A framework to lower maternal mortality and morbidity rates in Kenya using mobile technology

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Victoria Mukami

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Supervisor: Prof. Richard Millham. PhD Date: Nov 15, 2019

Co-Supervisor: Prof. Threethambaal Puckree, PhD
Date: Nov 15, 2019

DECLARATION

I, Victoria Mukami hereby declare that this dissertation is a depiction of my own research work and has not been previously submitted in any form to any other university or institution of higher learning by other persons or myself. This work has not been submitted in any form for another degree at any university or institution of higher learning. I further declare that all the sources of information used in this dissertation have been acknowledged.

_____ 15/November/2019

Victoria Mukami Date

Supervisor: _____ 15/November/2019

Prof. Richard Millham Date

Co-Supervisor: _____ 15/November/2019

Prof. Threethambal Puckree Date

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DEDICATION

To God
We give the glory

For my husband Ndegwa Kinyanjui ♥
Thank you for urging me to finish. Thank you for always believing me.
Thank you for always understanding

My three children ♥, Wangu, Njeri, and Kinyanjui (two of whom were born during the journey).
I know it has been tough as I was studying, but we made it.

For my mother
You taught me to be a go-getter. I thank you for that.

This is for you guys.

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ACRONYMS

MMR	Maternal Mortality Rate
MDG	Millennium Development Goal
SDG	Sustainable Development Goal
ANC	Antenatal Care
SMS	Short Messaging Service
WHO	World Health Organization
HRP	Human Reproductive Programme
MOH	Ministry of Health
OHC	Ongata Health Center
NSD	Ngong Sub District
DSRM	Design Science Research Methodology
RCT	Randomized Control Trial

ABSTRACT

Background. Maternal health represents an area of significant concern in the world. With various innovations in healthcare, maternal mortality rates are decreasing exponentially. However, this is not the situation in developing countries, specifically Kenya. Several causes of maternal mortality exist; however, it is noted that one of the key causes is due to a lack of information by pregnant women. Traditional strategies such as free maternal health care at public hospitals have been in place to improve overall pregnancy outcomes. While this is aimed at a reduction in maternal mortalities, it has not been as effective in Kenya. Non-conventional strategies are needed to improve maternal health outcomes and reduce maternal mortality. Information Communication Technology (ICT) is one of the areas that has been proven successful in reducing maternal mortality.

Aim. The aim of the research was to create an ICT framework that aided in educating pregnant women using an mHealth dissemination tool and thus reduce complications that led to mortalities within Kajiado North Constituency.

Methods. The study utilized a sequential mixed-method design. **Phase one** consisted of a retrospective chart review and a cross-sectional survey on nurses and pregnant women. The first phase focused on understanding the maternal mortality rates within Kajiado North and to determine procedures pregnant women and nurses took during pregnancy. The retrospective chart review was conducted for a period of six months at two health facilities, the Ongata Health Centre (OHC) and Ngong Sub District hospital (NSD). The cross-sectional survey interrogated the mitigation strategies with a focus on information and communication technologies (ICT). **Phase two** was a prospective multi-location randomized clinical trial (RCT). A two-arm, two-site RCT was conducted using an intervention in the form of an ICT prototype with messages aimed at educating the pregnant participants. The trial was conducted at two public health facilities namely the

Ongata Health Center and the Ngong Sub District. A total of 211 pregnant women were recruited from both locations after they had met the inclusion and exclusion criteria and after providing consent to participate in the study. During the RCT, an intervention was developed using the Design Science Research Methodology (DSRM) and was used to send messages to participants within the intervention arm. The DSRM approach allowed for two iterations to be created, with one iteration being tested during the pilot test and the other during the RCT. Pregnant participants within the intervention groups received messages on their mobile phones about well-being during pregnancy. Women in the control group continued to receive their established standard of care. Both groups completed a post-test survey at the end of the trial. Data were analysed using ANOVA with the probability set at $p \leq 0.05\%$. The relationship between the number of antenatal visits and the place of delivery on the complication rate was shown using the correlation coefficient. Additionally, a multiple regression model was generated based on the antenatal visits, place of delivery and the study arms and their impact on the complications.

Results. Data from phase one of the study showed a need for a messaging system to send messages to pregnant women. The retrospective data showed no maternal mortalities, however, the nurse survey highlighted possible explanations for the lack of mortalities. From the RCT, there were no known maternal mortalities. There were three neonatal mortalities ($p=0.154$), one from the OHC intervention group and two from the OHC control group. The ANC visits relationship towards the complication rate was calculated. At the NSD site, the effect size of the ANC visits based on the participants' study arm toward the complication rate was low (0.027) and statistically insignificant ($p=0.15$). At the OHC site, the effect size was moderate (0.405) and statistically significant ($p=0.003$) for the ANC visits variable. The place of delivery relationship towards the complication rate was calculated. At the NSD site, the effect size of the place of delivery based on the participants' study arm toward the complication rate was

moderate (0.366) but statistically insignificant (p=0.479). At the OHC site, the effect size of the variables was low (0.237) and statistically insignificant (p=0.789). The stepwise regression model at the OHC site showed significance when ANC visits (p=0.007), place of delivery (p=0.003) and participants study arm (p=0.008) were sequentially entered. The multiple variables (R=0.516) Only had a medium effect size (0.266) toward the complication rate. The stepwise regression model at the NSD site was statistically insignificant when the place of delivery (p=0.283), participants study arm (p=0.445) and ANC visits (p=0.655) were sequentially entered. The multiple variables (R=0.217) had a small effect size (0.047) toward the complication rate.

Conclusion: Qualitative findings revealed that maternal health was affected adversely by several lengthy health worker strikes. Negligence on part of the health worker was a lead contributor to neonatal deaths. The study also found that accountability systems for referrals were lacking within the county and measures needed to be put in place to mitigate the consequences. In addition, feedback from the study participants indicated that the messages had aided in helping them to take necessary action based on complications and warning symptoms. Based on the data, the study finally proposed a framework that would allow for a reduction of maternal and neonatal mortality rates using ICT technologies. The study equally contributed to knowledge when using technology to empower women on maternal health matters as well as areas of maternal health practice that need improvement.

CHAPTER 1: INTRODUCTION

1.1. Background

The rapid explosion in ICT applications using mobile devices has impacted almost every field of practice. Health care has benefitted from this innovation through the implementation of ICT solutions to mitigate various challenges, especially within maternal health. Maternal health received additional significant attention worldwide when it was adopted as a Millennium Development Goal (MDG) in 2000. However, since targets were not achieved at its conclusion in 2015, it was retained as a Sustainable Development Goal (SDG) with an achievement date of 2030 (United Nations, 2016; World Health Organization, 2015). Specifically, MDG-5 was directed toward a reduction of maternal mortality by three quarters between 1990 and 2015 while the SDG-3.1 is aimed at reducing the worldwide maternal mortality rate to lower than 70 for every 100,000 live births. Despite attracting significant funding for research, action, and outcomes, maternal mortality and morbidity remain one of the key burdens in modern health care especially in developing countries (Alkema, Chou, Hogan, Zhang, Moller, Gemmill et al., 2016). Maternal health is defined as the health of a woman during pregnancy, childbirth and the postpartum period (World Health Organization, UNICEF, United Nations Fund for Population Activities, World Bank, United Nations et al., 2014). The International Classification of Diseases (ICD-10) defines maternal death as the death of a woman during pregnancy or within 42 days of termination (voluntarily or involuntarily) of the pregnancy. The maternal death is regardless of the length and site of the pregnancy, from any cause in relation to or worsened by the pregnancy or its management, but not from unintentional or incidental causes (World Health Organization, 2011, p. 156).

Maternal Mortality Ratio (MMR) is a statistic used to determine the total number of deaths within a country within a timeframe. The ratio looks at the number of

deaths per 100,000 live births within a given period. Approximately 303,000 women around the globe die each year as a result of complications during pregnancy and childbirth (World Health Organization, UNICEF, United Nations, Department of Economic and Social Affairs, Population Division, World Bank, 2015). Roughly, 99% of these women are from developing nations. While the MMR within Sub-Saharan Africa fell by 49%, the region still accounts for 201,000 of these deaths (United Nations, 2015). Globally ten countries account for nearly 59% of the world's maternal deaths. Kenya, a member state of Sub-Saharan Africa, is currently ranked at number seven with approximately 8000 maternal deaths per year. The maternal mortality rate in Kenya declined by 25% between 1990 and 2015 (World Health Organization et al., 2015). While this may seem like substantial progress, this was not the case owing to the medical advancements over the time period. The high MMRs are a burden to the society and the country and action are required to lower the MMRs.

By the year 2015, at the close of the MDG's, only nine countries had achieved the goal set by the MDG, while 39 other countries had been categorized as having made progress (World Health Organization et al., 2015). In addition, 21 other countries had been categorized as having made insufficient progress and a further 26 countries categorized as having made no progress during the same period. Kenya was ranked as having made no progress towards lowering MMRs by the close of the MDGs. The country was required to come up with strategies to mitigate the barriers that resulted in high maternal mortality rates to achieve the new SDG goals by the year 2030. Iran and Rwanda were two countries that managed to achieve the MDG goal. The MMR for Rwanda and Iran in the year 2015 was 290 and 25 respectively while that for the year 1990 was 1300 and 123 respectively. This showed a percentage annual decrease of six and 6.4 for each country respectively within the stated years (World Health Organization et al., 2015). In comparison, Kenya's MMR decreased by only 1.2% within the same period.

Rwanda took it upon itself to ensure that their health sector was reformed and focused on the community as a starting point for the health reform (Sayinzoga and Bijlmakers, 2016). This then led to an impressive annual decrease in maternal mortality. Iran, on the other hand, focused on an increase in the satellite medical centres in addition to improving the quality of maternal health (Soltani, Fair and Hakimi, 2015). Both countries have experienced challenges like those in Kenya. These challenges include severe health worker shortages, limited health infrastructure and home-based deliveries without a skilled birth attendant being present (Gitobu et al., 2018). Within Iran, the severe health worker shortages were due to regulation within the country where only women medical students were allowed to train in obstetrics and gynaecology (Moazzeni, 2013). Even with the various challenges, some commonalities existed in their strategies to lower MMRs. A common denominator for both countries that helped lower the MMRs at an unprecedented rate was the education and empowerment of women in regard to maternal health (Moazzeni, 2013; Sayinzoga and Bijlmakers, 2016; Soltani et al., 2015). Empowering women should, therefore, be considered as a catalyst towards a reduction in MMRs.

Women die because of difficulties during pregnancy and childbirth. Most of the complications that develop during pregnancy can be prevented or are treatable. The World Health Organization (2018) indicates that the factors that influence whether pregnant women will seek care include poverty, distance to the health care facilities, unawareness, sub-standard services at the health centre as well as cultural practices. Most women lack the information necessary to help manage their pregnancy such as recognizing risk symptoms and when to seek medical attention (World Health Organization, 2018). One of the ways to help lower MMRs is by providing access to information on basic knowledge for the well-being of the pregnant mother while refining life skills of the pregnant women and families on the danger signs that could lead to complications in pregnancy (Soltani et al.,

2015). An intervention that disseminates knowledge is one strategy toward reducing MMR and morbidity.

This strategy that was adopted in Rwanda was in the form of a mobile-based system with the goal of lowering MMRs. This strategy considered variables like pregnant women, the number of health officers and media available to help design this framework. The country used a system called RapidSMS to aid in lowering their MMRs (Ruton et al., 2016). RapidSMS is a free and open-source platform which targeted pregnant women, community health workers (CHW) and other stakeholders within the health sector. The system was used by the CHW's to communicate with other stakeholders within the health setup. The system enabled the community health workers to collect and use real-time data on maternal and neonatal indicators. In addition, the system generated reminders for clinic appointments, delivery and post-natal care visits with the aim of increasing ANC and post-natal care visits. The system was one of the key interventions that led to a reduction of MMR rates within Rwanda.

Information communication technology (ICT) is recognised as one significant contributor to solving health challenges. In the African context, ICT has been used within the health sector to solve every day national problems (Barron et al., 2018; Morof et al., 2019; Munos et al., 2016; Obasola and Mabawonku, 2018). Globally, ICT in health has been used to support data collection by health workers, communication between healthcare providers, communication with patients, notification of disease outbreaks, management of patients, storage of patient records among others (Vanagas et al., 2018). Due to the diversity and ease of use, ICT in health has grown as it has been readily adopted by medical professionals and patients (Vanagas et al., 2018). For patients, benefits include the provision of self-management tools and increased interaction with the health professions while medical professionals benefit through the use of the training

tools and information they are able to access as well as increased decision support (Azlan, Yusof and Razali, 2012).

The use of ICT in the health sector is either defined as eHealth, which refers to any health services that are provided with the use of ICT devices like computers, mobile phones or satellites, while, mHealth is a subset of eHealth and refers to solely the use of a mobile phone or tablet to provide health services (Moss, Süle and Kohl, 2019). eHealth has been used to aid in hospital management through processes such as patient record keeping, financial and logistical activities, procurement and appointment logs (Ossebaard and Van Gemert-Pijnen, 2016).

Substantive progress has been achieved within the mHealth regarding mobile phones. A variety of studies have utilized mHealth with diverse patient populations such as visually impaired children, and diverse uses such as a malaria reporting tool, for ANC uptake as well as a general informational avenue to promote wellness (Larocca, Moro and Marconi, 2016; LeFevre et al., 2018; Lund et al., 2014; Rono et al., 2018). mHealth represents one technology within ICT that has been accepted within sub-Saharan Africa due to availability and ease of use (Radcliffe, 2018). mHealth is more feasible is sub-Saharan Africa due to the use of existing infrastructure, the perversity of mobile phones, and the use of the existing skill set of user participants.

While the most standard way that the mobile phone has been used is in appointment reminders as well as an informational tool, several enhancements to the mobile phone have allowed for more creative uses. Mobile enhancements like wearable devices, use of sensors with the mobile phone as well as apps used mainly to monitor patients diagnostics have transformed mHealth (Munos et al., 2016). While mobile enhancements have provided a reliable way in which to employ mobile devices in health, its greatest drawback within the African setting

is the high device and service costs, high cost of internet bandwidth and deployment difficulties (Munos et al., 2016).

Within the maternal and neonatal area, text messaging has surpassed expectations and provided significant outcomes as a dissemination tool to educate mothers, to collect information from mothers as well as a communication tool with health workers (LeFevre et al., 2018; Lund et al., 2014; Obasola and Mabawonku, 2018; Willcox et al., 2019).

This study was conceived with the intention to develop a mHealth messaging intervention suitable for the Kenyan context that will be used to educate expectant women on pregnancy matters to ensure their wellness during and after pregnancy. The idea was to develop an ICT intervention that was feasible and viable to reduce complications of pregnancy, childbirth and thereby reducing maternal mortality. The intervention aimed at improving ANC attendance through access to knowledge on pregnancy and childbirth at a time when Kenya's mortality rates were shockingly poor.

1.2. Statement of the Problem

Maternal mortality is a global concern and more so in Kenya where the nation was unable to meet the MDG-5 goal which outlined that countries were required to reduce MMR rates by three quarters by the end of 2015 (World Health Organization et al., 2015). As per the outlines the country was meant to reduce their MMR to 171, however, they only managed to lower their MMR to 510 by close of 2015, down from 687 in 1990 (World Health Organization et al., 2015). With the close of the MDGs, the SDG's were introduced which recommended that countries were to reduce their MMRs to less than 70 by the end of the year 2030 (United Nations, 2016). This was not the case for other countries in the region who were able to meet the MDG-5 target such as Rwanda. For Kenya to make

any progress by the close of the SDG's, the country needs to address the problem and ensure that all measures to reduce the MMRs are being deployed.

Women die as they lack information to identify danger symptoms during pregnancy and childbirth and are in turn unable to seek medical attention (Soltani et al., 2015). Effects of these maternal deaths include financial instability for the family left behind, loss of education of orphaned children and an increase in mortality of the infants left behind (Tulloch, 2015). The repercussions of this are long term and affect both the family unit as well as the nation (Soltani et al., 2015; Tulloch, 2015). One of the ways to reduce MMRs brought about by a lack of information is by empowering pregnant women by providing access to knowledge related to pregnancy and childbirth (Soltani et al., 2015).

To improve maternal health, obstacles that limit access to quality maternal health services must not only be identified but addressed in all aspects of the health system (World Health Organization, 2018). In most cultures, the woman is the backbone of the society and if she dies prematurely, an economic breakdown on the society may ensue. Children rely on their mothers for the care of their nutrition and health. A child without a mother is less likely than an infant with a surviving mother to survive up to age two (Scott et al., 2017; Tlou, Sartorius and Tanser, 2018). Managing maternal health while avoiding maternal mortality is also crucial in reducing neonatal and child mortality.

Most mHealth interventions in Sub-Saharan Africa have revolved around the use of text messages, use of Unstructured Supplementary Service Data (USSD) services as well as the use of mobile apps. Mobile apps and USSD services have not been readily accepted and utilized due to high device cost, bandwidth cost as well as initial setup costs in the case of USSD. In addition, mobile apps target specific patients who need to own smartphones to access the service. With the aforementioned limitations, reliance on certain technologies such as text

messages and phone calls are considered more feasible within Sub-Saharan Africa and specifically Kenya.

Kenya is one of the nations whose mobile penetration is high at 88.2 % of the population. Creation of a mobile system specifically a text messaging system would enable adequate information to be passed on to the pregnant women. The information would be custom tailored depending on the stage of their pregnancy and would include appointment reminders, information on well-being and risk symptoms as well as the health centre notifications. This, in turn, would help inform and empower the women with information on the management of their pregnancies.

1.3. Aims and Objectives

The primary aim of the study was to create an ICT framework that aided in educating pregnant women using an mHealth dissemination tool and thus reduce complications that led to mortalities within Kajiado North Constituency..

The aim of the study was achieved by ensuring that each of the objectives stated below was completed in phases.

1.3.1. Phase 1

1. To determine the current status of maternal mortality and morbidity rates within Kajiado North Constituency.
2. To determine the strategies used by pregnant women and health workers, to manage pregnancy and childbirth.
3. To develop and test a data collection and messaging system to disseminate messages and collect feedback from pregnant women.

1.3.2. Phase 2

4. To implement a mobile messaging system to increase Antenatal Care (ANC) uptake as well as deliveries by skilled staff within selected facilities
5. To investigate whether the MMR rates are lowered as a result of complications by increasing ANC visits and skilled worker deliveries.
6. To propose a framework to reduce complications that may lead to high MMRs.

1.4. Hypothesis

A direct mobile intervention toward pregnant women will result in an increase in ANC appointments and an increase in the number of births attended to by skilled birth attendants thereby reducing complications that lead to high maternal mortality rates.

The null hypothesis stated: A direct mobile intervention toward pregnant women will not result in an increase in ANC appointments nor an increase in the number of births attended to by skilled birth attendants thereby will not reduce the complications that lead to high maternal mortality rates.

1.5. Justification

While there is a high mobile penetration within Kenya, it has not been harnessed and leveraged to aid in lowering MMRs. This is largely attributed to the various applications designed that target the middle class while the high MMRs are seen by individuals of low socio-economic situations (Gitobu et al., 2018; Munos et al., 2016).

The research is important as it creates a framework that can be used to aid in educating pregnant mothers throughout their journey. The framework shall also be a useful tool toward eHealth and mHealth developers and researchers. In

addition, stakeholders in the health sector such as nurses, doctors and community health workers will benefit from the framework.

1.6. Significance of the Study

This study was beneficial to the Kajiado County Health Department as it added to the existing knowledge of maternal health and mortality. It was also beneficial to the health workers within the health centres because it improved adherence toward ANC visits and skilled birth attendance.

The contributions of the study greatly assisted the Government of Kenya, Ministry of Health, by coming up with strategies to lower MMR. With a focus to decrease the MMRs to fewer than 70 deaths for every 100,000 live births by the targeted year (World Health Organization et al., 2015), it was vital that the government of Kenya look for strategies and innovative solutions that would help achieve that goal. The ICT prototype is one way that can help the government attain the goal. The prototype has been tested in real-world settings with it focusing on mitigating conditions that cause various diseases. Specifically, it has assisted in the reduction of maternal mortalities where the ICT prototype can educate women on a low-cost basis to reduce complications that end up causing maternal mortality (LeFevre et al., 2018; Lund et al., 2014; Obasola and Mabawonku, 2018; Willcox et al., 2019).

While the study's focus was on assisting the women of Kajiado County, the framework can be replicated around other counties within the country to reap benefits. As indicated in the literature, one of the factors that would help lower MMR is the empowerment and education of the woman (Moazzeni, 2013; Sayinzoga and Bijlmakers, 2016; Soltani et al., 2015). The study educated the

woman and in turn, empowered them beyond their pregnancy. With the information, they received the woman was able to continue with a search for relevant information beyond her pregnancy.

1.7. Operational Definitions

Antenatal Care (ANC): Also known as prenatal care. This is the care, mainly preventative healthcare given to pregnant women to help manage their pregnancies. Its aim is to promote the well-being of the mother and unborn baby.

Skilled Birth Attendant: This is the medic or medical personnel trained in midwifery, obstetrics, and gynaecology. This may include a clinical officer, nurse or doctor.

Women empowerment: This involves the creation of an environment where a woman can voice her concerns, be educated and get help where necessary. In other terms, a woman can speak her mind.

Mobile: Also, Mobile Phone. This is a telephone that uses a cellular network and does not require a physical connection.

Maternal Mortality Rate (MMR): is a gauge used to define the number of deaths for every 100,000 live births within a country.

Maternal Death: the death of a woman while expectant or within 42 days of cessation of the pregnancy, regardless of the duration and the site of the pregnancy, from any reason related to or worsened by the pregnancy or its management, but not from unintended or incidental cause (WHO, 2010).

Short Message Service (SMS): Also known as text messaging. This is a cellular network method that allows a sender to send a message with up to 160 characters to other mobile devices.

1.8. Flow of the Thesis

This thesis is structured into seven chapters.

The first chapter is the introductory chapter that discusses the background and rationale for the study as well as the problem statement. This chapter also shows what the objectives were, the hypothesis in addition to the implication of carrying out the study.

The second chapter looks at the global, regional and local view of maternal health, maternal mortality, and morbidity. The chapter also focuses on theories used, mitigating factors, and success stories while outlining the gaps that need to be filled and any viable options that have been used.

The third chapter is a compilation of the methods used during the study and includes the design, sampling methods and well as sample sizes, instruments use to collect data, procedures for data assemblage, data analysis, and ethical considerations. This chapter also looks at the exclusion and inclusion criteria for the participants.

The fourth chapter is a review of the modules developed as part of the intervention. The chapter highlights the main methodology used and the iterations used during the development of the artefact.

The fifth chapter presents the findings based on statistical outputs in the form of tables, graphs, and narratives. Data collected through the study, specifically during the interventional study was analysed and compared to formulate results as well as to pave way for discussion of the results.

The sixth chapter discusses the results in relation to the context and the available relevant literature. It also proposes a framework to be submitted to policymakers in Kenya.

Finally, chapter seven presents the conclusions, limitations and any recommendations as well as a summary of the entire document.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

This chapter focused on the literature on maternal mortality. It is a critical review of the literature and looks at the history and status of maternal mortality. In this chapter, conventional ways were discussed and the use of technology to lower maternal mortality. A review and discussion were done of countries that were able to lower maternal mortality (MM) using conventional methods versus those that have managed to use ICT as a tool in aiding a reduction of MM. Finally, relevant models, frameworks, and theories that explain maternal mortality are discussed.

Maternal mortality is a diverse topic with information being retrieved from several journals. Pubmed and Google Scholar were the main sources of information. Additional data was retrieved from JSTOR and BioMed Central. The Lancet journal was also equally useful when contributing to information on maternal mortality. Most of the information was retrieved from the year 2014 to 2019. However, there are older models that maternal mortality subscribes to from the early 1990s that were used. This older literature was to give perspective to the history of maternal mortality and to show how maternal mortality has been modelled over the years.

2.2. History of Maternal Mortality

Maternal mortality first gained awareness when the safe motherhood initiative was conceived in 1987 (Starrs, 2006). This led to a call by several organizations and global leaders to reduce maternal mortality by half within a decade (Center for Health and Gender Equity, 2015). While the safe motherhood initiative is still ongoing, a bigger focus on development arose that led to the establishment of the millennium development goals (MDGs). The MDGs were articulated by the United Nations, General Assembly (World Health Organization, 2015). One of the goals,

MDG-5 had a focus on the reproductive health of the woman. The goal stated that it was expected by the year 2015, each country would be able to lower its Maternal Mortality Rate (MMR) by three quarters (World Health Organization, 2015). The MMR calculates how many maternal deaths are recorded for every 100,000 live births.

Prior to the commencement of the MDGs, the global MMR was 385 per 100,000 live births. This contrasted with an MMR of 216 per 100,000 live births at the conclusion of the MDGs in the year 2015. Globally this was a decrease of approximately 44% (World Health Organization et al., 2015). While this was a substantial decrease, the goal of lowering the MMR by three quarters was not attained and instead only a reduction by half was realized. When the MDG timeline lapsed, implementation of the agenda for sustainable development was started and this led to the formation of the sustainable development goals (SDGs) (United Nations, 2016). The SDGs are still ongoing and are intended to reduce the MMR to lower than 70 per 100,000 live births.

2.3. Pattern and Trend of Maternal Mortality

Maternal deaths are not evenly distributed throughout the world (GBD 2015 Maternal Mortality Collaborators, 2016). Developing countries account for 99% of the global maternal deaths (World Health Organization et al., 2015). The Sub-Saharan African region accounted for the highest MMRs at 66% of the world's maternal deaths. The MMR for the Sub-Saharan Africa region in 2015 was 546 per 100,000 live births (WHO et al., 2015). This was three times higher than that of South Asia which was the second global contributor of MMRs. Figure 2.1 shows a comparison of MMR in Sub-Saharan Africa and other regions around the globe.

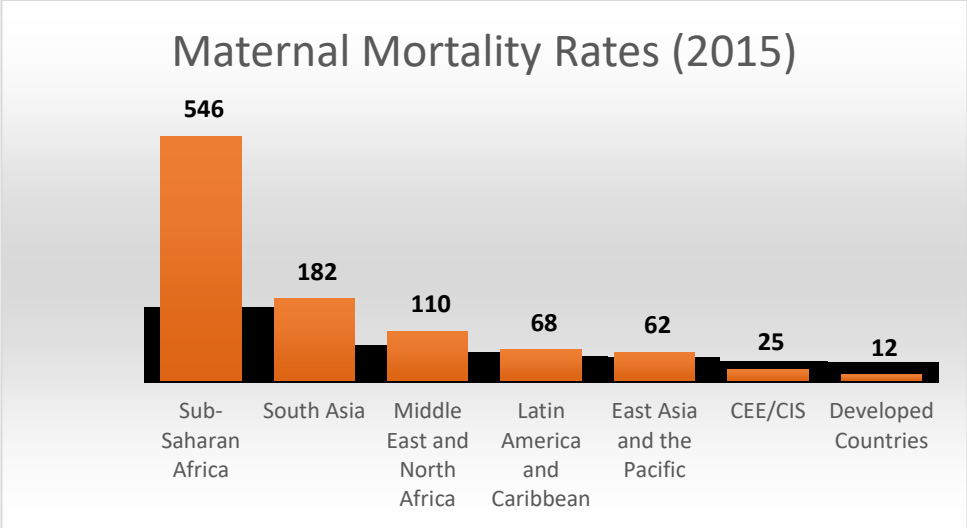

Figure 2.1: Regional Maternal Mortality Rates in the year 2015

Most of the Sub-Saharan Africa member states did not manage to lower their MMRs by the close of the MDGs based on the World Health Organization (WHO) recommendations. Sierra Leone, one of the member states had the highest MMR regionally and globally at 1360 per 100,000 live births (World Health Organization et al., 2015). Eighteen other nations, all within the Sub-Saharan Africa region had high MMRs ranging between 500 to 999 per 100,000 live births. While the situation seemed dire, two Sub-Saharan countries managed to have MMR's below 53 (World Health Organization et al., 2015). Significant progress needed to be achieved for the countries with the high MMRs to reduce to below 70 per 100,000 live births as per the SDG directive.

Kenya is one of the eighteen countries that recorded high MMRs. In 1990, the countries MMR was 687 while that of 2015 was 510 per 100,000 live births (World Health Organization et al., 2015). Kenya was unable to meet the MDG goals, as the country was only able to reduce the MMRs by one quarter as opposed to the targeted three quarters within the period. This led to a categorization of insufficient progress of Kenya towards meeting the MDG goal (World Health Organization et al., 2015). Strategies need to be implemented for the country to lower their MMRs

to less than 70 by the end of 2030. Achieving the goal will require the country to reduce its MMR by at least 7.5% each year (World Health Organization et al., 2015).

2.4. Causes of Maternal Mortality

There are nine groups that categorize the causes of maternal deaths during pregnancy and childbirth (Filippi et al., 2016). The nine groups are classified as either direct or indirect causes of maternal deaths. Direct causes are those that result from obstetric difficulties of the pregnancy, from interactions, oversights, inappropriate treatment or from a chain of events resulting from any of the above (Filippi et al., 2016). Indirect causes are those resulting from an earlier prevailing disease that develops during pregnancy and was not due to direct obstetric causes but was worsened by pregnancy. The nine groups and related categories are represented in Table 2.1.

Table 2.1: Classification and groups of maternal death causes (Filippi et al., 2016)

Classification	Groups
Maternal death: direct	1. Pregnancies with abortive outcome
	2. Hypertensive disorders in pregnancy and childbirth
	3. Obstetric haemorrhage
	4. Pregnancy-related infection
	5. Other obstetric complications
	6. Unanticipated complications of management
Maternal death: indirect	7. Non-obstetric complications
Maternal death: unspecified	8. Unknown/undetermined
Death during pregnancy and childbirth	9. Coincidental causes

Nearly 73% of maternal deaths globally are attributed to direct obstetric causes while a quarter of the deaths were due to indirect causes (Say et al., 2014). The lead causes of maternal mortality in Sub-Saharan Africa are classified as direct causes. These include postpartum haemorrhage, postpartum infections, pre-eclampsia and eclampsia, delivery complications and unsafe abortion (World Health Organization, 2018). Sub-Saharan Africa was the second-highest for deaths caused by indirect causes at 28..5% (Say et al., 2014). In Kenya, the causes of maternal mortality are no different from those in Sub-Saharan Africa. Direct causes of maternal mortality represent 72% of all the cases in Kenya. The specific causes of maternal death in Kenya include haemorrhage, indirect causes as well as hypertension during pregnancy (Ministry of Health Kenya, 2016). These are consistent with the regions (Sub-Saharan Africa) leading causes and are presented in Figure 2.2.

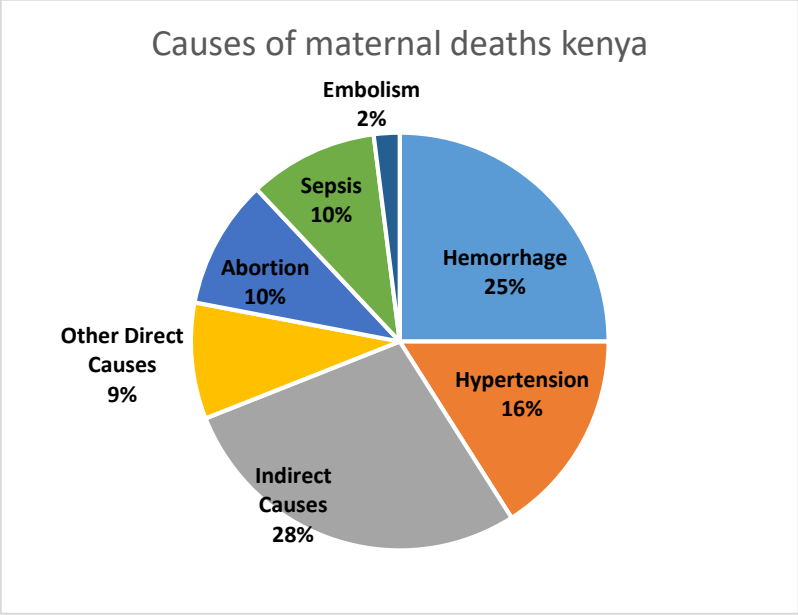

Figure 2.2: Causes of maternal deaths in Kenya *(Ministry of Health Kenya, 2016)*

2.5. Determinants of Maternal Mortality

Women die as a result of complications through and after pregnancy and childbirth (World Health Organization, 2018). This is as a result of women not getting the care they need at the right time. Poor women in isolated areas are the least probable to obtain adequate care (World Health Organization, 2018). There are four determinants that enlighten as to whether a woman will receive care or not during pregnancy and childbirth. These include socio-cultural factors, perceived benefit/need, economic accessibility and physical accessibility (Gabrysch and Campbell, 2009). Specific factors toward each determinant are further shown in Table 2.2.

