UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

TOWARDS EFFECTIVE SMS MODEL FOR HEALTHCARE INFORMATION DISSEMINATION

By

ELIZABETH MWASHUMA

P51/73542/2014

Supervisor

Dr. Christopher Chepken

June 2016

Submitted in partial fulfillment of the requirements of the Master of Science Applied Computing

DECLARATION

This research project is my original work and has not been submitted to any other University.

Signature: ..... Date: .....

ELIZABETH MWASHUMA

P51/73542/2014

SUPERVISOR

This research project has been submitted for examination with my approval as University Supervisor.

Signature: ..... Date: .....

DR. CHRISTOPHER CHEPKEN

SCHOOL OF COMPUTING AND INFORMATICS

UNIVERSITY OF NAIROBI

DEDICATION

To my family and close friends.

ACKNOWLEDGEMENT

I appreciate God Almighty for the opportunity to do this work.

I wish to acknowledge my supervisor Dr. Christopher Chepken for his continual guidance and valuable support.

I am also grateful for friends for their time and contribution towards this study. Special appreciation to my family members for their support, encouragement and prayers.

ABSTRACT

The healthcare sector uses SMS to disseminate health care information to a large population of people. Maternal and postnatal healthcare information is widely delivered through the SMS platform. Evidence of a structure used when sending the healthcare information via SMS, which ensures that the message received is effective, remains very limited. This report presents a study which was aimed at proposing a model that can be used to effectively send healthcare information via SMS.

A total of 80 people were initially recruited to take part in the study. However, 63 out of the 80 people participated in this study. 52 respondents were interviewed over the phone using semi-structured scripts; six of them participated in a focus group discussion carried out at a Hospital in the Eastern part of Nairobi. Five respondents responded to questionnaires issued to them. All participants resided in Nairobi.

Following review of relevant literature and analysis of data collected from the study, five factors emerged which influence effectiveness of healthcare messages sent via SMS. The factors include: the day of the week most preferred to receive the SMS, the time of day in which respondent has most access of their phone, frequency of receiving the healthcare messages, topics of interest to the receiver and preferred language.

This study shows that to ensure healthcare messages sent over SMS are effective, it is important that information is sent to the recipient subject to their availability and preferences. Healthcare institutions need to consider these factors when sending healthcare information, to ensure information sent is relevant and convenient to the receiver thus resulting in expected behavior change. The model can be adopted in other sectors which rely on SMS to send information to its beneficiaries.

TABLE OF CONTENTS

DECLARATION i

DEDICATION ii

ACKNOWLEDGEMENT iii

ABSTRACT iv

LIST OF TABLES AND FIGURES viii

List of Tables viii

List of Figures viii

LIST OF ABBREVIATIONS x

CHAPTER ONE 1

INTRODUCTION 1

1.1. Background 1

1.2. Problem Statement 3

1.3. Research Objectives 4

1.4. Research Questions 4

1.5. Justification 4

1.6. Scope 4

1.7. Significance 5

1.8. Assumption and Limitations to the project 5

CHAPTER TWO 6

LITERATURE REVIEW 6

2.1. Introduction 6

2.2. The current mHealth Landscape: Review of interventions supported by SMS applications in healthcare 6

2.3. Evidence of use of SMS to support maternal and newborn child healthcare 7

2.4. Summary of Models used 10

2.5. Conceptual Framework 12

CHAPTER THREE 13

RESEARCH METHODOLOGY 13

3.1. Introduction 13

3.2. Data Collection 13

3.3. Sampling 13
Sample Size 13
3.4. Data Collection instruments 14
3.5. Data Analysis and Interpretation 15
3.6. Ethics 15
CHAPTER FOUR 16
ANALYSIS AND SYSTEM DESIGN 16
4.1. Introduction 16
4.2. System Design 16
4.2.1. Existing Systems 16
4.2.2. Proposed System 20
4.2.3. Description of proposed system 21
4.2.4. Overview of the proposed system 21
CHAPTER FIVE 23
RESULTS AND DISCUSSION 23
5.1. Introduction 23
5.2. Results 23
5.2.1. Demographic of respondents 23
5.2.2. Respondents access to their mobile phones 24
5.2.3. Best time to receive healthcare SMS 24
5.2.4. Day of the week which respondents preferred to receive the healthcare message 25
5.2.5. How often respondents preferred to receive the TotoHealth messages 25
5.2.6. Topics respondents preferred to receive SMS on 26
5.2.7. Channels other than SMS which respondents preferred to receive healthcare information on. 28
5.2.8. Language in which respondents preferred to receive the messages 28
5.2.9. Method used to enroll respondents to TotoHealth 29
5.3.Model Developed 30
5.4. Discussions and Research Findings 34
5.4.1. Usefulness of messages sent by the new TotoHealth system. 35
5.4.2. How often respondents accessed the TotoHealth helpdesk 35
CHAPTER SIX 37
CONCLUSION AND RECOMMENDATIONS 37

6.1. Introduction 37
6.2. Summary of the findings 37
6.4. Limitations of the Study 37
6.5. Recommendations for future work 38
REFERENCES 39
APPENDICES 41

LIST OF TABLES AND FIGURES

List of Tables

Table 1: Summary of Models used

Table 2: Demographics of respondents

Table 3: Respondents access to their mobile phones

Table 4: How often respondents preferred to receive the TotoHealth messages

Table 5: Language in which respondents preferred to receive the messages

Table 6: Usefulness of messages sent by TotoHealth

List of Figures

Figure 1: Mortality rates estimates developed by the UN Inter-agency Group for Child Mortality Estimation

Figure 2: WelTel's model of sending weekly SMS

Figure 3: Conceptual Framework

Figure 4: Screenshot of the current TotoHealth registration process

Figure 5: Screenshot of the current TotoHealth registration process

Figure 6: Screenshot of the current TotoHealth registration process

Figure 7: Rapid Application Development Model

Figure 8: Best time to send healthcare SMS

Figure 9: Day of the week which respondents preferred to receive the healthcare message

Figure 10: Topics respondents preferred to receive SMS on

Figure 11: Channels other than SMS which respondents prefer to receive healthcare information on

Figure 12: How often respondents accessed the TotoHealth helpdesk

Figure 13: Method used to enroll respondents to TotoHealth

Figure 14: Model developed for sending healthcare information through SMS

Figure 15: Screenshot of the new TotoHealth registration process

Figure 16: Screenshot of the new TotoHealth registration process

Figure 17: Screenshot of the new TotoHealth registration process

Figure 18: Screenshot of the new TotoHealth registration process

Figure 17: How participants responded to the new system

Figure 18: Screenshot of the new TotoHealth registration process

LIST OF ABBREVIATIONS

3G – 3rd Generation

ANC – Ante Natal Care

ART – Anti –Retroviral Treatment

CDMA - Code Division Multiple Access

CHMI – Center for Health Market Innovations

CHW – Community Health Worker

EPI - Expanded Program on Immunization

GPRS - General Packet Radio Service

GSM - Global System for Mobile Communications

HIS – Health Information System

ICT – Information, Communication and Technology

ITU - International Telecommunication Union

IVR – Interactive Voice Response

J2ME - Java 2 Platform, Micro Edition

LMIC – Low and Middle-Income Countries

MCH – Maternal and Child Health

MNCH – Maternal Newborn and Child Health

NFC - Near Field Communication

PDA - Personal Digital Assistants

RFID- Radio Frequency Identification

SMS - Short Message Service

SMS - Short Message Service

SSA – Sub Saharan Africa

UN - United Nations

UN DESA – United Nation Department of Economic and Social Affairs

UNICEF - United Nations Children's Fund

USAID – United States Agency for AID

WHO – World Health Organization

CHAPTER ONE
INTRODUCTION

1.1. Background

The mobile industry continues to scale rapidly, with a total of 3.6 billion unique mobile subscribers as at the end of 2014. (GSMA Intelligence, 2015) Half of the world's population now has a mobile subscription—up from just one in five 10 years ago. Technology advances has seen the use of mobile devices increase significantly in the recent years in African countries and the world at large. The introduction of mobile computing devices such as mobile phones, smartphones, tablets and personal digital assistants (PDAs), has greatly impacted many fields.(Lewis, Synowiec, Lagomarsino, & Schweitzer, 2012)

These devices have found their way into the health sector. Studies affirm that smartphones and other high-technology gadgets appear to be increasingly used by healthcare workers, particularly physicians and nurses, and are now necessary and accepted devices in the different healthcare fields. (Mahadeen, 2015)

The use of mobile and wireless technologies to support the achievement of health objectives (mHealth) has the potential to transform the face of health service delivery across the globe. To this extent, many health organizations are designing projects that use mobile technology to support health services and health education. (WHO, 2011). Health information systems communicate to their intended users via various communication channels such as text messaging, calls, interactive voice response (IVR), and emails among others, to enhance medication adherence, improve health literacy and ensure appointment attendance. (Middleton, 2006)

SMS Technology

Short messaging service (SMS) (a.k.a. text messaging) is a fast, low cost and popular mode of communication found on all mobile phones across all technologies, including GSM, CDMA and 3G. SMS is a short message that can be sent from a phone to phone, and pushed to the recipient's device when sent. Some key advantages of SMS include short messages of 160 characters, good interoperability between networks and technologies (GSM and CDMA); it is low cost and free for the receiver. (Talariax)

SMS messages have a number of characteristics that make them very appropriate for use in a healthcare setting including direct patient communication, privacy, confidentiality, swift delivery of messages and receipt of responses, convenient for health providers and patients, provides an opportunity to improve health knowledge, behaviors, and clinical outcomes, particularly among hard-to-reach populations. Text messaging is also easy to use and affordable.

SMS messaging technology also allows the dispatching of substantial numbers of messages simultaneously, so reducing labor expenditure. (Koshy, Car, & Majeed, 2008)

Maternal and newborn child healthcare

Post-Natal is defined as the few weeks after birth of a child. This is a period which is critical to the health and survival of both mother and child. Lack of proper care during this time may result to death or disability of both mother and child. Neonatal mortality rate (NMR) refers to the death of newborns per 1000 live births. (The University of Texas School of Public Health, 2008)

Sub-Saharan Africa has the highest rates of neonatal mortality in the world and has shown the slowest progress in reducing newborn deaths, especially deaths in the first week of life. Each year, at least 1.16 million African babies die in the first 28 days of life – and 850,000 of these babies do not live past the week they are born. This is largely attributed to poor post-natal clinical attendance. (Adanikin, Awoleke, & Adeyiolu, 2014)

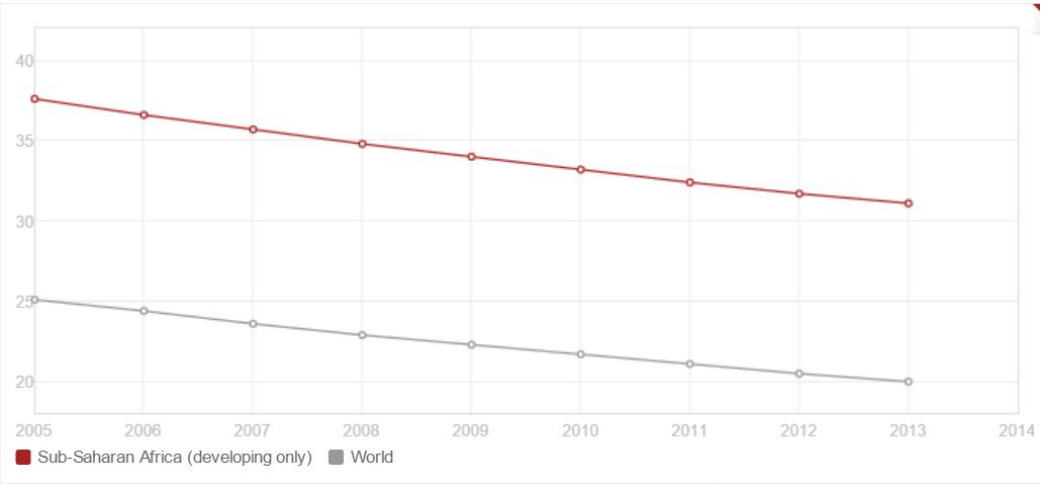

Figure 1: Mortality rates estimates developed by the UN Inter-agency Group for Child Mortality Estimation www.childmortality.org.

