\s+", "%20");
    taskTopics = new MyTask_Topics();
    taskTopics.execute(new String[]{URL_TOPICS});
}

public void ListDrawer_Topics(List<ProductGetter_Topics> customList) {
    recyclerViewAdapterTopics = new RecyclerViewAdapter_Topics(customList);
    recyclerViewAdapterTopics.notifyDataSetChanged();
    recyclerViewListTopics.setAdapter(recyclerViewAdapterTopics);
}

private boolean haveNetworkConnection() {
    boolean haveConnectedWifi = false;
    boolean haveConnectedMobile = false;

    ConnectivityManager cm = (ConnectivityManager)
getSystemService(Context.CONNECTIVITY_SERVICE);
    NetworkInfo[] netInfo = cm.getAllNetworkInfo();
    for (NetworkInfo ni : netInfo) {
        if (ni.getTypeName().equalsIgnoreCase("WIFI"))
            if (ni.isConnected())
                haveConnectedWifi = true;
        if (ni.getTypeName().equalsIgnoreCase("MOBILE"))
            if (ni.isConnected())
                haveConnectedMobile = true;
    }
    return haveConnectedWifi || haveConnectedMobile;
}

//send the activity to the background
public boolean onKeyDown(int keyCode, KeyEvent event) {
    if (keyCode == KeyEvent.KEYCODE_BACK && event.getRepeatCount() == 0) {
        this.moveTaskToBack(true);
        return true;
    }
    return super.onKeyDown(keyCode, event);
}

private void showchangelangDialog() {

    final String[] listitems = {"English", "Swahili"};
    AlertDialog.Builder mBuilder = new AlertDialog.Builder(MainActivity.this);

```



```

        mBuilder.setTitle("Choose Language...");
        mBuilder.setSingleChoiceItems(listItems, -1, new
DialogInterface.OnClickListener() {
            @Override
            public void onClick(DialogInterface dialogInterface, int i) {
                if (i == 0) {
                    setLocale("en");
                    recreate();
                } else {
                    setLocale("sw");
                    recreate();
                }
                dialogInterface.dismiss();
            }
        });

        AlertDialog alertDialog = mBuilder.create();
        alertDialog.show();
    }

    private void setLocale(String lang) {
        Locale locale = new Locale(lang);
        Locale.setDefault(locale);
        Configuration config = new Configuration();
        config.locale = locale;
        getBaseContext().getResources().updateConfiguration(config,
getBaseContext().getResources().getDisplayMetrics());

        SharedPreferences.Editor editor = getSharedPreferences("Settings",
MODE_PRIVATE).edit();
        editor.putString("My_Lang", lang);
        editor.apply();
    }

    public void loadLocale() {
        SharedPreferences prefs = getSharedPreferences("Settings",
Activity.MODE_PRIVATE);
        String language = prefs.getString("My_Lang", "");
        setLocale(language);
    }
}

```

## Appendix III: Main activity XML File for the Mobile Application

```
<?xml version="1.0" encoding="utf-8" ?>
<LinearLayout 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:id="@+id/container"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:background="@color/wood_color"
    android:orientation="vertical"
    tools:context="com.tanzania.nmaist.bernard.cama.MainActivity">

    <LinearLayout
        android:layout_width="match_parent"
        android:layout_height="match_parent"
        android:layout_weight="1"
        android:orientation="vertical">

        <TextView
            android:layout_width="match_parent"
            android:layout_height="wrap_content"
            android:id="@+id/show_map"
            android:textAlignment="center"
            android:textStyle="bold"
            android:textSize="@dimen/default_text_normal_size"
            android:onClick="widgetClicked"
            android:textColor="@color/myBlack"
            android:text="@string/show_map" />

        <ImageView
            android:id="@+id/imageView"
            android:layout_width="match_parent"
            android:layout_height="180dp"
            android:layout_weight="1"
            android:padding="20dp"
            android:src="@drawable/camaicon" />

        <ScrollView
            android:layout_width="fill_parent"
            android:layout_height="wrap_content">

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

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

                    <LinearLayout
                        android:layout_width="fill_parent"
                        android:layout_height="wrap_content"
                        android:orientation="horizontal"
                        android:paddingTop="5dp"
                        android:paddingBottom="4dp">

                        <TextView
```

```

        android:id="@+id/textviewLiveChat"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_marginLeft="7dp"
        android:layout_marginRight="10dp"
        android:textAppearance="?android:textAppearanceSmall"
        android:layout_weight="1"
        android:background="@drawable/textviewbackgrounddrawable"
        android:gravity="center_horizontal|center_vertical"
        android:onClick="widgetClicked"
        android:padding="5dp"
        android:text="@string/live_chat"
        android:textColor="#000000" />