Table 2.2: Determinants and factors affecting Maternal Mortality (Gabrysch and Campbell, 2009)

Determinant	***Factors***
Sociocultural Factors	Age
	Marital Status
	Ethnicity, Religion, Traditional Beliefs
	Family Education
	Woman's Status
Perceived benefit/need	Information availability
	Health Knowledge
	ANC Care
	Planned Pregnancy
	Complications
Economic Accessibility	Mothers Occupation
	Husbands Occupation
	Ability to pay
Physical Accessibility	Region: Urban or Rural
	Distance
	Transport/Roads

Socioeconomic inequalities and lack of skilled workers exist in all countries and have important impacts on health (World Health Organization, 2018, 2016). This is especially true for the Sub-Saharan region where in the year 2013, only 55% of deliveries were attended by skilled workers (World Health Organization, 2016). This translated to 45% of deliveries not attended by skilled workers. This is in

comparison to 62% of births in Kenya attended by a skilled health worker between 2009 and 2018 (World Health Organization, 2019). Other factors that prevent women from accessing care include limited availability and poor quality health service and lack of information (World Health Organization, 2016). A woman's uptake of health services is directly dependent on her economic, educational and empowerment status (Gitonga, 2017; Hanson et al., 2017). This is consistent in Kenya, where most maternal deaths are due to poor health-seeking behaviour among mothers (Obare et al., 2016). Delays at the individual and household level are due to a failure to recognize danger signs early and ignorance of available services (Obare et al., 2016). The decision making process when accessing health services is complicated and is normally done after consultations with various family members, with the father as the ultimate decision-maker (Aborigo et al., 2018; Nyandieka et al., 2016). In this regard, fathers need to be actively involved when health interventions are set up to ensure they make informed decisions.

A survey conducted by the Kenya National Bureau of Statistics showed a direct relationship between women's education and access to health services (Kenya National Bureau of Statistics et al., 2015). Only 24% of women with no education gave birth in a health facility as compared to 84.4% of women with a high school certificate and above (Kenya National Bureau of Statistics et al., 2015). A similar survey showed that about 53% of deliveries in Kenya, take place away from health facilities. This is despite more than 88% of mothers living less than five kilometres from a health facility and 93% of pregnant women having at least one ANC visit during pregnancy (Karanja et al., 2018; Kitui et al., 2013). A more recent study showed that where a woman delivered was affected negatively by high parity and culture (Karanja et al., 2018). For instance, women of the Maasai community did not make birth plans as it was considered as a taboo to do so in advance. Additionally, the women did not give thought to where they would give birth unless the woman had complications during prior pregnancies.

In 2014, only 61.2% of women gave birth in a health facility while 37.4% gave birth at home (Kenya National Bureau of Statistics et al., 2015). In the same year only 57.6% of women had four ANC visits while the rest, 42.1% had less than three visits. This does not meet the prior WHO guidelines that recommend a minimum of four ANC visits for every pregnancy. In November 2016, the World Health Organization provided new guidelines where recommendations made detailed that every pregnant woman was to attend a minimum of eight ANC visits. With the women unable to meet the previous guidelines, the country will need major strategies that will improve ANC uptake.

Low levels of education, high parity and not attending ANC clinics decrease the possibility of delivering in a health facility (Kitui et al., 2013). The close association between education and the use of maternal health services partly results from the fact that formal schooling exposes women to information about reproductive health and pregnancy care (Dimbuene et al., 2018). Fast-tracking socioeconomic development, and efficiently addressing basic human necessities of schooling, economic welfare, and gender-based discrimination can be achieved by considerably increasing the use of maternal health services (Taukobong et al., 2016; Yaya et al., 2018). The MDG's paved way for the improvement of gender equality and women empowerment and this continued with the current ongoing SDGs.

2.6. Strategies Towards a Reduction of Maternal Mortality

With the conclusion of the MDG's and the inception of the SDGs, it is paramount that countries work toward lowering MMRs. Barriers that limit access to quality maternal health services must be identified and addressed at all levels in order to reduce maternal mortality and improve maternal health (World Health Organization, 2018). There are several strategies for ending avoidable maternal mortality. The first strategy is in addressing inequalities in access to and quality

of sexual reproductive, maternal and newborn health (RMNH) (HRP, 2015). Inequities in women's empowerment are linked to lower maternal health service as well as lower contraceptive use (Yaya et al., 2018). This is especially prevalent in African countries (Taukobong et al., 2016). Empowerment is defined as having control over one's life and their purpose as well as the ability to create and direct actions for a specific purpose (Fox and Romero, 2017). It is extensively known that family planning contributes to the reduction of maternal mortality by dropping the number of births and the number of fertility cycles a woman is exposed to (Mubangizi, 2016). Family planning prevents approximately 272,000 maternal deaths per year (Ahmed et al., 2010). Evidence recommends that the decrease in high-risk births brought about by contraceptive use lowers MMRs (Brown et al., 2015). Information Communication Technology (ICT) can be used to solve social health inequalities. According to Latulippe, Hamel and Giroux, (2017), ICT tools that are effective in solving health inequalities use tools that are guided by an awareness of the population's literacy levels and that can accommodate cultural differences in populations. In addition, people at the highest risk of health inequalities need to be invited to participate in the design and development of ICT tools.

The second strategy addresses universal health coverage for comprehensive sexual RMNH (HRP, 2015). Providing universal health coverage is the simplest step of granting people access to much-needed health services (Firoz et al., 2018). A way to achieve the strategy is by reducing the obstacles that people face to gain access to necessary health care. Universal coverage is much more challenging to attain than to advocate and may not work mainly if the better-off groups were to receive the benefits first before the poorer groups (Neal et al., 2015). Universal access to health care will be one of the ways to lift barriers that limit access to maternal health only if they target to reach and dispense benefits to hard-to-reach poorer groups. Roth, Landry and Parry, (2015) view ICT as a way of achieving universal health. Based on the concept of universal health coverage,

a reduction in the waste of health resources, a maximization in the coverage of care, and the provision of quality yet cheap healthcare can be addressed by investing in ICT. Information Communication Technologies that have been used to lead the road towards universal health care have included SMS, geographic information systems and mobile data collection (Roth, Landry and Parry, 2016).

The third strategy addresses all the causes of maternal mortality, reproductive and maternal morbidities and related disabilities (HRP, 2015). For a country to effectively lower MMRs, they need to understand the causes of the high MMRs. Interventions to directly address the medical causes of maternal mortality would be achieved through the use of improved and more widely obtainable prenatal care and emergency obstetric services (Brown et al., 2015). The gaps in coverage of effective interventions for both direct and indirect causes of maternal deaths have large implications and need to be addressed to effectively to lower MMRs (Say et al., 2014). To be effective in the explicit setting where it is to be applied, each country's plan must be modified to fit its individual population health needs, health system capacity and available resources (HRP, 2015). ICT has been used in various applications of maternal and child health and has successfully been able to lower maternal and neonatal mortality. A review of the literature by Rivera-Romero et al. (2018) has shown that the use of ICT is capable of management of hypertensive disorders during pregnancy. On the other hand, a study conducted in India involving a mobile health intervention with community health workers was found to have positive outcomes (Ilozumba et al., 2018). Maternal health programs focusing on a management of pregnancy, systems involved in the provision of maternal care and systems used by the health workers have successfully been implemented through the use of ICT (Barron et al., 2018; Entsieh, Emmelin and Pettersson, 2015; Gelano et al., 2018; LeFevre et al., 2018; Tobe et al., 2018).

The fourth strategy focuses on strengthening health systems to respond to the needs and priorities of women and girls (HRP, 2015). Health strengthening consists of recognizing issues that interfere with the provision of services while looking at the means with which to solve said issues (Kutzin and Sparkes, 2016). Health systems strengthening requires committed involvement from all stakeholders within the country. Lack of commitment leads to a catastrophe where there is a reversal in gains made to lower maternal mortality (Lerberghe et al., 2014). ICT can be used to strengthen health systems by facilitating the collection of health-related data, accurately reporting data, and evaluation of programs running (Roth et al., 2016). Bangladesh, Laos, Mongolia, Philippines and Thailand are countries that have successfully enhanced their health systems through the use of ICTs (Roth et al., 2016).

The final strategy ensures accountability to improve quality of care and equity (HRP, 2015). This mainly involves the ability to track and measure progress towards ending preventable maternal mortality and social accountability (HRP, 2015). Despite limited resources, countries that met the MDG-5 objective established capacities to collect, analyse and use robust evidence to notify policy, investment, implementation, and accountability (Kuruvilla et al., 2014). Ideally, an accountable government or institution should be able to collect and keep track of progress toward lowering MMRs. Similar to the fourth strategy, accountability can be achieved through the use of ICT's by having accurate and timely reports (Roth et al., 2016).

The guidelines discussed herein gives an indication of what each country needs to work on to ensure that maternal health is available and that maternal mortality reduces within reasonable levels. For the SDG's to be met at its conclusion, women empowerment, health systems that work, accountability and most of all catering to the less privileged to ensure equity during access to health services

need to be addressed. Use of ICTs is one way in which the guidelines can be met to ensure that each country is on track to meet the SDGs.

2.7. Reduction in Maternal Mortality

In line with the MDG's, several countries were able to gain progress and lower their MMRs. Varying interventions were used by different countries. Laos is one of the nine countries that achieved the MDG-5 goal. The country was able to have a 78.2% change in MMR between the year 1990 and 2015. This made the MMR at 197 per 100,0000 live births in 2015, down from 905 in 1990 (World Health Organization et al., 2015). Laos lowered the MMR's by abolishing user fees during access of maternal services in order to improve care-seeking by women and children (Ahmed et al., 2016). In addition, the country invested in educational programs to inform the community on maternal matters. Earlier studies showed that even when women understood the importance and necessity of current obstetric care, their decision to seek care was mainly influenced by their husbands and community who in turn had negative attitudes towards the health facility (Ngan et al., 2016). Positive attitude and accessibility of modern practice among the women, husbands and other members of the community had been witnessed due to the educational programs ran by the government meant to empower on pregnancy matters.

The Islamic Republic of Iran is another country that was able to meet the MDG-5 goal. The country had a 79.7% change between 1990 when the MMR was 123 and 2015 when the MMR was 25. This was an annual decrease of 6.4% per year (World Health Organization et al., 2015). Iran has had and still has a contentious socioeconomic and political past, which has repercussions on maternal health and mortality (Soltani et al., 2015). Iran was able to move beyond cultural and political issues and lower their MMRs. Key contributors to the decrease in maternal mortality were the education of women, access to facilities and timely

transfers of mothers with complications (Soltani et al., 2015). Additional contributors toward a reduction of maternal mortality comprised of family planning education, an increase in facility-based deliveries and an introduction of numerous satellite clinics within the rural areas. According to Soltani et al. (2015), progress was made through the education of the girls from the primary level to higher education. This was a key determinant towards a reduction of maternal mortality and education can be viewed as a catalyst to lower maternal mortality.

Rwanda a member of Sub-Saharan Africa is one of the few countries within the region that managed to achieve the MDG-5 goal. In 1990 the MMR for the country was 1300 while that of 2015 was 290. This was a 72.9% decrease between 1990 and 2015 with an annual reduction of 6% per annum, the highest in Africa (World Health Organization et al., 2015). Rwanda has had a difficult past both politically and economically. The country had 1 million deaths in 1994, due to genocide against the Tutsis (Binagwaho et al., 2014). Since then, the government has made great strides both politically, economically and in infrastructure. On health matters, the government worked on community-based insurance and performance grounded financing systems were implemented countrywide. A key indicator towards a reduction of MMRs was the introduction of 45,000 community health workers to make available health services (Ahmed et al., 2016). Additionally, the country also insisted on a community reporting system for births and maternal deaths by developing a nationwide internet access and rapid short messaging service (SMS) technology for community health workers (Ahmed et al., 2016).

Of the three countries discussed, a common denominator was the introduction of more health personnel, education of various stakeholders, accountability and reporting as well as an increase and accessibility to health facilities. This is in line with the guidelines discussed that show the procedures necessary for a country to lower their MMRs. A mix of conventional and unconventional methods was used by all three countries. In Kenya, the government took action in 2013 to

address the high MMRs by introducing a policy of free maternal and antenatal services in all government facilities (Pyone et al., 2017). In the year 2013 prior to the policy implementation, the MMR in Kenya was 540, while that of 2015 was 510. This was a 5.5% reduction (World Bank, 2015). In a similar period between 2010 and 2013, the reduction in change was 7.1%. An inference to this would be, before the introduction of free maternity services, the country was making greater strides in reducing the number of maternal deaths than after an introduction of said services. This initiative by the government while focusing on the guideline on universal health was noble but has not yet been effective as the government needs to work more on the remaining guidelines (Gitobu, Gichangi and Mwanda, 2018).

Supplemental to the free maternal services offered, several interventions were launched with an aim to lower MMRs. The 'Beyond Zero' campaign was launched in January 2014 and targeted a reduction in maternal mortality while using several strategies to lower the rates (Beyond Zero, 2018). The campaign ensured that the health systems were strengthened to ensure service equity, as well as providing 47 mobile clinics, one for each county that provided both postnatal and antenatal services. A strategy that has been used successfully to improve the number of maternal and child health services within remote areas, is the African Medical Research Foundation (AMREF) Boma model. The Boma model was designed to address the national health sector strategic plan II that boosts the delivery of essential packages for health through the community strategy (AMREF, 2013). While this model contributed to an upsurge in the number of maternal and health services and was able to bring health closer to the mother and child, it did not provide family planning counselling, nor health worker education. Non-conventional methods need to be implemented to meet the SDG goal by 2030 and to adhere to the guidelines.

2.8. ICT as a Tool to Lower MMRs

As seen in the previous section, strategies aimed at increasing resources and reducing maternal mortality in resource-starved areas were shown to improve the uptake of health services. Additional methods aimed at reducing maternal mortality beyond the current levels are required to take care of inadequate and inappropriate knowledge barriers. Information Communication Technology (ICT) is one of the ways that can be used to eliminate these barriers. *The Collins Dictionary* online (2017) defines ICT as technologies that provide access to information through telecommunication. The impact of ICT is dependent on the country's problem necessities and infrastructure and could further be improved if the technology was suitable to the local situation (Mimbi and Bankole, 2015). Mobile phones are a type of ICT tool that have been at the forefront of health interventions. Mobile telephony has been speedily accepted by millions of Africans as they are moderately affordable, portable, multi-functional, and easier to use than other technological tools (Radcliffe, 2018). The term 'staggering' and 'extraordinary phenomenon' has been used to describe the rapid adoption of mobile phone technology as well as the dramatic benefits enjoyed by Africans (Asongu, 2015; Radcliffe, 2018).

This has given rise to the number of Mobile Health (mHealth) interventions in developing countries specifically in Sub-Saharan Africa (Tomlinson et al., 2013). mHealth is seen as having the potential to improve well-being and lessening the cost of healthcare (Kumar et al., 2013). Any medical or public health practice supported by mobile phones is known as mHealth (Tomlinson et al., 2013). Applications for mHealth vary and may include improving the point of service data collection, care delivery and communication (Tomlinson et al., 2013). New methods for collecting biological, behavioural or environmental data and the outcomes of the interventions are all supported by mHealth technologies (Kumar et al., 2013). Of course, mHealth has its own limitations and the most significant limitation is the lack of consistent data on the implications of mHealth related research. Consistency is witnessed when different results from mHealth

implementations can be easily scaled up. This is not the case since many mHealth interventions lack a foundation that would permit evidence-based scale-up (Tomlinson et al., 2013). While the road to mHealth may have quite the number of challenges and lacks clear guidelines on running clinical trials, a few trials have been conducted that have shown that mHealth is still a lead technological advancement tool.

One such trial was conducted in Kenya to investigate the effectiveness of a smartphone-based sight test, to check for visual impairment among children. Findings from the study showed an increase in adherence to hospital referrals when the smartphone system was used (Rono et al., 2018). mHealth has also been successfully used as a malaria reporting system in Uganda (Larocca et al., 2016). Uganda is one of the countries that made progress towards achieving the MDG-5 goal (World Health Organization et al., 2015). An SMS system was used to report data and presented a way to get feedback on key malaria indicators. Additionally, mHealth studies conducted in Ghana were used to increase ANC and skilled birth attendance. The study showed that there was a good value for money in regard to service delivery and uptake (LeFevre et al., 2017).

The wired mothers' intervention in Zanzibar, was a project done within 12 health facilities in the region (Lund et al., 2014). It consisted of an automated SMS system providing mothers with unidirectional text messaging and a mobile phone voucher system. This offered the possibility of direct two-way communication with primary health care providers (Lund et al., 2014). The study increased odds for skilled delivery attendance and prenatal care visits among pregnant women with mobile phones.

From the mHealth interventions discussed above, it is evident that the results of the studies increased positively after the intervention. The study in Kenya ensured

adherence toward hospital referrals when the smartphone was used. Similarly, the studies in Ghana and Zanzibar also ensured an increase in adherence. From countries like Rwanda who used mHealth in addition to a change of policies, they were able to rapidly lower their MMR rates to the point that they achieved the MDG goals.

While mHealth has its own benefits as discussed above, there are numerous challenges that have been witnessed. In many mHealth applications, it is impossible to calculate the scale of value and to replicate similar results elsewhere (Tomlinson et al., 2013). For instance, SMS is more likely to work under a set of parameters when there is a follow-up, when the message is personally tailored and when the frequency, wording, and content are highly relevant (Tomlinson et al., 2013). Sending generic SMS's to participants, will not have the same desired effect as those that receive messages tailored to their situation. Prior to SMS interventions being used, study researchers are required to run baseline studies to understand the participants and tailor the intervention based on the study participants.

In mHealth, the time lag during clinical trials is critical as technology may be obsolete before the trial is complete (Kumar et al., 2013). Most randomized control trials run for an average of 5 years and have challenges such as cost that may end up increasing the time lag (Kumar et al., 2013). Lack of funds may cause the clinical trial to run for longer thus causing a longer time lag. This may then affect the type of mHealth technology that would be used to ensure that the technology is not obsolete. Additionally, if a clinical trial will run for a long time, then it is advised that the researchers provide updates to the technology on a regular basis while at the same time run a continuous evaluation to ensure validity is maintained (Kumar et al., 2013).

Mobile penetration would also be a key to successful mHealth implementation. As of December 2014, the mobile subscription in Kenya was 30.731 Million as compared to a total population of 46.05 million (CAK, 2015). Statistics from December 2017 showed mobile penetration at 88.2% of the population in 2016 (CAK, 2017). This was an increase in the active mobile subscription to 38.9 Million (2016), an increase of 79% over 3 years. With this high rate of penetration, it would be easy to gain access to various stakeholders through a mobile platform with the aim of disseminating information.

One such positive application is the UNICEF supported RapidSMS. This is a system in Rwanda that not only helped community health workers track pregnancies within their communities, but also report on danger signs by the women during pregnancy. The RapidSMS system was able to register pregnant mothers, creation of reminders sent out for pre-natal and ante-natal check-ups, tracking of birth, death, and other vital statistics of the foetus and new-born. Additionally, the system was to be developed to allow the community health workers to subscribe to emergency alerts and guarantee pregnant women access to emergency obstetric care in the event complications occurred. The system offered a real-time inter-country surveillance tool for maternal health (Ruton et al., 2016). The country managed to lower its MMR from 910 in 1995 to 340 in 2010 (World Health Organization et al., 2015). The RapidSMS-MCH was successfully used to increase skilled birth attendance and an increase in ANC visits (Ruton et al., 2016). The Rwanda case was a success due to a number of factors including an already existing and organized community-based health program, good cell phone coverage and a substantially lower recurrent cost of SMS to ensure sustainability (Ruton et al., 2016)

The Ondo State in Nigeria used a different approach to lower MMRs using ICT. The initial baseline of the project in Ondo state found that only 16% of women who attended antenatal clinics returned to the hospital to deliver babies (Oyeyemi

and Wynn, 2014). The mobile phones were used to track women, inform them of upcoming clinics as well as answer questions asked by the expectant women. This led to a reduction of 47% of MMRs. The study concluded that giving pregnant women free cell phones would generally improve services by increasing the pregnant women's utilization of the primary health care system (Oyeyemi and Wynn, 2014). However, this could be considered a limitation as high costs would be incurred ensuring that each pregnant woman was allocated a phone.

Mimba Bora (Great or Better Pregnancy) is a Kenyan system that was initiated to assist in the access to free maternal information, access to health blogs and various discounts supported by the program such as hospital and pharmacy discounts. The project is an Android system that targets women with access to Smartphones (Mimba Bora, 2017). The downside of the said system is that it targets people with smartphones, specifically women who are able to work on downloading an application and can use it on an Android phone. Through a study, it was seen that the use of a mobile phone to disseminate information as opposed to a computer or through the use of the internet was found very helpful by pregnant women (Obasola and Mabawonku, 2018). Feasible alternatives, tailored for a population with fewer technology advancements, must be developed.

While successful mHealth applications have been shown as a solution to health-related challenges, failures in mHealth applications are sometimes inevitable. An application aimed at improving the outcomes of patients with uncontrolled diabetes and hypertension failed after a four-month trial period due to a low-enrolment and inconsistent use of the application (Thies, Anderson and Cramer, 2017). According to Thies et al. (2017), one of the biggest or greatest reasons why the trial failed was due to a poor fit between the application, the end-users, and the recruitment and treatment approach used. The application did not have usability testing during the development phase and therefore the application was not fully understood or utilized well by the staff and patients (Thies et al., 2017).

The system was not integrated into existing systems and added the workload because both the patients and staff had other systems they needed to attend to. Recommendations from the trial by Thies et al. (2017) revealed that for an application to be successful, a good fit needs to be made and during design, it is important that the needs of the users are placed first. Testing is one way in which to find out whether an application is effective or not. This can be achieved by a pilot test prior to conducting the main study to ensure application effectiveness.

According to Meyers et al. (2017), a mobile system was designed that was aimed at bridging the amount of time that it took for patient data collected by community health workers to be reported back to the main hospitals. The aim of the system was to have the community health workers collect and report patient data so that it could be received by the hospital in a timely manner leading to faster treatment time. After operating for two years, the system was discontinued due to the increase in cost versus the goal the system was meant to achieve, that is improving the overall population health (Meyers et al., 2017). Several recommendations made after the closure of the project included: 1) ensuring that the organizational process development was adequate to ensure the success of a project and 2) any and all goals of the intervention needed to be unified across the entire organization (Meyers et al., 2017)

In order to have a substantial impact on total maternal health indicators in Kenya, any efforts must be targeted toward women in low-resource settings. Women within the marginalized areas are the ones affected the most, due to lack of facilities, personnel and most of all knowledge. Mitigating factors and solutions, therefore, need to be created to address problems seen in the marginalized areas to ensure a decrease in MMRs. Additionally, the mHealth applications need to be tailored for the user to ensure that personalized messages are sent to participants (Tomlinson et al., 2013). The study also needs to run for a specified time to ensure

that the application or trial is successful and to ensure that the technology does not become obsolete (Kumar et al., 2013).

In the case of Rwanda, mHealth applications need to be combined with existing working systems on the ground to ensure maximum benefits to the participants. Running an mHealth application without the inclusion of health workers and ANC officers within the hospitals will not reap benefits as compared to similar trials that involve the above stakeholders (Ruton et al., 2016). Additionally, prior to running mHealth applications, baseline studies need to be conducted to the study participants to ensure that any interventions conducted, directly appeal towards certain concerns and information.

2.9. Theories, Models, and Frameworks

While appropriate applications have been discussed, it is necessary to understand any theories or models that have been created to comprehend maternal health and mortality. These models and theories would guide the creation and implementation of the intervention to ensure that studies and trials leave a positive mark when concluded. Theories related to the evolution of a population and disease are used to understand why certain countries are prone to higher MMRs as opposed to others. Several frameworks have been created to understand the causes and determinants of maternal mortality. The lead causes of maternal deaths include severe bleeding during childbirth, infections after birth, high blood pressure during pregnancy (pre-eclampsia and eclampsia), complications during and after delivery and unsafe abortions (Filippi et al., 2016). Barriers or determinants that contribute to high maternal mortality include poverty, distance, lack of information, inadequate services and cultural practices (World Health Organization, 2018; Yaya et al., 2018). Two theories and three conceptual frameworks are discussed that are related to maternal mortality causes and determinants. According to a review done, conceptual models are used to guide

research and practice and may help to determine how best to reduce adverse outcomes, by grouping determinants and stressing their associations with events in the trail from health to death (Filippi et al., 2016).

2.9.1. The Demographic Transition Theory

The demographic transition theory refers to the movement towards modernity that a population passes through and entails a logical succession of specific historical phases (Kirk, 1996). The theory is characterized by five phases that most populations go through. The first phase is known as the pre-transition phase. This phase is characterized by high birth rates and equally high death rates. This phase is also considered as the initial awareness of population control. The second phase is seen by declining mortality, high fertility rates as well as a growth in the population. This differs from the first stage due to the advancements in medical technology and medicine in general. According to the theory, mortality decline is a precondition to fertility decline (Grover, 2014; Kirk, 1996).

The third phase is considered as the peak population growth. During this phase, the birth rates decline mainly due to increased financial stability by the population or empowerment of the woman by society. The population continues to grow at this stage but is slowed down due to the birth rate decline. Both stage four and five are characterized by a decline in birth rate as well as an equal decline in death rates. In some cases, stage five is characterized by a lower decline in birth rate compared to the death rate. This would be a case where the elderly population is higher than the youthful population (Grover, 2014).

Kenya is currently in stage three having moved from stage two that was characterized by a rapid drop in the death rates due to an increase in improved food, sanitation, access to technology, basic healthcare and education. The country currently has a stalled fertility decline. Contraceptive rates increased in Kenya between the year 2012 and 2017 by 12.7% (Ahmed et al., 2019). However, this has declined to less than 1% annually. Foreign investment was one of the key things in Kenya that led to higher prevalence rates between 2012 and 2017 (Tsui et al., 2017). Reasons for this lowered contraceptive uptake would be due to wealth-related inequalities, perceived and actual side effects of contraceptive

methods and poor knowledge of contraceptive methods (Ahmed et al., 2019; Tsui et al., 2017). Wealth-related inequalities basically determine whether a population will be able to afford short-term or long-term contraceptive measures. Additionally, individuals have poor knowledge of the benefits of different contraceptive measures. In many ways, empowerment of the woman would affect the society at large and would contribute to the financial empowerment of the society and higher prevalence rates of contraceptives.

Of course, the demographic transition theory has its own limitations. It is not possible for the theory to cater for statistics of migrated populations, neither is it possible to determine how long a country will last in each stage. Most of the stages in the theory are calculated based on past events. With advancements in medicine, a country may rush through the stages as has been witnessed in a country like Kenya that moved from stage two to stage three (Eastwood and Lipton, 2011). By having formal economic empowerment of a countries population and ensuring maternal mortality reduction, the country would then be able to move from one stage to the next.

2.9.2. The Epidemiological Transition Model

The epidemiological transition model is the second model we look at that provides a means of appreciating the evolution and spread of emergent diseases (Mercer, 2018). This model looks at the complex changes in patterns of health and disease and or the interactions between these patterns and their demographic, economic and sociological determinants and consequences (Mercer, 2018). Basically, the model looks at mortality rates and how these affect a population. There are four transition stages in this model. The first transition is known as the age of pestilence and famine. This stage is marked by a shift to agriculture and civilization. There is a substantial increase in infectious disease due to an increase in the population size and a concentration of the population in urban areas. This

phase normally causes an increase in mortality. The second stage is the age of receding pandemics. This stage enjoys a decline of mortality rates and an even major decline of infectious diseases due to improved nutrition, standards of living, advancements in public health measures and medical treatments (Mercer, 2018). The third stage is the age of degenerative and man-made diseases. This stage is characterized by the prominence of chronic and non-infectious disease. In this stage fertility is a major factor for population growth. Advancement of the original theory was created and there was an inclusion of two more stages. The fourth stage is considered as the age of declining cerebrovascular mortality, ageing, lifestyle modifications and resurgent diseases while the fifth was the emergence of new diseases and re-emergence of old diseases (Santosa et al., 2014).

Most of Sub-Saharan Africa is seen as being in the third stage (Defo, 2014). However, none of the Sub- Saharan member states benefitted from the second phase since most of the countries within the region did not truly gain the benefits of the second stage prior to moving to stage three. Consequences of this included a slow mortality decline and an even slower gain in life expectancy (Santosa et al., 2014). Most low-income countries such as Kenya never benefitted from the second epidemiological transition and this is considered as one of the reasons why Kenya is having high MMRs (Santosa et al., 2014). Advancements in medicine and the development of a healthcare system were features of the second stage, features which were not developed nor enjoyed by Kenya. The epidemiological transition is more multifaceted and dynamic where both disease and health change in varied ways and is considered an endless transformation cycle.

2.9.3. The Three Delays Model

The three delays model (Thaddeus and Maine, 1994) is the final model reviewed that looks at obstacles that later lead to high maternal mortality. It mainly looks at

the delays that are caused by untimely medical treatment. It has three phases of delay. The first phase is the delay in deciding to seek care on the part of the individual, family or both (Thaddeus and Maine, 1994). This focuses on the time elapsed between the start of a complication and the recognition of the need to transport the patient to a facility (Filippi et al., 2016). Factors that cause the delay vary and include the status of a woman, illness characteristics, and distance to the facility, financial costs and previous experience with the facility (Thaddeus and Maine, 1994). The second phase is the delay in reaching an adequate health facility. This phase mainly considers the time that has elapsed between leaving home and reaching a health facility (Filippi et al., 2016). Access is influenced by the distribution of facilities, distance, availability, and cost of transportation (Thaddeus and Maine, 1994). An argument is made on the other hand that, while many factors may inhibit access, the real problem to the access of health services is inequity (Pacagnella et al., 2012).

The final phase of delay is the delay in receiving adequate care at the health facility (Thaddeus and Maine, 1994). The phase looks at the elapsed time from the point the mother reaches the facility to the point at which they receive appropriate treatment (Black et al., 2016). Phase three may be looked at as a direct consequence of the outcomes and decisions made during phase one and two. Delays of the phase will contribute to the number of women who actually reach the facilities in an already serious condition (Morof et al., 2019). The determinants of the third delay are related to the quality of care, such as the number and training of staff members and the availability of blood supplies and essential equipment (Filippi et al., 2016).

The three delays model is largely based on the premise that maternal complications are mostly emergencies, cannot be predicted and that maternal deaths are largely preventable through tertiary prevention (Filippi et al., 2016). While the model only refers to emergency obstetric care, it does not address

missed opportunities for primary prevention. It missed or possibly ignores the concept of primary prevention (Preventing pregnancies) and secondary prevention (avoiding complications once pregnant) (Filippi et al., 2016). Additionally, it does not address the opportunities of early detection of pregnancy complications during ante-natal care (Filippi et al., 2016). Prevention of pregnancy could quite possibly address the issue of unwanted pregnancies which normally lead to unsafe abortions which is one of the causes of maternal deaths. The model thus ignores family planning as well as non-communicable chronic diseases, antenatal care and postpartum care (Filippi et al., 2016). The model does not create an opportunity to improve the care of a specific woman.