At the same time, mortality in children under the age of five has been reported to have fallen from an average rate of 90 per 1000 live births in 1990 to 43 in 2015, while maternal mortality has declined by 45%. (United Nations, 2015)

A number of efforts have attempted to connect the evidence relating to improved maternal, newborn and child health (MNCH) in low and middle income countries (LMIC), to technology. Numerous examples of mHealth interventions, mostly SMS-based, have being used to support mothers through safe pregnancy and childbirth and to facilitate neonatal and infant health but there is no rigorous systematic documentation of what structures are in use to send the healthcare information via SMS.

Measuring Effectiveness

Effectiveness can be measured through assessment of objectives to be achieved versus achievement of desired results. The measures quantify the results to be obtained and can be expressed as probabilities that the system will perform (Measures of Effectiveness). The measures of effectiveness can further be decomposed into measures of performance and measures of suitability.

When measuring effectiveness, one needs to observe the current state, the performance of current system, identify environmental conditions that affect the current state and provide solutions to identified challenges.

1.2. Problem Statement

The healthcare sector continues to use text messaging to disseminate healthcare information to a large population of people. There are numerous examples of mHealth interventions, mostly SMS-based, that have been used to support mothers through safe pregnancy and childbirth and to support the health of a newborn. However, there is limited evidence of systematic documentation of what structures are in use to send the healthcare information via SMS.(Kannisto KA, 2014)(Judy Gold, 2008).

This study aimed at proposing a model to be used to send healthcare information using SMS, to ensure that the message sent is effective.

1.3. Research Objectives

The objective of this study was to propose a model to be used when sending healthcare information through SMS to ensure that the message is effective.

The study intends

- To identify current structures of sending healthcare messages through SMS
- To identify factors that influence effectiveness of healthcare messages sent via SMS
- To propose a model which ensures healthcare information sent via text messages is effective

1.4. Research Questions

- What parameters influence the level of effectiveness of health messages sent via SMS?
- How can the parameters be modeled to ensure that health messages sent via SMS are effective?

1.5. Justification

SMS is a potentially powerful tool because it is widely available, inexpensive, and instant. However, to ensure that healthcare messages sent via SMS are effective and result to a change in behavior, the message has to consider certain factors. This study aimed to identify these factors and proposes a model to be followed in delivery of healthcare information through SMS.

1.6. Scope

This research wasconducted within Nairobi region. The proposed system was tested in TotoHealth. TotoHealth is a social enterprise committed to revolutionizing the maternal and child health industry in Kenya. It uses an SMS-based platform to allow parents and caregivers to record milestones in their child's physical development, which helps with the timely detection of abnormal growth in children below 5 years. TotoHealth sends life-saving information to mothers and caregivers in Kenya particularly among rural low-income populations. TotoHealth provided names of mothers who were currently receiving messages every Monday on maternal and newborn health care.

1.7. Significance

The model developed is highly useful as it can be used in other healthcare organizations that send healthcare information to its beneficiaries though text messages. If adopted, it increases the chances of a message being effective. This in turn ensures better health outcomes.

1.8. Assumption and Limitations to the project

In this study, the following was assumed

- That SMS remains the best medium for communicating to large populations at a low cost.
- That the target population answered truthfully to the surveys conducted.
- That the sample selected was a representation of the population this study made inferences to.

CHAPTER TWO
LITERATURE REVIEW

2.1. Introduction

The use of mobile and wireless technologies to support the achievement of health objectives (mHealth) has the potential to transform the face of health service delivery across the globe. Factors such as rapid advances in mobile technologies and applications, a rise in new opportunities for the integration of mobile health into existing eHealth services, and the continued growth in coverage of mobile cellular network are leading to such. (WHO, 2011)

According to the International Telecommunication Union (ITU), there are now over 5 billion wireless subscribers; over 70% of them reside in low- and middle-income countries. The GSM Association reports commercial wireless signals cover over 85% of the world's population, extending far beyond the reach of the electrical grid. (WHO, 2011)

SMS Text messaging has become a preferred mechanism of communication in modern society. It has continued to gain popularity over time presenting an opportunity to improve health care through new forms of interactive mobile health (mHealth) services that promote personal wellness, preventive care, and disease management. (Shib Sekhar Datta, 2014)

This section will assess the current mHealth landscape, review some notable health interventions supported by SMS and compare the models used to send healthcare information via SMS.

2.2. The current mHealth Landscape: Review of interventions supported by SMS applications in healthcare

There are numerous ways SMS is being used in the healthcare sector globally. Some of its uses include broadcasting of urgent and important information across a wide geographical area, increased efficiency in monitoring patient progress and condition, diet and health tips, emergency toll-free telephone services, managing emergencies and disaster outbreaks, mobile telemedicine, appointment reminders, community mobilization and health promotion, treatment compliance, mobile patient records, information access, patient monitoring, health surveys and data collection, surveillance, health awareness raising, and decision support systems (Talariax)

In 2014, the US department of health and human services conducted an environmental scan to highlight a number of text messaging initiatives that address various health issues. (U.S Dept of

Health and Human Services, 2014) The scan represented text messaging initiatives in maternal and child health, tobacco control, emergency response and preparedness among others. The initiatives focused on health promotion and disease prevention. The use of SMS was seen to positively result to behavior change.

In a study conducted by the Center for Population Health to determine the impact of text messaging for sexual health promotion for young people, text messaging was found to be an effective method and improvement in sexual and health knowledge was observed. (Judy Gold, 2008) This was largely attributed to the messages being short, catchy, and informative, and where possible, tied into particular events (e.g., Valentine's Day, Mother's Day).

2.3. Evidence of use of SMS to support maternal and newborn child healthcare

2.3.1. Wired Mothers

Wired Mothers is a mHealth project that seeks innovative ways to ensure access to ANC and skilled attendance at delivery, and to examine the beneficial impact mobile phones can have on maternal and neonatal morbidity and mortality. It is designed with the aim of linking pregnant women to their primary health care provider throughout their pregnancy, childbirth and post-partum period. (USAID & African Strategies for Health, mHealth Compedium, Volume 3, 2013).

During the pilot study conducted in 2009-2013, nearly 1300 pregnant Zanzibar women registered their mobile phones with the local health clinic upon their first antenatal visit. The women received a number of benefits, such as helpful text messages on their mobile phones about what kinds of foods to eat, how to prepare for the arrival of their babies and reminders on when to attend the next antenatal checkup. They were also given a nurse's cell phone number in case of any questions or emergencies.

Wired Mothers sends two SMS in Kiswahili, every month before 36 weeks of pregnancy; one reminding the pregnant woman of her next ante-natal care visit and another on health education. After the woman gives birth, she is put on post-pregnancy health information, where she receives reminders for her baby's vaccinations.

2.3.2. Interactive Alerts

The biggest IT challenge in the health and medical fields continues to be the ability to track large numbers of patients and materials. As mobile phone availability becomes ubiquitous around the world, the use of Near Field Communication (NFC) with mobile phones has emerged as a promising solution to this challenge. The decreasing price and increasing availability of mobile phones and NFC allows the application of such technologies in developing countries to overcome patient identification and disease surveillance limitations, and permit improvements in data quality, patient referral, and emergency response. This is the case for Interactive Alerts. Interactive Alerts offers child tracking and referral via general packet radio service (GPRS) using near field communication (NFC) mobile phones and radio frequency identification (RFID) tags. It provides a J2ME mobile client application for data collection and a web based server side application for data monitoring and storage. A child's caregiver first enrolls in a lottery system during an Expanded Program on Immunization (EPI) center visit and then receives SMS reminders about vaccination appointments. To assure each child completes the scheduled vaccines on time, health workers also individually track enrolled children using the mobile phone-based RFID system. The amount of cash the caregiver is eligible to win increases with each subsequent vaccine their child completes.

Caregivers receive higher cash amounts for vaccinations that are administered at the recommended age. After winning the lottery, the caregiver is sent a winning lottery code via SMS. The lottery winnings can be used at the participating stores offering groceries and medicines located in close vicinity to each EPI center, and codes cannot be exchanged for cash. Each time a lottery prize is won, the health worker who administered the vaccination also receives a mobile money transfer payment which is equivalent to 40% of the lottery prize. Interactive alerts enrolled more than 14,000 infants over a period of 6 months. (USAID & African Strategies for Health, mHealth Compendium, Volume 5, 2015) IRD's Interactive Alerts application sends SMS reminders about vaccination appointments to caregivers

2.3.3. M-chanjo

M-chanjo is a mobile based system that creates awareness on child immunization schedules and provides basic health facts. It is a mobile based system that seeks to reduce the rate of child mortality especially in the developing world.

The idea was born out of the realization that out of the 8.1 million children under 5 years of age who die every year, a large percentage dies from preventable diseases such as pneumonia, measles and diarrhea. These diseases can be prevented by administering vaccinations which are given free for all children under five years. Still, the rate remains high. The millennium development goal 4 is geared on reducing the rate of child mortality by two-thirds by the year 2015. (UN Secretariat, 2014)

The system works by sending automated reminders via SMS to parents to keep them informed on any future immunization dates and appointments for their children. The text messages also include basic health care tips to manage common diseases.

M-chanjo banks on the negligible costs in sending text messages and on the high mobile phone penetration rate. The use of mobile phones and SMS is thus efficient and in the long run reduces costs on outreach and treatment of diseases that could otherwise have been prevented. (CHMI, M-Chanjo, 2014)

2.3.4. ChildCount+

ChildCount+ is a mHealth platform developed by the Millennium Villages Project aimed at empowering communities to improve child survival and maternal health. The main program goal is to register every child under 5 and pregnant woman and record the MUAC of every child from 6 months to 5 years every 90 days for malnutrition. The child is also monitored for diarrhea, malaria and pneumonia, the three major preventable causes of death in children under 5.

Full child immunization support: Group all children in monthly age groups to know when a particular immunization is due. Record all immunizations and follow up with all children who are behind with their immunization schedule. Help manage vaccination campaigns.

The program uses SMS messages to facilitate and coordinate the activities of community-based healthcare providers, and to register patients and their health status on a central web dashboard that provides a real-time view of the health of a community. Automated alerts help reduce gaps in treatment. (CHMI, ChildCount+, 2014)

2.3.5. WelTel Kenya

WelTel Kenya conducted a randomized controlled trial to test the clinical effectiveness of text message support for HIV treatment adherence in Kenya. This trial showed that patients receiving

text message support had significantly improved treatment adherence and viral suppression, than patients who received standard care alone. (Lester RT, 2010)

The WelTel intervention involved sending weekly SMS using the WelTel Kenya1 model and an automated text-messaging platform (WelTel and Vertical Labs). Each week for 6 months during the study period (January to December 2012), enrolled participants were sent a text message asking, “How are you?” Responses were categorized into those that were reassuring and those that required follow-up by clinic staff. Participants who indicated a problem or question were either texted or called (Figure 1). If participants had not responded within 48 hours of the first text, a second text was sent asking, “Haven't heard from you … how is it going?” Mobile phones and phone plan support were provided to participants without a phone: 15 participants owned a mobile phone at baseline and 10 were provided with phones and phone plans. In addition, 4 participants who had their own phones had their plans upgraded for unlimited texting.

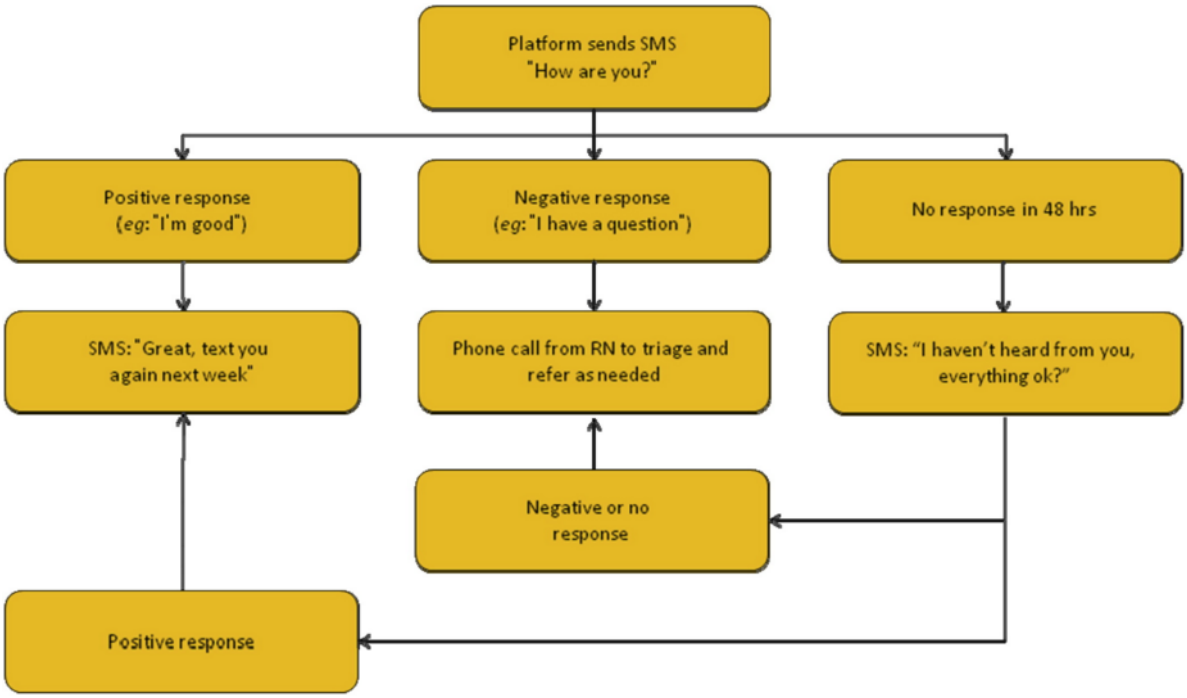

Figure 2: WelTel Kenya model sending weekly SMS

2.4. Summary of Models used

Table 2.1 below provides a summary of the models used in sending healthcare messages from the review of literature listed above. The table confirms that they are many versions of models

used when sending healthcare information over SMS. There needs to have a common and standardized model which considers all the relevant factors thus ensuring that healthcare information sent over SMS is effective.