<TextView
    android:id="@+id/textviewDirectory"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_marginLeft="10dp"
    android:layout_marginRight="10dp"
    android:layout_weight="1"
    android:textAppearance="?android:textAppearanceSmall"
    android:background="@drawable/textviewbackgrounddrawable"
    android:gravity="center_horizontal|center_vertical"
    android:onClick="widgetClicked"
    android:padding="5dp"
    android:text="@string/directory"
    android:textColor="#000000" />

<TextView
    android:id="@+id/textViewReminders"
    android:layout_width="wrap_content"
    android:layout_height="wrap_content"
    android:layout_marginLeft="10dp"
    android:layout_marginRight="7dp"
    android:layout_weight="1"
    android:textAppearance="?android:textAppearanceSmall"
    android:background="@drawable/textviewbackgrounddrawable"
    android:gravity="center_horizontal|center_vertical"
    android:onClick="widgetClicked"
    android:padding="5dp"
    android:text="@string/reminders_button"
    android:textColor="#000000" />
</LinearLayout>

<TextView
    android:id="@+id/textviewHealthTopics"
    android:layout_width="match_parent"
    android:layout_height="wrap_content"
    android:layout_marginLeft="10dp"
    android:layout_marginRight="5dp"
    android:onClick="widgetClicked"
    android:padding="3dp"
    android:text="@string/healthy_topics"
    android:textAppearance="?android:textAppearanceSmall"
    android:textStyle="bold" />

<ProgressBar
    android:id="@+id/my_progressBar"
    style="@style/Widget.AppCompat.ProgressBar.Horizontal"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:layout_marginLeft="5dp"

```

```

        android:layout_marginRight="5dp"
        android:indeterminate="true"
        android:progressDrawable="@drawable/prog_color" />

<TextView
    android:layout_width="95dp"
    android:layout_height="3dp"
    android:layout_marginLeft="10dp"
    android:layout_marginTop="6dp"
    android:background="@color/colorPrimary" />

<android.support.v4.widget.SwipeRefreshLayout
    android:id="@+id/swipeTopics"
    android:layout_width="fill_parent"
    android:layout_height="130dp"
    android:scrollbarAlwaysDrawHorizontalTrack="true"
    app:layout_behavior="@string/appbar_scrolling_view_behavior">

    <android.support.v7.widget.RecyclerView
        android:id="@+id/recyclerListTopics"
        android:layout_width="fill_parent"
        android:layout_height="130dp"
        android:layout_marginLeft="5dp"
        android:layout_marginRight="5dp"
        android:background="@drawable/card_background" />
</android.support.v4.widget.SwipeRefreshLayout>

<TextView
    android:id="@+id/textviewNewsandAlerts"
    android:layout_width="match_parent"
    android:layout_height="wrap_content"
    android:onClick="widgetClicked"
    android:padding="3dp"
    android:layout_marginLeft="10dp"
    android:text="@string/latest_news_amp_alerts"
    android:textAppearance="?android:textAppearanceSmall"
    android:textStyle="bold" />

<TextView
    android:layout_width="134dp"
    android:layout_height="3dp"
    android:layout_marginLeft="10dp"
    android:layout_marginTop="6dp"
    android:background="@color/colorPrimary" />

<android.support.v4.widget.SwipeRefreshLayout
    android:id="@+id/swipe"
    android:layout_width="fill_parent"
    android:layout_height="130dp"
    android:scrollbarAlwaysDrawHorizontalTrack="true"
    app:layout_behavior="@string/appbar_scrolling_view_behavior">

    <android.support.v7.widget.RecyclerView
        android:id="@+id/recyclerList"
        android:layout_width="fill_parent"
        android:layout_height="130dp"
        android:layout_marginLeft="5dp"
        android:layout_marginRight="5dp"
        android:background="@drawable/card_background" />
</android.support.v4.widget.SwipeRefreshLayout>

</LinearLayout>

```

```
        </LinearLayout>
    </ScrollView>

</LinearLayout>

<android.support.design.widget.BottomNavigationView
    android:id="@+id/navigation"
    android:layout_width="fill_parent"
    android:layout_height="wrap_content"
    android:layout_marginStart="0dp"
    android:layout_marginEnd="0dp"
    android:background="#ffffff"
    app:layout_constraintBottom_toBottomOf="parent"
    app:layout_constraintLeft_toLeftOf="parent"
    app:layout_constraintRight_toRightOf="parent"
    app:menu="@menu/navigation" />