2.9.4. Framework for Analysing the Determinants of Maternal Mortality

A framework was created that analysed the determinants of maternal mortality (McCarthy and Maine, 1992). It is determined that there are three stages found in the process of maternal mortality. Closest to the event of maternal death is a sequence of outcomes that culminate in death (McCarthy and Maine, 1992). A woman must be pregnant, experiencing some complication or has a pre-existing condition that aggravates pregnancy. This outcome is then directly influenced by five intermediate determinants (McCarthy and Maine, 1992). The intermediate determinants include the health status of the woman, reproductive status, access to health services, health care behaviours and unknown factors. This is similar to the intermediate determinants of health which include health service use, dietary and sanitary practices as well as behavioural factors (Mills and Cumming, 2016). The furthest component is a set of socioeconomic and cultural factors (McCarthy and Maine, 1992). Socioeconomic factors are those that regulate where people and communities live, including the kind of location they occupy, how others behave towards them, the resources they can make available for themselves, and what their community can offer for them (Mills and Cumming, 2016). Figure 2.3

below clarifies the stages by incorporating specific variables (McCarthy and Maine, 1992).

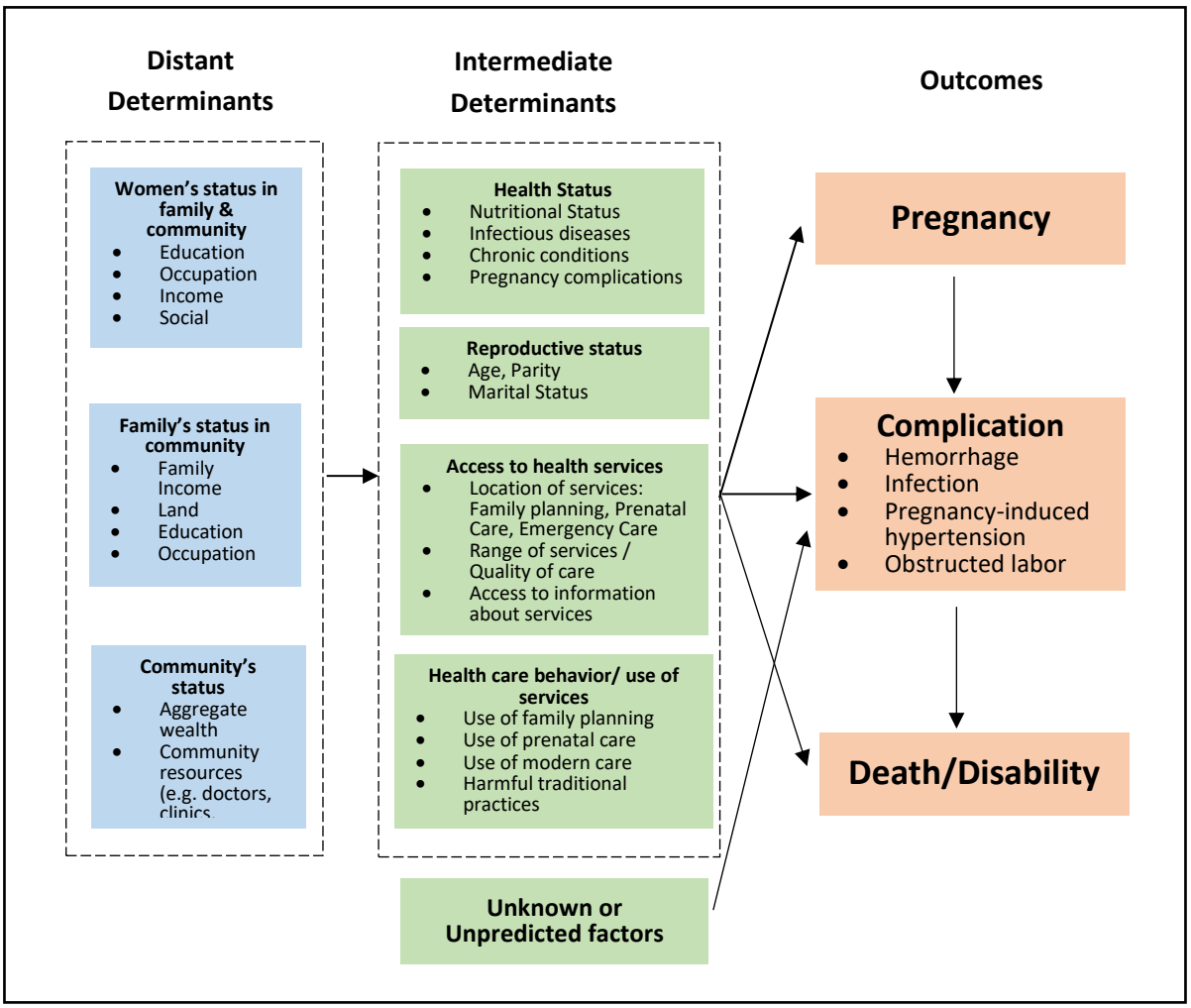

Figure 2.3: An Adapted framework for analysing the determinants of maternal mortality and morbidity *(McCarthy and Maine, 1992)*

Unlike the three delays model (Thaddeus and Maine, 1994) which ignores the concept of primary and secondary prevention (Filippi et al., 2016), the framework by McCarthy and Maine (1992), understands that three main efforts have to be undertaken to lower maternal mortality. The first effort includes reducing the likelihood that a woman will become pregnant (McCarthy and Maine, 1992). For an individual woman, the risk of maternal death is directly influenced both by the

risk associated with pregnancy and by the number of times she becomes pregnant (Bauserman et al., 2015). The more times a woman is pregnant, the higher and greater the risk of maternal death. Of the pregnancies reported in Africa, approximately 89 pregnancies out of every 100 are from unintended pregnancies (Bearak et al., 2018). Unintended pregnancies normally lead to self-induced and unsafe abortions which could generally contribute to maternal death (Bearak et al., 2018). Efforts are therefore necessary to reduce the likelihood of pregnancy.

The second effort includes reducing the likelihood of women experiencing complications during pregnancy while the third is concerned with improving the outcomes for women who actually get complications (McCarthy and Maine, 1992). Complications can occur in any pregnancy. However, the outcome is dependent on whether the women are in a developing country or not. The women in developing countries are less likely to get prompt care and as a result more likely to pass on (Bauserman et al., 2015). Most maternal deaths are not a consequence of disease but of pregnancy-related complications (Nanda, Switlick and Lule, 2005). In addition to the women who die, many more suffer from serious but not fatal problems. Most of these women who have obstetric complications recover, but some suffer long-term disabilities (Bauserman et al., 2015).

Un-empowered women are often unable to act on their own behalf to obtain contraceptive services or seek care in the event of a complication (Brown et al., 2015; Yaya et al., 2018). The same group believes that bearing many children will provide security during their old age. Women, therefore, need to be empowered with knowledge on maternal health to rise above maternal mortality. There is an urgent need to improve women’s education and job prospects if the women are to assume greater control of their lives (Brown et al., 2015; Yaya et al., 2018).

2.9.5. Conceptual Framework on the Causes of Maternal and New-born Deaths

A conceptual framework (UNICEF, 2008) similar to the framework by McCarthy and Maine (1992) was introduced that shows the interrelated factors that cause maternal and neonatal mortality and morbidity. The framework demonstrates that health outcomes are determined by correlated factors surrounding nutrition, water, sanitation and hygiene care services and healthy behaviours in addition to disease control (UNICEF, 2008). These factors are defined as proximate, underlying and basic. Proximate factors are individual risk-based factors that are preventable at the individual level. Underlying factors include the family or household, the community and the district level (UNICEF, 2008). The basic factors occur at the societal level and include potential resources as well as the availability of the said resources (UNICEF, 2008). Figure 2.4 shows an expanded view of the factors and their inter-relation.

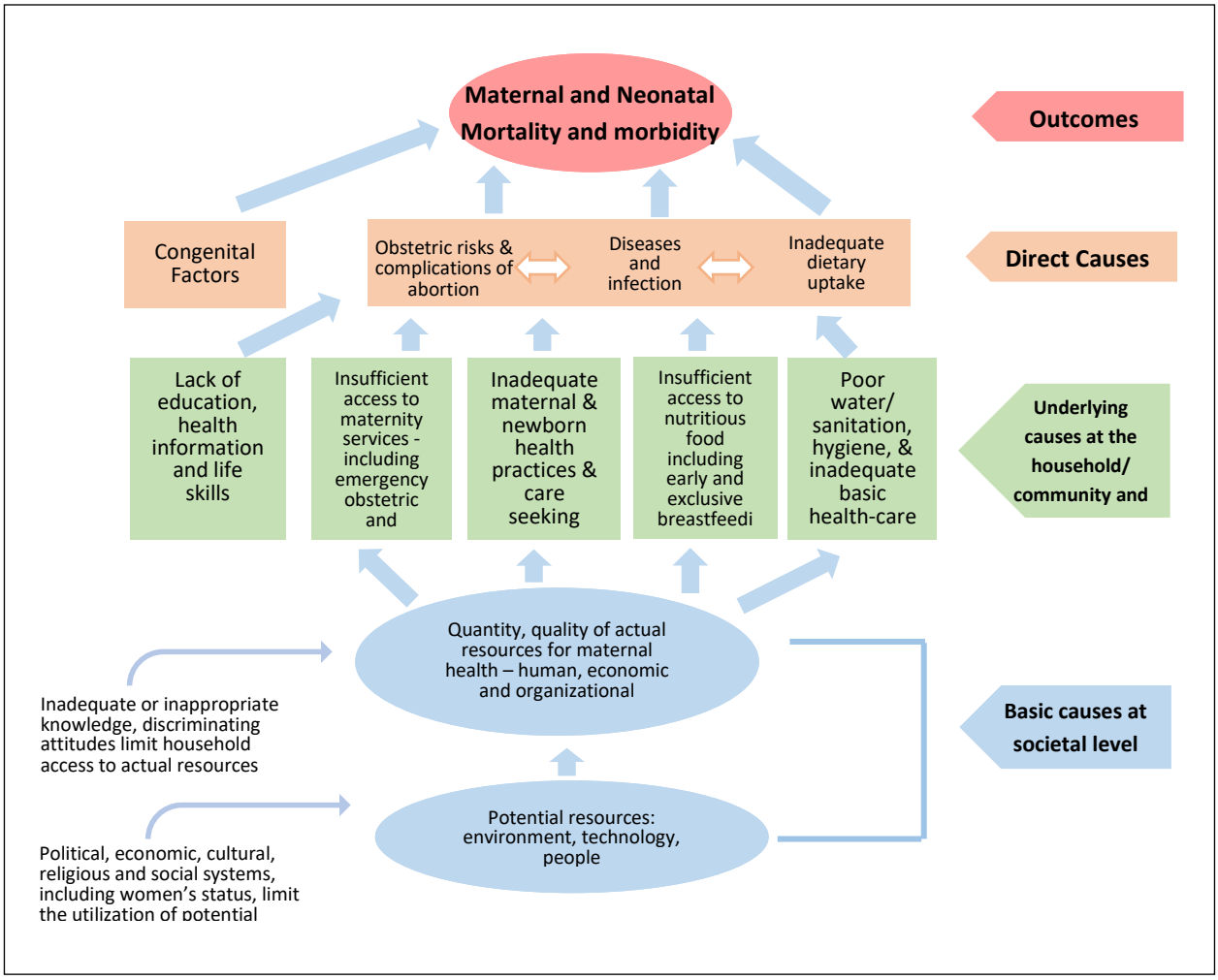

Figure 2.4: Conceptual Framework for maternal and neonatal mortality and morbidity *(UNICEF, 2008)*

According to UNICEF (2008), the main methods of reducing maternal mortality and morbidity include 1) access to family planning, 2) quality ante-natal care, 3) basic preventative and curative interventions, 4) better access to improved water and sanitation, 5) access to skilled personnel and facilities, 6) knowledge and life skills for pregnant women and 7) maternal nutrition counselling and supplementation.

The two frameworks discussed above cater to different resources and settings that can be used to improve maternal health while most importantly reducing

maternal mortality. Both frameworks discuss the determinants that lead to maternal mortality and the UNICEF frameworks goes a step further and lists the direct causes of maternal mortality. While the frameworks are comprehensive, they lack ways in which these determinants and direct causes can be eliminated or reduced to lower MMRs. The inclusion of mitigating factors within the framework would provide a comprehensive feel on how the MMRs can be reduced. The mitigating factors would be implemented directly based on the recommendations of the two frameworks.

2.9.6. Socio-Technical Information Systems Design Science Theory

In Information Systems (IS), design science research involves building socio-technical artefacts from a varied range of artefacts (Peffers et al., 2018). The artefacts would be other systems such as decision support systems, specific strategies or IS specific interventions (Drechsler, 2015). Design science is meant to address the present gap in IS specific research (Baskerville et al., 2018). This is achieved using various artefacts present in relation to the formulation of design theories. This makes IS design science key in solving real-world problems. While IS design science research is concerned with theory and knowledge for action, the socio-technical IS design science (STISD) acknowledges knowledge as a valid outcome of the method (Carlsson et al., 2011). Figure 2.5 is a summary of the STISD approach which shows the need to continuously test design knowledge and theories.

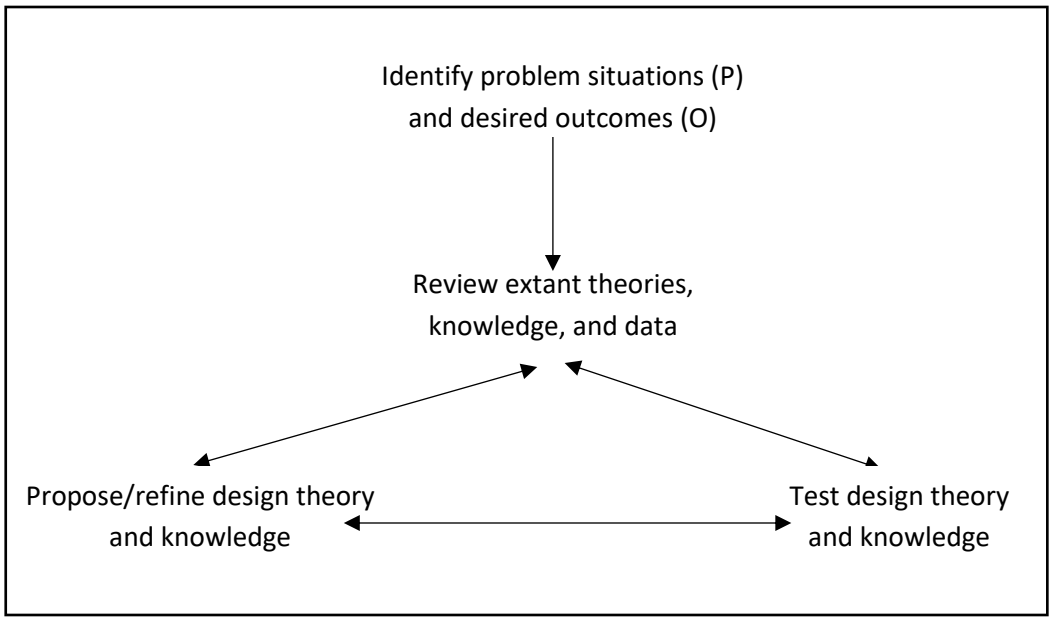

Figure 2.5: Socio-technical IS design theory development (Carlsson et al., 2011)

Design science has been used widely within the healthcare sector. Schnall et al., (2014) conducted a study aimed at designing a mobile application that was aimed toward individuals living with HIV. The study was informed by design science and involved the use of participants to first identify features they would like to use in the application while the second step involved having the participants work with systems based on their feedback from the first step (Schnall et al., 2014). Findings from the study concluded that the use of the design science theory during system development offered a systematic and comprehensive process in comparison to the process used in existing healthcare systems. These findings were reaffirmed by a review study conducted between 2010 - 2016 that was aimed toward mHealth applications developments and their development process (Miah et al., 2016). Several mHealth applications were developed using traditional development system methodologies and most did not evaluate the solution directly or indirectly with the target user groups. A messaging communication system used by patients used the phases of design, development and evaluation but did not evaluate the solution with the targeted users. Going beyond the

traditional methodology, and working with the target group would ensure participation by the users (Miah et al., 2016). Results from the study by Miah et al. (2016) indicated that mHealth applications that were developed through the use of design science were more relevant to healthcare practices (Miah et al., 2016). While design science mainly focuses on the development process and the involvement of the users, STISD adds to the process by focusing on knowledge as well.

STISD was originally created for organizational redesign such as mergers and acquisitions (Carlsson et al., 2011), but has since been implemented within the health sector. A spinal cord injury living and learning system was created using a socio-technical design theory to ensure management of patients once released from hospital (Ackerman et al., 2018). The system was created through the interactions of both the patients or the patient-caregiver as well as that of clinicians. The system while still in development has shown the capability of learning and improving through the use of the iterative development process (Ackerman et al., 2018). Information received from the caregivers and sent to the clinicians is one way that has made the system far superior to existing systems. The socio-technical perspective considers the changing environment during the design of a system. In this regard, a patients' routine, as well as their social environment must be considered during the design and implementation of any given system. Systems lack the personal touch and the interactivity with the environment necessary to cater to a patient's needs. This ends up with a gap that needs to be addressed during system development and there is a need to involve and test the developed solution directly with the users. Very few systems use design science and thus is necessary that users of the system are placed forward during system implementation.

2.10. Summary

From the various studies reviewed, it is imperative that action is taken to reduce maternal mortality. Methods used to lower MMRs are both conventional and unconventional. Conventional methods mainly focus on providing adequate services and personnel, reducing the distance to facilities and promoting skilled worker deliveries. Unconventional methods focus on imparting knowledge to promote awareness while empowering the mothers and the community at large. These methods are also used to ease the work of the health workers during data collection and allowing for easier communication with pregnant women. Unfortunately, mHealth as one of these methods does not have a set of governing guidelines on how to run studies and trials successfully. mHealth, while still considered a relatively new interventional tool, has great potential to empower women, impact and lower MMRs. Additionally, socio-technical design theories have been used to expound mHealth applications and their practicability.

CHAPTER 3: METHODOLOGY

3.1. Introduction

This chapter describes the methods and techniques used to achieve the objectives of the study. The research plan includes a two-phase approach that is explained in more detail in the chapter. Information is outlined on the population inclusion and exclusion criteria, the sampling methods, data collection and analysis. The chapter also focuses on system development in relation to the design science research methodology. Finally, the chapter provides information on the ethical guidelines followed in the study.

3.2. Approach

The study utilized a sequential mixed-methods approach conducted in two phases. According to Creswell (2009), there are three types of approaches used in research. These include quantitative, qualitative or a mixed of both known as mixed methods. Quantitative research is mainly used to test theories through an examination of relationships between variables while qualitative research is focused toward understanding human beings perspective on social problems (Creswell, 2009:4). Mixed methods are considered as the best of both worlds where it combines both qualitative and quantitative approaches for a complete understanding of the research problem (Creswell, 2009:4) Qualitative and quantitative approaches were utilized throughout the study to ensure a thorough review and understanding of the research problem. The first phase utilized both qualitative and quantitative approaches while the second phase was quantitative.

The current study held a post-positivist worldview. Post-positivists reflect the need to identify and assess the causes that influence outcomes such as found in experiments (Creswell 2009:7). The worldview is reductionist in that its intent is to reduce the ideas into a small discrete set of ideas to test, such as variables that

comprise hypothesis. The current study used a post-positivist worldview and focused on answering the study hypothesis which stated that a direct mobile intervention toward pregnant women will see an increase in ANC visits as well as an increase towards the number of births attended to by skilled birth attendants thereby reducing complications that lead to high maternal mortality rates.

Design: Study designs provide specific direction for procedures in research (Creswell, 2014, p. 11). The study utilized a variety of designs to ensure that each objective of the study was achieved. Phase one design consisted of a retrospective chart review and a cross-sectional survey on nurses and pregnant women. The second phase design was a prospective multi-location randomized clinical trial (RCT). The methodology for each phase is discussed separately. It is important to contextualize the study and therefore the location is described below.

3.3. Study Location

The study was conducted in Kajiado North constituency within Kajiado County, Kenya. Kajiado county is one of 47 counties that make up the Republic of Kenya. A constituency is a smaller county unit represented by a Member of Parliament. Kajiado County has five constituencies (Annexure 10). Kajiado county was projected to have a population of 999,819 in 2017 with 50.2% male. Of the 467,742 projected female population, 52.2% represented women of childbearing age (16-49) (County Government of Kajiado, 2013). Additional details on the County and constituency statistics, population and the maps are provided in Annexure 10.

There are 294 health facilities in Kajiado county (County Government of Kajiado, 2013). Of these, 80 are government health facilities with four sub-county hospitals, 16 health centres and 60 dispensaries. Kajiado North constituency has 31 health facilities with one sub-county hospital, three health centres and 27 dispensaries (Kenya National Bureau of Statistics, 2013). The sub-county hospital

and health centres are classified as level four and level three facilities respectively. Annexure 11 illustrates the different tiers and level of care as defined by the Ministry of Health. The tier and level system determine how referral cases are handled from one tier to the next (Kenya National Bureau of Statistics, 2013). Annexure 11 expounds more on the functions of different levels of hospitals.

The study was conducted at the sub-county hospital (level four) and one of the level-three health centres. Both facilities had an uptake of approximately 400 antenatal care (ANC) cases per month and were approximately 19.59Km apart in a densely populated area. They also managed emergency services and had bed capacities for admission specifically for maternity-related situations.

The sub-county hospital used in the study was the Ngong Sub-District (NSD) hospital. At the time of the study, the hospital had two wards with a 25-bed capacity as well as three neonatal cots. The maternity ward admitted patients for vaginal deliveries only as they did not have a theatre to perform caesarean sections. Additionally, the hospital admitted patients to the general ward and provided services like ANC, labour, birth, child vaccinations as well as general outpatient diagnostic services. The hospital had no theatre and all emergencies were referred to the nearby Mbagathi level four District Hospital or level six Kenyatta National Hospital.

The Ongata Health Centre (OHC) was the level three health centre selected for the study. At the time of the study, the health centre had one ward a bed capacity of 16 beds and one cot for neonatal admissions. It provided services like NSD other than admission to the general ward. The health centre had no theatre and therefore all emergencies were referred to the same referral hospitals that NSD referred to. Only one ambulance operated between the hospitals and the health centre therefore simultaneous emergencies at both facilities resulted in one of the patient's family looking for an alternative means of transport.

The rationale used in selecting the two health facilities was informed by the number of tiers within the county, the services offered within the facilities and the population near and that accessed the health facilities. The population selected was additionally informed by cost, time as well as the objectives of the study.

The study was conducted in two phases and details including specific methodology for each are described below.

3.4. Phase 1: Retrospective study and cross-sectional survey

Objectives 1, 2 and 3 were realised through studies in phase 1. The phase included a retrospective chart review, a cross-sectional survey of nurses at the OHC and NSD and a cross-sectional survey of pregnant women at the OHC that were conducted sequentially.

3.4.1. Phase 1a: Retrospective Chart Review

Design: A retrospective chart review was used to achieve objective 1. A review of patient records from the two locations was conducted during this phase between 2016 and 2017. The period of review was selected as information prior to the period was not available from the health facilities.

3.4.1.1. Study Population

The chart review focused on records relating to pregnant women. The specific information collected on pregnant women included the number of new patients, number of re-visits, teen pregnancies and patients with four or more ANC visits. Information from the delivery ward included the number of deliveries, babies born while in breech, the number of stillbirths and maternal deaths.

3.4.1.2. Sample

Purposive sampling was used to select the charts for review. This was informed by the availability of records within the OHC and NSD facilities. Purposive sampling was used as it offered the best method that allowed for identification and selection of information-rich charts (Palinkas et al., 2015). A sample size of six months was selected for review of the two facilities. This was informed by the length of the main RCT.

3.4.1.3. Instrument

During the chart review data were collected using a digital camera. The digital camera used was on an iPad and had lent security features to maintain the privacy of all information recorded. A chart collection sheet (Annexure 14) was also used to record the specific statistics from the digital photographs. This was done to ensure that there was no missing or erroneous data (Matt and Matthew, 2013). A retrospective chart review is a fast and inexpensive way to achieve results (Panacek, 2007). In addition, it can quickly evaluate associations which can later be evaluated by a prospective study. While the benefits make the chart review ideal for the study, it does have drawbacks like the potential of bias, inability to establish all associations as well as issues with missing data (Matt and Matthew, 2013; Panacek, 2007). In the study, the chart review provided information on various ANC and delivery statistics within the two health facilities in a timely manner. The chart review was used as it provided an inexpensive and timely way in which the researcher could collect valuable data that was then used to guide the prospective study.

3.4.1.4. Procedure

After obtaining ethical approval to conduct the study (Annexure 1) and permissions from the respective authorities (Annexure 2 and 3) to access the

data, this part of the study commenced. The chart data were summarized at both health facilities and were displayed within public spaces. The health centres were equipped with record books supplied by the government that were used to keep the patient's health records. At the end of each day, the record book contained a section for a summary of the day's events. At the end of the month, the nurses within the antenatal clinic (ANC) and the delivery ward compiled a report showing the various statistics of each department. These statistics known as workloads were then displayed on a wall within the departments (Figure 3.2).

1. ANC Workloads

ANC Clinic						
OHC						
Activities	Jan	Feb	Mar	Apr	May	Jun
First Visit	157	194	136	150	107	208
Revisit	255	284	309	315	286	327
Completed 4th Visit	47	78	69	66	72	95
0 - 14 Year Olds	0	0	0	0	0	0
15 - 19 Year Olds	76	73	60	33	47	48
NSD						
First Visit	205	207	190	230	181	218
Revisit	462	359	471	318	320	402
Completed 4th Visit	89	69	55	51	60	69
13 - 19 Year Olds	28	23	18	16	21	24

2. Delivery Ward Workloads

OHC						
Activities	Jan	Feb	Mar	Apr	May	Jun
Normal Deliveries	52	50	53	65	73	74
Breech Deliveries	3	1	0	3	3	3
Live Births	49	49	51	65	76	77
Referral	6	6	14	5	11	12
FSB (Fresh Still Birth)	3	1	2	0	0	0
NSD						
SVD (Spontaneous Vaginal Deliveries	106	101	102	99	82	105
Breech Deliveries	0	1	0	1	0	0
Live Births	107	99	101	101	83	105
Referral	9	12	10	12	22	11
FSB (Fresh Still Birth)	1	2	0	1	0	0

Figure 3.1: Delivery ward and ANC workloads from OHC and NSD

The ANC workload indicators at both OHC and NSD included: new patients, number of re-visits, teen pregnancies, patients with four ANC visits, women who had been counselled and tested, number of women who had tested positive for HIV, partners who had tested positive for HIV, couples counselled, women with a haemoglobin of eleven or lower, women issued with iron supplements and insecticide-treated nets and the number of women who had received the tetanus shot. The delivery ward indicators included the number of deliveries, babies born while in breech, number of stillbirths, maternal deaths, patients referred to other hospitals, underweight babies, as well as mothers on HAART (Antiretroviral HIV medication). The ANC and delivery ward statistics were captured on camera then fed into the chart collection sheet.

3.4.1.5. Data Analysis

Chart data collected, was in the form of various summaries. Microsoft Excel XLStata was used for analysis and it found patterns or associations within the two health facilities. XLStata a Microsoft Excel analysis add-on was used for analysis of the responses. Independent t-tests were used to compare the deliveries, specifically the breech and stillbirths within both facilities. The results were considered significant if the p-value was equal to or less than 0.05.

3.4.2. Phase 1b: Cross-Sectional Survey

Design: Cross-sectional surveys on nurses and pregnant women were used to achieve objective two aimed at understanding the challenges faced by the health workers as well as the procedures used within the health facility. The surveys also explored the current communication and information diffusion strategies as well as current technologies that the pregnant women used on a day to day basis. The researcher also sought to verify that the expectant women were able to communicate by phone and to ascertain that they owned mobile phones. Interviews and questionnaires were used to collect data.

3.4.2.1. Study Population

The target population included both nurses and pregnant women and specific details are discussed.

a) Nurses

The population included nurses at the two health facilities. Factors used to identify the nurse participants included those who had worked in both the ANC and maternity wards and had progressed to become heads of departments within the selected facilities. Senior nurses were selected based on those who had interacted with the hospital day to day activities for a period of twenty years or more.

b) Pregnant women

Pregnant women participants in the cross-sectional survey included those who had attended the ANC visits at OHC as well as those who consented to answer the questionnaire. The rationale for using pregnant women for the cross-sectional survey from only the OHC location was informed by the main RCT and pilot study. The questionnaires were only conducted at the OHC location prior to the main RCT. Additionally, the OHC location was the first of the two facilities where the RCT was conducted.

3.4.2.2. Sample

Sampling was done to select both the nurses and pregnant women to be used for the cross-sectional survey. Details are discussed below.

a) Nurses

Purposive sampling was used to identify nurses. This was done after determining the longest-serving nurses within both the ANC and delivery wards. Purposive sampling was used as it enabled the researcher to identify and select individuals who were widely knowledgeable on ANC and delivery matters within the health

facilities (Palinkas et al., 2015). The rationale for using purposive sampling was to ensure both experience and knowledge were on the forefront of the nurses selected to ensure concise data was collected (Kothari, 2004:15). The nurses selected needed to have worked for at least 10 years within the Ministry of Health and should have worked in both the ANC and delivery sections of the hospital. Only one nurse in each facility met the criteria and they were both selected for the interview session.

b) Pregnant women

Purposive sampling was used to select the pregnant women. With limited resources such as cost and time, purposive sampling was used since it allowed for a realistic sample to be selected (Palinkas et al., 2015). Only women who attended the ANC clinic at the OHC location within the selected period of the week and gave consent were invited to participate. Women were interviewed until the point of data saturation. Recommendations for sample size is varied and depends on the main study and the general rule of thumb approximates 20-40 participants (Whitehead et al., 2016). Thirty women participated.

3.4.2.3. Instrument

The in-depth interview (IDI) on nurses was conducted to explore the current challenges within the health facility. It was also used to collect information on the mitigating factors to prevent complications from becoming maternal deaths. In addition, the process that pregnant women used at the clinic was gleaned. The interview was crafted based on the study problem and objectives. A semi-structured interview was used to collect data (Annexure 8). The main advantage of using a semi-structured interview was the option that the researcher could easily restructure questions based on responses received. The interview is also considered less invasive due to the use of face to face interaction (Seltman, 2018). The interview was most appropriate for this phase as it enabled the

researcher to get a good understanding of the situation and procedures at both health facilities.

The interview included recording the demographic data, understanding the maternal health situation within the facility as well as the process that women took during the visit. Additionally, it included questions on the viability of the proposed solution. The interview included follow-up questions and validation questions that were used to ensure that accurate data was recorded. To ensure reliability, the interviews were recorded on a digital recorder while the researcher took short notes. Data accuracy was achieved during the transcription of the recorded interview responses (Creswell, 2014). The qualitative data collected after the transcription was used to compare the notes collected by the researcher to check for consistency.

A face-to-face questionnaire was used to collect information on the pregnant women's history, language preferences, the viability of an SMS intervention as well as the kind of information pregnant women would like to receive (Annexure 5). Advantages of face-to-face questionnaires include good response rates, the researcher is able to observe the participants attitude toward the questions (Safdar et al., 2016). Disadvantages of the face-to-face questionnaire included a lengthy process. The researcher needed to move from one participant to the next. Another disadvantage was the use of a non-representative sample of pregnant women (Safdar et al., 2016). The questionnaire was used for the phase as it provided the researcher with an impression on the pregnant women, their knowledge and attitude towards a proposal of an intervention to manage their pregnancies.