Table 1:Summary of Models used

Intervention	**Number of SMS sent in a month**	**Frequency**	**Type of SMS**	**Preferred Language**
Wired Mothers	2		Health Education, Ante-natal visit reminders, baby vaccination reminders	Kiswahili (predominantly native language)
Interactive Alerts			Vaccination	English
WelTel	4	Weekly	Follow up on ART medication, Reminders for next ART visit	Kiswahili
ChildCount			CHWs receive SMS notifications to conduct follow-up visits and to remind women and children in their catchment area of upcoming clinic visits	

Two parameters are identified from the model summary in table 2.1 above. Each of the factors message were since frequency of messages sent in a month ensured that the recipient , message content had to be of interest to the receiver and language of the significant

2.5. Conceptual Framework

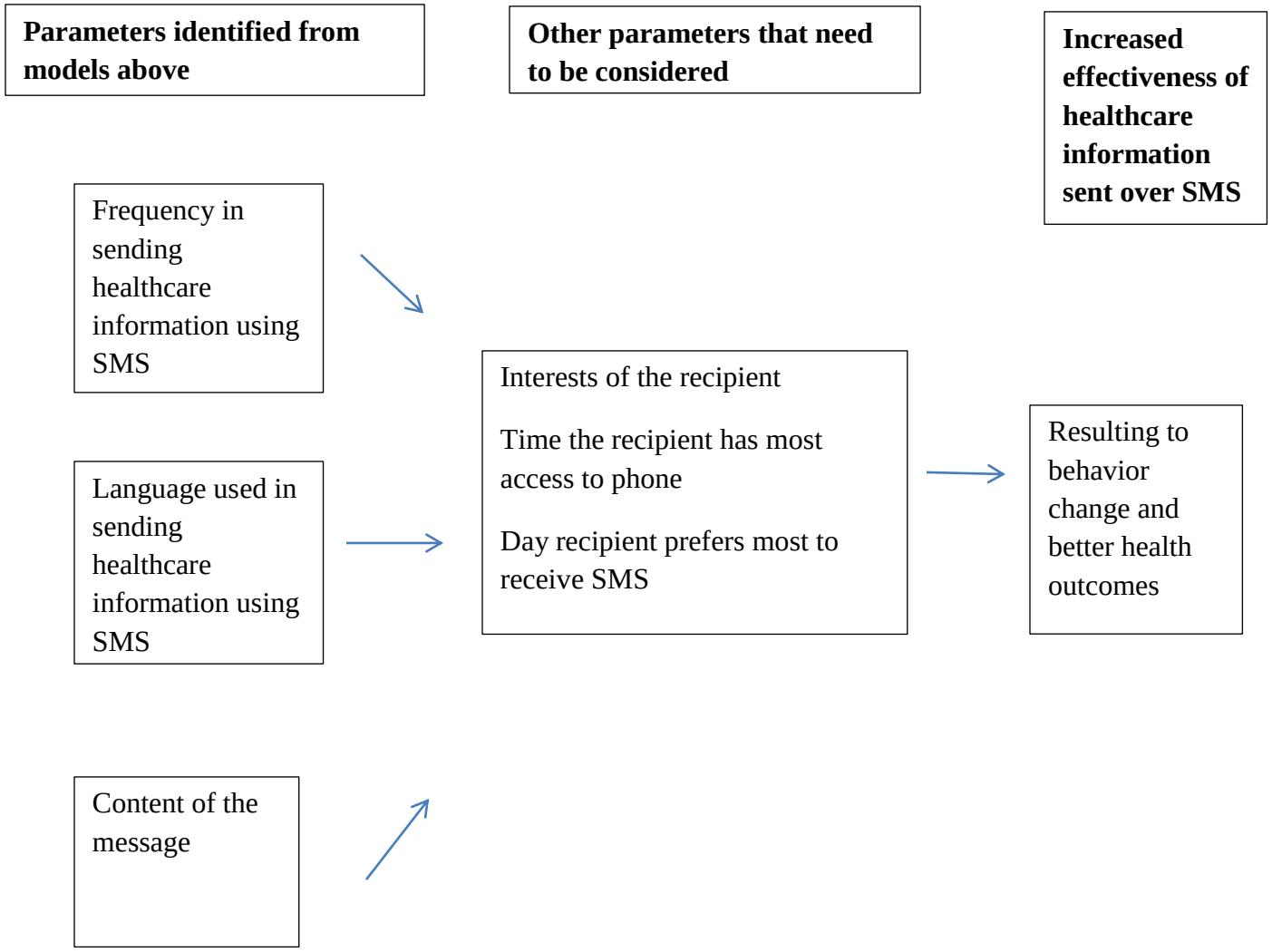

Figure 3: Conceptual Framework

CHAPTER THREE
RESEARCH METHODOLOGY

3.1. Introduction

The purpose of this study was to gather information on how to increase effectiveness of healthcare information sent over SMS technology. This chapter gives a comprehensive account of the research methodology that was used by the researcher to address the research problem. The geographical setting where the study will take place, research design and the targeted population will be identified here, as well as the research sample. The research instruments to be utilized to gather research data together with the techniques applied to preserve reliability and validity of the research instruments will be keyed out. In addition, justification for the various research strategies are given here, and the sampling technique will be adopted besides the various ethical issues taken into consideration

3.2. Data Collection

This research study was based on information gathered on how to increase effectiveness of healthcare information sent over SMS technology. A mix of both qualitative and quantitative research methods were used to verify the hypothesis that sending healthcare information via SMS requires certain parameters to ensure effectiveness.

3.3. Sampling

Sample Size

A sample is a subset of a population. The sample size of the respondent's students was calculated using the Slovins formula. (Ellen, 2012)

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

Where:

n= sample size

N= population size

e= margin of error10.41%

n= 600/ (1+600(0.104^2) = 80.11

Sample size for the study was 80 respondents, selected from a population of 600 people within the TotoHealth database.

The sample consisted of 11 males and 69 females from Nairobi's urban center and low resource setting areas such as Kibera, Mukuru wa Njenga and Embakasi.

3.4. Data Collection instruments

Both qualitative and quantitative research methods were used as follows:

- Literature review of existing models used to send healthcare messages using SMS - Study and review of material from past studies and projects done in the same research area was conducted. This involved analyzing existing information found on journals such as Global Health Action and PubMed and was used to understand the models currently used and the effect the models have had on delivery of healthcare information through SMS.
- 52 respondents were interviewed over the phone using semi-structured scripts. Interview topics included time of day in which respondent has most access of their phone, day of the week most preferred to receive the SMS, frequency of receiving the healthcare messages, topics of interest to the receiver, preferred language, education level and general demographic of the receiver (age, cadre (father, mother, young mother). Interviews were conducted over the phone due to lack of availability of the respondents. Interviews lasted approximately 10 - 20 minutes, were tape recorded and transcribed verbatim. The interviews were conducted in either English or Swahili. Questionnaires collected information on demographic characteristics, mobile phone use, and perceptions of the intervention. The interview consisted of 34 elderly mothers, 11 young mothers and 8 fathers.
- A focus group discussion consisting of 6 participants was held at Kayole II Hospital Center in Kayole, Nairobi. The discussion topics included time of day in which participants had most access of their phone, day of the week most preferred to receive the SMS, frequency of receiving the healthcare messages, topics of interest to the receiver

and preferred language of receiving the healthcare messages. Participants received Kshs 200 to reimburse them for their time.

- Questionnaires were also conducted. 5 questionnaires were filled at the Kayole II Hospital center. Questionnaires collected information on demographic characteristics, mobile phone use, and perceptions of use of SMS in delivering healthcare messages intervention. Participants received Kshs 200 to reimburse them for their time.
- Immersion - The researcher subscribed to TotoHealth as a recipient of the SMS' sent containing healthcare information. This was done in order to fully analyze the messages received.

3.5. Data Analysis and Interpretation

The data collected for this study was both quantitative and qualitative and a statistical analysis using Microsoft Excel was performed. Results of the study were analyzed. For the qualitative analysis, the text data obtained through the interviews, questionnaires, observations and documents reviewed was coded and analyzed for themes to enable analysis using Excel.

3.6. Ethics

Ethical approval was granted by TotoHealth Limited after signing of a non-disclosure agreement (NDA). Respondents were also informed that their participation was voluntary, that they can withdraw at any time and that all data will be confidential.

CHAPTER FOUR
ANALYSIS AND SYSTEM DESIGN

4.1. Introduction

Data collected was analyzed to identify the factors that influence the level of effectiveness of healthcare messages sent though text messaging and understand perceptions, acceptability and engagement of target population. Quantitative data was analyzed using Microsoft Excel

4.2. System Design

This section provides a summary of the existing TotoHealth system, highlighting the challenges experienced and the design of the new system.

4.2.1. Existing Systems

TotoHealth's current system contains both front end and back end. The front end relays healthcare information via SMS short code. The service is available to the end users including mothers and fathers.

TotoHealth registers its users through the online platform, through SMS short code and through a mobile app.

TotoHealth system registration process flow is as follows

Registration process

- Via SMS, a user sends the word "Toto" to the short code 20209 ->
- System replies with options for preferred language (English/Kiswahili) - >
- Once the user selects, another message is received with request for first and last name
- Once the user replies, another message is received with a request to know whether the user has a child or is expecting a child
- Once the user replies, user receives a message to provide details of expected delivery date or child's birth date
- Once the user replies, another message is received with a request for messages relating to mom or dad
- Once the user replies, another message is received with a request for the county the user lives in

- Messages are then received every Monday for expectant mothers and every Monday and Thursday for mothers with newborns