</LinearLayout>
```

## Appendix IV: The Example Login PHP File

```
<?php

//request a connection to the database using connect file

$conn = mysqli_connect("localhost","cama_database_usr","123PassW","cama_database");

$username= $_REQUEST['userName'];

$password = $_REQUEST['password'];

//select items from the table

$sql = mysqli_query($conn,"SELECT * FROM profile WHERE username='$username' and
password='$password'");

//execute the sql query and check the results

//$result=mysqli_query($stmt);

if (mysqli_num_rows($sql) > 0)

{

//using a loop to fetch content from the table one by one

while ($row = mysqli_fetch_assoc($sql))

{

echo

$row['fullname']."#".$row['phonenumber']."#".$row['username']."#".$row['password']."#".

$row['firebase_token']."#".$row['region_selected']."#";

}

}

else {

echo "0";

}

?>
```

**Appendix V: The Designed Mobile Application's Logo**



©Bernard Mramba & NM-AIST

## Appendix VI: Research Questionnaire

1. How old are you?

- Less than 20 years       20-34 years       More than 34 years

2. What is your current marital status?

- Single       Married       Divorced       Widowed

3. Which group of special health status are you currently in?

- Pregnant  
 Lactating and infant care

4. Which Hospital/Health centre do you regularly receive antenatal care?

- Mwananyamala Hospital  
 Temeke District Hospital

5. What is your highest education level?

- Primary School and below  
 Secondary Education  
 Further education (Certificate or Diploma)  
 Higher Education (Bachelor degree and above)

6. Do you own a mobile phone?

- Yes       No

7. What type of mobile phone do you own?

- Featured phone  
 Smartphone



8. Do you have internet access on your mobile phone?

Yes                       No

9. How often do you use the Internet on your mobile phone?

Daily                       Weekly                       Monthly

10. On average how many hours do you spend on the Internet per day?

Less than 1 hour per day

1 – 2 hours per day

2 – 3 hours per day

3 – 4 hours per day

More than 4 hours per day

11. Are you aware of any mobile applications that are used to provide clinical support to you as a mother?

Yes                                       No

12. What are the Mobile applications you know that are used to provide clinical support?

(Mention if any)

---

---

---

13. Have you installed on your phone any mobile application that is used to provide clinical support?

Yes                                       No

14. Did you get any clinical support on your phone during pregnancy or as a mother of an infant?

Yes

No

15. What form of support did you get?

#	Support form	Tick for Yes
1	Recorded voice messages	
2	Real-time voice communication	
3	SMS messages (general)	
4	Timed SMS reminder messages	
5	Information display (smartphones offline)	
6	Information display (through the internet)	
6	Feedback function	
7	Data collection (Data entry form)	
8	Report generation (Smartphones)	
9	Personalisation function	
10	Information search	
11	Question and answer	
12	Chatting function	
13	Discussion forum	

16. Have you used any application installed on your mobile phone for maternal and infant care?

Yes

No

17. How useful were the applications used to you?

Not at all useful

Slightly useful

Moderately useful

Very useful

Extremely useful

18. How likely that you will install or use a mobile application for supporting you during pregnancy and infant care?

Not at all likely

Slightly likely

Moderately likely

Very likely

19. What are functions will you like to have in a mobile application for supporting you during pregnancy and infant care?

#	Support form	Tick for Yes
1	Recorded voice messages	
2	Real-time voice communication	
3	SMS messages (general)	
4	Timed SMS reminder messages	
5	Information display (smartphones offline)	