The questionnaire was made up three sections: 1) demographic data, 2) maternal health information and 3) ICT information. Each questionnaire picked the patients name initials and introduced the purpose of the questionnaire. The demographic

data were collected to ensure transferability of study findings. The maternal health information with the study objectives and was aimed at understanding the participants' history in relation to pregnancy. The ICT information section was aimed at finding out the viability of the mobile system as well as finding the women's preferences regarding pregnancy information.

Reliability and validity were ensured through training that the researcher undertook on the instrument creation, data collection procedure and coding of the instruments. The tools were verified during the training by experts within the health field and pre-testing was done on peers to verify the questions. During the face-to-face data collection process, the questionnaires were checked to avoid systematic errors and to ensure completeness of data (Safdar et al., 2016). Cronbach's alpha was used to test the internal reliability of the questionnaire. It was used to check the scale of the various questions within the questionnaire. The questionnaire consisted of 20 questions from which the computed Cronbach's alpha score was 0.879 as shown in Table 3.1. This implied that the questionnaire was found to have high internal reliability.

Table 3.1: Cronbach's reliability statistics

Reliability Statistics		
Cronbach's Alpha	**Cronbach's Alpha Based on Standardized Items**	**N of Items**
.879	.768	20

An additional ten questions covered information on the patient's demographics, location of residence, income per month and preferred pregnancy content.

3.4.2.4. Procedure

After ethical approval to conduct the study was obtained (Annexure 1) the relevant permissions (Annexure 2 and 3) and fully informed consents (Annexure 4) were obtained then the cross-sectional survey was carried out.

a) Nurses

Nurse interviews were conducted at each health facility with two senior nurses. Initial questions which included demographic data were used to encourage a rapport between the researcher and the nurses. Both interviews were face-to-face and were conducted at the nurse's offices with informed consent being provided before the start of the interview process. Interview responses were recorded using a secure voice recording application. The responses from the interview were stored within the voice recording application called SuperNote. The application allowed for a passkey authorization prior to accessing the interview notes and this ensured that the interviews were safeguarded.

b) Pregnant Women

The researcher introduced the project to the selected participants prior to data collection. The questionnaire was handed out to the participants who gave oral consent to answer. The researcher was then available to clarify any questions that were not clear. The questionnaires were conducted within the OHC location during the ANC visit by the pregnant women. The questionnaire was conducted in English and Kiswahili, both national languages, therefore a translator was not necessary.

During the phase, pre-testing was done prior to running the questionnaires by observing the response rate and how the users understood the questions. An undeclared pre-test was performed by having the participants' answer the questions like as if it was the main survey being conducted. Based on observations by the researcher and questions by the participants, it was necessary to modify parts of the questionnaire. Modifications were made to the questionnaires where similar data was categorized to ensure the flow of questions when participants were answering.

3.4.2.5. Data Analysis

The interviews were transcribed using Express Scribe software which is a PC audio player that allows a user to transcribe audio recordings. The results were then categorized, and relationships sought to inform the RCT. The data was then thematically described.

The questionnaire answers were pre-coded to allow for easier analysis. A pre-coded questionnaire allows for answers to be stored in a coded format, thus allowing for analysis as soon as the data is collected. Pre-coding involving allocating numbers to various answers, for instance ‘yes’ could be coded as ‘1’ and ‘no’ as ‘2’. The participants' ID was coded as well to ensure anonymity. The responses were filled into Microsoft Excel for analysis using XLStata. Participant data were coded with participant ID’s to ensure anonymity. The mean and the frequency of responses were analysed and presented in chapter 4. Variables presented included the demographic details of the pregnant women, topic preferences and phone ownership.

3.5. Phase 2: Prospective Study

Objectives 4, 5 and 6 were realised through phase 2 of the study.

Design: A two-site, two-arm, post-test only randomized control trial (RCT) was conducted at the OHC and NSD facilities to test whether a direct intervention toward pregnant women would see an increase in ANC visits and an increase in the number of births attended to by skilled birth attendants thereby reducing complications that led to high maternal mortality rates. The RCT was first conducted at the OHC location and later at the NSD location.

3.5.1. Study Population

The study population included all pregnant women who attended their ANC clinics at the OHC and NSD health facilities over a period of a month. The women were then followed up for a period of five months at each facility. Within the OHC facility, the women were followed between November 2016 and March 2017, while at the NSD facility they were followed between April 2017 and August 2017.

3.5.2. Inclusion and Exclusion Criteria

3.5.2.1. Inclusion Criteria

Eligible participants were women of gestation between 20-35 weeks and who could comprehend the nature of the study. Patients who were termed as high risk and attended their ANC visits at either of the two facilities were also eligible. Additionally, women with baseline medical history which revealed no significant disease or history of illness that could affect the investigation were eligible. Finally, signed written informed consent (Annexure 4) by all participants was required (informed consent of participants under 18 years of age was provided by guardians).

3.5.2.2. Exclusion Criteria

Pregnant women who had any evidence or history of terminal diseases that required continuous care were excluded. Any pregnant women who were admitted to the hospital or were on bed rest up till the delivery were excluded. Any pregnant women with a documented history of drug or alcohol abuse were excluded. Finally, any pregnant women referred to the national or referral hospitals during ANC visits were excluded.

3.5.3. Sampling

Random sampling was used to select pregnant women who met the inclusion and exclusion criteria. The sample size was calculated based on recommendations by

Whitehead et al. (2016). A sample size of approximately 94 participants in the main RCT with a 95% confidence limit was considered ideal. This sample size was also informed by a pilot study of 22 participants. As the pilot study had an enrolment of 30 participants, the main study was increased to 100 participants with an increase of 10 participants assuming a dropout rate of 10%.

At the OHC location, 439 women were assessed for eligibility. Of these 110 women were randomized in the trial as shown in the flow diagram in figure 3.2. Simple randomization was used to allocate participants to an intervention or control group. This was based on recommendations by Shibasaki and Martins (2018) where trials with a sample size larger than 60 benefitted from simple randomization as selection bias was minimized. Schulz and Grimes (2002) argue that discrepancies in the numbers of each group are unavoidable and expected when one uses simple randomization. Simple randomization is sampling where each participant has an equal chance of either being placed in the control or intervention group (Kothari, 2004:15). Each eligible participant at the OHC was randomly placed in the control or the intervention group. Due to the utilization of simple randomization, OHC trial had 44.55% (n=49) in the control group while the intervention group had 55.45% (n=61) of the respondents.

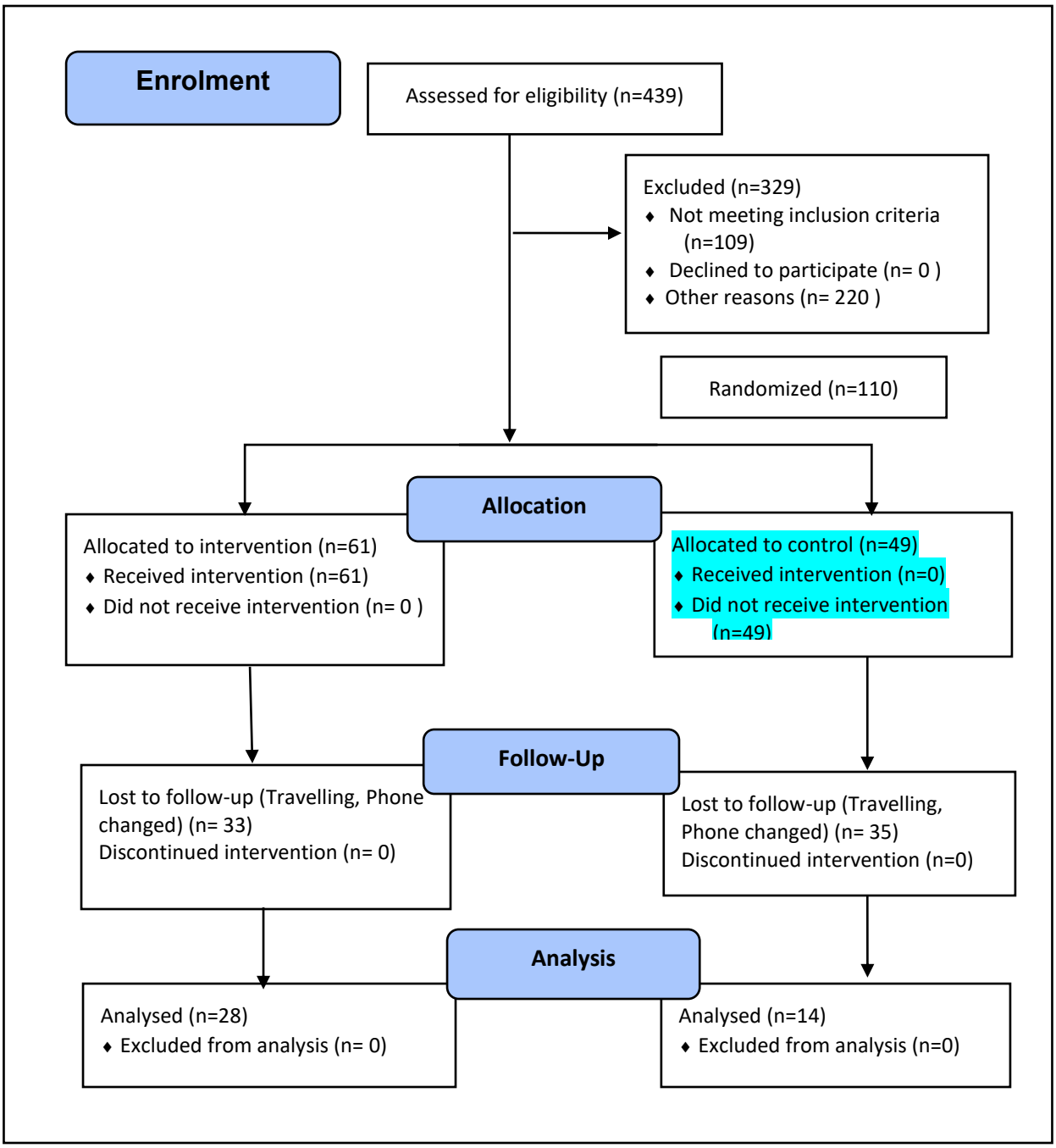

Figure 3.2: OHC RCT flow diagram

Only 101 women were assessed for eligibility at the NSD and were all included for the study as shown in the flow diagram in Figure 3.3. Once the sample of participants was identified, all the respondents were randomly allocated using Microsoft Excel to either the control or the intervention group.

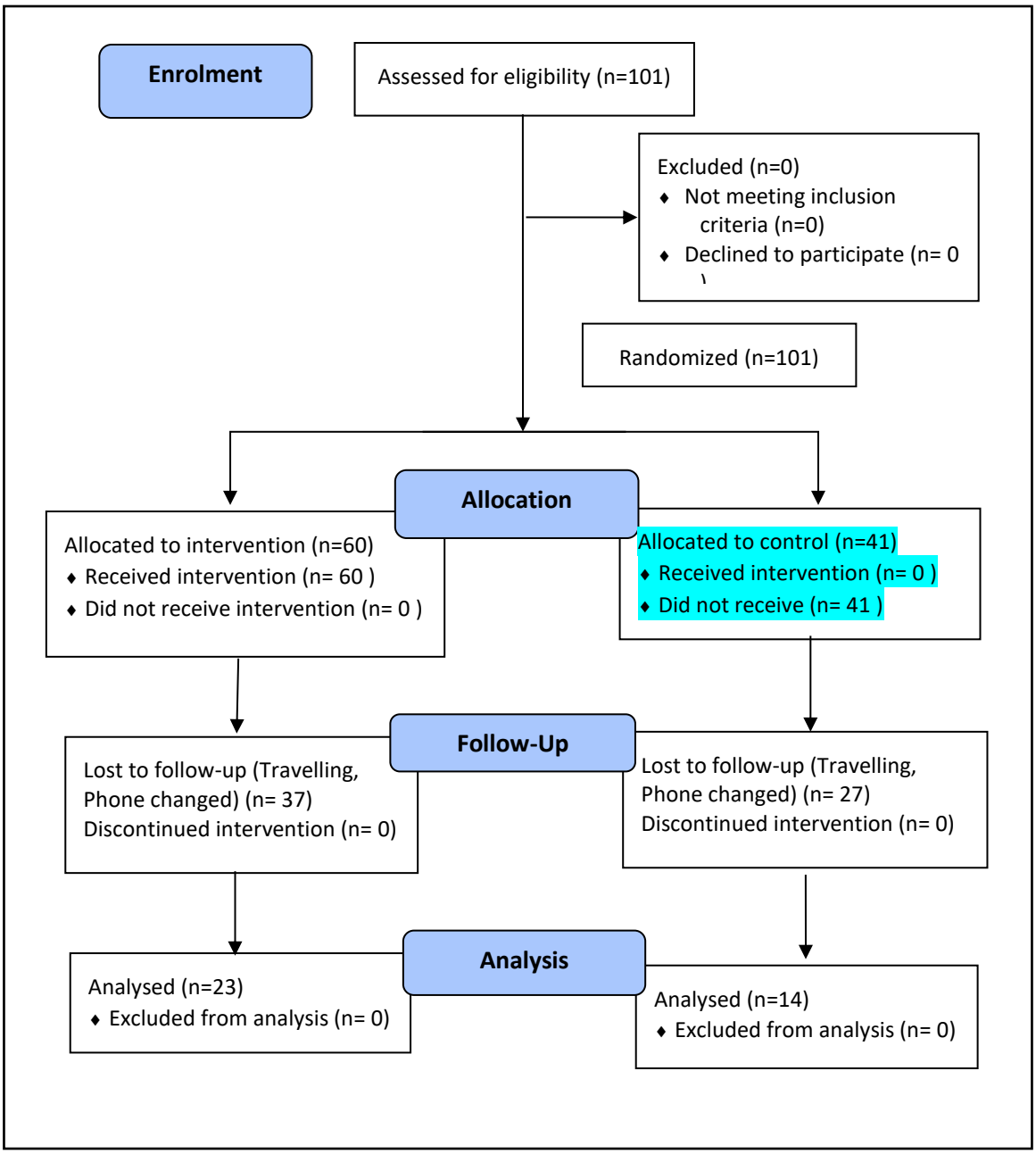

Figure 3.3: NSD flow diagram

Simple randomization was used at the NSD location with allocation at 40.59% (n=41) in the control group with 60 in the intervention group 59.41%.

3.5.4. Study Instrument

Questionnaires were administered to all participants telephonically after the intervention (Annexure 6). Advantages of using a phone questionnaire include rapid data collection, flexibility and quality control (Safdar et al., 2016).

The respondent responses to questions were recorded on a tablet. The researcher could glean the general feel of the participants' attitude toward the intervention. The questionnaire consisted of 22 questions from which a computed total score of 14 questions (Cronbach's alpha = 0.698) was found to have substantial reliability as shown in Table 3.2.

Table 3.2: Chronbach's Reliability Statistics

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.698	.673	14

The additional five questions covered information on the participant demographics, location of residence, income per month, job title as well as the delivery date. Additionally, a messaging system was used as the main instrument to educate pregnant women.

3.5.5. Study Procedure

After ethical approval to conduct the study was obtained (Annexure 1), the relevant permissions (Annexure 2 and 3) and fully informed consents (Annexure 4) were obtained the RCT was conducted. All participants within the intervention groups at both OHC and NSD were each clustered into groups and were issued with a participant identification (ID) number. The cluster group was based on the women’s gestational weeks. For instance, all pregnant women in the OHC

interventional arm who were 28 weeks were clustered into one group. This allowed for messages to be custom-made for users within a specific week. Details included in the messaging system included the participant ID, telephone number and the cluster they belonged to. Two messages were sent per week to the pregnant women in the intervention arm at both locations. The messages were customized based on their cluster. These messages (Annexure 7) were sent to the women until the end of their pregnancy at week 40. The messages were placed into eleven categories where the frequency was determined through the results from the cross-sectional survey conducted in phase 1.

Once the participants passed week 40, a call was made to inquire about their delivery status. If the participant had given birth, then the post-test questionnaire (Annexure 6) was administered. In the event the woman had not given birth, a follow-up call was done two weeks later. The post-test questionnaire was then administered after the woman had given birth. It was important to run the questionnaire after delivery because it accurately covered details like the place of delivery, mode of delivery, type of complication as well as any mortalities.

For the control arm, a consent letter was signed, and the participant details were recorded. No information was sent to the women, however, the women continued with their usual standard of care. A post-test questionnaire (Annexure 6) was administered once the women had given birth.

3.5.6. Data Analysis

Data from the questionnaires were captured using an application called Open Data Kit (ODK) (ODK, 2017) and was stored on a Google aggregate server. Open Data Kit is a data collection tool which allows for the creation of a digital questionnaire and recording of the answers on a mobile phone. Data were retrieved and analysed directly as it was already classified. All the statistical

analyses for the prospective RCT were performed using SPSS software version 20.0.0 (IBM, 2011)

Creswell (2014) suggests research tips when analysing data. Relevant steps used in the study include:

1. Reporting on filled and non-filled questionnaire responses
2. Discussing methods to identify response bias
3. Discuss a plan to provide statistical analysis
4. Interpretation of the results

3.5.6.1. Data Processing

During this step, data cleaning was done to identify respondents who returned vs those who did not return the questionnaire. Creswell (2014) recommends the usage of a table with percentages describing the respondents and non-respondents. Data acquired from the aggregate server was imported into excel as a .csv file. A copy was made prior to cleaning to ensure that the original data was not corrupted. This step involved looking at the data record to ensure that there were no inconsistencies. There were no major changes to the data because the collection was made primarily by a system created to ensure consistent error-free, reliable data.

3.5.6.2. Identification of Response Bias

Creswell (2014), defines response bias as the effect of nonresponses on survey estimates. It means that if non-respondents had responded, their responses would have significantly changed the overall results (Creswell, 2014). The non-respondents in the study were participants who did not answer calls or had changed their phone numbers by the end of the questionnaire. The researcher called the non-respondents after a period of two weeks and with their responses

compared the results to the already analysed data. This was done to check if any bias was present.

3.5.6.3. Statistical Analysis

The inferential analysis is a form of multivariate analysis which may be defined as all statistical methods which simultaneously analyse more than two variables on a sample of observations (Seltman, 2018). According to Springer Nature Limited (2020), statistical methods are "mathematical formulas, models, and techniques that are used in statistical analysis of raw research data". Three statistical measures were used to analyse the post-test questionnaires.

First was the measure of central tendency. Central tendency is used to specify where the mid of a probability distribution lies (Seltman, 2018). Mean is one central tendency measure and was used in the study on the participant demographic data.

$$Mean\ (or\bar{\chi}) = \frac{\Sigma\chi_i}{n}$$

Specifically, the income, age, distance to the health facility, ANC visits, place of birth, complication rate and mortalities were variables that were reported based on their mean. The second statistical measure used was the standard deviation. Standard deviation is used to calculate the spread of a distribution (Seltman, 2018).

$$\text{Standard deviation } (\sigma) = \sqrt{\frac{\Sigma(\chi_\iota - \bar{\chi})^2}{n}}$$

Within the study, standard deviation was used to calculate the ANC visits, place of delivery, complication as well as mortalities.

Independent t-tests were performed on the ANC visits, delivery location, mortalities and complication rates to find out whether there was a statistically

significant difference between the intervention group and the control group at both locations. Independent t-tests were also used to check whether there were any significant differences in participants age.

The final statistical analysis was a measure of relationships on the two location variables between the intervention and control groups on the following: a) the relationship of the ANC visits on the complication rate, and b) the place of birth and its relationship on the complication rate. For a) and b) Pearson's coefficient correlation was used to show the relationship of the ANC visits and delivery location on the complication rate.

$$Pearson's correlation\ coefficient\ r_{XY} = \frac{\Sigma_{i=1}^{n}(X_i - \overline{X})(Y_i - \overline{Y})}{\sqrt{\Sigma_{i=1}^{n}(X_i - \overline{X})^2}\sqrt{\Sigma_{i=1}^{n}(Y_i - \overline{Y})^2}}.$$

A two-factorial ANOVA was also used to verify the effect of the two variables (ANC and delivery) on the complication rate based on the intervention or control group.

Lastly, multiple regression an equation used to analyse the relationship between two or more independent variables was used. (Kothari, 2004:142).

$$Multiple\ regression\ assumes\ \widehat{Y} = a + b_1X_1 + b_2X_2$$

A multiple regression analysis was performed on the two locations to determine the prediction of complications based on ANC visits, delivery location as well as the intervention or control group participants. The prediction was based on where the mother gave birth, how many ANC visits she had as the effect of the intervention. Effect size using Partial Eta Squared was also calculated. The small effect size was between 0.14 – 0.39, a medium effect size was between 0.39-0.50 while a large effect size was above 0.50 (Sullivan and Feinn, 2012).

$$Partial\ eta^2 = SS_{effect} / SS_{effect} + SS_{error}.$$

The test was used to accept or reject the null hypothesis. The probability of accepting the null hypothesis was set at 95% confidence level.

3.6. Study Validity

Creswell (2014) indicates that there are eight validation strategies used by qualitative researchers. Credibility for the entire study was achieved through triangulation, prolonged engagement, and peer debriefing. Peer debriefing involved locating a peer debriefer who reviewed and asked questions about the study (Creswell, 2014). Peer debriefing was achieved as the researcher was required to report to the academic supervisors and provide progress reports periodically. This allowed for an external view of the research to ensure that there was no bias during the entire study. Triangulation was accomplished through several data collection methods including questionnaires, interviews and available chart data. Use of different sources and instruments helped establish themes and validated the study (Creswell, 2014).

Reliability and prolonged engagement were achieved as the study was conducted over a year. This brought about a period where the researcher was able to get in touch with and learn about the behaviour of the participants while collecting data. Research shows that when a researcher spends a prolonged time in the field, they are able to gain an in-depth understanding of the study location and participants (Creswell, 2014). Reliability was reached due to the structuring of questions found both in the interview and questionnaire. Internal reliability and validity were conducted as was explained in each instrument section during phase one and two.

3.7. Ethical Considerations

There are three principles that go towards safeguarding the participants of a health study. These include beneficence, which requires a good result, the

respect for rights and justice which will require an equal distribution of burden and benefit (DeCamp et al., 2018). All the participants were treated in accordance with these three principles. During the study, the intervention proposed was to provide information that was pre-approved by the health officer. Although there are no discernible risks to pregnant women since the information sent had been pre-approved by a doctor and midwife, the following considerations were kept in mind when dealing with pregnant women. All interviews and questionnaires done were anonymous and the data were analysed in a random manner. A permit to perform a study within Kajiado North constituency was acquired from the government of Kenya prior to the start of the research (Annexure 2 and 3). This letter acted as an introduction to the various offices and facilitated co-operation from the various stakeholders.

The researcher followed ethical guidelines, as specified by the Ethics and Review Board, Durban University of Technology. A summary of some of the considerations is listed below with the detailed rules listed in Annexure 1.

1. The research participants were not subjected to harm in any way.
2. Full consent was obtained from the participants prior to the study.
3. Protection of the privacy of research participants was ensured.
4. The research data remained confidential throughout the study and participants remained anonymous throughout and after the study
5. Biased or misleading information was not passed to the research participants.

3.8. Summary

This chapter talks about the methods used in the study. The chapter additionally gives a detailed plan of the data collection and analysis procedures used. Validity and ethical considerations were also explored within the chapter. The next chapter will focus on the system design, development and implementation.

CHAPTER 4: DESIGN, DEVELOPMENT AND IMPLEMENTATION OF THE RCT ARTEFACT

4.1. Introduction

The chapter presents the solution developed and used as the intervention during the randomized control trial (RCT). The chapter focused on objective three: develop and test a data collection and messaging system to disseminate messages and collect feedback from pregnant women.

The chapter discusses how the RCT intervention was designed, developed, tested and implemented. The chapter consists of the design methodology used and the various iterative steps used during design and development.

4.2. RCT Artefact Methodology

The intervention used was a messaging system that sent out messages to pregnant women within the intervention group. The messaging system was selected due to its applicability and cost-effectiveness within the two study locations (LeFevre et al., 2018; Lund et al., 2014; Tomlinson et al., 2013). Additionally, a messaging system has been shown as an effective tool to educate pregnant women (Obasola and Mabawonku, 2018). The system was also selected based on the results of the cross-sectional survey from phase 1 of the study. Challenges of developing and implementing an SMS system include speed and functionality, standardization across implementation sites, cost, malfunctions and data management from the system (Brown et al., 2018).

Various methodologies exist that tackle the challenges presented differently. Based on the study and use of an RCT, the development of the intervention utilized a Design Science Research Methodology (DSRM). Motivation to use the design science methodology was due to its rigorous process toward solving

problems through the design or artefacts (Wieringa, 2014). The DSRM uses a six-step process to design artefacts and the process diagram is outlined in figure 5 (Peffers et al., 2018). An adapted version used for the study is also shown in Figure 4.1. The specific steps are thereafter discussed in relation to the study intervention.

The DSRM model was carefully chosen since it was the researcher's intent to select, design and develop tools that would be appropriate to not only empower the women but also allow for easier data collection and avail the results of the study to other researchers. This was based on the recommendations that health systems can be strengthened by ICT through assisting in the collection and accurate reporting of data as well as evaluating existing programs (Roth et al., 2016). Additionally, the Kenyan eHealth strategy recommends that data collected during trials is shared with other researchers while maintaining confidentiality (Kenya National Bureau of Statistics et al., 2015). The DSRM model was thus well suited as it would allow for an iterative process.

Two iterations were proposed as part of the DSRM model that factored the pregnant women needs as well as the researcher needs. During system development of the first iteration, the user needs were put at the forefront. During the second iteration, additional focus was placed on the researcher's needs to ensure that data sent could be tracked, to ensure faster analysis and automatic storage. In addition, DSRM was well suited as a model for choice because it provided the option for iterations that allowed for a range of options that would work well together. Use of the adopted DSRM allowed for a creation of a unique system that allowed for user requirements and researcher needs to be factored to allow for data transparency collection, in real-time (Steiner et al., 2016). The diagram below shows the DSRM process model.

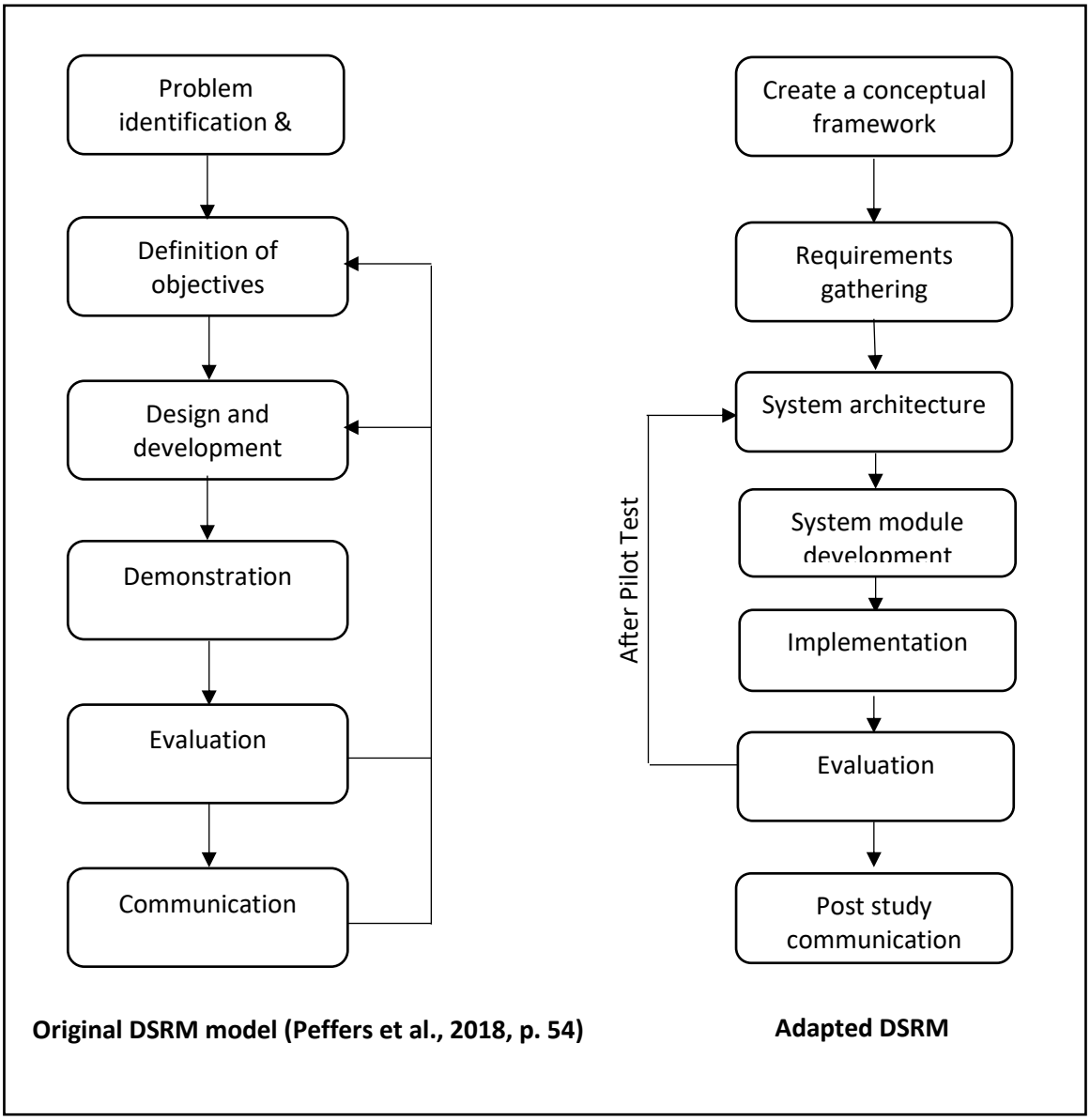

Figure 4.1: A DSRM process model

The original DSRM model calls for an iteration that goes back to the objectives design and development, evaluation and finally communication. While this is an ideal process, during the study, it was not possible to review the objectives as they were already approved by both the university and two different ethics

committees. The adopted DSRM allowed for an iteration to run after the requirements gathering stage. The adopted model allowed for a creation of a framework and adopted requirements gathering similar to the definition of objectives. The design and development phase of the original phase was exploded to represent the system architecture, system module development and implementation processes. The main advantage of the adopted DSRM was its customization to the study to allow for an iteration of the system design and development.

4.3. Artefact Design and Development

4.3.1. Step 1: Conceptual Framework

Wieringa (2014) treats the problem investigation step as a phase to find the relevance of the study. This includes identifying a need, data collection as well as the creation of a conceptual framework. The problem was already defined during the inception of the study. It involved empowering pregnant women to seek and attend ANC visits as well as give birth in the presence of a skilled birth attendant thereby reducing complications that led to maternal mortality. Women die during pregnancy and childbirth due to a lack of information that is necessary to identify danger symptoms. Empowering a woman has been shown to have direct positive outcomes regarding mortalities (LeFevre et al., 2018; Lund et al., 2014; Oyeyemi and Wynn, 2014; Rono et al., 2018).

With the problem defined the first step in the DSRM was the creation of a conceptual framework that would guide the further steps of the DSRM process model. Section 1.2 noted that women died due to a lack of information to identify danger symptoms throughout pregnancy. Additionally, section 2.5 showed that complications during pregnancy occurred because of an inadequacy of ANC visits and a lack of skilled workers during delivery.

Section 2.9.3, 2.9.4 and 2.9.5 presents a discussion of existing frameworks that are aimed at understanding the causes of neonatal and maternal mortality. The frameworks, however, do not provide mitigating factors that would result in favourable outcomes during pregnancy and childbirth. Based on the problem statement and the gaps identified within the frameworks, a conceptual framework was developed by the researcher that informed the design of the artefact. Figure 4.2 shows the conceptual framework.