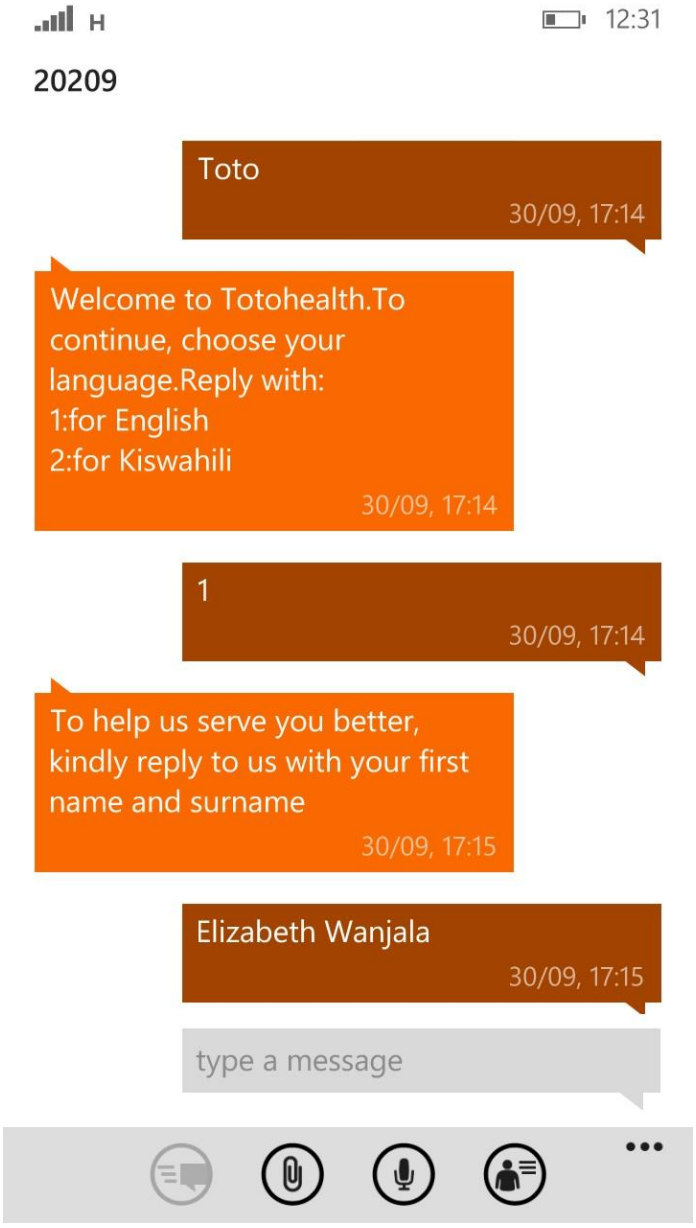

Figure 4: Screenshot of the current TotoHealth registration process

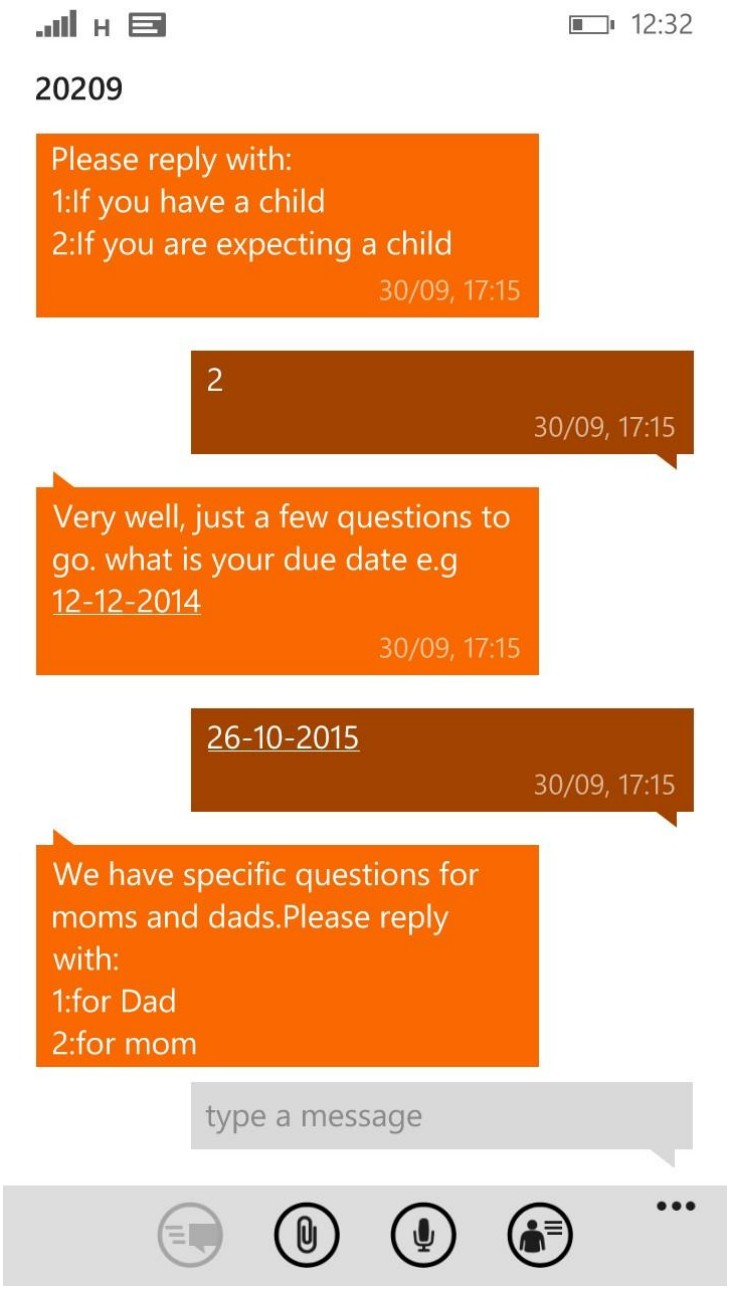

Figure 5: Screenshot of the current TotoHealth registration process

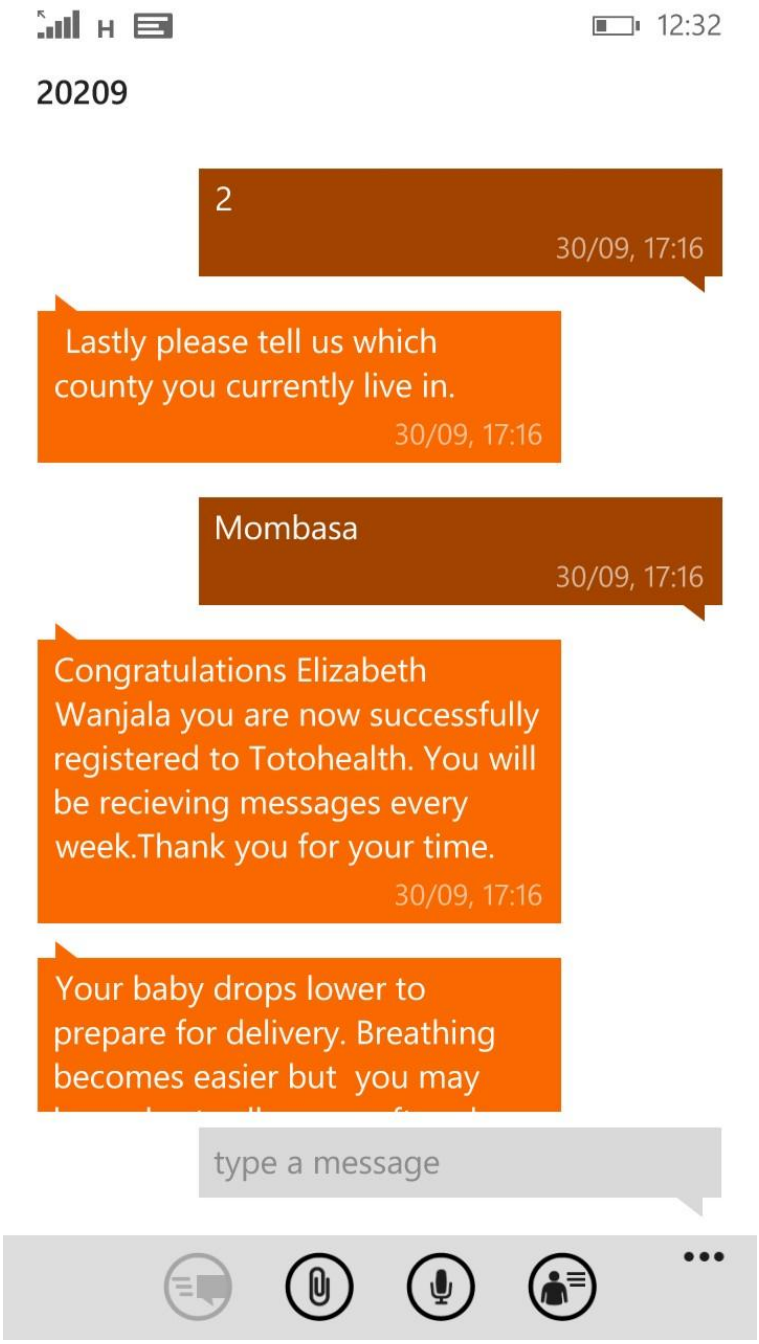

Figure 6: Screenshot of the current TotoHealth registration process

Limitations of existing system

- The recipient does not propose which time and day they most prefer to receive the healthcare messages - The healthcare messages sometimes go unread because they are sent when the user does not have free time.

- The recipient of the message does not select topics that they would like to receive messages on SMS - the client easily loses interest because they receive messages of topics that do not interest them
- The recipient does not choose how often they want to receive the healthcare information.

4.2.2. Proposed System

One of the goals of this research study is to develop a model that can used to send healthcare messages, ensuring the messages received by the intended recipient are actually read and result to the receiver becoming better or change in behavior. Another objective was to enhance the existing system in order to ensure messages sent to the recipients are according to their availability. This can be achieved by adopting the model derived from data collected in this study.

For the development of the proposed system, the preferred methodology is rapid application development

Rapid Application Development (RAD)

RAD is a development lifecycle designed to give much faster development and higher-quality results than those achieved with the traditional software development lifecycle. Fundamentals or this methodology are:

- Gathering requirements using interviews and focus groups
- Prototyping and early, reiterative user testing of designs
- The re-use of software components - to save time, resources and reduce redundancy by taking advantage of assets that have already been created in some form within the software product development process

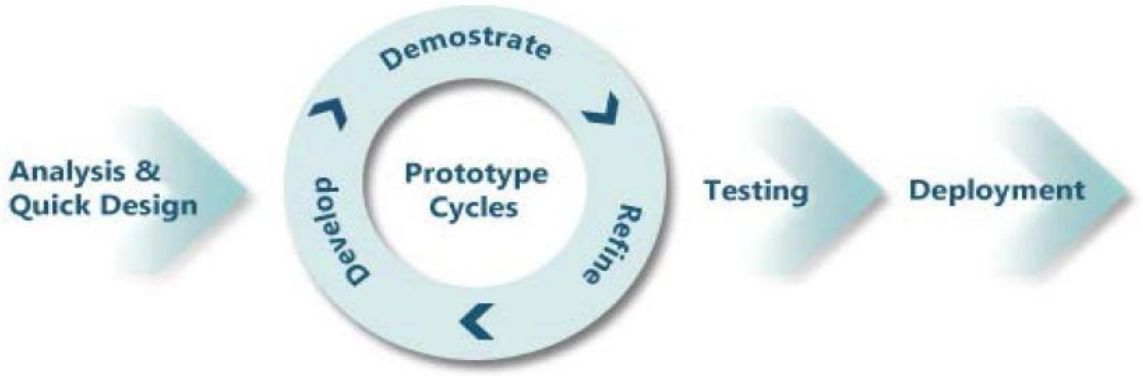

Figure 7: Rapid Application Development Model

4.2.3. Description of proposed system

The current TotoHealth system sends messages to its users but does not send when the recipient is most available. During the registration process, the system only captures the preferred language and the names of the users.

The proposed solution extends the functionality of the existing TotoHealth system, to enable the user to

- select which day of the week they most prefer to receive the healthcare messages
- select which time of day they most prefer to receive the healthcare messages
- select how frequently they prefer to receive the healthcare messages
- select which language they most prefer to receive the healthcare messages
- select which topics they most prefer to receive the messages on

4.2.4. Overview of the proposed system

This new system enables the user to select when and how frequently they want to receive the healthcare information.

Propose day of the week

The system enables the user to select which day of the week they would like to receive the messages. This enables the user to create a habit of expecting the healthcare message on a particular day when he/she is most available.

Propose the time of day

This function enables the user to select which time of day selected would they prefer to receive the message. This enables the user to select the best time which will enable them to read the message. This is mostly the time they are most free with little or no distractions.

Propose frequency of receiving the messages

This function enables the user to determine how frequently they would like to receive the healthcare messages. According to the data collected, new and young mothers preferred to receive the healthcare messages as frequently as possible compared to older and more experienced mothers.

Propose topics of interest

Although the topics covered by TotoHealth are all important, young mothers were seen to prefer receiving specific messages compared to elderly and experienced mothers. This therefore shows their level of interest with regards to the various topics.

CHAPTER FIVE
RESULTS AND DISCUSSION

5.1. Introduction

This section highlights the results of data collected during the study.

5.2. Results

The results from survey are divided into two sections; the first section contained questions asked to all respondents, and the second section contains questions asked to respondents who have been receiving TotoHealth messages.

Section containing questions asked to all respondents

5.2.1. Demographic of respondents

Table 2 shows the demographic of the respondents. A sample of 80 respondents was randomly selected from a population of 600. The sample comprised of 11 fathers, 10 educated mothers, 12 young mothers between the ages of 19 – 25 and 47 mothers residing in Kibera, Mukuru wa Njenga and Embakasi.