6	Information display (through the internet)	
6	Feedback function	
7	Data collection (Data entry form)	
8	Report generation (Smartphones)	
9	Personalisation function	
10	Information search	
11	Question and answer	

12	Chatting function	
13	Discussion forum	

Other functions (List them):

---

---

---

---

## **Appendix VII: Research Questionnaire Translated to Kiswahili**

### **DODOSO LA UTAFITI**

Lijazwe na kinamama wajawazito na wenye watoto wachanga.

**UTAFITI UNAHUSU “KUBORESHA HUDUMA KWA KINAMAMA WAJAWAZITO NA WENYE WATOTO WACHANGA KWA KUTUMIA MFUMO WA SIMU ZA MKONONI”**

Jina langu ni Bernard Mramba, mwanafunzi wa mwaka wa pili wa shahada ya Uzamili (Masters), ya Sayansi ya uhandisi wa mifumo ya mawasiliano katika Taasisi ya Sayansi na Teknolojia ya Nelson Mandela, Arusha.

Ninafanya utafiti ulioainishwa hapo juu kama sehemu ya programu yangu ya mafunzo.

#### **Lengo la Utafiti:**

Utafiti huu una lengo la 'kutengeneza mfumo wa simu ya mkononi, unaotoa fursa ya mwingiliano (interactive), kwa ajili ya kutoa msaada kwa wakati kwa kinamama wajawazito na wenye watoto wachanga'. Mfumo huu utapatikana bure na unaweza kutumiwa na hospitali na watumiaji kuwasaidia kupunguza kiwango cha juu cha vifo vya akina mama na watoto wachanga nchini Tanzania.

#### **Ushiriki wa Hiari:**

Unatakiwa kujibu maswali fulani kwenye dodoso hili la maswali. Upo huru kuchagua ama kushiriki au kutoshiriki. Mtu anayekusaidia katika kujaza dodoso hili anaweza kuuliza maswali mengine kwa ufafanuzi zaidi wakati wa kujibu maswali yaliyoainishwa kwenye dodoso.

#### **Hatari:**

Hatutarajii hatari yoyote zitakazotokana na ushiriki wako katika utafiti huu.

**Faida:**

Faida inayotarajiwa ya utafiti huu ni programu ya simu ya mkononi (programu ya simu ya mkononi) ambayo inaweza kuwekwa kwenye simu za watumiaji kwa itakayoweza kuwapam huduma mbalimbali za usaidizi wakati wa ujauzito na huduma ya watoto wachanga.

**Usiri wa Taarifa za Mshiriki:**

Taarifa zote za kibinafsi zitahifadhiwa na zitakuwa siri. Hazitatolewa mahali popote, na wala kutumika katika kutoa ripoti yoyote. Mimi tu na timu ya utafiti tutapata habari zozote za kibinafsi zilizotolewa. Matokeo ya utafiti wetu yanaweza kuchapishwa katika Jarida, kujadiliwa kwenye mikutano ya kisayansi, au kwa matumizi mengine ya kitaaluma na yasiyokuwa ya kibiashara. Baada ya kukamilika kwa utafiti huu, kumbukumbu zote zenye taarifa binafsi zitaharibiwa au kuhifadhiwa mahali salama.

**Gharama:**

Hutatakiwa kufanya malipo yoyote ya kushiriki katika utafiti huu na hakuna malipo ambayo ytafanyika kwako.

Kama una maswali au ungependa kupata taarifa Zaidi, wasiliana nasi kwa anuani zifuatazo:

**Mwanafunzi Mtafiti:**

Bernard Mramba

NM-AIST, Arusha, Tanzania.

Cell no: +255 712 473 712

Email: [bmramba@gmail.com](mailto:bmramba@gmail.com)

**Msimamizi**

Dr. Shubi Kaijage

NM-AIST, Arusha, Tanzania.

Email: [shubi.kaijage@nm-aist.ac.tz](mailto:shubi.kaijage@nm-aist.ac.tz)

**Mkataba wa Mshiriki**

Nimesoma / nimeambiwa juu ya yaliyomo kwenye fomu hii na nimeelewa maudhui na malengo yake. Nakubali kushiriki katika utafiti huu.

## Taarifa za msingi

1. Una umri gani?

Chini ya miaka 20

Mika 20-34

Zaidi ya miaka 34

2. Hali yako ya sasa ya ndoa ni ipi?

Sijaolewa

Nimeolewa

Tumeachana

Mjane

3. Kwa ajili ya utafiti huu wewe ni:

Mjamzito

Nina mtoto mchanga

4. Ni hospitali ipi au kituo kipi cha afya unapopatia huduma za kliniki mara kwa mara?

Hospitali ya Mwananyamala

Hospitali ya Wilaya ya Temeke

5. Una elimu ya kiwango gani mpaka sasa?

Elimu ya msingi au sina elimu

Elimu ya Sekondari.

Elimu ya Cheti au Diploma

Elimu ya Juu (Degree moja au zaidi)

## Umiliki wa Simu na matumizi ya Intaneti.

6. Je, unamiliki simu ya kiganjani?

Ndiyo

Hapana

Simu yako ya kiganjani ni ya aina gani?

Simu ya kawaida