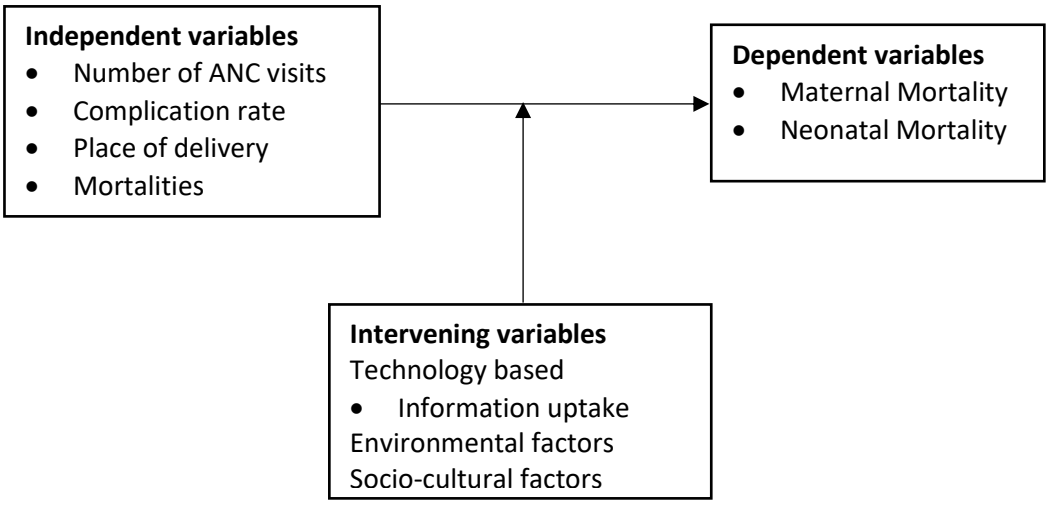

Figure 4.2: Conceptual Framework

The proposed system relied on four main independent variables: the number of ANC visits, the complication rate, the place of delivery and the number of mortalities. The independent variables led to the detection of maternal and neonatal mortalities. This, in turn, was dependent on the intervening variables including the information uptake which was technology-based. The intervening variables used the global system for mobile communication (GSM) technology to inform the system design. GSM is defined as "*the universally accepted standard for digital cellular communication*" (N.Sasikiran, 2015). The dependent variables included maternal and neonatal mortality and a reduction in both would be influenced by the intervention based on the intervening variables.

4.3.2. Step 2: Requirements Gathering

The requirements gathering phase was used to collect data based on the study objectives. The main study used a two-phase approach and the requirements were gathered in phase 1. Phase 1a of the retrospective study used a chart review where various statistics from the health centre were collected, recorded and analysed. Additionally, a cross-sectional survey was employed. Specifically, an interview and questionnaire tool were used to collect data from nurses and pregnant women respectively. The questionnaire was used to check the viability of using a mobile intervention and as a data collection tool for areas that the intervention would cover. The nurse's interview was used to collect data on the problem situation and suggested possible solutions. The data collection instruments were discussed in the methodology chapter. The requirements were informed by the results from phase 1 of the study and through recommendations from the literature review.

Based on a review of literature, an SMS system was deemed suitable to inform and empower pregnant women within Kajiado North Constituency. This was informed due to the availability of the technology, the cost and literacy levels. Baseline studies were conducted prior to the system design to collect requirements. Interviews, document review and surveys were conducted to check the viability of using an SMS system to empower the pregnant women. The results from the three tools guided the requirements of the system. The requirements had at least three parts. First, the system would allow for messages to be sent to the participants. Second, the system would allow for participant details to be recorded and for the participants to be clustered into groups. Third, the system would allow for messages to be scheduled in advance based on the messaging schedule (Annexure 7). Fourth, the system would allow for delivery reports that would allow the researcher to monitor messages sent. Finally, the system would allow for reports to be extracted.

Additional requirements collected from the literature were based on recommendations by Tomlinson et al. (2013) where the system designed would allow for personally tailored messages, were sent based on user preferences (frequency) and wording of the messages was customizable and relevant.

4.3.3. Step 3: System Architecture

Based on the analysis of the requirements gathering phase, it was determined that a mobile SMS system would be a viable tool to send messages aimed at empowering to pregnant women. This was influenced by the women's comfort level with the use of technology and interaction with ICT technology. Each participant owned or had access to a phone where they could receive messages. Most of the users did not have a mobile phone that could neither download nor install a mobile application; hence, the design had to be based on feature rather than smartphones. In addition, the cost of technology development and acquisition influenced the selection of ICT tool.

Based on the requirements gathering, the system architecture components were designed. The main component was an SMS module which interacted with the pregnant women through their mobile phone. The system architecture components are shown in figure 4.3 and the components are discussed in step 4.

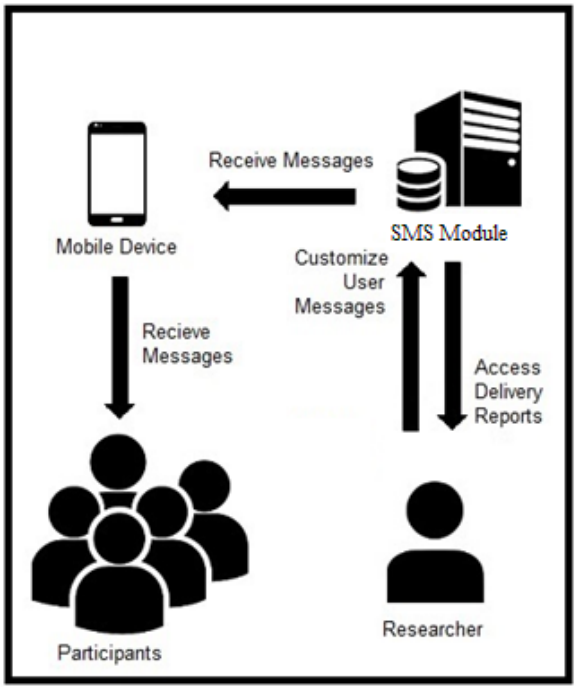

Figure 4.3: First iteration of the system architecture model

The use case shown in Figure 4.4 was used to model the interaction between the researcher and the system.

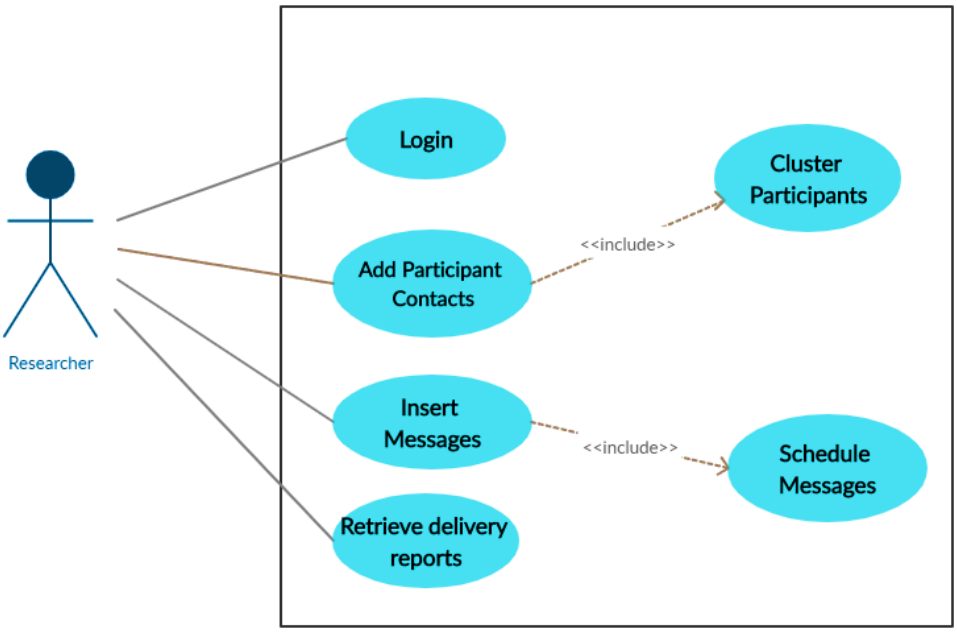

Figure 4.4: The researcher Use Case

Additionally, as shown in Figure 4.5, a context diagram was developed that showed an overview of the system users and their roles.

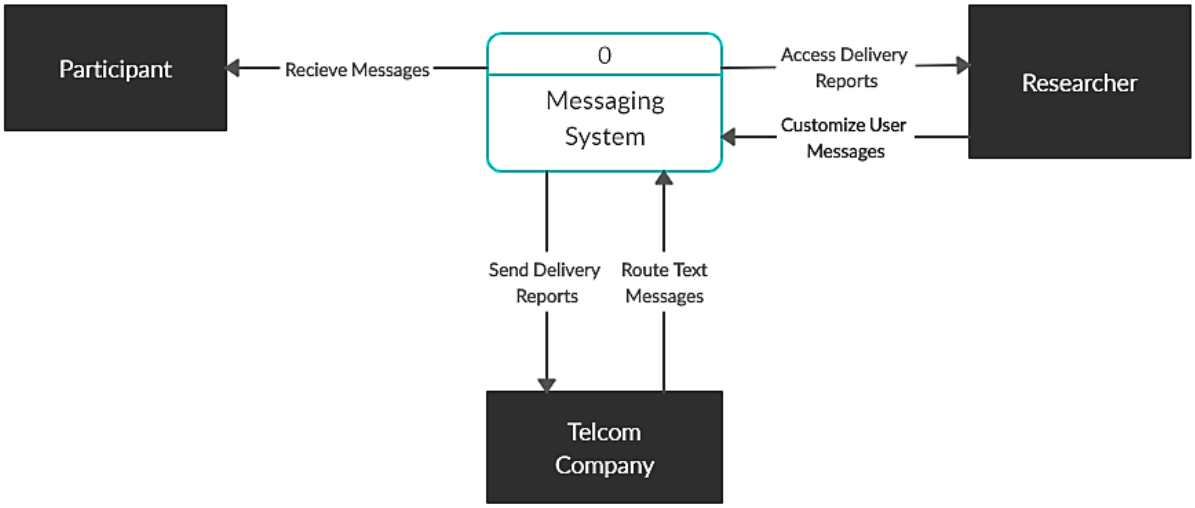

Figure 4.5: System Context diagram

4.3.4. Step 4: System Module Development

The system that was designed was informed by the requirements gathering, the conceptual framework and the system architecture. During the first iteration, the data collection and storage tools were manual as the focus was on the pregnant women receiving messages. An SMS system was developed during this phase.

The system that was to be designed included an SMS module, a data collection module and a storage module. The SMS module as shown in the system architecture would be used to send messages to the Randomized control trial (RCT) participants. In the first iteration, data collection and data storage were done manually.

SMS system module

The bulk SMS application was created in collaboration with a bulk SMS reseller. A web application was created that included an SMS dashboard as shown in annexure 16 (Alpha Manuscript Limited (2016). This was selected due to the ease

and reliability of using from any location and any machine. The requirements for the SMS dashboard included PHP 5.3 and the Altorouter framework. The AltoRouter is a routing class for PHP 5.3 and was chosen and it provided dynamic and reversed routing which was necessary when building the SMS dashboard. The SMS dashboard was then integrated with an SMS API that would be used as a gateway to send out messages. This was done to allow for messages to be sent out by the Telcom company. The SMS API allowed for a status update from the telecommunication company, while the SMS dashboard picked the response from the SMS API. This then allowed for messages to be tracked. The SMS API used was Africa's Talking API cloud. Africa's Talking API was selected due to its versatility, the capability to scale up and overall reliability as a tested system.

The SMS dashboard contained two sub-modules: a user details module and reporting module. The user details module was used to enter the participants' ID, phone number and the cluster they belonged to. Clustering allowed for personalization of the messages sent to participants. The reporting module allowed the researcher to view delivery reports of messages sent. Furthermore, the system was automated where messages could be scheduled in advance to go out on a certain day at a certain time based on user preferences. The reporting module was key in determining failed and undelivered messages.

4.3.5. Step 5: Implementation

The first iteration involved running a pilot test to run a system check on the SMS module developed in step 4. The pilot test was conducted using a quasi-experimental approach that involved 30 participants. The pilot test was used to check on the viability, usability and reliability of the module developed. Additional details on the pilot test are discussed within the pilot test section.

Pilot Test

Walliman (2018) defines a pilot study as a preliminary undertaking where a researcher may need to do a pre-run study or do a field observation. A pilot test was conducted at the OHC location. The pilot test was used to perform usability testing in order to ensure that the users did not reject the system nor use the system inappropriately and that the system did not fail (Thies et al., 2017). The results of the pilot test paved the way for an iteration that included a modified system architecture.

The pilot test used a quasi-experimental design. The pilot test was used to evaluate the feasibility, cost and reliability of the system prior to the main RCT. Thirty participants were used to validate the SMS system. The methods outlined were piloted in order to assess the viability of the system, test the appropriateness of the delivery method while refining the tool used based on the recommendations.

4.3.6. Step 6: Evaluation

During the pilot test, usability and integration testing were done and both failed. During the pilot phase, the SMS dashboard encountered errors and network issues. The SMS module was unable to send messages as scheduled and messages recorded as sent out were not received by the recipients. In addition, the delivery reports could not be accessed, and it was challenging to check which participants had not received the messages.

Owing to the various challenges, it was determined that the use of an already existing system was necessary to save time and the cost that would have been necessary to overhaul the system to fix these errors.

A manual survey was conducted on the participants from the pilot test. The researcher spent a great deal of time, checking the manual questionnaires and recording the responses. Additionally, several participants were unavailable to provide responses as they were busy tending to their new-borns. In order to

reduce time, the system incorporated the functionality of an automated way of collecting and storing participant survey data.

4.3.7. Step 3: Iterative System Architecture

Based on the results of the pilot test, it was determined that a mobile bulk SMS system would be used together with an automated data collection and storage tool. In addition, one of the challenges of implementing an SMS system is data management (Brown et al., 2018). The automated data collection and storage tools were aimed at easing the work of the researcher and to ensure transparency during data collection (Steiner et al., 2016).

The system architecture was redesigned and recreated based on the recommendations from the various challenges during the pilot test. The system architecture was modified to ensure that data management was done properly from the researchers' end. The system architecture lent to the modification and design of additional modules that were implemented in a two-site two-arm randomized trial.

The system architecture components are shown in figure 4.6 and are discussed in the iterative implementation step. A combination of the three system modules was proposed as it would allow message reliability, consistent data collection and storage

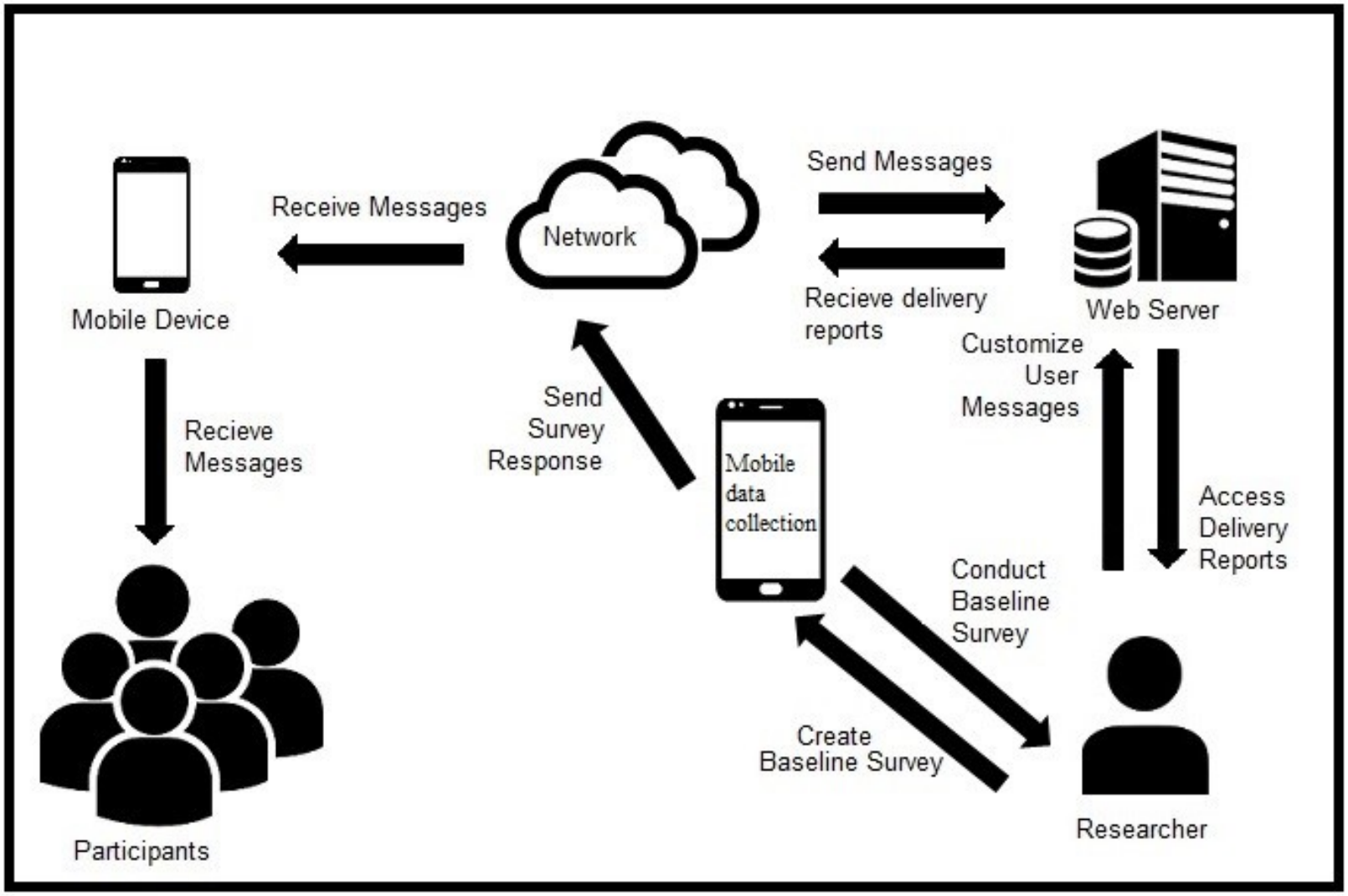

Figure 4.6: Modified system Architecture

4.3.8. Step 4: Iterative System Module Development

Based on the iteration system architecture, additional modules were developed. The SMS system would be used to send messages to the RCT participants and retrieve reports for the researcher. The data collection module would be used to create and collect participant survey data at the conclusion of the main study. Finally, the data storage module would work in tandem with the data collection module and would allow for results to be stored online.

4.3.8.1. SMS System Module: Iteration 1

Selection of a bulk SMS system was done based on provider reviews, cost, and reliability. Uwazii bulk SMS system was selected. Details of the bulk SMS system are provided in the section below.

The Uwazii bulk SMS service entailed three modules: 1) communicate, 2) target and 3) analyse. The communicate module allowed for a broadcast system where the researcher could schedule messages based on the participants' cohort. Within the module advanced options allowed for delivery reports to be pulled from the Telcom servers. The target module allowed for the participant details to be keyed in including details of the cohort they belonged in. Finally, the analyse module allowed for reports on the delivery status (delivered, pending, rejected, undeliverable and expired messages), and logs based on messages sent out within a couple of hours. This message logs and reports allowed for data to be exported for further analysis. Figure 4.7 below is an illustration of the messaging pathway.

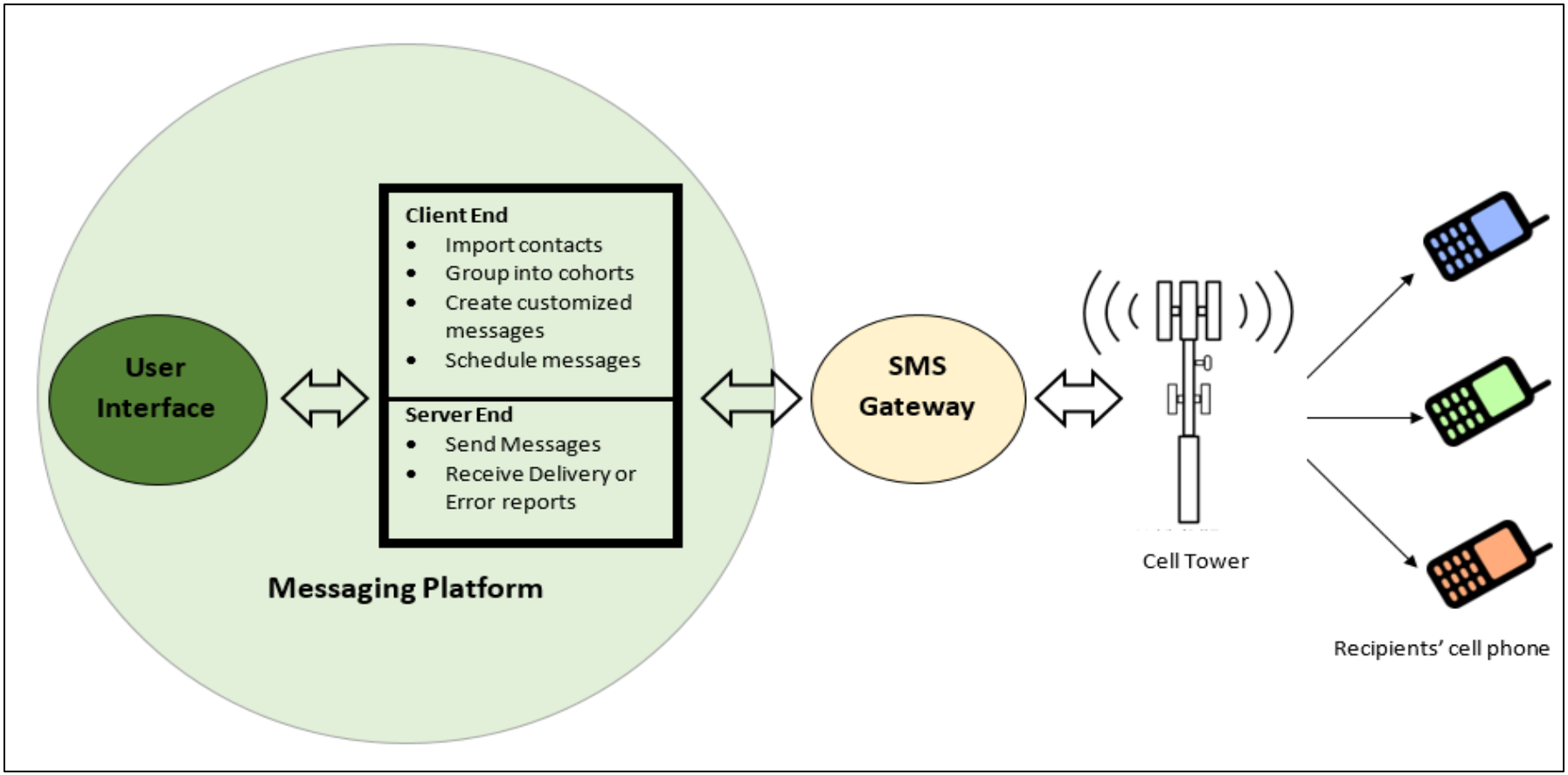

Figure 4.7: Bulk SMS messaging pathway

4.3.8.2. Data Collection Module

One of the challenges the researcher faced during the pilot test was tracking pregnant women and having them answer questions through a physical questionnaire. It was deemed necessary to come up with an online system that would allow the researcher to collect and record participant responses in real-time and in a more convenient manner for participants. Consequently, the cell-phone automated questionnaire was designed and used during the second iteration of the DSRM model. The questionnaire was automated as answers were automatically captured and coded on the phone or tablet and stored in a manner that allowed for easier retrieval during analysis.

Open Data Kit (ODK) was used to collect the post-test questionnaire (Annexure 6) data (ODK Community, 2017). The post-test questionnaire was automated as this allowed an easier way to monitor responses and to analyze the data in a more efficient way. Additionally, automation of the questionnaire (sample provided in annexure 17) allowed the researcher to save time and reduce the amount of effort required to track the women down physically. Automation of the questionnaire allowed for phone calls to be made while indicating responses of the participants on the online questionnaire.

The post-test questionnaire (annexure 6) was first created and coded in eXtensible Markup Language (XML) form. This was an ODK requirement and was created directly on Microsoft Excel. Creating the form directly on Microsoft Excel ensured that a specific format was followed an all core areas of the form were created. The health worker interview questions (Annexure 8) and the pre-trial questionnaire (Annexure 5) were also created and coded in XML form. Once the answers and questions had been coded, then a tool called XLSForm was used to convert the XML form into an XLS form. The XLS version is used by many data collection applications such as ODK that was used in the project. Once the XLS form was created, it was validated through the ODK Validate tool. The ODK

Validate tool was used to ensure that XLS forms created from XML conformed to the specifications set out by ODK. XLS forms were used due to their flexible application. Additionally, XLS forms are versatile allowing for a wide range of forms and allow for coding to be done directly during form creation. One advantage of using the ODK tool was the fact that forms were coded prior to data collection hence making the analysis faster, more accurate and less prone to errors. Due to the automation, this aided in clean data and more reliable study results. Open Data Kit open-source nature made it a cost-effective solution as a data collection tool.

The ODK Collect was the tool used to collect data. The tool was set up on the researchers' tablet to test the XLS form. The ODK tool could be installed on any Android phone thus allowing for faster and easy data collection. Sample screens of the forms used on ODK are shown in figure 4.8.

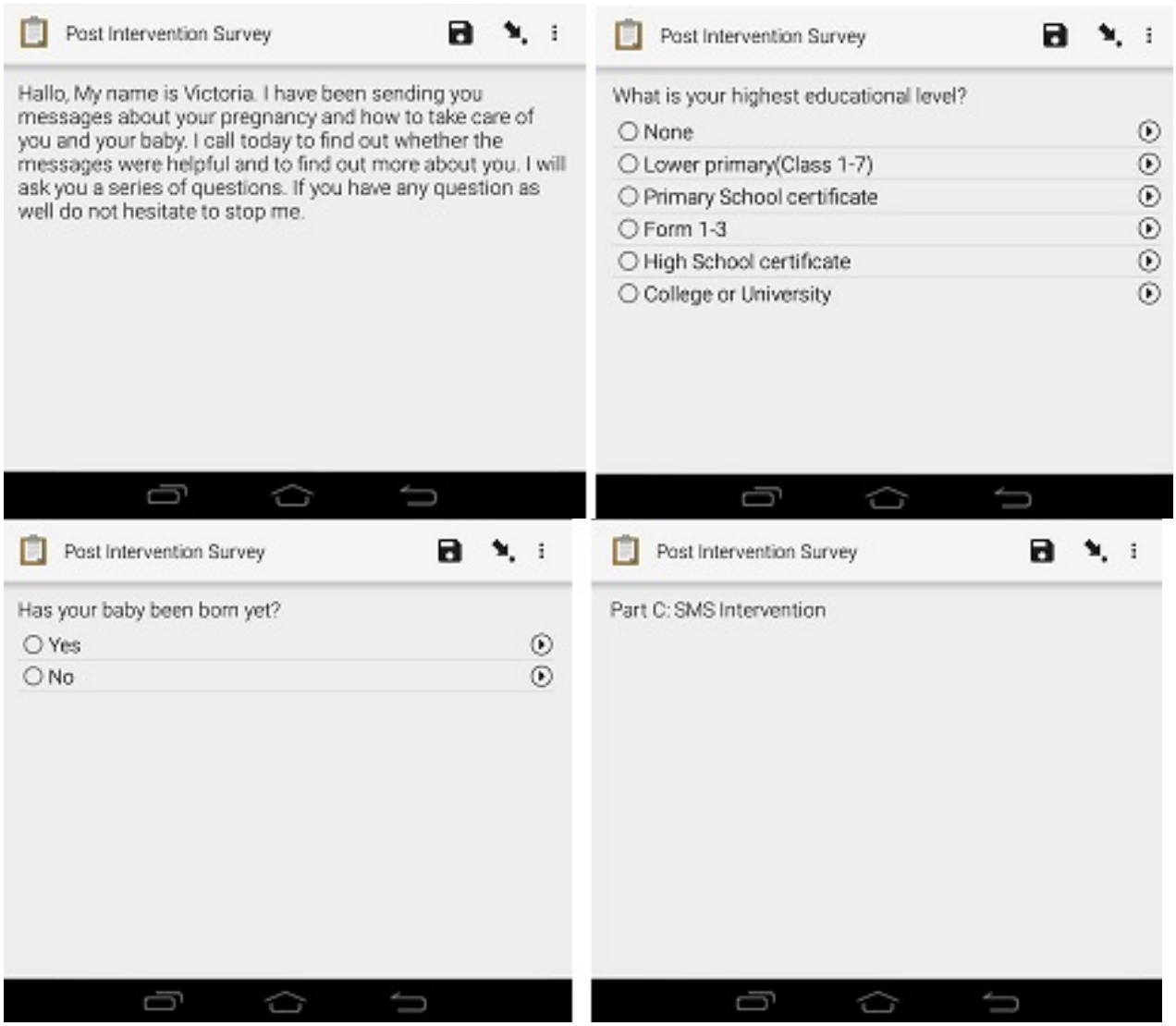

Figure 4.8: Sample ODK screenshots

4.3.8.3. Data Storage Module

The ODK Collect tool from the data collection module needed an online storage facility. A Google aggregate server was selected located on the URL: https://maternalhealth-1287.appspot.com/Aggregate.html. The Google Aggregate was selected due to its wide versatility, scalability to accommodate larger projects and its cost-effective nature. Since all the participant data was coded and had identifiers, the data stored could not be associated with one specific individual.

The Google Aggregate server database is proprietary hence unavailability of the database design. The database stored information of single forms as tables and did not mix up data from multiple fields or multiple forms. This was an advantage because it separated the various forms used within the study and allowed for better analysis. The study had three different questionnaire forms that were used with different fields hence data was not compromised as it was stored in separate tables.

In addition to the Comma Separated Values (CSV) that were used during the study, the database also supported the generation of Keyhole Markup Language (KML) output files. The use of CSV and KML was key as most statistical software such as SPSS and Stata accept manipulation of data in the two formats. The database stored integer and decimal values as integer and numeric datatypes. This was useful as the datatypes allowed the data visualization software direct access to the data and could be accessed directly from the aggregate homepage. Google Query Language (GQL) is like Structured Query Language (SQL) and was used in the storage, retrieval and manipulation of the data. The data was also put in a data set that allowed for access by other parties in the event they needed to conduct a similar study. The data set can be accessed from the Google Aggregate URL provided at the beginning of the section. The datatypes used for the dataset included integer and decimal values.

Information collected in the Google Aggregate server was then exported using the export feature directly on the website. The data was later analysed using SPSS and an add-on called XLSTAT within Microsoft Excel. The XLSTAT is a data analysis tool comparable with SPSS for everyday Microsoft Excel users. The functionality and performance of XLSTAT are also comparable to those of STATA. The XLSTAT was used to perform independent t-tests as well as performing descriptive statistics. Figure 4.9 is a workflow of the form data and its capture on the Google aggregate server and analysis on XLSTAT.