From the sample of 80 selected, only 63 participants responded to the study, approximately 79%

Table 2: Demographics of respondents

Variable	Attribute	Total Respondents	% of Respondents
Age	Below 20	3	4.1%
	20 – 25	19	30.6%
	26 – 30	23	37%
	31 – 35	15	24.2%
	36 – 40	3	4.1%
	41 – 50	0	0.0%
Gender	Male	8	13%
	Female	55	87%
Marital Status	Single	24	38.1%
	Married	33	52.4%
	Divorced/ Separated	0	0.0
	Not married but with father of child	6	9.5
Category of respondents	Fathers	8	11%
	Young Mothers (19 – 25)	12	19%

	Educated mothers	8	13%
	Other Mothers	35	57%

5.2.2. Respondents access to their mobile phones

Table 3 shows the respondents access to their mobile phones. 100% of the respondents owned a personal cell phone. 21% had access to their phones in the morning hours only, while 29% of the respondents had access to their phones in the evening. 51% had access to their phones at all times.

Table 3: Respondents access to their mobile phones

At what time do you access your phone the most in a day		
Answer Options	Response Percent	Response Count
In the morning only	21.0%	13
In the evening only	29.0%	18
The whole day/ at all times	51.0%	32
I do not own a phone	0.0%	0
answered question		63

5.2.3. Best time to receive healthcare SMS

Figure 8 shows the best time during a day when respondents would like to receive healthcare SMS. 46% of the respondents preferred to receive the messages in the morning hours between 8:00am – 12:00 noon, 4.8% preferred to receive the messages in the afternoon between 12noon and 5:00pm. 28.5% preferred receiving the SMS in the evening, between 5:00pm and after 7pm. 20.6% prefer to receive the messages anytime.

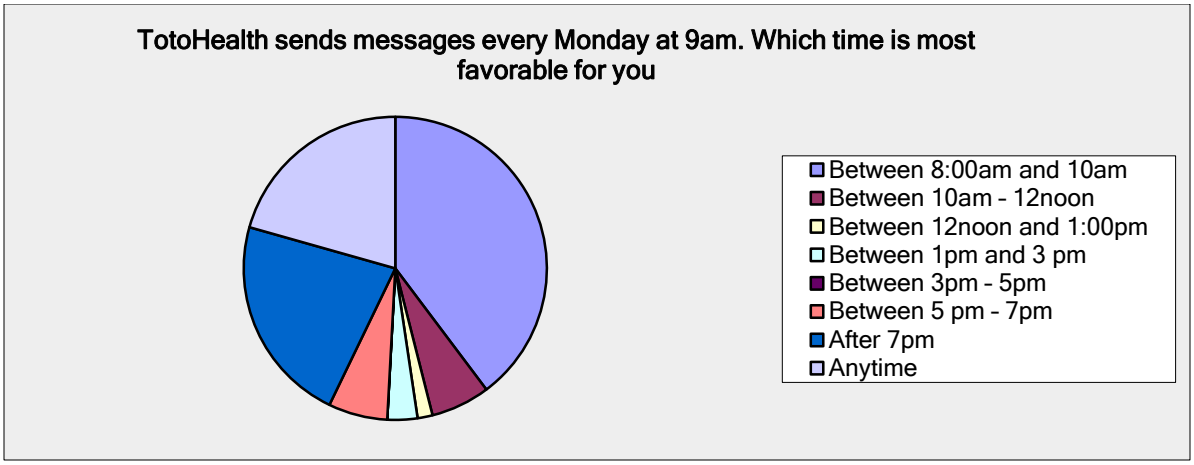

Figure 8: Best time to send healthcare SMS

5.2.4. Day of the week which respondents preferred to receive the healthcare message

Figure 9 shows which day of the week the respondents preferred to receive the healthcare message. 58.7% of the respondents preferred receiving the healthcare messages on Monday, 7.9% on Tuesday, 4.8% on Wednesday and Friday, 9.5% on Saturday, 3.2% on Sunday and 11.1% every day.

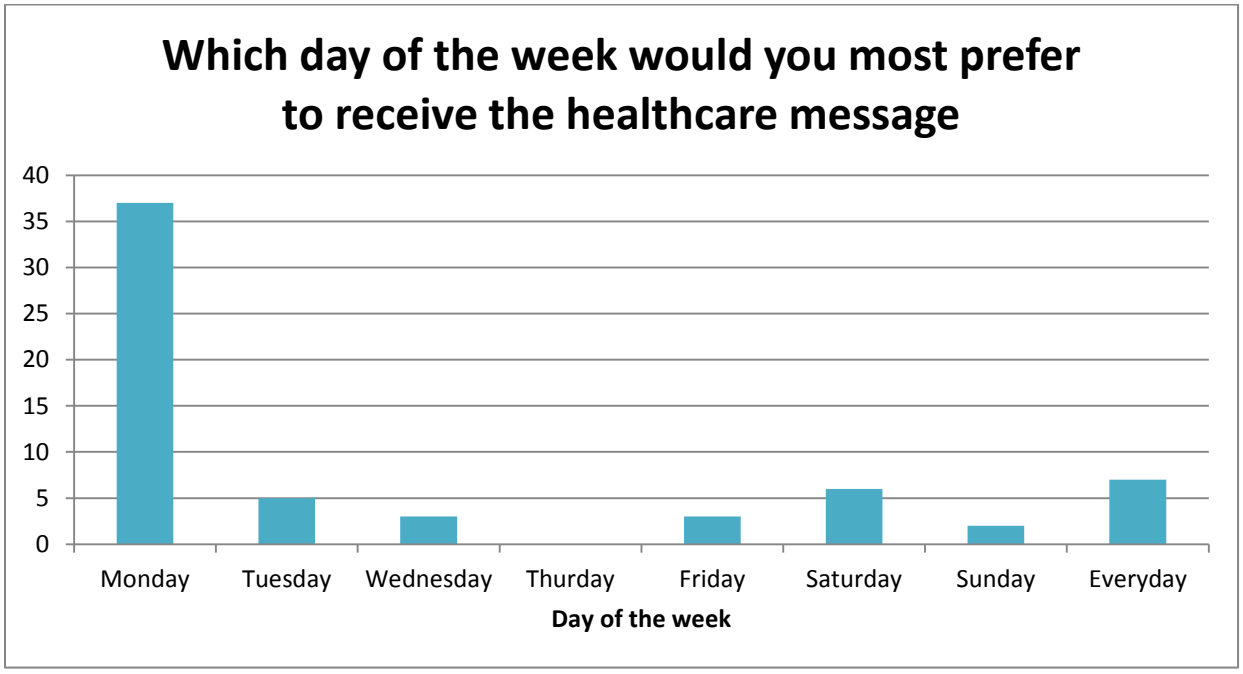

Figure 9: Day of the week which respondents preferred to receive the healthcare message

5.2.5. How often respondents preferred to receive the TotoHealth messages

Table 4 shows how often respondents would like to receive the TotoHealth messages. 44.4% of the respondents prefer to receive healthcare messages once in a week. While 29% preferred to

receive the messages at least twice in a week.22.2% preferred to receive the SMS as frequently as possible. Further analysis of the data showed that young mother interviewed preferred to receive the messages as frequently as possible. This can be attributed to the fact that they needed a lot of information given that they were new mothers.

Table 4: How often respondents preferred to receive the TotoHealth messages

How often would you like to receive the TotoHealth messages		
Answer Options	**Response Percent**	**Response Count**
Once a week	44.4%	28
Twice in a week	28.6%	18
Once in two weeks	4.8%	3
Once a month	0.0%	0
As frequently as possible	22.2%	14
answered question		63

5.2.6. Topics respondents preferred to receive SMS on

77.8% of the respondents were interested in receiving SMS on child development and stimulation. 71.4% were interested in SMS on breastfeeding and nutrition. The respondents were least interested in health pregnancy and safe delivery information.

Further analysis of the responses revealed that young mothers were interested in receiving information on child development and stimulation by 91.7%, breastfeeding and nutrition by 91.7% and parenting by 91.7%.

Fathers were seen to be interested in receiving messages on first aid (100%), child development and stimulation (100%), immunization reminders (85.7%) and parenting (85.7%)

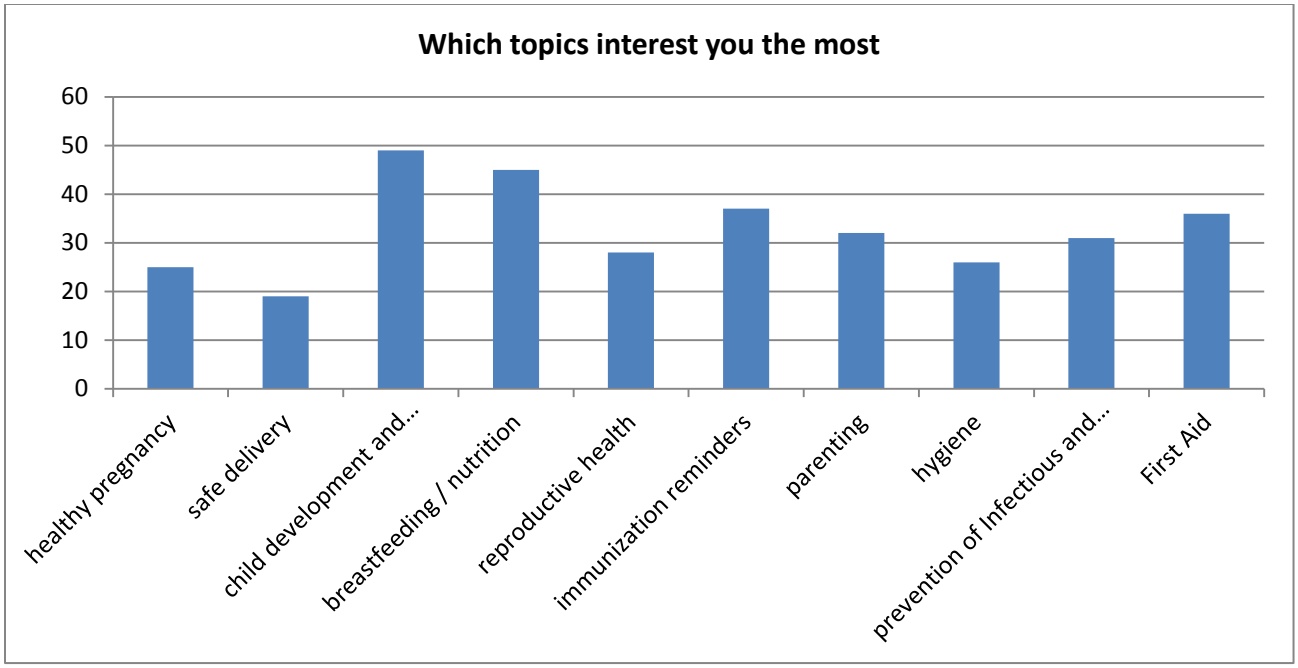

Figure 10: Topics respondents preferred to receive SMS on

5.2.7. Channels other than SMS which respondents preferred to receive healthcare information on

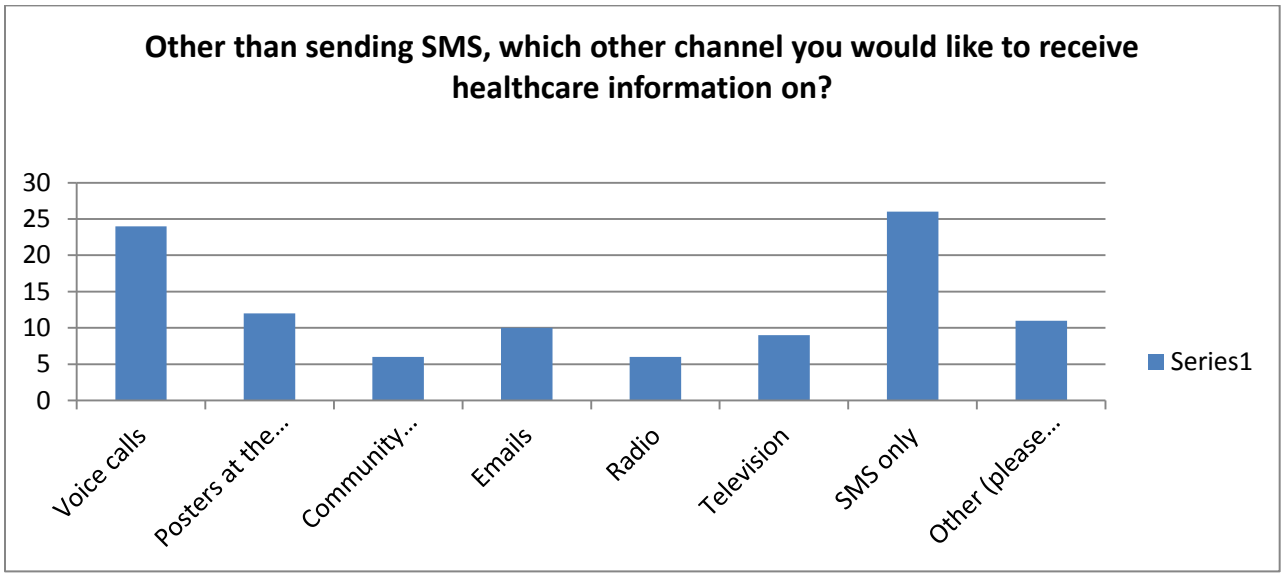

Figure 11: Channels other than SMS which respondents prefer to receive healthcare information on.