Simujanja (Smartphone)

7. Unapata huduma ya Intaneti kwenye simu yako ya kiganjani?

Ndiyo       Hapana

8. Kwa wastani unaweza kuelezeaje ni mara ngapi unatumia Intaneti kwenye simu yako ya kiganjani?

Angalau kwa siku mara moja

Andalau kwa wiki mara moja

Angalau kwa mwezi mara moja.

9. Unaweza kuelezeaje muda unaokuwa kwenye Intaneti kwa siku moja?

Chini ya saa moja(1)

Saa moja(1) hadi mawili(2)

Masaa mawili(2) hadi matatu (3)

Masaa matatu(3) hadi manne (4)

Zaidi ya masaa manne(4)

### **Ufahamu wa program za simu ya kiganjani**

10. Unafahamu program yoyote ya simu za kiganjani itumikayo huduma kwa mama mjamzito au mwenye mtoto mchanga?

Ndiyo       Hapana

11. Kama unaifahamu moja au zaidi, tafadhali ziorodheshe hapa chini.

(Orodhesha)

---

---

---



12. Umewahi kuweka/kuwekewa kwenye simu yako ya kiganjani program ya kutolea msaada kwa akinamama wajawazito na wenye watoto wachanga?

Ndiyo

Hapana

13. Uliahi kupata msaada kupitia programu ya simu ya kiganjani ya kutolea msaada kwa akinamama wajawazito na wenye watoto wachanga?

Ndiyo

Hapana

14. Kama umewahi kupata msaada wowote, ni upi kati ya hizi?

#	Aina ya msaada	Umepata?
1	Ujumbe wa sauti uliorekidiwa	
2	Mawasiliano ya sauti moja kwa moja	
3	Ujumbe mfupi wa maneno	
4	Ujumbe wa kukumbusha kwa muda maalum	
5	Taarifa bila mtandao	
6	Taarifa kwenye mtandao	
6	Uwezo wa kutoa maoni	
7	Kukusanya taarifa	
8	Ripoti kwenye smartphone	
9	Kufanya utambulisho (Personalization)	
10	Kutafuta taarifa (Search)	
11	Maswali na majibu	
12	Kuchati (Chatting)	
13	Kujadili kwenye mtandao	

15. Umewahi kutumia programu iliyopo kwenye simu yako ya kiganjani kwa ajili ya kupata huduma katika ujauzito au malezi ya mtoto mchanga?

Ndiyo

Hapana

16. Kama umewahi kutumia, zilikuwa na msaada kiwango gani?

Haikuwa na msaada kabisa

- Ilikuwa na msaada kidogo
- Ilikuwa na msaada kiasi
- Ilikuwa na msaada wa kuridhisha
- Ilikuwa na msaada sana

17. Unaonaje, utapendelea kuweka na kutumia programu ya simu ya kiga njani ili kupata huduma na msaada wakati wa ujauzito na malezi ya mtoto mchanga?

- Sitaweka kabisa
- Nitatafakari kuweka
- Nitaweka
- Nitafurahia na nitaweka
- Nitafurahi sana na nitaweka

18. Ni aina gani ya msaada utakaopendelea uwepo kwenye program ya simu ya kiganjani?

#	Aina ya msaada	Utapendelea
1	Ujumbe wa sauti uliorekidiwa	
2	Mawasiliano ya sauti moja kwa moja	
3	Ujumbe mfupi wa maneno	
4	Ujumbe wa kukumbusha kwa muda maalum	
5	Taarifa bila mtandao	
6	Taarifa kwenye mtandao	
6	Uwezo wa kutoa maoni	
7	Kukusanya taarifa	
8	Ripoti kwenye smartphone	
9	Kufanya utambulisho (Personalization)	
10	Kutafuta taarifa (Search)	
11	Maswali na majibu	

12	Kuchati (Chatting)	
13	Kujadili kwenye mtandao	

Aina nyingine (Orodhesha):

---

---

---

---

Appendix II: Usability Testing Questionnaire for MNCH Support Mobile App

#	Question	Percent				
		Strongly Agree	Agree	Disagree	Strongly disagree	Not Sure
1	The mobile app is easy to install, learn and use					
2	The mobile app interactive					
3	The contents and features of the app meaningful					
4	I did not get any compatibility problem with my phone					
5	Internet connectivity works perfectly with the mobile app					
6	I will need technical assistance in using the mobile app					
7	The labels and buttons text clear and concise					
8	The font size and spacing are suitable for readability of information					
9	The mobile app provides a confirmation option when deleting					
10	Error messages clearly explain how to correct the problem					
11	The information is useful and could be helpful					
12	I think that I would like to use the Application					
13	The application helps to communicate with healthcare providers					
14	The application helps to interact with other users					

15	I will recommend this mobile application for other users					
----	---	--	--	--	--	--