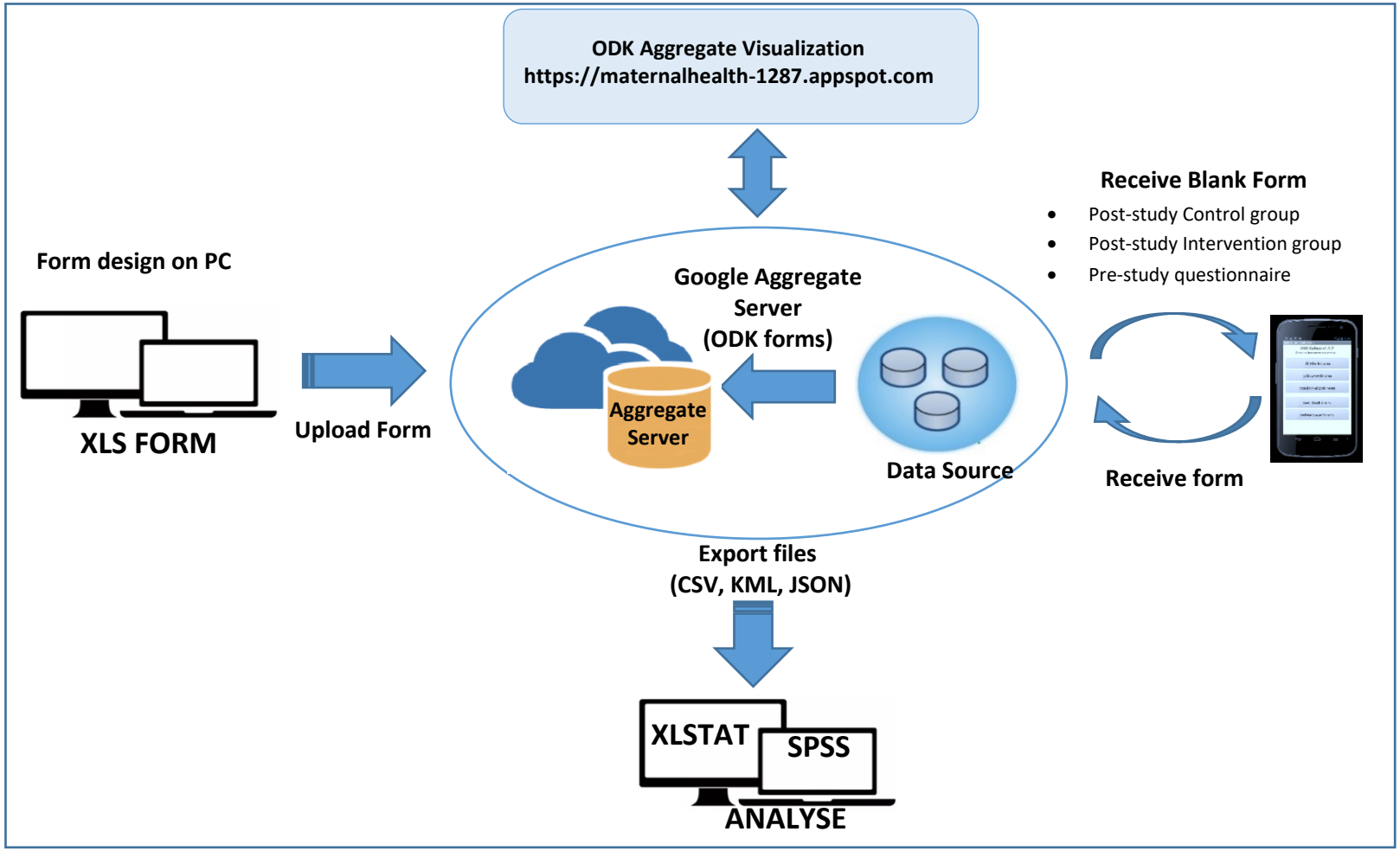

Figure 4.9: ODK form workflow with Google Aggregate server

4.3.9. Step 5: Iterative System Implementation

Once the system was developed, a two-site, two-arm, RCT was conducted using the three-module intervention: a) bulk SMS system, b) automated data collection, and c) automated data storage. Messages were sent bi-weekly to women in the intervention arm of the RCT. The messages ranged from well-being messages to appointment reminders. Messages were sent to various cohorts during the RCT. The cohort was based on a group of women within the same gestational week of pregnancy. Women were grouped into cohorts prior to their details placed into communicate module. The messages that were then sent out were based on each cohort and recommendations by the health workers.

Participant data stored on the Google Aggregate server, the bulk SMS system and collected on ODK was treated confidentially and was anonymous. Each participant was issued with a participant ID that was used to store the records on the three modules. The conclusion of the RCT allowed for a collection of results to understand the impact of the intervention. Results from the RCT are reviewed in chapter five while the inferences from the results are discussed in chapter six.

4.3.10. Step 6: Iterative Evaluation and Communication

The evaluation was done through the analysis of the results from the RCT. Users answered questions during the post-test survey on whether the system aided in improving their knowledge on matters maternal health and well-being. Post-study system evaluation on the effectiveness of the system was also conducted. The DSRM model requires findings to be communicated once the implementation phase is done. This was done exhaustively within chapter five and six.

4.4. Summary

This chapter described the DSRM methodology that was used to design and implement the RCT artefact. The various DSRM steps were detailed. The next chapter reviews the results from the retrospective phase and the prospective RCT phase.

CHAPTER 5: RESULTS

5.1. Introduction

Chapter five presents the findings from phases 1 and 2 of the study. Data relationships were explored in this chapter as well. The data collected in phase 1 is presented first, hence informing the data that was collected in the prospective phase. This allows the reader to understand how the data from the retrospective phase was used in the prospective phase.

5.2. Phase 1: Retrospective and Cross Sectional Results

5.2.1. Objective 1: Status of Maternal Mortality and Morbidity Rates Within Kajiado North Constituency

The aim of this section is to determine the maternal and mortality rates within the two health facilities in Kajiado North Constituency. This is provided by information on ANC and delivery ward records. During this first phase, data were collected for a period of six months at the constituency level between January and June 2016. Data collected included statistics on the Antenatal care (ANC) records from Ongata Health Centre (OHC) and Ngong Sub-District (NSD). Additional data included delivery rates by skilled staff at both locations. The six-month data allowed for a comparison with data collected during the subsequent months when the intervention was applied.

5.2.1.1. ANC Records

A total of 2728 and 3563 patients were seen at the OHC and NSD respectively during the six-month data collection period. Various indicators and statistics are represented on Table 5.1. The average number of first time ANC visit patients at the OHC and NSD were 149 and 207 respectively.

Table 5.1: 6-Month ANC records at OHC and NSD

	OHC	NSD
Indicators		
First Visit	*952 (34.9 %)*	*1231 (34.6%)*
Revisit	*1776 (65.1%)*	*2332 (65.5%)*
Total Visits	***2728 (100%)***	***3563 (100%)***
Completed 4th Visit	*427 (15.7%)*	*393 (11%)*
15 - 19 Year Olds	*337 (12.4%)*	*130 (3.7%)*

5.2.1.2. Maternity Ward Records

A total of 367 births were recorded at OHC while NSD recorded a total of 595 births. Out of the births at OHC, 54 (14.7%) were women referred to other hospitals while a total of 76 (12.8%) women were referred to other hospitals at NSD. Both facilities did not register any maternal deaths during the six-month period. Within the same period, the number of stillbirths reduced in both centres to 0%. The breech babies in NSD decreased to 0% while that of OHC remained unaffected. Table 5.2 shows the number of neonate mortalities and breech births at both OHC and NSD. The data (Breech vs Still-Birth deliveries) from the maternal wards are described.

Table 5.2: Numbers of Breech vs Still-Birth Deliveries for each clinic by month during the retrospective study period.

	OHC		*NSD*	
	Breech	**Still Birth**	**Breech**	**Still Birth**
January	3 (6%)	3 (6%)	0 (0%)	1 (0.01%)
February	1 (2%)	1 (2%)	1 (0.01%)	2 (0.02%)
March	0 (0%)	2 (4%)	0 (0%)	0 (0%)
April	3 (6%)	0 (0%)	1 (0.01%)	1 (0.01%)
May	3 (6%)	0 (0%)	0 (0%)	0 (0%)
June	3 (6%)	0 (0%)	0 (0%)	0 (0%)
Total	**13(20%)**	**6(12%)**	**2(0.02%)**	**4(0.04%)**
Breech Vs Still Birth (p)	**0.418**		**0.150**	
OHC Breech vs NSD Breech (p)	**0.019**			
OHC Stillbirth vs NSD Stillbirth (p)	**0.6**			

Statistic p = significant p<=0.05

There was no significant difference between breech and stillbirth deliveries in each clinic. Breech births at OHC was significantly different from that at the NSD (p=0.019). Additionally, analysis done between the stillbirths at OHC and NSD was not found to be significant.

5.2.2. Objective 2: Determine the Strategies Used by Pregnant Women and Health Workers, to Manage Pregnancy and Childbirth

Results on how pregnancy management was conducted by both the nurses and pregnant women are described below.

1. Nurse

The findings from the IDI are described. There were only two nurses interviewed. Coding allowed the researcher to remain consistent when extracting key points.

The information collected is narrated. Key topics discussed during the IDI are included.

The nurses were drawn from the two health facilities and the data presented is based on the services offered at both facilities, maternal mortality rates within the health facilities and procedures used during ANC, labour and delivery. Additional data is also presented on complications and preventative methods used during labour and delivery and recommendations given to pregnant women.

5.2.2.1. Topics Discussed During Interviews

a) Services Offered at the Health Facilities

The OHC and NSD facilities offered ANC and delivery services. The nurse from the OHC location indicated that the centre offered family planning campaigns in addition to child vaccinations and general outpatient services. The nurse from the NSD location indicated that they had awareness campaigns targeted towards childbearing women and vaccination programs for children below five. The NSD facility also admitted patients to the general ward.

b) Maternal Mortality Concerns Within Kajiado North Constituency

The nurses from the OHC and NSD indicated that there were no maternal mortalities at both facilities during the retrospective period. It was unanimously stated during the interviews that some complications that presented themselves during labour and delivery could be prevented.

Nurse-OHC: "*Sometimes women come to the hospital when they are in the third stage of labour. When we check, the woman has never attended any of the ANC visits and has only come to the hospital due to complications. In most cases, the only thing we can do for the lady is to refer them to Mbagathi or Kenyatta….*"

Similar sentiments were shared by the nurse at the NSD who indicated that most mortalities occur at the referral hospital. Nurse-NSD: "*We have seen women being brought by relatives to the hospital because they had tried to give birth with a traditional birth attendant and when they realised that the woman was about to die, they transferred her to hospital…. When we transfer these women and they die, the hospital they were transferred to ends up with the mortality….".*

According to both nurses' reasons for complications include women not attending ANC clinic in a timely manner (starting ANC visits past the second trimester), not taking supplements, use of traditional birth attendants and women waiting until the last minute to visit a health facility.

c) Procedures Used During ANC and Delivery

The NSD and OHC hospitals employ similar procedures because they are government-owned and are located within the same County. The set procedures at the ANC includes registration of the pregnant woman, wellness talks and thereafter queueing to see the ANC nurse. The pregnant woman's records are recorded on the main hospital record book and on the woman's clinic record book. The records from the main record book were later summarized and placed on the mainboard. In both facilities, first time ANC patients are scheduled on specific days. The OHC location schedules first-time patients for Tuesdays and the NSD on Wednesdays. All other days are reserved for revisits.

Both hospitals only offer vaginal deliveries and referrals are made for any woman who requires a caesarean section (CS). A woman is admitted to the delivery ward when she presents signs of labour. If active labour is not wasn't detected during examination, the woman is asked to return home and come back she is in active labour. After birth, the new mothers are typically discharged from the facility within a day.

d) Preventative methods toward complications

Complications witnessed during pregnancy, labour and delivery were varied. They included hypertension, gestational diabetes, prolonged labour, obstructed labour and severe bleeding. In both OHC and NSD, the nurses indicated that the facility considered a previous CS as a complication. Complications that arose during pregnancy prompted the nurses to refer the women to either Mbagathi or Kenyatta hospital for the remainder of their pregnancy.

Complications during labour and delivery depended on the complexity, resources such as medication available and staff numbers during the shift. Nurse-OHC indicated: "*Sometimes we will get several women on the same night in labour and we only work in twos. In case one of the women has a complication as simple as the water breaking and the labour is progressing slowly, we will transfer them so that we can take care of others…"*

Nurse-NSD: "*It is frustrating that we transfer women for simple complications that we can manage if we had the right resources. We rarely have a doctor on call since the medical director who is the main doctor works during the day and is rarely available at night. Other times we transfer women when we even know the child is already dead and there is nothing, we can do to fix it. It is disheartening but what do you do?"*

Both nurses stated that the main mechanism for preventing complications is to identify them during pregnancy and promptly refer the women to better facilities for their ANC clinics. During childbirth, they use their knowledge to resolve any complication that they can before they consider referring the patients.

e) Information provided to women

Nurse at OHC indicated that information given to women is conducted weekly through a talk by the ANC nurses. The talk covers a variety of topics including

nutrition, mother well-being, baby well-being, the importance of supplements and the importance of ANC visits. The nurse at the NSD reiterated the same sentiments and added that they sometimes had non-governmental organizations providing talks to the pregnant women on a designated day. The nurses were however sceptical on the effects the talks had and the implementation of the information by the pregnant women.

Nurse-OHC: "*We make sure we have talks once a week with pregnant women. We normally have a good quorum because the women come very early for their clinics. We teach them how to take care of their bodies and when to tell if something is wrong. We try to cover a wide range of topics because the group is normally mixed with women at the beginning of their pregnancy and those that are about to give birth. Sometimes we feel that the women are not normally listening because they tend to not follow what we say…."*

Nurse-NSD: "*We will announce a talk from an NGO. Unless there are goodies to be given, pregnant women who did not have an appointment on the day will not come. Sometimes we will do the talk and then when we start seeing them for their visit, you ask if they have been taking IFAS supplement tablets consistently. They say they forgot…"*

According to both nurses, it is imperative to remind the pregnant women about their appointments, to remember to take their supplements and to educate the women. The nurses specified that while the talks were a good start, they would possibly be enhanced by having classes for women within the same trimester as opposed to bundling women together in one class.

2. Pregnant women

The cross-sectional survey was conducted only at the OHC facility. Data were collected on the demographic details of the pregnant women, mobile system viability and the informational preferences of each woman. A total of 30

questionnaires were handed out and a total of 27 were returned to be analysed resulting in a response rate of 90%.

5.2.2.2. Demographic Profile of the Participants

The respondents' age range was 17 years to 38 years (mean=23). Most of the respondents (n=11) were 21 to 25 years old, 48.2% (n=13) of the respondents preferred English and Kiswahili as the means of communication while 44.4% (n=18) of the respondents had completed high school. The majority, 81.4% were married while 40.7% of the respondents were dependent on their families or spouses. Out of the married respondents, 63% of them were either unemployed (n=6) or dependent (n=11) on their spouses. Thirteen (43.3%) respondents were on their first pregnancy, 46.7% (n=14) had more than one pregnancy while 10% of the respondents did not answer the question.

With 63% of respondents being dependent on their spouse or other relatives, the average household income rate as shown was quite low. Over 66% (n=18) of the respondents earned less than 10,000 Kenya shillings (KShs) per month. The amount of time and cost incurred while travelling to the health centre was also recorded. Of the respondents, 43.3% (n=13) took one to two hours of travel time, while 23.3% (n=7) took less than 30 minutes to get to the clinic. Four of the respondents (13.3%) did not respond to the question. Travel cost ranged between 20 and 100 KShs with 26.7% (n=8) spending 50 KShs to get to the clinic and 20% (n=6) spending 20 KShs to get to the clinic. The mean cost of the participants to get to the health centre was 53 KShs. The discussions discussed are represented in Table 5.3 which shows the respondents demographic data from the cross-sectional survey that was conducted at the OHC location.

Table 5.3: Demographic profile of participants from the cross-sectional survey conducted only at the OHC

Demographic Features	Frequency	Percent
Age of the Respondents		
17 - 20 Years	10	37.04
21 - 25 Years	11	40.74
26 - 30 Years	2	7.41
30 - 35 Years	3	11.11
>35 Years	1	3.70
Total	**27**	**100**
Language Preference		
Both English and Kiswahili	13	48.15
Kiswahili	6	22.22
English	6	22.22
Other languages	2	7.41
Total	**27**	**100**
Educational Level		
Lower Primary	4	14.81
Primary School Certificate	5	18.52
Form 1-3	6	22.22
High School Certificate	11	40.74
College or University	1	3.70
Total	**27**	**100**
Marital Status		
Married	22	81.48
Single	4	14.81
Missing	1	3.70
Total	**27**	**100**
Employment Status		
Part-Time	1	3.70
Self-Employed	8	29.63
Dependent (Work at home)	11	40.74
Unemployed	6	22.22
Missing	1	3.70
Total	**27**	**100**
Average Household income (Shillings)		
<2000	8	29.63
2001 - 10,000	10	37.04
10,001 - 40,000	5	18.52
> 40,000	1	3.70
Missing	3	11.11
Total	***27***	***100***

Part of the questionnaire conducted at the OHC location was focused on finding out the viability of the mobile intervention. Out of the 27 respondents, 81.5% (n=22) owned a phone. Five respondents did not have phones but had access to other mobile phones. Three had access to their husbands' phone and the other two had access to a mobile phone within their household. A total of 26 (96.3%) respondents indicated that they would like to receive notifications in the form of SMS with 48.2% preferring more than two messages per week. In addition, 37% preferred two messages per week and 11.1% preferred one message per week. The questionnaire also sought to find out topics' respondents were interested in receiving notifications on and has been summarized in Table 4.3.

A total of 21 (77.9%) respondents indicated they would like to receive information on diet and nutrition. Nineteen (70.4%) of the respondents would like information on things to avoid as well as information on pregnancy and delivery courses. Information to be sent was reviewed by the nurses at the health centres. The messages were randomized to determine which week each message would be sent. Once the messages were scheduled, all participants received the same type of message on the same day based on their gestation week. The messages were also configured as per respondent preference listed in Table 5.3. In total 40 messages were to be sent to women enrolled after the 20th week and each participant received two messages a week. Each message was sent on a specific day of the week for each participant. The message schedule and configuration are attached on Annexure 5c. Table 5.4 also shows how many messages were sent per topic.

Table 5.4: Responses on information participants (n=27) wanted to receive

Message Code	Topics	Respondent Preference	Number of messages
DN	Diet and nutrition	11%	5
TA	Things to avoid	10%	4
PD	Pregnancy & delivery courses	10%	4
AHC	Announcements by the health centre	10%	4
FP	Family planning	9%	4
MH	Mental health	9%	4
AR	Appointment Reminders	9%	4
PA	Physical Activity	9%	3
WE	What to expect at different trimesters	9%	3
WL	What to look out for	7%	3
WD	When to call a doctor	6%	3
	Total	100%	***40***

5.3. Phase 2: Prospective Study

This phase involved deploying the intervention in a two-site, two-arm RCT.

5.3.1. Objective 4: Implement A Mobile Messaging System to Increase ANC Uptake as well as Deliveries by Skilled Staff Within Selected Facilities

The mobile system developed as part of objective three was implemented as an intervention within the RCT. The results presented herein are results from the post-test survey conducted at the conclusion of the RCT.

The OHC location had the RCT conducted first. Once the OHC location RCT concluded and the post-test questionnaire conducted, the NSD study was initiated.

5.3.1.1. Response Rate

The study after consultation with the ANC nurses focused on women who were between 20 and 36 weeks of pregnancy. Advice by the ANC nurses indicated that most of the women who attended the ANC clinic did so during their second trimester, around 20 weeks. Additionally, for the messages to be effective it would be ideal to recruit women below 36 weeks of pregnancy.

Out of the 61 intervention respondents in the OHC trial and 60 at the NSD only 28 and 23 respectively answered the phone and responded to questions from the post-test survey. From the 49 control participants at the OHC trial and 41 at the NSD, only 14 in each responded to the phone and responded to the survey questions. Figure 5.1 shows the distribution of the response rate of the participants.

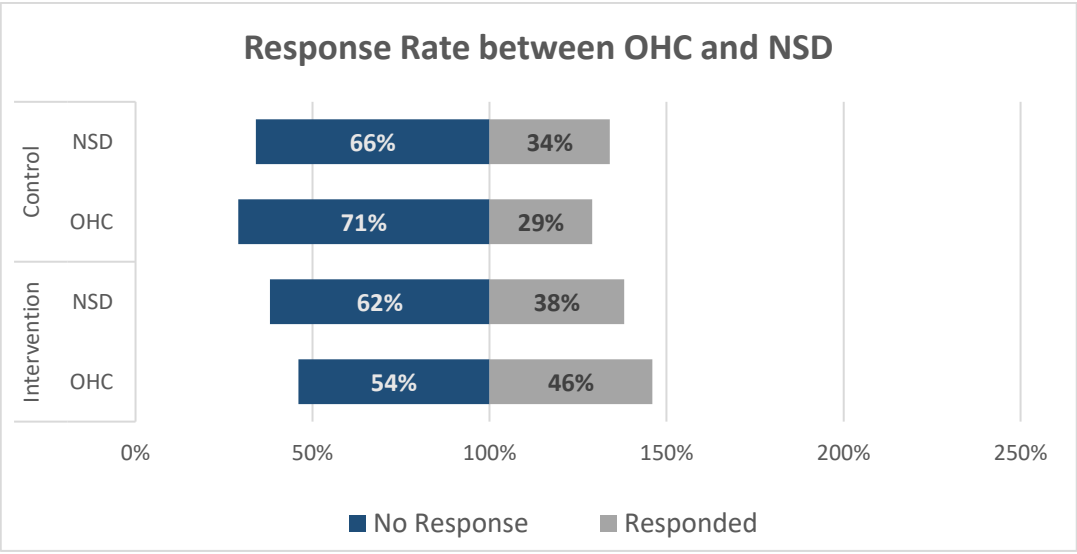

Figure 5.1: Mapping of participants location in relation to the NSD facility

Most women had moved upcountry to seek help with raising their babies and most phones were unanswered or were not in service. The information collected on the demographic details of the participants is described.

5.3.1.2. Age

The average age of the participants at the OHC trial was 27± 4.8. For the intervention, the average age was 26± 4.69 with an age range of 18-39 years. The control group was 27± 4.92 with an age range of 21-38 years.

The average age of the participants at the NSD control trial was 27± 4.874. From the intervention, the average age was 23± 4.86 with an age range of 21-40 years. The control group was 26± 5.08 with an age range of 21-37 years. Figure 5.2 shows the age range of both the intervention and control group within both locations.

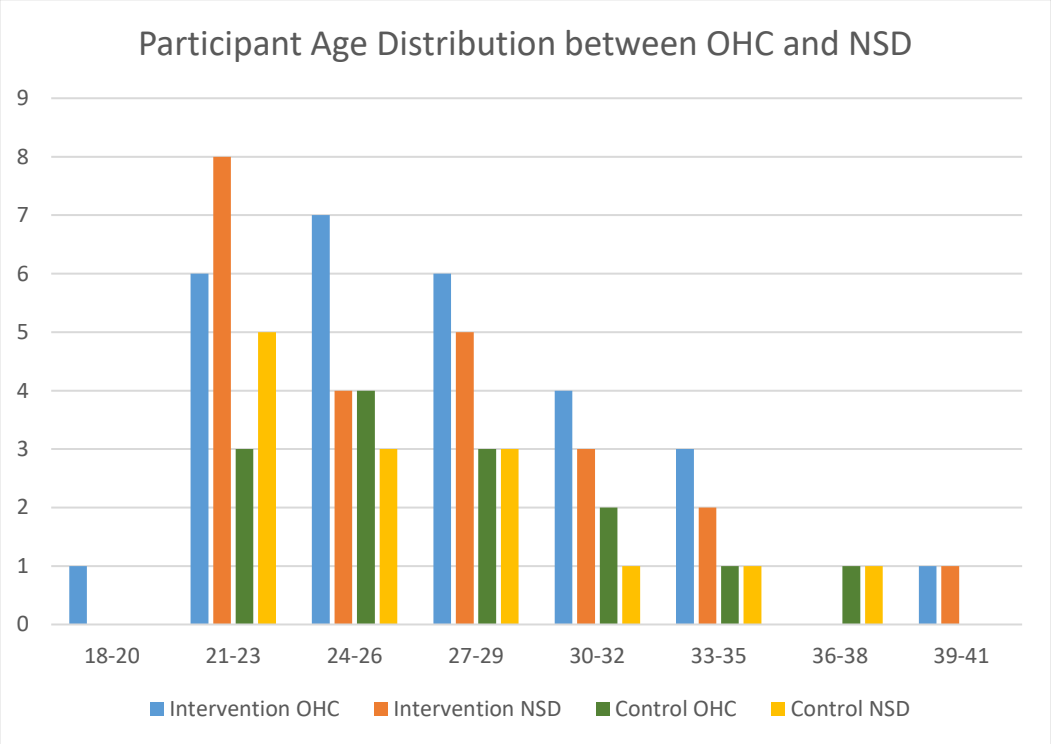

Figure 5.2: Participant Age Distribution between OHC and NSD

Table 5.5 shows the statistical significance between the control and intervention groups at both the OHC and NSD.

Table 5.5: Number of women by age category in the intervention and control arms for each of the two facilities studied

	OHC		*NSD*	
Age Range	***Intervention***	***Control***	***Intervention***	***Control***
Total	**28**	**14**	**23**	**14**
p	**0.733**		**0.969**	

5.3.1.3. Marital Status

From the participants at the OHC location, 85.7% of the participants were either married (n=36) or cohabitating (n=1). At the NSD 73% were either married (n=27) or cohabiting (n=1). At the OHC eight (21.6%) participants were living alone while at NSD the number of participants was 6 (14.3%). At NSD one of the participants was recently widowed. Figure 5.3 represents the marital status of participants at both the NSD and OHC.

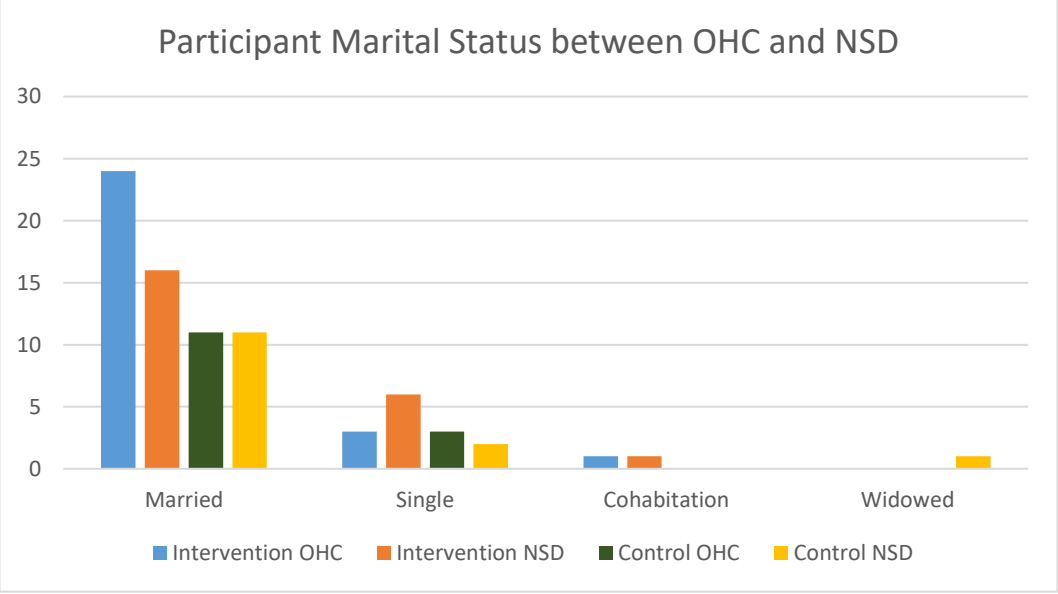

Figure 5.3: Participant Marital Status between OHC and NSD:

5.3.1.4. Educational Background

The educational background of the participants varied. Within the OHC intervention arm, 16 of the participants (57.14%) had a high school certificate and above. In comparison, the OHC control only had two participants (14.28%) with a high school certificate and above. One participant did not provide her educational background details. At the NSD intervention arm, twelve of the participants (52.17%) had a high school certificate and above. This was almost comparable with the control arm where seven of the participants (50%) had a high school certificate and above. Two of the participants within NSD did not have any educational background. Figure 5.4 shows the educational background of the participants at both OHC and NSD locations.

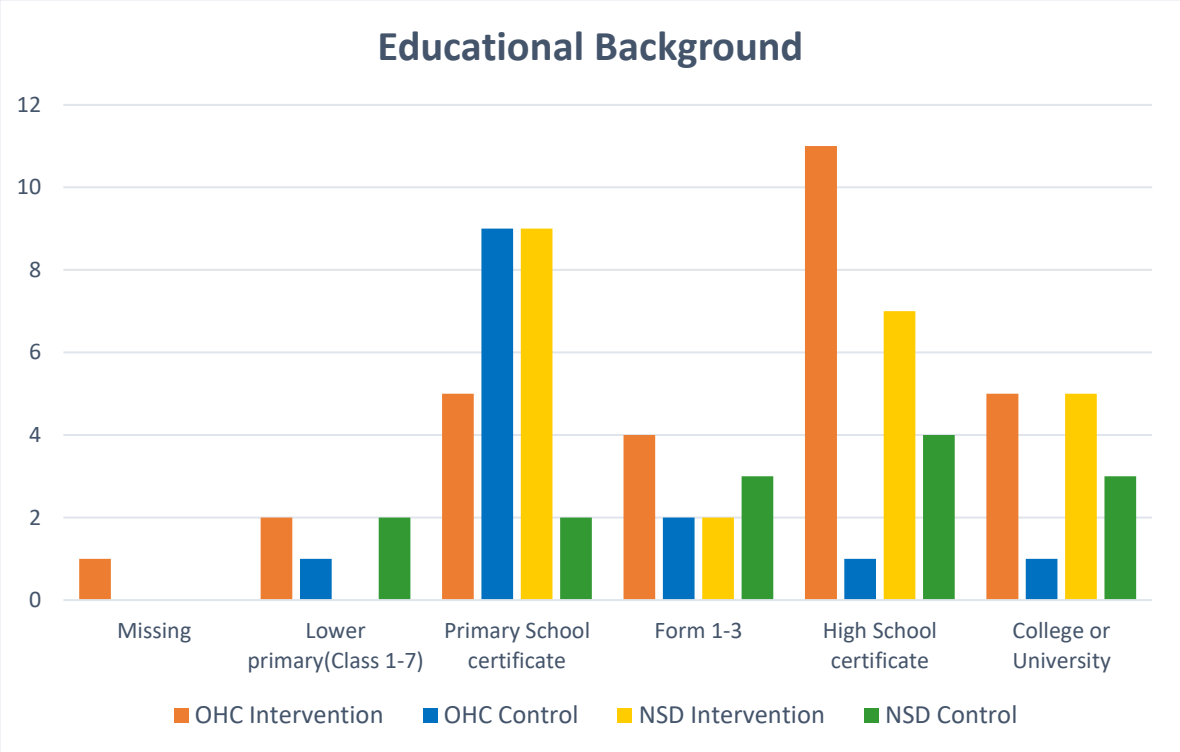

Figure 5.4: Educational background status of participants at OHC and NSD.

5.3.1.5. Employment and Income

At the NSD intervention arm, 60.87 % (n=14) participants were formally employed and 26.09% (n=6) were self-employed or worked on a part-time basis. Within the control arm, 42.86% (n=6) were formally employed and 14.29% (n=2) self-employed or worked on a part-time basis. The number of unemployed participants at the intervention and control arms was 13.04% (n=3) and 42.86% (n=6) respectively. During data collection, the participants were requested to fill in their job titles. The following are the unique job titles found within the NSD location: Teacher, Tailor, Waitress, Petrol Station, Attendant, M-Pesa agent, Chef, Hairdresser, Business lady, Shop attendant, Nanny, Saleswoman, Receptionist, Cleaning and a Kiosk vendor.

The average income at NSD was 7573 ± 3847 KShs with the lowest-earning 1800 and the highest-earning 20000 with. On average thirteen (32.5%) participants earned 5000 KShs per month. Comparing the intervention and the control arms of the trial, the average income for both arms was comparable at 7531 and 7642 KShs respectively.

At the OHC intervention arm, 35.71% (n=10) participants were formally employed and 14.29% (n=4) self-employed or worked on a part-time basis. Within the control arm, 7.14% (n=1) were formally employed and 57.14% (n=8) self-employed or worked on a part-time basis. The number of unemployed participants at the intervention and control arms was 46.43% (n=13) and 35.71% (n=5) respectively. One of the respondents from the intervention arm did not respond to the income question. The following are the unique job titles of the participants within the location: Advocate, Salon, Tailor, Hair Dresser, Nanny, Sales Lady, Videography, Waitress, Business Lady, Kiosk Vendor, M-Pesa attendant, Store Keeper and a Hairdresser.