Figure 11 shows channels other than SMS respondents would like to get information from TotoHealth. Most of the respondents preferred to receive information via SMS only, followed closely by Voice calls. Use of radio and community health workers was least preferred

5.2.8. Language in which respondents preferred to receive the messages

Table 5: Language in which respondents preferred to receive the messages

In which language would you most prefer to receive the messages		
Answer Options	**Response Percent**	**Response Count**
English	60.0%	38
Kiswahili	40.0%	25
Native Language	0.0%	0
Other (please specify)	0.0%	0
answered question		**63**

Table 5 shows the language the respondents preferred to receive the healthcare messages from TotoHealth. The English language was highly preferred over Swahili language by 60% of the respondents. No respondent selected a native language as their preferred language.

5.2.9. Method used to enroll respondents to TotoHealth

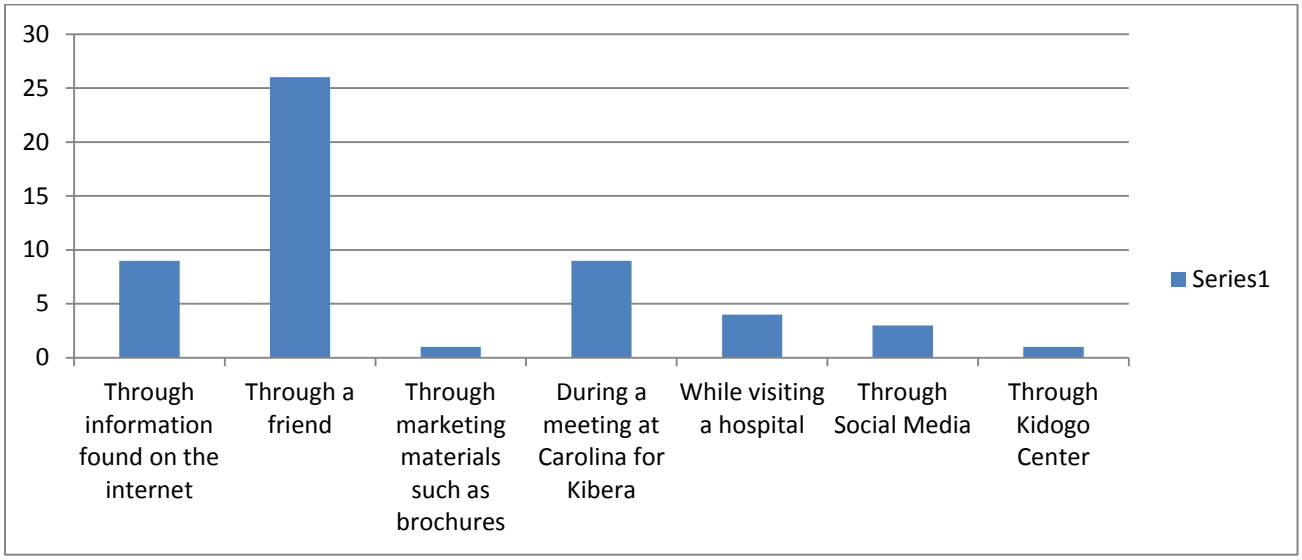

Figure 13: Method used to enroll respondents to TotoHealth

Figure 13 shows the channels used to enroll respondents to the TotoHealth Service. More respondents were introduced to TotoHealth through a friend followed closely by information found on the internet and during meetings at the Carolina for Kibera center. Other channels included through marketing materials such as brochures, during a hospital visit, while at one of the centers, Kidogo center and also through social media

Discussions with respondents revealed that they would like to get more information on Family Planning along with the other maternal and child health related messages. The respondents also commented on the amount of time taken to respond to feedback, requesting that the feedback process should be hastened. A number of the respondents were greatful of the service especially on immunization reminders, requesting that TotoHealth should provide more information on the purpose of the immunizations along with the immunization dates. Generally the respondents felt the service was very educative and felt as if TotoHealth was also looking after the child. Other issues raised include insufficient information on the website, requesting that TotoHealth place more information on MNCH on their website for ease of access.

5.3.Model Developed

Development of the solution involved closely working with the TotoHealth team to adopt the model suggested from the study conducted.

The model considers the following additional variables;

- Find out what time the user has most access to their phone in a day
- Find out which day of the week the receiver most prefers to receive the SMS containing the healthcare information
- Find out how often the receiver would like to receive the healthcare information
- Find out what type of information/ topic is the receiver interested in most
- Find out which language the receiver would like to receive the healthcare information in

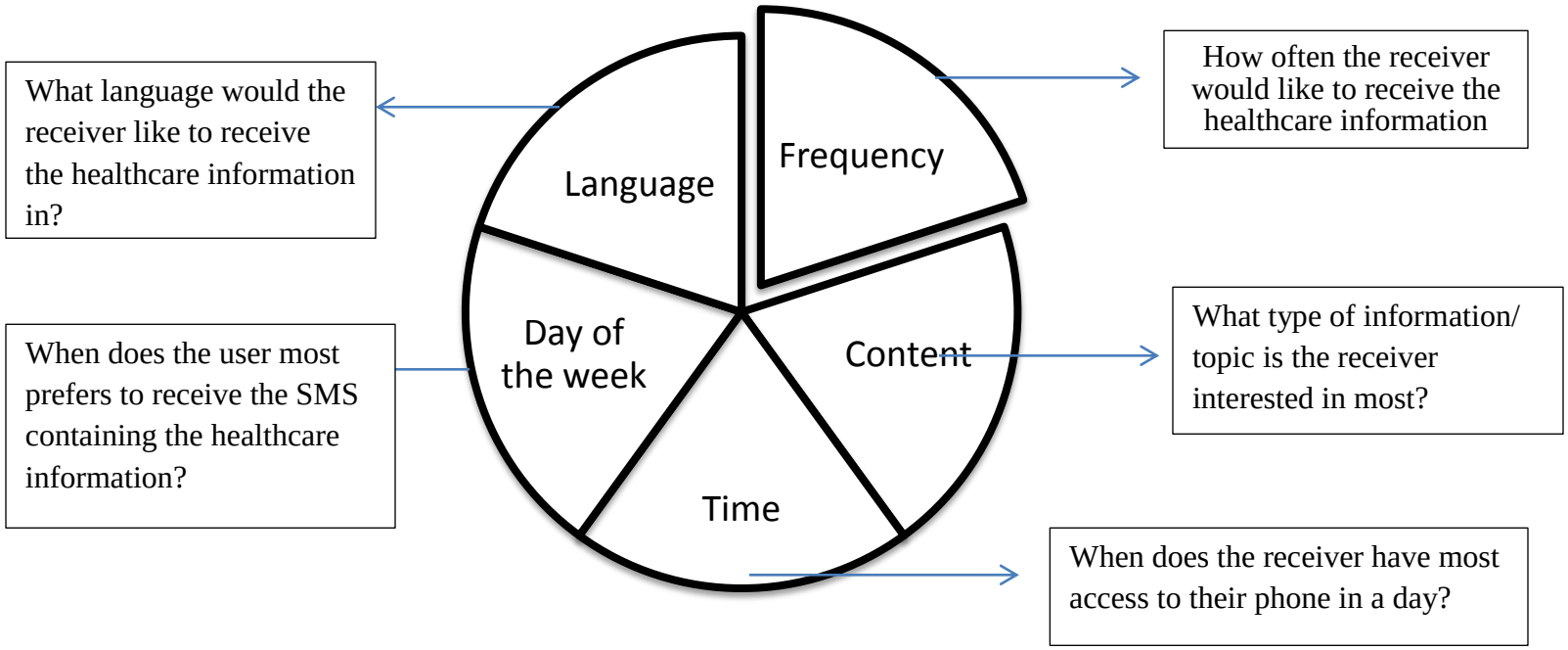

Figure 14: Model developed for sending healthcare information through SMS

The adoption of this model has led to change of the registration process to factor in the above model. SMS are now sent according to the receivers' availability and preferences to receive the messages.