At the OHC, the average income was 9268 ± 8100 KShs with the lowest participant earning 1800 KShs and the highest-earning 40000 KShs. The respondent with the title advocate earned the highest income at 40000 KShs and

thus gave OHC a higher SD. Additionally, 17 (17.5%) of the respondents earned 10000 KShs. Comparing the intervention and the control arms of the OHC location, the average income for both arms was seen at 11000 and 6015 KShs respectively. The higher average can be explained as the advocate was part of the intervention arm. Figure 5.5 shows the income distribution of both arms of the study at the OHC and NSD locations.

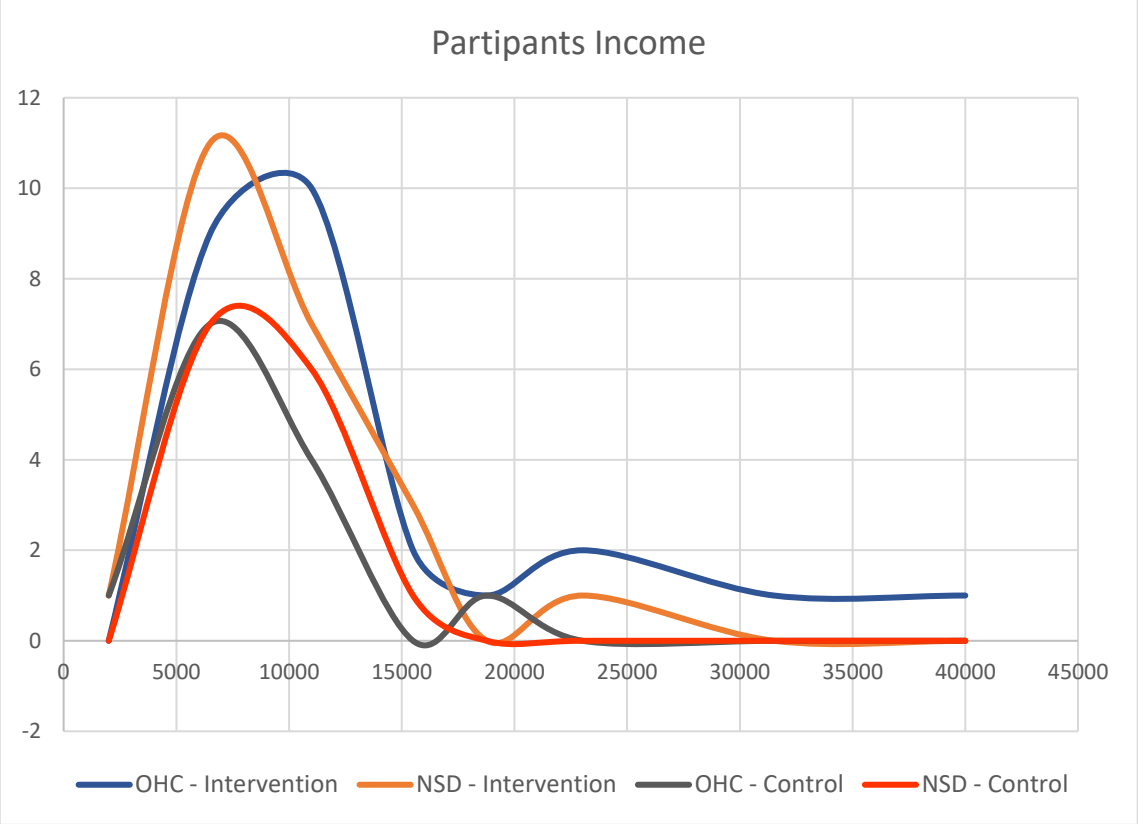

Figure 5.5: Income distribution of the participants at both locations.

5.3.1.6. Area and Distance to the Health Centre

The participants' distance to the health centres was mapped and the distance calculated to each centre. At the OHC the range was 0.354 kilometres (km) 7.191 km from the health centre. The closest distance for the intervention and control arms were 0.354km and 0.713km respectively. The furthest was 7.191 km and

5.462 km respectively. The average distance of the participants at the intervention arm was 1.74 km ±1.55 and those in the control arm at 2.34 km ± 1.76. Figure 5.6 shows a map of the location of the participants at the OHC trial.

Figure 5.6: Mapping of participants location in relation to the OHC facility

At the NSD, the range was 0.717 km to 8.282 km from the health facility. The closest distance for the intervention and control arm was 0.717 km and 0.811 km respectively. The furthest was 8.282 km and 7.372 km respectively. The average distance of the participants at the intervention arm was 3.89 km ± 2.39 and those in the control arm at 3.58 km ± 2.26. Figure 5.7 shows a map of the location of the participants at the NSD trial.

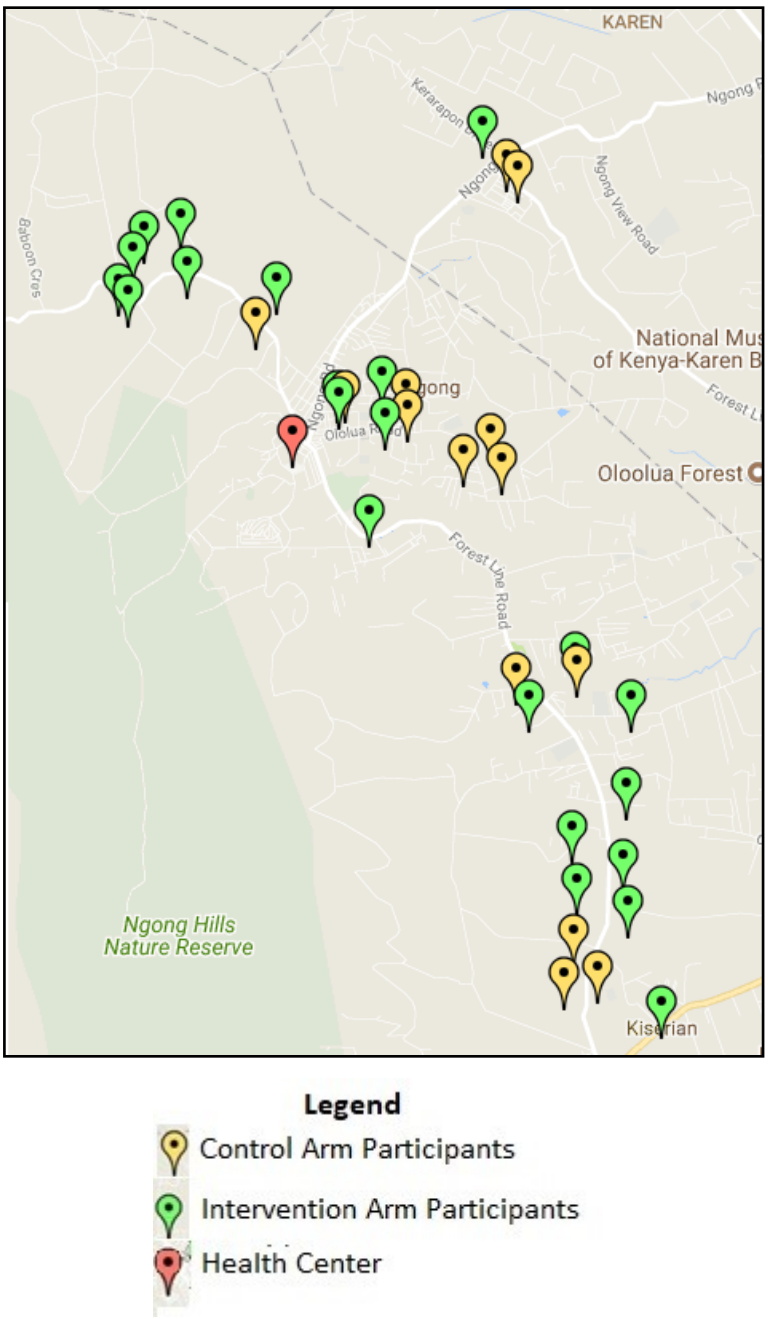

Figure 5.7: Mapping of participants location in relation to the NSD facility

5.3.1.7. Parity

At the NSD 16 (43.5%) participants were primiparous. This percentage for participants who were primiparous was similar in both the intervention and control

arm with 43.5% and 42.5% respectively. At the OHC 13 (30.95%) participants were primiparous. The control group had less primiparous participants at 21.4% with the intervention arm at 35.7%. Figure 5.8 shows the parity between the participant at both locations.

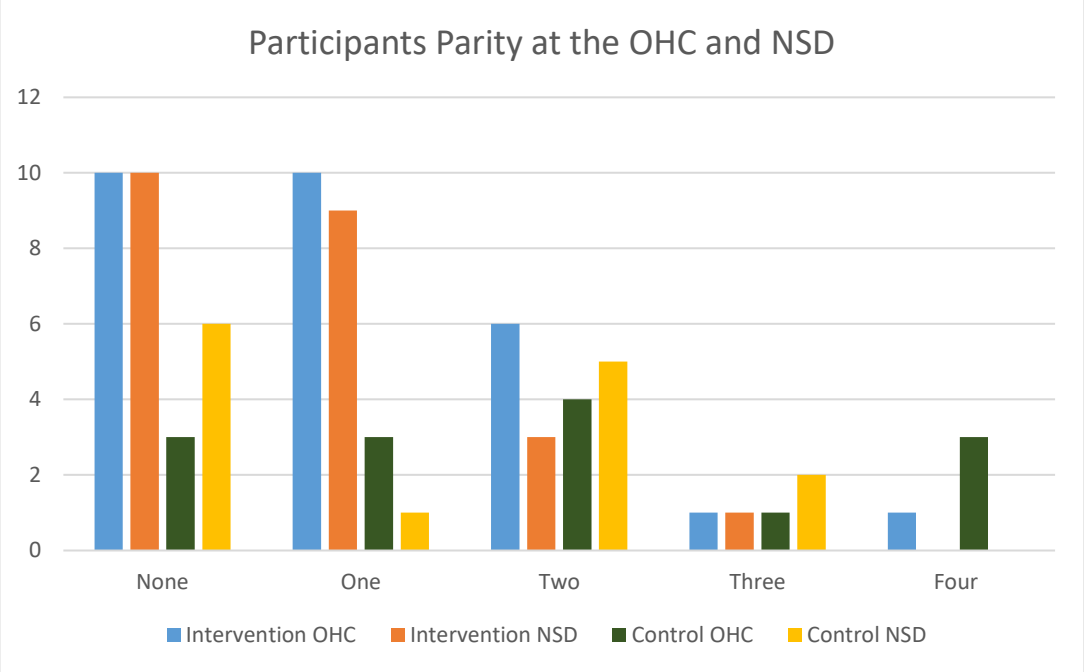

Figure 5.8: Participants Parity at the OHC and NSD

Table 5.6 shows the significance between both arms of the trial at OHC and NSD

Table 5.6: Number of participants by parity at the NSD and OHC

	NSD		*OHC*	
	Intervention	**Control**	**Intervention**	**Control**
Total Parity	**23**	**14**	**28**	**14**
Intervention vs Control (p)	**0.206**		**0.041**	
Intervention Arms (p)	**0.35**			
Control Arms (p)	**0.21**			

There was no significant difference between the intervention and control arm at the NSD. There was a significant difference between both arms at the OHC. The analysis was conducted between the two intervention arms (p=0.35) and between the two control arms (p=0.21) at OHC and NSD. There was no significant difference between the sites.

5.3.1.8. Clinic Visits and Complications

Data presented in this section focuses on the participants' clinic visits during the RCT, the place of birth, complications and mortality rate during the RCT.

5.3.1.8.1. Antenatal Clinic Visits

The ANC visits focused on the current pregnancy during the RCT. All the women in both locations and both arms had more than one visit to the ANC clinic. At the NSD the average visits during the study period were 4.2 visits with the average visits for the intervention arm at 4.1 while that of the control arm was 4.4.

The OHC trial recorded a higher average number of visits at 4.5. This was attributed to a higher number of visits being recorded at the centre. The OHC intervention arm had more participants with seven, eight and nine visits. This brought the average of the intervention arm at 4.7 and that of the control arm to 4.1. Figure 5.9 shows the number of ANC visits between the OHC and NSD locations.

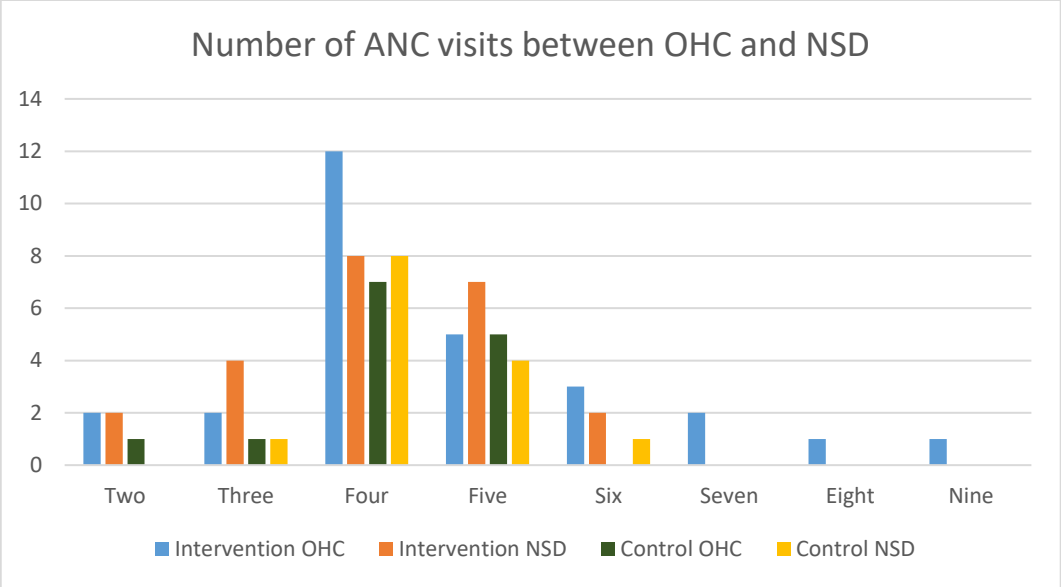

Figure 5.9: Number of participants of ANC visits for each arm at the OHC and NSD locations.

Table 5.7 shows the frequency of the visits in each arm as well as the percentage occurrence at both the NSD and OHC.

Table 5.7: Statistical significance of ANC visits for between the OHC and NSD locations.

	NSD		*OHC*	
	Intervention	**Control**	**Intervention**	**Control**
Total Number of Visits	**23**	**14**	**28**	**14**
Mean	**4.1304**	**4.3571**	**4.7143**	**4.1429**
SD	**1.0998**	**0.7449**	**1.6297**	**0.8644**
Intervention vs Control (p)	**0.5**		**0.228**	
Intervention Arms (p)	**0.14**			
Control Arms (p)	**0.48**			

There was no statistical difference in the ANC visits within both arms at the OHC and NSD locations. The analysis was conducted between the two intervention

arms and between the two control arms at both the OHC and NSD. There was no significant difference between the sites.

5.3.1.8.2. Place of Delivery

Place of delivery indicates the place where the women delivered their babies. Women gave birth at various facilities depending on whether there was a strike ongoing at the time of labour and delivery. The data presented here was collected from the participants then coded based on whether they delivered at NSD/OHC (Local centre), at a referral hospital or on another mission, public or private hospital. The referral hospitals include Kenyatta National Hospital, Mbagathi District Hospital as well as Kikuyu Hospital.

At the NSD location, 40.5% (n=15) of the participants gave birth at the facility while 35.1% (n=13) delivered in a referral hospital and 24.3% (n=9) delivered in other hospitals. At the OHC location, 42.5% (n=17) of the participants gave birth at the facility while 22.5% (n=9) delivered in a referral hospital and 35% (n=14) delivered in other hospitals. Figure 5.10 shows the numbers of deliveries at each health centre, referral hospital and other hospitals at both locations.

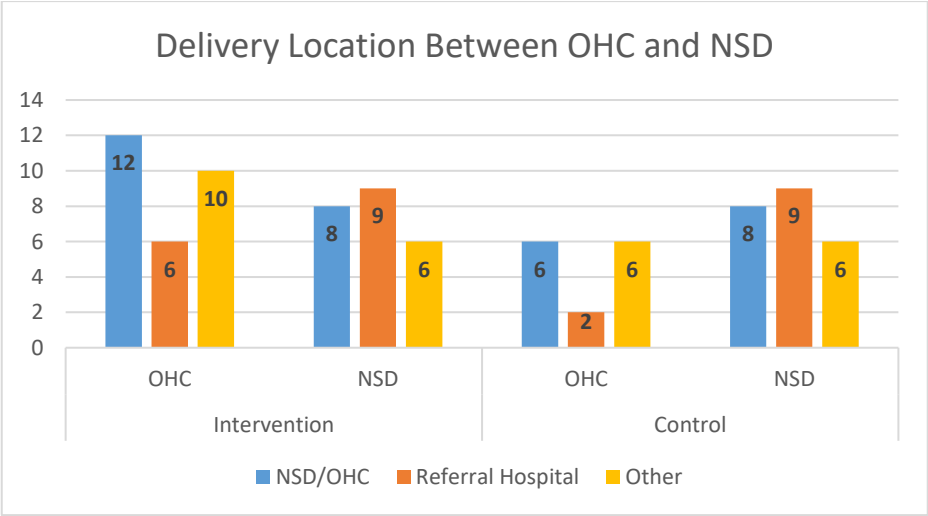

Figure 5.10: Number of participants from NSD and OHC by the location of delivery

Table 5.8 shows the statistical significance between the two arms at both locations.

Table 5.8: Statistical significance between both arms at the NSD and OHC by the location of delivery

	NSD		*OHC*	
	Intervention	**Control**	**Intervention**	**Control**
Place of Birth Totals	**23**	**14**	**28**	**14**
Mean	***1.913***	***1.714***	***1.9286***	***2***
SD	***0.793***	***0.825***	***0.8997***	***0.9608***
Intervention vs Control (p)	***0.477***		***0.818***	
Intervention Arms (p)	***0.95***			
Control Arms (p)	***0.41***			

There was no statistical difference between both arms at the OHC and NSD locations. The analysis was conducted between the two intervention arms and between the two control arms at OHC and NSD. There was no significant difference between the sites.

5.3.1.8.3. Complications

Complications were recorded as those events that may have led to a woman being referred to another hospital or that may have led to a woman having a CS instead of normal vaginal birth. Complications are also recorded as those that may have led to mortality. The complications discussed here are only those that arose during labour and delivery.

At the NSD location, 73.9% (n=17) and 71.4% (n=10) participants did not have any complications within the intervention and control arms respectively. A total of 20 (86.9%) participants and 10 (71.4%) participants had normal vaginal deliveries within the intervention arm and control arms respectively.

Within the OHC location, 71.4% (n=20) and 78.6% (n=11) participants did not have any complications within the intervention and control arms respectively. A total of 25 (89.2%) participants and 12 (85.7%) participants had normal vaginal deliveries within the intervention arm and control arms respectively. Figure 5.11 shows the complication rate compared to the type of delivery in each of the health centres.

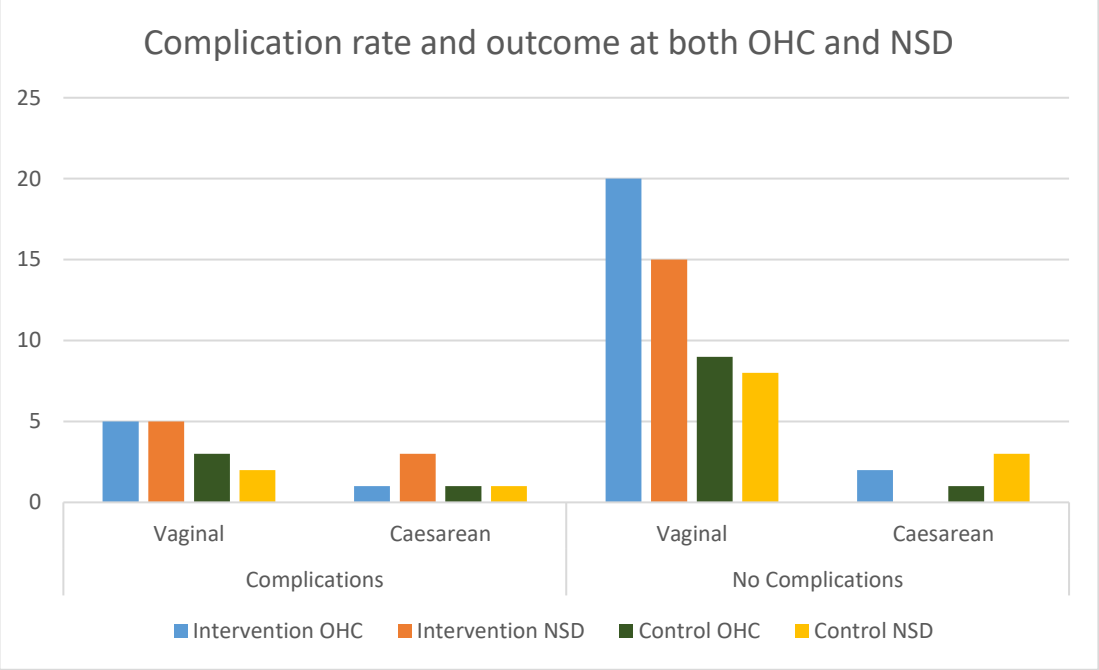

Figure 5.11: Number of participants by the complication rate and the type of delivery for each arm at the NSD and OHC locations

Table 5.9 shows the statistical significance of the complication rate on both arms at the OHC and NSD.

Table 5.9: Number of participants by the complication rate and the type of delivery for each arm at the NSD and OHC locations

	NSD		*OHC*	
	Intervention	***Control***	***Intervention***	***Control***
Complication rates	23	14	28	14
Mean	*1.7857*	*1.6522*	*1.7143*	*1.7857*
SD	*0.4258*	*0.487*	*0.4688*	*0.4179*
Intervention vs Control (P)	*0.183*		*0.723*	
Intervention Arms (P)	*0.314*			
Control Arms (P)	*0.43*			

There was no significant difference between both sites or between the intervention and control arm at the OHC and NSD. The reasons for the complications included prolonged labour, failure to progress, foetal macrosomia (large baby), foetal distress and a baby in a posterior position. The specific reasons for the complications are illustrated below. The women described their experiences as follows:

"My labour went on for days and thus I was asked referred to Kikuyu hospital and they did a CS." (N041 participant from NSD intervention.)

"I did not progress past three cm for several hours and I was referred the next day to Kenyatta National Hospital where I delivered via CS" (N050 participant from NSD intervention)

"They found out that my baby was really big when I went into labour and therefore referred me to Mbagathi hospital." (N057 participant from NSD intervention)

"My baby was in distress and the doctors were on strike, therefore, I could not be referred to a public referral hospital. I ended up getting a CS at St. Anne's." (NI019 participant from NSD control.)

"When I went into labour the baby had turned and was facing the wrong way. I was referred to Mbagathi District hospital and delivered through CS." (S053 participant from the OHC intervention.)

"My baby was growing weak and I was told (the baby) was not getting enough oxygen. An ambulance was called and I was transferred to Mbagathi where I got my baby" (SC27 participant from the OHC intervention.)

5.3.1.8.4. Mortalities

For the study, only neonatal mortalities could be measured. At the NSD no neonatal mortalities were recorded. At the OHC, 7.1% (n=3) of the births were neonate deaths. The intervention arm had one neonatal death while the control arm had two neonatal deaths. The reasons for the neonatal mortalities include intra-uterine foetal death and intrapartum death. The women provided the following explanations as given to them by the doctors about the reasons for the neonatal death. The women described their experiences as follows.

"When I went for my last check-up, the baby's heartbeat could not be located. I had not felt my baby move for some time. They told me my baby died but did not tell me what happened" (S057 from the OHC intervention). The woman visited a different hospital as she indicated the nurses were on strike.

"My water broke but I was not in pain. I went to the hospital and they said I was not in pain and I was sent away. I came back later when in pain and they referred me to another hospital. When I got there the baby had already died" (SC02 from the OHC control) The woman was referred to a different hospital and had to transport herself there since the doctors were on strike in the public hospitals.

"I travelled just when I was due. My labour started on the bus on my way to upcountry. I suffered pain on the bus. When I got to the hospital I was told my child had passed on. I do not think it was the labour on the bus that caused my child to die. My husband was beating me that's why I had to go back home" (SC48 from the OHC control).

There was no significant difference at the OHC clinic between the intervention and control arm. Table 5.10 shows the results of the mortalities at the OHC.

Table 5.10: Neonatal mortalities at each arm at the OHC location

	OHC	
	Intervention	***Control***
Neonatal deaths	1	3
No neonatal deaths	27	11
Totals	**28**	**14**
Mean	***0.036***	***0.214***
SD	***0.036***	***0.113***
Intervention vs Control (p)	***0.154***	

5.3.2. Objective 5: Lower the MMR Rates that are a Result of Complications by Increasing ANC visits and Skilled Worker Deliveries.

This section presents the results that focused on looking at the relationship between ANC, delivery, place of birth and their effect on complications.

5.3.2.1. Antenatal Clinic Visits in Comparison to Complications

Data on both ANC visits and complications were both individually presented in the previous section. This section looks at the relationship between a low or high ANC intake and a low or high rate of complications between both locations. Low visits are defined as less than 4 visits.

At the NSD trial, only one participant (N050) in the intervention group had a low number of ANC visits (n=3) and ended up with complications. The participant, however, was referred to the national referral hospital and the baby was born alive and well.

At the OHC trial, only one participant (SC48) in the control group had a low number of ANC visits (n=3) and ended up with complications. Unfortunately, the participant neither visited the OHC clinic to deliver nor were they referred to a different hospital and ended up with a neonate death. Figure 5.12 presents the complication rates in relation to the ANC visits at the NSD and OHC trial.

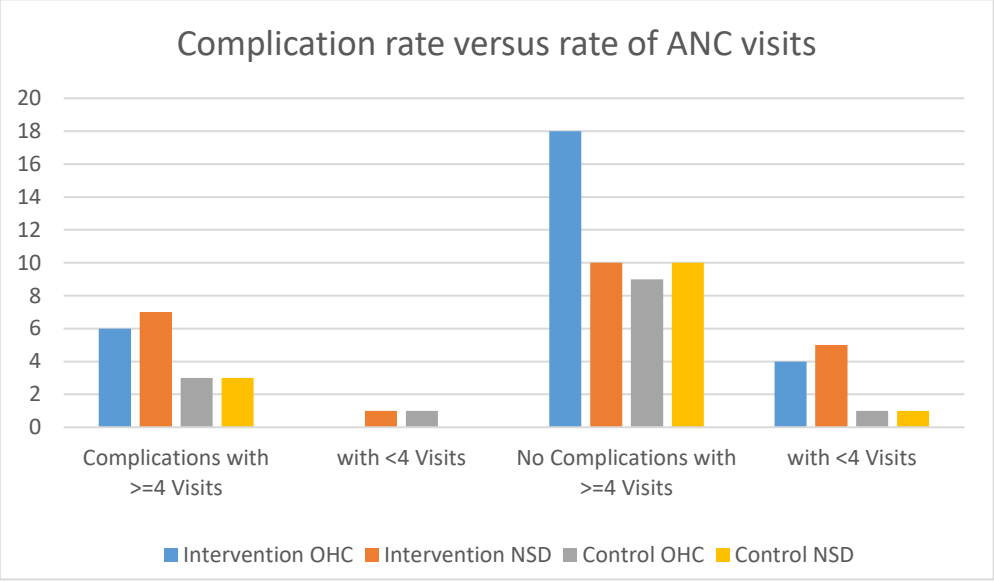

Figure 5.12: Number of participants by complication rates in relation to the ANC visits at each arm at the NSD and OHC sites

The correlation between the number of visits and complications is also shown in Table 5.11.

Table 5.11: Correlation between complication rates and number of visits in each arm at each site.

	NSD		***OHC***	
	Intervention	**Control**	**Intervention**	**Control**
Complication rate values	23	14	28	14
Correlation coefficient	*0.018*	*0.145*	*-0.284*	*-0.645*
P value	*0.47*	*0.31*	*0.07*	*0.006*

The relationship between the complication rate and visits was weak in both the control and intervention arm at the NSD site. At the OHC site, an inverse relationship was observed between the complication rate and number of visits. While the negative correlation between these variables was moderate for the OHC control group, it was significant. This was not true for the intervention group at the OHC.

Further analysis was conducted to explain the effect of the ANC visits based on the participants' arm on the complication rate. Table 5.12 shows the results within the NSD and OHC location.

Table 5.12: Effect size between the ANC visits based on participants study arm on the complication rate at the OHC and NSD locations.