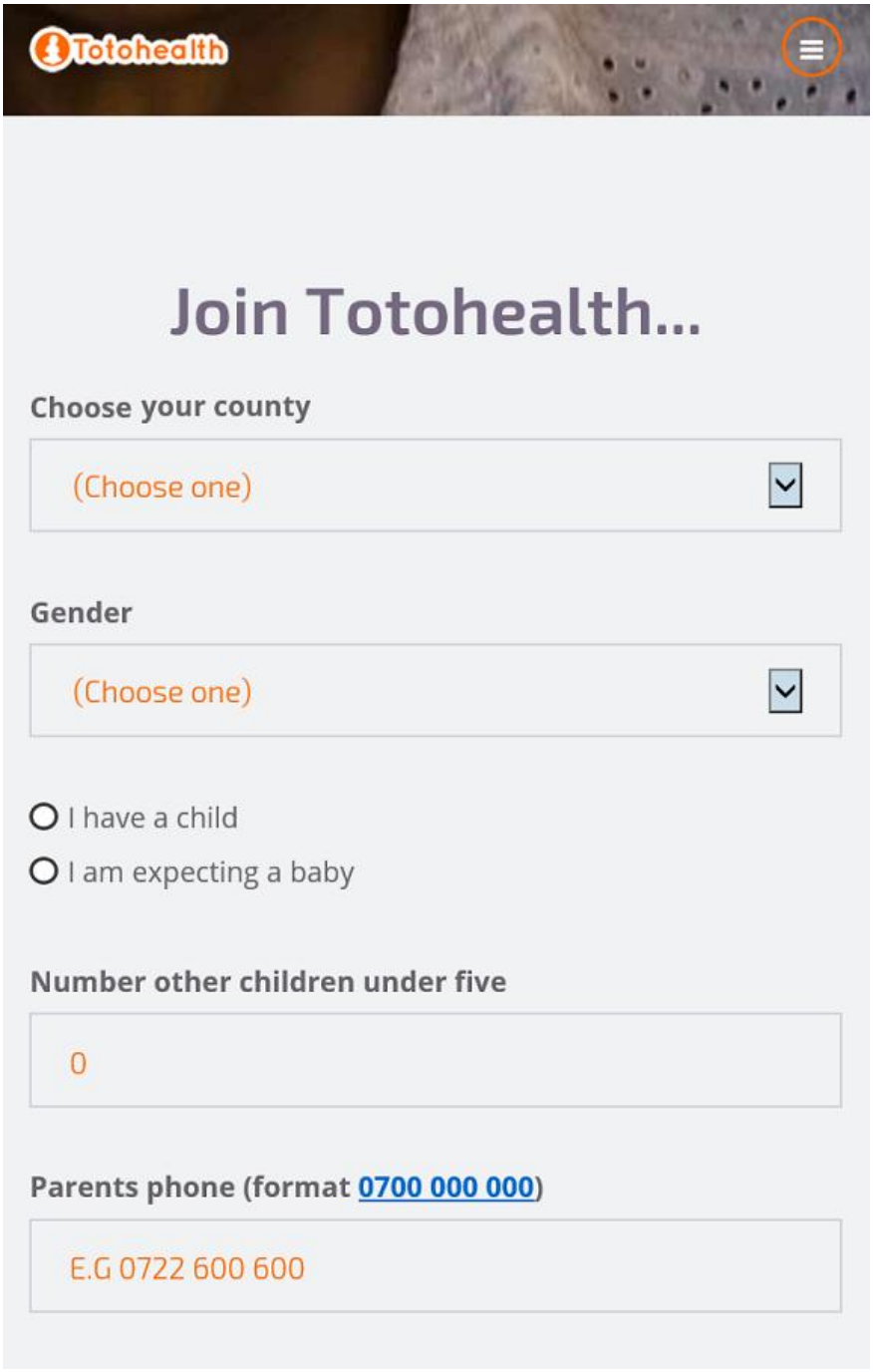

Figure 15: Screenshot of the new TotoHealth registration process

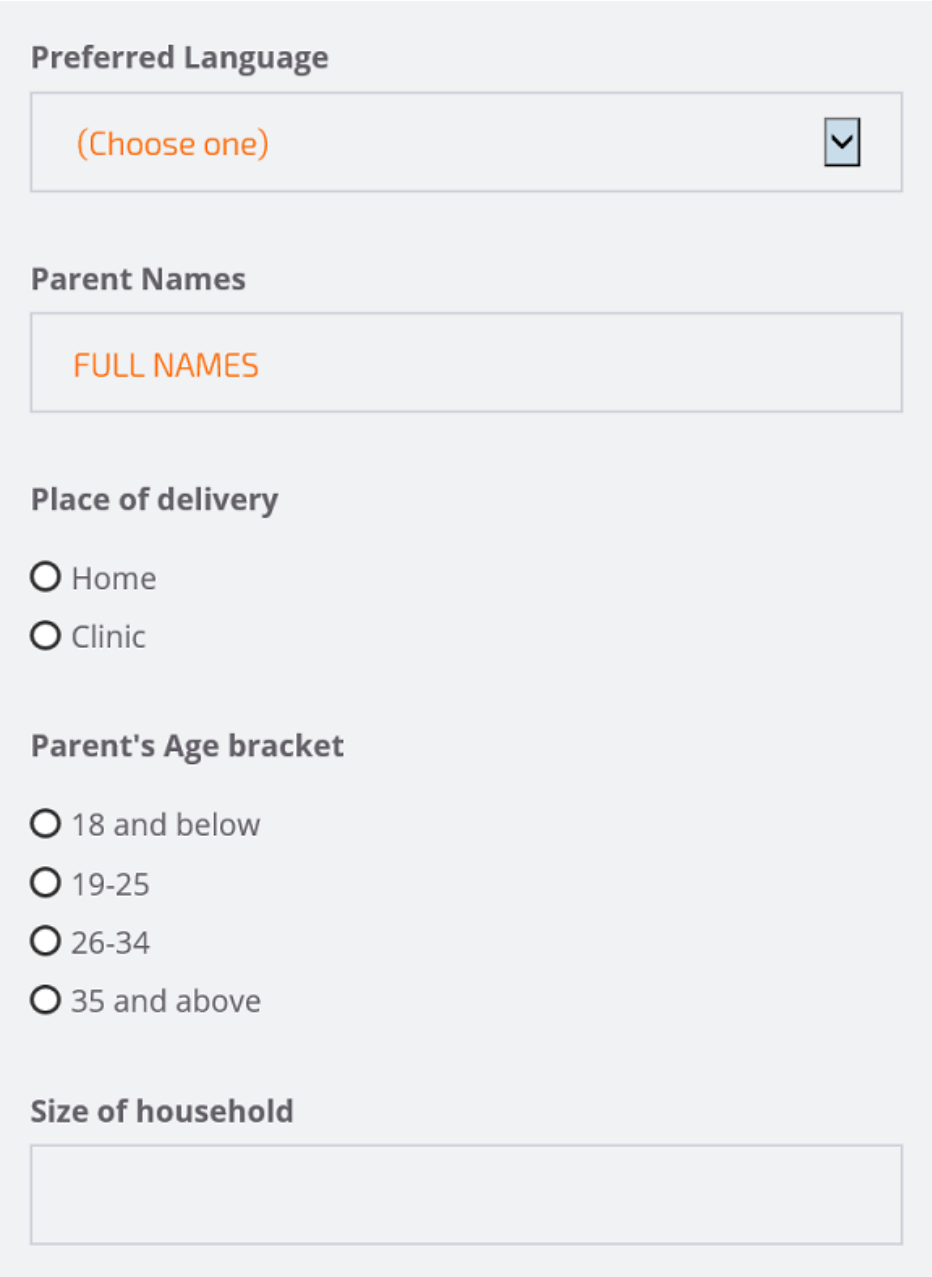

Figure 16: Screenshot of the new TotoHealth registration process

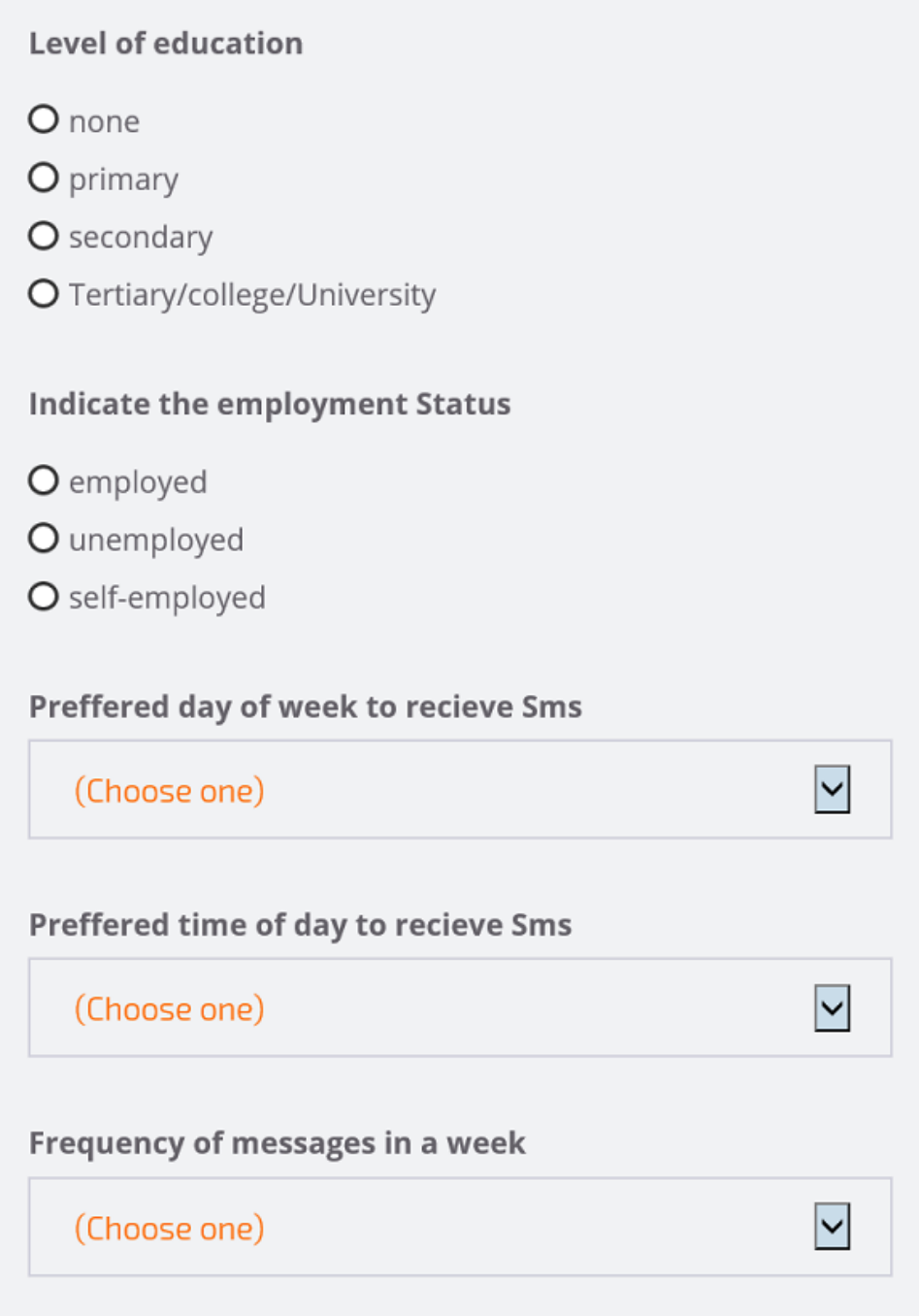

Figure 17: Screenshot of the new TotoHealth registration process

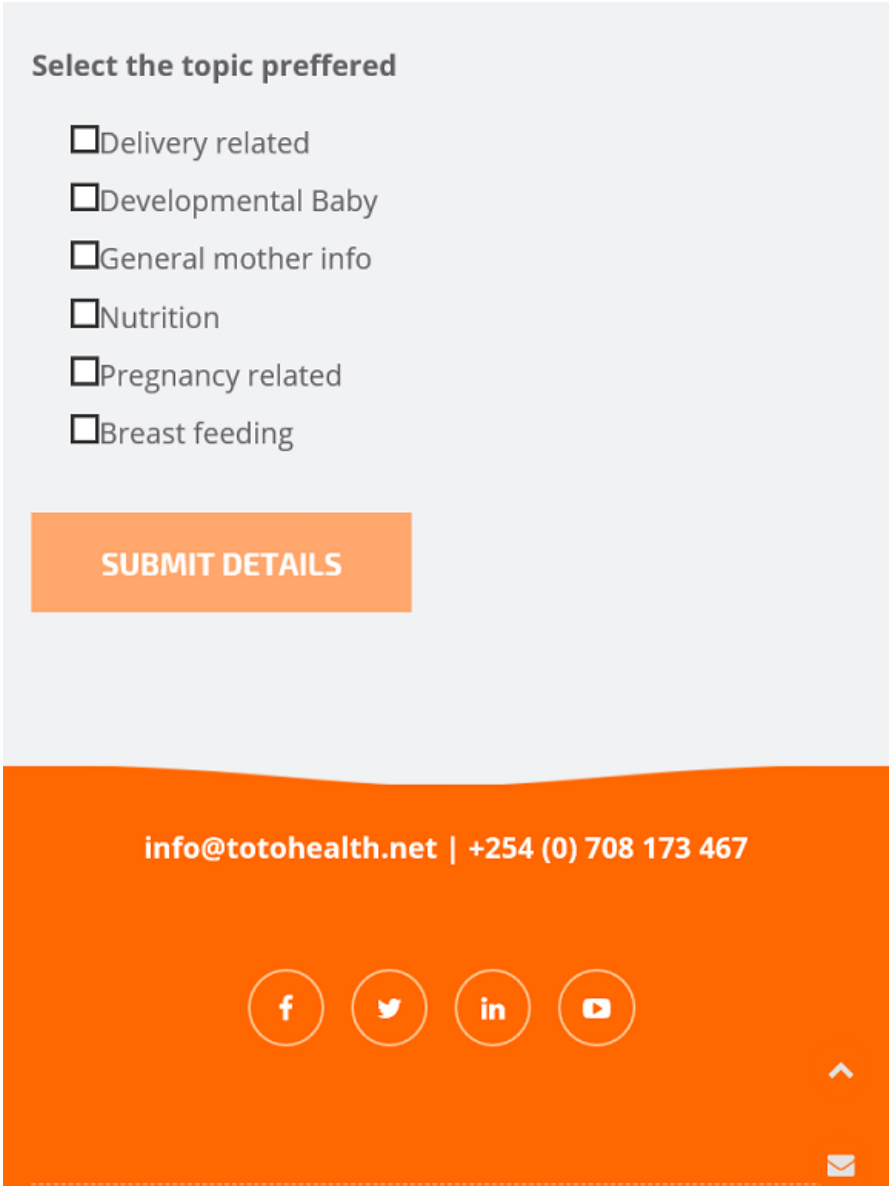

Figure 18: Screenshot of the new TotoHealth registration process

5.4. Discussions and Research Findings

A second survey was administered to a section of the respondents to assess the new features of the prototype. 16 people were registered on this prototype system after which they filled in questionnaires to determine if the new system considered their preferences.. The results below compare the current systems used by TotoHealth and the prototype system. This is to show the gaps that has been filled by the prototype system.

From the preliminary study that was conducted to gather information on how to increase effectiveness of healthcare information sent over SMS technology only 16 of the 80 respondents (20%) were contacted.

All of the 16 respondents indicated that they received the SMS;

- When they had the best time to receive the message
- With information that interested them the most.
- At a good rate

5.4.1. Usefulness of messages sent by the new TotoHealth system

Table 6 shows the participants responses on the usefulness of the healthcare information received from the prototype. 80% of the respondents found the messages useful.

Table 6: Usefulness of messages sent by the new TotoHealth system

How useful do you find the timing of the messages sent by TotoHealth		
Answer Options	**Response Percent**	**Response Count**
Very useful	87.5%	14
Somewhat useful	12.5%	2
Not very Useful	0.0%	0
Not at all Useful.	0.0%	0
answered question		**16**

5.4.2. How often respondents accessed the TotoHealth helpdesk

To assess how engaged the respondents were, the participants were asked how often they now accessed the TotoHealth help desk. Figure 12 demonstrates how often the respondents accessed the TotoHealth helpdesk through using the prototype. 87% of the respondents had never used the TotoHealth helpdesk before since the messages they received went unread. But now with the new system,

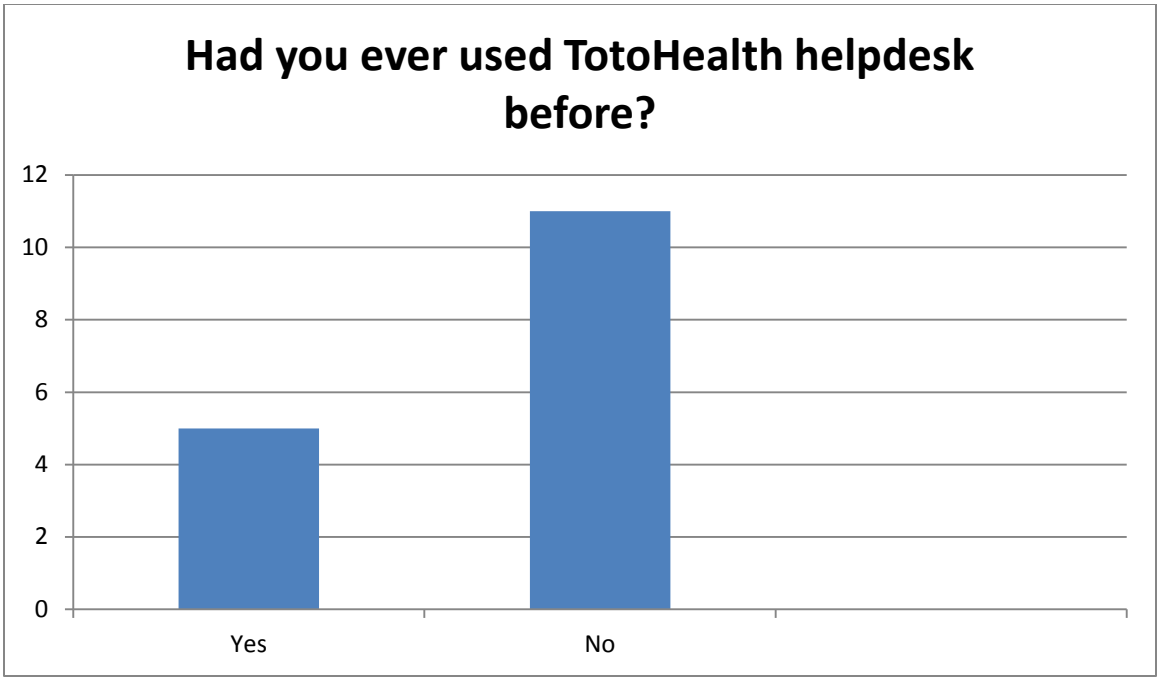

Figure 12: How often respondents accessed the TotoHealth helpdesk

Table 6 and figure 12 shows that majority of the correspondents appreciated the new system and were able to read the SMS at more convenient time. This meant they were able to take time to internalize and respond to SMS received.

The results explain why respondents would prefer the prototype system as it enables them to receive the healthcare messages when they are best available to read and action on them.

.

CHAPTER SIX
CONCLUSION AND RECOMMENDATIONS

6.1. Introduction

This chapter presents a summary of the research findings, accompanied by a discussion of the study's results are linked to the statement of the problem, the research question and the purpose of the research. Based on the data analysis from chapter four, specific conclusions are drawn. Implications of the research are then examined, followed by recommendations for better use of SMS to disseminate healthcare information effectively for future research.

6.2. Summary of the findings

This report presents a research study, which aimed to identify a model that can be used to send healthcare information via SMS. In order to examine the research topic, the study proposed two research questions. The research questions were 1) what parameters influence the level of effectiveness of health messages sent via SMS and 2) how can the parameters be modeled to ensure that health messages sent via SMS are effective?

From the series of questionnaires and reviewed literature on the research subject, it has become clear in this study that several versions of models have been used to send healthcare information over SMS. There is need to have a common and standardized model which considers all the relevant factors which ensure that healthcare information sent over SMS is effective. From the data collected in this study, the following model was derived. The model outlines the parameters that need to be considered when sending healthcare information over SMS. It is a guide to be used when sending healthcare information over SMS and ensures that the messages received by the recipient lead to change in behavior.

6.4. Limitations of the Study

The following are the limitations of the study

- Data collection required signing of a non-disclosure agreement from TotoHealth Limited which took several weeks thus limiting the amount of time left for collecting data for the preliminary study.
- Data collection had costs constraints. Each respondent was reimbursed Kshs 200 for participating in the study

6.5. Recommendations for future work

The parameters identified in this research are generic and potentially recognizable in any other healthcare environments. However, upon close inspection, it is apparent that other factors need to be considered to ensure that healthcare information sent over SMS is effective. These additional factors include persons reading level, reader's level of comprehension, use of simplified messaging, understandability of the healthcare information and presentation of the message; i.e. have a clear organizational structure and follow the grammar and spelling rule, consideration to disability

REFERENCES

Adanikin, A. I., Awoleke, J. I., & Adeyiolu, A. (2014). *Role of reminder text messages in enhancing postnatal clinic attendance.* Lagos: CrossMark.

CHMI. (2014). *ChildCount+*. Retrieved July 29, 2015, from Center for Health Market Innovations: http://healthmarketinnovations.org/program/childcount

CHMI. (2014). *M-Chanjo*. Retrieved July 29, 2015, from Center for Health Market Innovations: http://healthmarketinnovations.org/program/m-chanjo

Ellen, S. (2012). Slovin's Formula Sampling Techniques.

GSMA Intelligence. (2015). *The Mobile Economy 2015.* GSMA Intelligence.

Judy Gold, B. (. (2008). *Determining the Impact of Text Messaging for Sexual Health Promotion to Young People.* Melbourne: ResearchGate.

Kannisto KA, K. M. (2014). Use of Mobile Phone Text Message Reminders in Health Care Services: A Narrative Literature Review. *J Med Internet Res 2014;16(10):e222*.

Koshy, E., Car, J., & Majeed, A. (2008). *Effectiveness of mobile-phone short message service (SMS) reminders for ophthalmology outpatient appointments: Observational study.* BioMed Central.

Lester RT, R. P. (2010). Effects of a mobile phone short message service on antiretroviral treatment adherence in Kenya (WelTel Kenya1): a randomised trial. *PubMed*.

Lewis, T., Synowiec, C., Lagomarsino, G., & Schweitzer, J. (2012). *E-Health in low and middle income countries: Findings from the Center for Health Market Innovations.* Build World Organ.

Mahadeen, B. M. (2015). Factors affecting readiness of medical doctors and patients with chronic conditions towards usage of smartphones in the Saudua Arabian health sector. *International Journal of Interactive Mobile Technologies*.

Middleton, B. (2006). *Evaluating the value of healthcare information technology: finding the diamond in the rough, and tumble.* AMIA Annu Symp Proc.

Shib Sekhar Datta, P. R. (2014). *A study to assess the feasibility of Text Messaging Service in delivering maternal and child healthcare messages in a rural area of Tamil Nadu, India.*

Talariax. (n.d.). *SMS Healthcare & Pharmaceuticals Reducing Costs & Improving Patient Care Services* .

The University of Texas School of Public Health, P. &. (2008). *Maternal Health Care Utilization in Rural Jordanian Villages: Patterns and Predictors.* ProQuest.

U.S Dept of Health and Human Services. (2014). *Using Health Text Messages to Improve Consumer Health Knowledge, Behaviors, and Outcomes: An Environmental.* Retrieved July 10, 2015, from US Department of Health and Human Services: http://www.hrsa.gov/healthit/txt4tots/environmentalscan.pdf

UN Secretariat. (2014). *Millenium Development Goals.*

United Nations. (2015). *The Millennium Development Goals Report.* New York: UN DESA.

USAID, & African Strategies for Health. (2013). *mHealth Compedium, Volume 3.*

USAID, & African Strategies for Health. (2015). *mHealth Compendium, Volume 5.*

WHO, W. (2011). *mHealth: New horizons for health through mobile technologies.*

APPENDICES

APPENDIX 1: QUESTIONNAIRE

Introduction

This independent research is being conducted together with TotoHealth in fulfillment for the award of a degree in Masterof Science Applied Computing

This questionnaire is for collecting information that will be used in determining a model for effectively sending healthcare information using SMS.

Your involvement in this study

Your involvement is purely on voluntary basis, any information that you provide will be confidential to the researcher and your participation will remain anonymous such that no personal information concerning you will be made public either during or after the completion and release of the results of this study. During the study no one else apart from TotoHealth, my supervisor and I will have access to any participants' responses. The responses will be destroyed once the study has been completed.

Thank you for participating

Yours sincerely

Elizabeth Mwashuma

0726444641

elizamwashuma@gmail.com

SECTION 1: Background Information

1. Name (optional) ……..
2. Please enter you telephone number (optional) …….
3. AGE
    a. 20 – 25
    b. 25 - 30
    c. 31 – 35
    d. 36 – 40
    e. 41 – 50
4. Marital Status
    a. Single
    b. Married
    c. Divorced
    d. Never Married
    e. Widowed
5. At what time do you access your phone the most in a day
    a. In the morning only
    b. In the evening only
    c. The whole day/ at all times
    d. I do not own a phone

Section 2: TotoHealth Messages

1. Since when have you been receiving messages from TotoHealth
    a. One month ago
    b. Nearly 2 months ago
    c. Between 3 – 6 months ago
    d. Nearly one year ago
    e. More than 1 year ago
2. Which of the following information did you enroll to first
    a. pregnancy related information
    b. child-related information

c. started with pregnancy information and were transferred to child related information

3. TotoHealth sends messages every Monday at 9am. Which time is most favorable for you
    a. Between 8:00am and 10am
    b. Between 10am – 12noon
    c. Between 12noon and 1:00pm
    d. Between 1pm and 3 pm
    e. Between 3pm – 5pm
    f. Between 5 pm – 7pm
    g. After 7pm
4. Which day of the week would you most prefer to receive the healthcare message
    a. Monday
    b. Tuesday
    c. Wednesday
    d. Thursday
    e. Friday
    f. Saturday
    g. Sunday
5. How often would you like to receive the TotoHealth messages
    a. Once a week
    b. Twice in a week
    c. Once in two weeks
    d. Once a month
6. Which topics interest you the most (Please select all that apply)
    a. healthy pregnancy
    b. safe delivery
    c. child development and stimulation
    d. breastfeeding / nutrition
    e. reproductive health
    f. immunization reminders
    g. parenting
    h. hygiene

i. prevention of Infectious and NCDs

j. First Aid

7. How important to you are the following topics

	Extremely important	**Important**	**Moderately important**	**Less important**	**Not Important**
a. Healthy pregnancy					
b. Safe delivery					
c. Child development and stimulation					
d. Breastfeeding / nutrition					
e. Reproductive health					
f. Immunization reminders					
g. Parenting					
h. Hygiene					
i. Prevention of Infectious and NCDs					
j. First Aid					

8. How useful do you find the messages sent by TotoHealth
    a. Very useful
    b. Somewhat useful
    c. Not very Useful
    d. Not at all Useful.
9. How frequently do you reply to the messages sent by TotoHealth?
    a. Often

b. Sometimes
c. Very Occasionally
d. Not at all

10. Do you feel more confident during your pregnancy or child upbringing because of receiving TotoHealth messages?
    a. Extremely Confident
    b. Somewhat Confident
    c. Not very confident
    d. Not at all confident
11. Because of receiving messages from TotoHealth, I did the following (Select all that apply.)
    a. I delivered my baby in a health facility
    b. I remembered to attend ANC and Vaccination
    c. I frequently visit a health facility
12. Have you used TotoHealth helpdesk before?
    a. Yes
    b. No
13. If No, please tell us why

    ……
    .
14. If Yes, please tell us why and how often do you call the helpdesk

    ……
15. The detection messages sent are very helpful
    a. Strongly Agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly Disagree
16. Other than sending SMS, is there any other channel you would like to receive healthcare information on
    a. Voice calls
    b. Posters at the health center

c. Community health workers s
d. Emails
e. Radio
f. Television

17. In which language would you most prefer to receive the SMS in
    a. English
    b. Kiswahili
    c. Native Language
18. What are some of the challenges you experiences
19. What can TotoHealth do to increase your participation?