	NSD			**OHC**		
	ANC	**Intervention**	**ANC * Intervention**	**ANC**	**Intervention**	**ANC * Intervention**
Effect size of each variable	0.006	0.021	0.005	0.206	0.405	0.405
***p* value**	0.211	0.699	0.15	0.003	0.187	0.187
ANC visits on complication (Effect Size)	0.027			0.213		

A graphical representation of the effect size at the OHC location is represented in figure 5.13

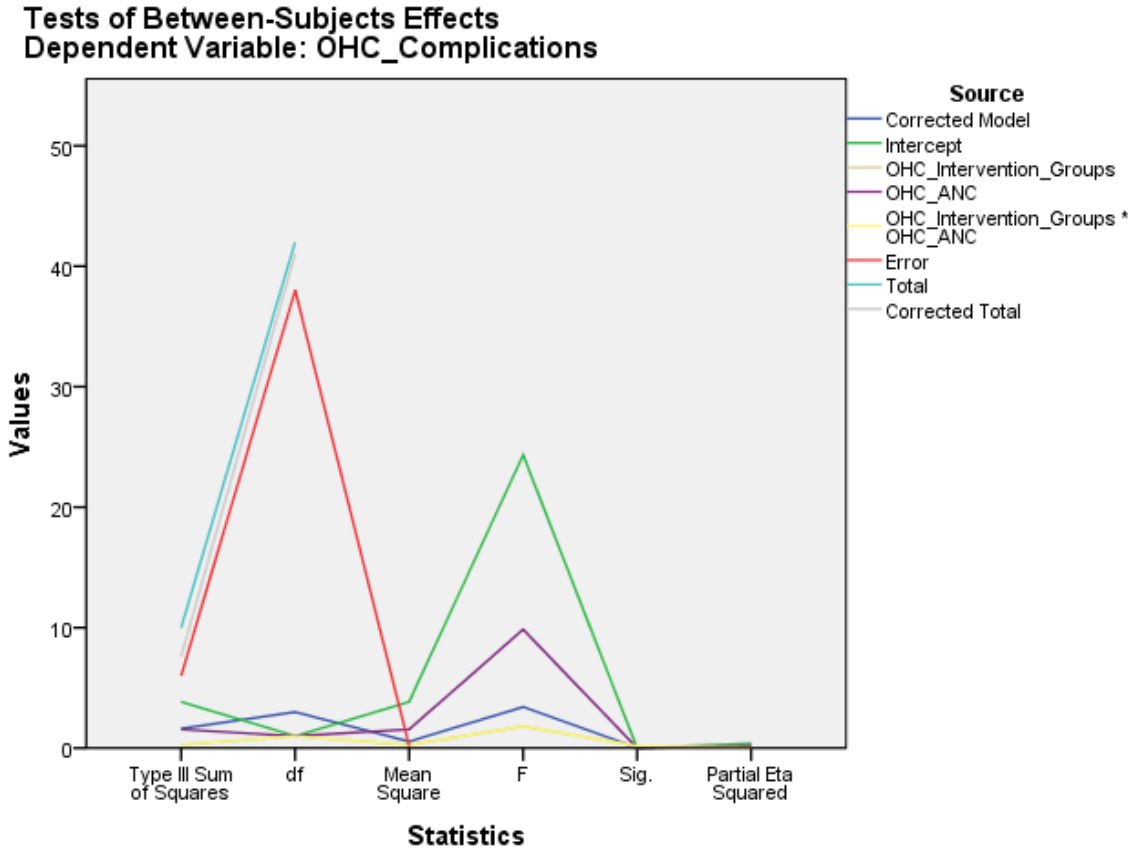

Figure 5.13: Effect size between the ANC visits based on participants study arm on the complication rate at the OHC

A graphical representation of the effect size at the OHC location is represented in figure 5.14

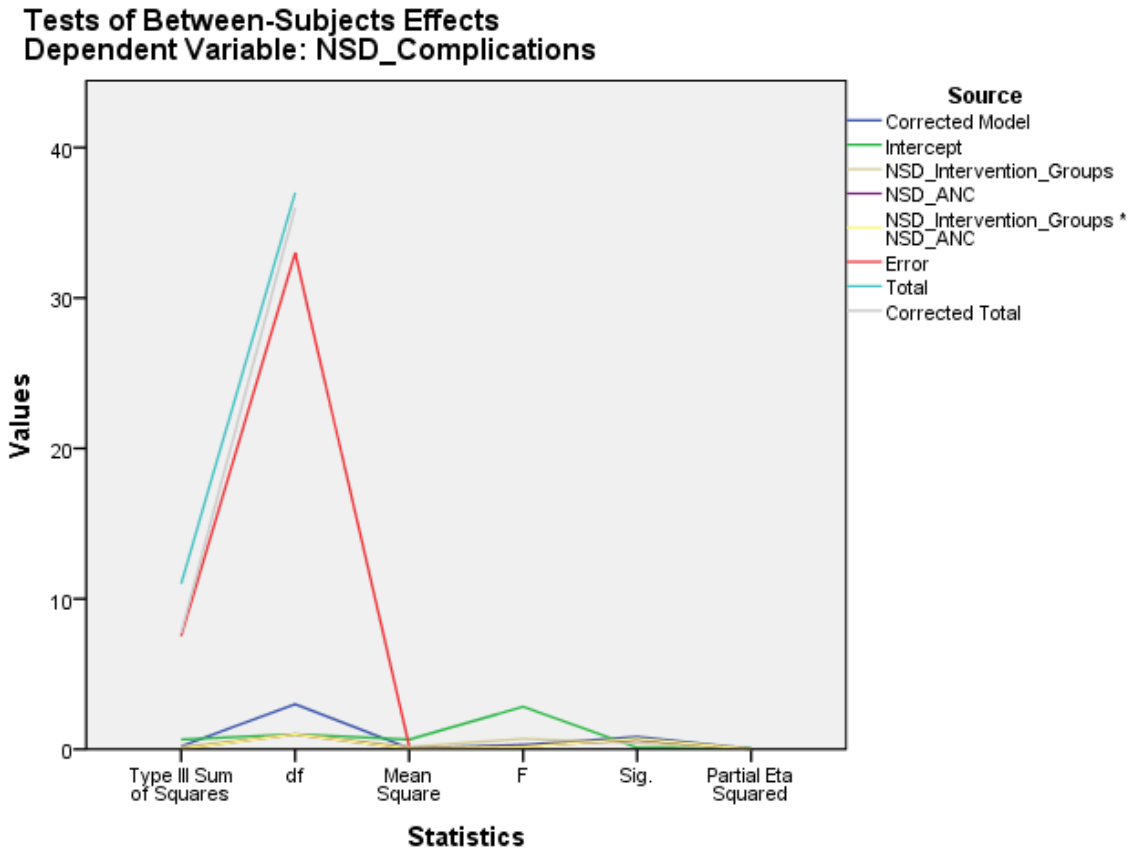

Figure 5.14: Effect size between the ANC visits based on participants study arm on the complication rate at the NSD

As shown in Table 5.12, a comparison of ANC visits, based on the intervention and the complication rate was explored. The effect size was based on the intervention and number of visits on the complication rate. At the NSD site, the effect size of the ANC visits on the complication rate was low and statistically insignificant. At the OHC site, the effect size was moderate and statistically significant for the ANC visits variable.

5.3.2.2. Place of Delivery in Comparison to Complications

The rate of complications was compared with the delivery location. Since all the women gave birth in the presence of a skilled worker the researcher presented

data to check the relationship between the locations the women gave birth in comparison to the rate of complications.

The NSD intervention arm had a total of eight complications with seven of the complications at the referral hospital. Within the control arm, there were a total of three complications with two of the complications at the referral hospitals.

The OHC intervention arm had a total of six complications with three of the complications at the referral hospital. Within the control arm, there were a total of four complications with one of the complications at the referral hospitals. Figure 5.15 shows the relationship between the place of birth and the complications rate for both the NSD and OHC location.

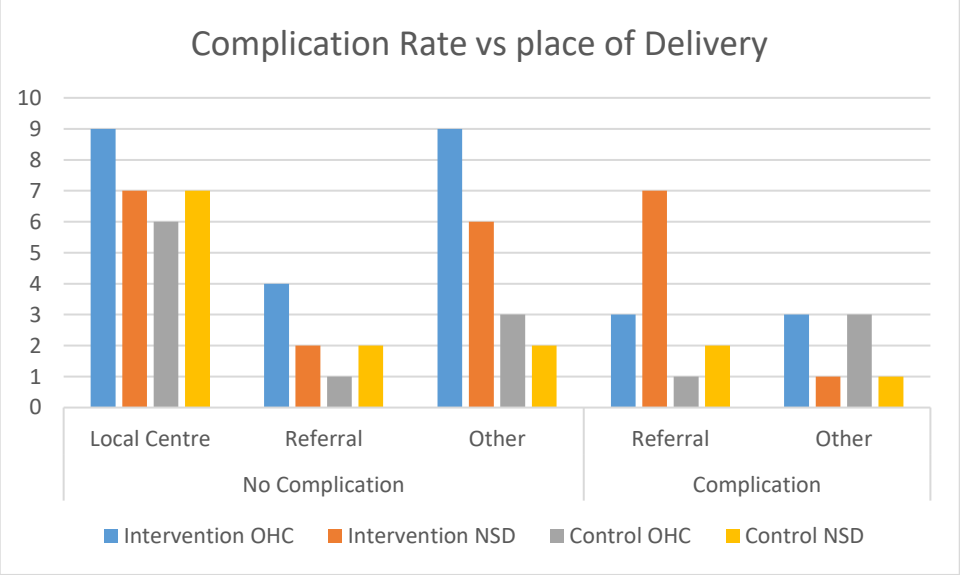

Figure 5.15: Place of Birth vs Complication rate at both NSD and OHC locations

Additionally, the correlation between the place of birth and complications is shown in Table 5.13.

Table 5.13: Correlation between complication rates and place of delivery in each arm at each site

	NSD		*OHC*	
Total Complications vs place of delivery	*23*	*14*	*28*	*14*
Correlation	0.039	0.406	0.323	0.512
***p* value**	0.429	0.07	0.04	0.03

The relationship between the place of delivery and complication rate was weak and statistically insignificant within the control arm at the NSD site. Within the intervention arm, the relationship was moderate and statistically significant. At the OHC site, the relationship was weak in the intervention arm and moderate in the control arm. Both relationships were significant.

Further analysis was conducted to explain the effect of the place of delivery relationship based on the participants' arm on the complication rate. Table 5.14 shows the results within the NSD and OHC location.

Table 5.14: p values and effect sizes for the relationship between complication rate and the place of delivery, intervention and factored place of delivery with intervention at the OHC and NSD locations.

	NSD			**OHC**		
	Place of delivery	**Intervention**	**Place of delivery * Intervention**	**Place of delivery**	**Intervention**	**Place of delivery * Intervention**
Effect size of each variable	0.289	0.006	0.046	0.215	0.011	0.013
P Value	0.005	0.664	0.479	0.013	0.536	0.789
Place of delivery on complications (Effect Size)	0.366			0.237		

A graphical representation of the effect size at the OHC location is represented in figure 5.16

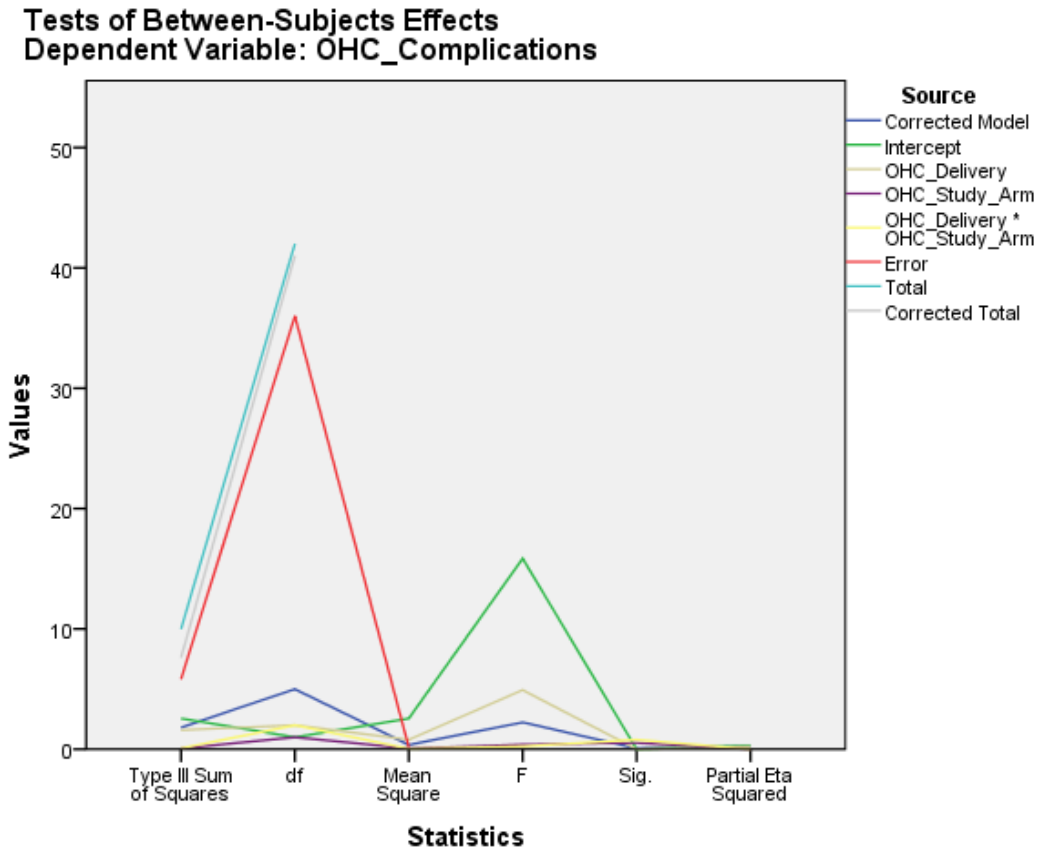

Figure 5.16: Effect size between the Place of Delivery based on participants study arm on the complication rate at the OHC

A graphical representation of the effect size at the NSD location is represented in figure 5.17

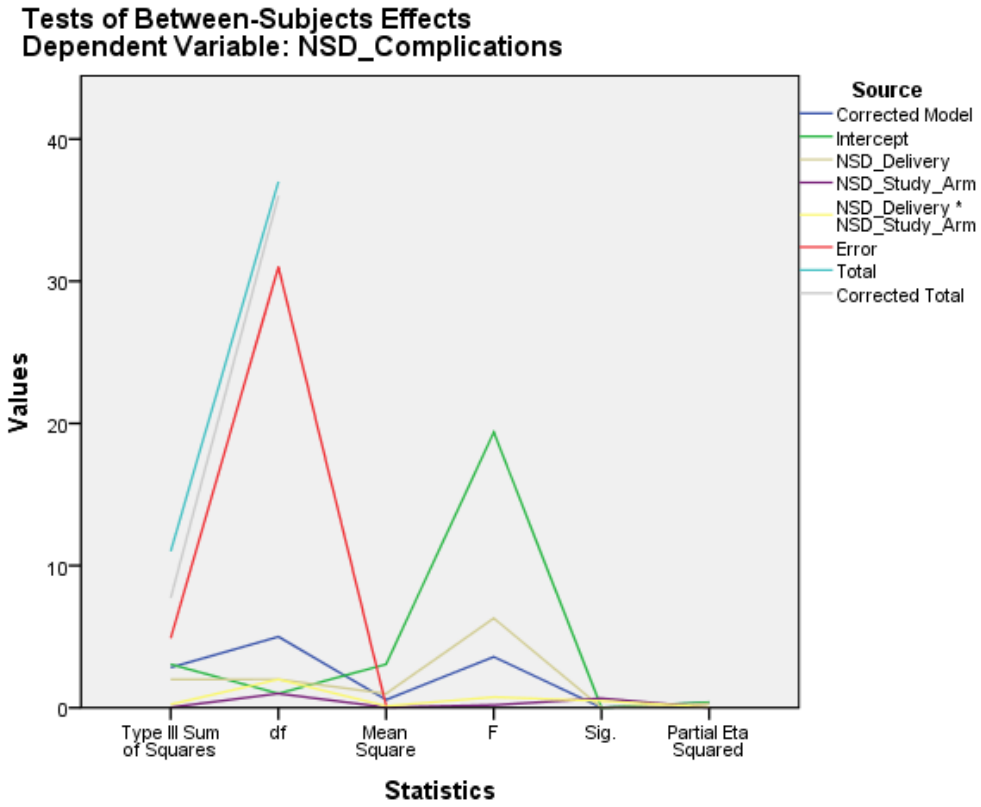

Figure 5.17:: Effect size between the Place of Delivery based on participants study arm on the complication rate at the NSD

As shown in Table 5.14, a comparison on the place of delivery, based on the intervention, on the complication rate was explored. The effect size was based on the participants' intervention and the place of delivery on the complication rate. At the NSD site, the effect size of the place of delivery on the complication rate was moderate but statistically insignificant. At the OHC site, the effect size of the variables was low and statistically insignificant. However, the effect size of only the place of delivery variable was moderate and statistically significant.

5.3.2.3. Antenatal Visits in Comparison to the Place of Birth and Complication Rate

The previous section concentrated on each variable (ANC and place of delivery) and its effect on the complication rate. This section focuses on a combination of the ANC visits, place of delivery and the participants' study arm and their mutual effect on the complication rate. multiple regression model is presented in the section that uses three predictor independent variables (ANC visits, place of delivery and intervention) on the dependent variable (complications). The effect size is additionally presented for each location. Table 5.15 presents the results of the OHC location. In testing the effect size Cohen's 1998 R effect size was used, 0.10 is a small effect, 0.30 is a medium effect and a 0.50 is a large effect.

Table 5.15: Stepwise regression *of ANC visit, place of delivery and intervention with the complication rate at the* OHC location

Model	*R*	*R Square*	*Significant Change (p)*
1. ANC	0.411	0.169	0.007
2. ANC with Place of Delivery	0.511	0.261	0.034
3. ANC with Place of Delivery and Intervention	0.516	0.266	0.602

The regression model showed that three independent variables significantly predicted an overall reduction in the complication rate at the OHC location. The three factors, however, had only a medium effect size, which explains that only 27% of the variance on the complication rates as being attributed to the ANC visits, place of delivery and the intervention. Table 5.16 is used to show the significance of each independent variable and its effect on the complication rate.

Table 5.16: Contributions of ANC, place of delivery and intervention to the complication rate at the OHC location

Dependent variable: Complication Rate	
Model	**Significance (*p*)**
1. ANC Visits	0.007
2. ANC visits with the place of delivery	0.003
3. ANC visits with the place of delivery and intervention	0.008

Table 5.17 presents results of the stepwise regression of the ANC visits, place of delivery and the intervention. At step 1, the ANC visits were significantly related to the complication rate (p= 0.007). At step 2, the OHC place of delivery was significantly related to the complication rate (p= 0.003). At step 3, the intervention (application of the intervention) was significantly related to the complication rate (p= 0.008).

Table 5.17: Stepwise regression of ANC visit, place of delivery and intervention with the complication rate at the NSD location

Model	***R***	***R Square***	***p***
1. ANC	0.181	0.033	0.283
2. ANC with Place of Delivery	0.216	0.046	0.491
3. ANC with Place of Delivery and Intervention	0.217	0.047	0.879

The regression analysis showed that three independent factors (ANC visits, place of delivery and intervention) did not significantly predict an overall reduction in the complication rate at the NSD location. The three independent variables also had a small effect size and only accounted for 4% of the variance on the complication rate.

Table 5.18: Contributions of ANC, place of delivery and intervention to the complication rate at the NSD location

Dependent variable: Complication Rate	
Model	***p***
1. Place of delivery	0.283
2. Place of delivery with the Intervention	0.445
3. Place of delivery with the Intervention and ANC visits	0.655

Table 5.18 presents results of the stepwise regression of the ANC visits, place of delivery and the intervention. At step 1, the place of delivery was not significantly related to the complication rate (p= 0.283). At step 2, the intervention was not significantly related to the complication rate (p= 0.445). At step 3, the ANC visits were not significantly related to the complication rate (p= 0.655).

5.4. Summary

The results within the section were used to provide information on four objectives (one, two, four and five). Results for objective three were discussed in chapter three and the creation of the framework from objective six is done at the conclusion of the discussion chapter five. The framework is proposed based on the results from objective five. While the results were presented within the chapter, the next chapter presents a discussion and outcomes of the results discussed herein.

CHAPTER 6: DISCUSSION

6.1. Introduction

This chapter discusses the findings of the retrospective and prospective phases of the study. The discussion of the results is guided by the objectives found in the first chapter and outlined in the results chapter. Descriptions of the population demographics in the health facilities place the findings in context.

6.2. Status of Maternal Health

The retrospective ANC records showed that a very low percentage of pregnant women at the OHC (15.7%) and NSD (11%) attended the recommended four ANC visits. Antenatal visits give an indication of whether a pregnant woman will get all the care required prior to birth. A recommendation by WHO that each pregnant woman should have four or more ANC visits was not achieved at either of the locations during the retrospective phase. In Kenya, the 2014 country ANC average attendance was recorded at 57.6% (Kenya National Bureau of Statistics et al., 2015). Within the county where the two health facilities are located, the average was recorded at 51.7% below the national norm (Kenya National Bureau of Statistics et al., 2015). This agrees with the study by Ewunetie et al., (2018) where both health centres recorded low fourth ANC visit patients compared to the rest of the County. This was attributed to the fact that the pregnant women within the health facilities typically started their ANC visits during the six or seventh month of their pregnancy. The late timing of ANC visits has been attributed to a lack of knowledge, unwanted pregnancies and a lack of resources such as money (Ewunetie et al., 2018). During the first phase of the study, the results showed that mothers who were approximately seven months pregnant only had one visit, or were attending their first visit to the health centre. It was alarming to note that women were attending ANC clinics so late in pregnancy and still defaulted on the required minimum number of visits. Community and mother education needs to

be done to sensitize the need for early ANC visits during pregnancy (Soltani et al., 2015).

The World Health Organization recommends that mothers start their first ANC visit during the first trimester (Kenya National Bureau of Statistics and ICF International, 2015). This disagrees with the study where during the cross-sectional study a higher percentage of the mothers started their ANC visits after week 20 of their pregnancy. When questioned about the late start of ANC visits, participants indicated that friends and relatives advised them to start clinic visits during the seventh month. This is in line to practices in other developing countries where women do not attend ANC on time due to misinformation (Ejeta et al., 2017; Ewunetie et al., 2018; Gulema and Berhane, 2017). Recommendations are made on the importance of communicating information to women of childbearing age on when to start ANC visits (Ejeta et al., 2017). Within the same study, 12.6% of participants started their visits as early as 12 weeks and went on to record a higher number of visits with six to eight visits during their pregnancy.

During the retrospective data collection period, NSD being a bigger hospital and catering to a larger population had a higher number of deliveries in comparison to OHC. However, the referral rates at OHC were higher. The main reason for the high referrals at both facilities was due to a lack of medical personnel and a lack of adequate facilities to deal with emergencies. This is in line with the World Bank, (2017) statistics where neither of the hospitals had a permanent doctor. In Kenya per the 2013 statistics, the physician to population ratio was two physicians per 10,000 population while the minimum recommended ratio was 23 physicians to 10,000 population (World Bank, 2017). Statistics from 2015 show two doctors for every 100,000 people within Kajiado county. (Ministry of Health, 2015). This is far below the recommended ratio and neither of the two public hospitals had any doctors working permanently which gave rise to the high number of referrals.

The results showed that the nurses referred women to the other hospitals as they did not have doctors who could deal with the complications that presented during labour and delivery. The need for on-call doctors at both facilities to deal with simple delivery emergencies was necessary because it would reduce the number of referrals sent to higher-level hospitals. Referrals to bigger and better-equipped facilities within public hospitals in Kenya did not necessarily mean a positive outcome for the referred patient. This was mainly determined by the time of the referral, whether the referral was done during the ANC visits or if it was as a result of an emergency. Additionally, the availability of an ambulance and bed space in the referral hospital would determine whether the outcome would be positive or not. Unfortunately, in Kenya, the higher-level hospitals are normally overwhelmed by referrals from the low-level hospitals and end up compromising their service due to overworked medical personnel (Oketch, 2018).

With ill-equipped facilities at both OHC and NSD, no cesarean section procedures could be conducted at either facility. Lack of ambulance services at OHC forced them to share the ambulance at NSD. If there were simultaneous referrals at both locations, then the patient at one of the locations was forced to find their own transport to the referral hospitals. During the entirety of the RCT, the ambulance had broken down forcing all referral patients to find their own transport. This agrees with the three delays study by Thaddeus and Maine (1994) and resulted in higher negative outcomes in case of complications because the nearest referral hospital was over 15 kilometres away. The third delay proposed by Thaddeus and Maine (1994) is the delay to receive adequate care at the health facility that may lead to complications and death. Ill-equipped facilities could inadvertently cause negative outcomes to complications that could have easily been solved had the resources at both facilities existed.

While referrals tend to ensure that the outcome is positive regardless of the complication, studies have shown that the quality of medical care received will be

based on available facilities and in most cases lead to a negative outcome (Pacagnella et al., 2014). Pacagnella et al., (2014) also indicate that the difference between life and death in obstetrics may be a matter of timely and proper care and management. With ill-equipped facilities and a lack of qualified personnel to deal with delivery complications, one is not guaranteed a positive outcome. A recommended short-term solution would be to work with nearby missionary facilities to ensure that any referrals are attended to promptly while a long-term solution would be the upgrade of the hospitals and hire permanent doctors within the hospitals. Additionally, specialized primary health care nurses could play a significant role in reducing mortality and morbidity in rural settings (Twahirwa, 2017).

The country statistics from 2015 showed still-births at 1.33% and neonatal deaths at 1.54% of the total births (Kenya National Bureau of Statistics et al., 2015). Both hospitals recorded low to none neonatal or maternal deaths. Stillbirths reduced to zero at both hospitals at the end of the retrospective data collection period. The main explanation for this was due to referrals of difficult cases as indicated by the nurses. During ANC visits, the nurse would refer any high-risk mother to a referral hospital. The mother was then required to attend ANC clinics at the referral hospital up until the time of delivery. Similar to the study by Singh et al. (2016), and Patel (2017), both hospitals supported only vaginal deliveries and when complications arose the patient was referred to a hospital which was adequately equipped. In the event of mortality after a referral, the mortality was recorded at the referral hospital and not at the home hospital, hence the zero maternal mortality rates during the retrospective phase. Studies conducted by Singh et al. (2016), and Patel (2017), shows that more than one half to two-thirds of pregnancies attended to at lower level institutions are likely to be referred during pregnancy or delivery. Singh et al. (2016) conducted a study that showed quality referrals were rarely conducted and hardly any follow-ups were done. Quality referrals include a treatment plan the patient received, transportation to the

referral hospital, someone to travel with the patient, availability of a health institution with specialist services as well as follow-up after the fact. Unfortunately, the home hospitals (OHC and NSD) never followed up on their patients especially if they did not deliver at their hospital. As a result, they could not account for the patients' well-being and this supported the findings from the study by Singh et al. (2016). This had an impact on the records because there was no way to know if any maternal or neonatal mortalities occurred. In all instances of follow-up, the mothers were given suggestions on which hospitals they could get better services They, however, chose nearby hospitals contrary to the suggestions given. A follow-up system needs to be created to monitor the progress of the mothers regardless of the location of delivery. This would ensure accountability, would help improve maternal health and reduce maternal mortality. This is the fifth strategy recommended to gain the SDG goals that ensure there is accountability to improve the quality of care as well as equity (HRP, 2015). Improved equity will ensure that services are responsive to community needs and demands.

6.3. Patient Profiles

6.3.1. County

The study recorded larger numbers of women younger than 20 years of age becoming pregnant in comparison to the country averages. However, they were also compliant and visited the health facilities consistently and regularly. This could be attributed to two reasons; due to the location of the facility near an informal settlement, or that the women had been educated about the importance of ANC visits despite their unintended pregnancies due to insufficient sexual education. In Nairobi, Beguy, Mumah and Gottschalk, (2014) showed that many matriculated secondary school girls lacked sexual education and ended up with unwanted pregnancies. However, due to community interventions specifically free maternal health care within the country and proximity to health centres, most of

the women younger than 20 years of age visited the health centres regularly. Studies conducted in Kenya have shown higher ANC coverage within informal settlements (Mberu et al., 2016) and this would explain the high number of ANC visits in both facilities.

The fact that the study participants were more educated than the average at the national level did not deter unwanted pregnancies. The national average of women with an education higher than primary school is shown at 35.74% (Kenya National Bureau of Statistics et al., 2015). The health centre recorded two times the national education levels. This was attributed to free primary education offered in the country and a high number of day secondary schools that were accessible within the area. The Kajiado North constituency, where the health centre is located had the highest number of residents with secondary education or higher at 49%, at constituency level. Ongata Rongai town where OHC is located had the highest values in the constituency at 59% (Kenya National Bureau of Statistics and Society for International Development, 2013). Accordingly, Ongata Rongai's average is 31% higher than the counties secondary school average. This was consistent with the number of pregnant women with secondary education or higher at the OHC location.

6.3.2. Control Trial Participants

The demographic profile of the participants was similar to or surpassed the county and country demographics. Both OHC and NSD showed great statistics and had very few participants aged above 33 years or below 20 years. The country average was tagged at 12.96% for pregnant women below 20 and at 13.36% for those above 33 years (Kenya National Bureau of Statistics et al., 2015, p. 122). The age ranges from OHC and NSD are explained by the fact that more participants had higher education qualifications than their peer counterparts within the county. More than half the participants at both locations had an education in secondary school and higher. With a higher percentage of women at both

locations with higher education, it was expected that more will make the decision to delay pregnancy and instead look towards finishing school (Kaffenberger, Pritchett and Sandefur, 2018). The number of participants younger than 20 years was higher than the national average. This was however not an indication of a lack of delayed pregnancy as the numbers of participants who had delayed pregnancies was high.

Both NSD and OHC reported more primiparous participants which were higher than the national average of 26.1% (Kenya National Bureau of Statistics et al., 2015). The higher percentages can be explained by the fact that more years in school result in delayed fertility as well as a reduction in the total fertility rate. A study conducted in Ethiopia showed this to be true where an additional year of schooling leads to a reduction in pregnancy rates (Pradhan, 2015).

6.4. Effects of Intervention

6.4.1. ANC Visits

There was a higher mean of ANC visits at the OHC location than the NSD location. This was attributed to the distance from the health facility to the participants' location. The OHC facility is located within a village and adjacent to an informal settlement. Most of the participants lived in close proximity to health centres, therefore distance was not a factor hence the higher ANC visits. The NSD was located within the town centre and did not have homes near it. The nearest informal settlement was further away than the OHC one thus the lower ANC visits. However, NSD had higher ANC visits than the national average which was 57.6% (Kenya National Bureau of Statistics et al., 2015). Distance from the facility affected the frequency of ANC visits and this was in line with the study by Kawungezi et al. (2015). The further the distance, the more the probability that a pregnant woman will not achieve the recommended four ANC visits (Kawungezi et al., 2015). The ANC visits statistics during the current study were not impacted

by the distance of the health facility as per the instance of the NSD location. Additionally, there was reliable and easily accessible transportation to both facilities.

The women in the current study were educated daily during their appointments by the nurses before ANC visits commenced in both hospitals. This was in line with the study by Kawungezi et al. (2015) and ensured higher numbers of ANC visits regardless of whether they belonged to the intervention or control group. A study done in Uganda attributed incomplete ANC visits to long-distance and indicated that much sensitization needed to be done in rural and poor areas to ensure empowerment of the women (Kawungezi et al., 2015). As suggested sensitization and intervention all geared towards women empowerment can ensure that women not only become more educated in matters of health but can be able to adhere to recommended guidelines. This needs to supplement the already free maternal health care offered by the government.

6.4.2. Place of Delivery

As indicated in the results, all the participants in both trials gave birth in a hospital setting. The main difference between the place of birth was whether the participants gave birth at the local facility, a referral hospital or at a private/mission hospital. Participants at both the OHC and the NSD trial were affected by the numerous health worker strikes, with a doctor's strike that lasted 100 days and a nurse's strike that lasted 5 months. This meant that most women had to travel to other facilities to give birth. More women at the NSD gave birth in other facilities since the nurses' strike overlapped with the control trial at that location. A follow up showed that while the nurses strike affected quite several women, most were able to organize delivery at a different facility in a timely manner.

Maternal health education impacts where a woman will give birth. Women with higher educational qualifications and who are educated on maternal health will

give birth in a health facility as compared to their counterparts (Adam, 2015). At both locations prior to the ANC visits all women were educated by the ANC nurses on pregnancy matters and this impacted on the place of delivery and agreed with the study by Adam (2015). Distance, on the other hand, is a factor when considerations are given to where a woman will give birth (Karanja et al., 2018; Kitui, Lewis and Davey, 2013). Both locations were within urban areas and while most participants lived near the facility, the rest had reliable modes of transportation to both facilities and agreed with the study by Kitui et al. (2013). When the strike was ongoing, the participants were able to access other private or missionary hospitals.

6.5. Impact of the Intervention

This section focuses on the impact of the intervention by looking at whether a reduction of complications was achieved based on the number of ANC visits, place of birth as well as the complication rate.

6.5.1. Influence of ANC visits on the Rate of Complications

Antenatal clinic visits are recommended to start during the first trimester of pregnancy (Kenya National Bureau of Statistics and ICF International, 2015). Most of the participants started their ANC clinics after the first trimester. Ideally, starting the clinic visits early and having more than the four ANC visits ensures that complications that may arise during pregnancy and delivery are recognized and addressed early (Kawungezi et al., 2015). At both locations, pregnant mothers with complications were referred during the ANC visits while those who presented complications during delivery prompted a referral to a different hospital equipped to handle such complications. Referrals during labour and delivery are not encouraged because they result in an increase in still-birth and neonate deaths (Patel et al., 2017). Patel et al. (2017) showed an increase in still-birth and neonate deaths by 7.3% as compared to 3.7% during labour and delivery referrals

in India. In the case of OHC and NSD, no referral records were maintained neither were follow-up calls conducted. Additionally, this agrees with a study by Singh et al. (2016) where the women were not provided referral slips to allow access to the referral facility. Singh et al. (2016) conducted a study that showed only 73% of participants had received a referral slip and even then, the slips did not contain vital information. Adoption of a follow-up mechanism of the current referral system needs to be embraced. A referral system with follow up will not only reduce mortality caused by referrals but also ensure accountability.

While there was no significant difference to show that the presence of an intervention made a difference during the trial, there were two women who had less than four ANC visits who developed complications. The timing and frequency of the ANC visits have been known to directly contribute towards complication rates during pregnancy, labour and delivery (Abbas et al., 2017; Ochako and Gichuhi, 2016). Based on research (Abbas et al., 2017; Ochako and Gichuhi, 2016), an explanation would be that the two mothers did not attend the minimum number of ANC clinics, nor did they start their ANC clinics early, thus ending up with referrals during delivery. An intervention arm participant at the NSD location identified some complications and due to the intervention, sought care and proceeded to deliver a healthy baby. The second participant at the OHC location control arm was not so lucky and suffered neonate mortality. Abbas et al. (2017), has shown a direct relationship between irregular ANC visits, complications and stillbirths. Presence of the intervention gave the first participant a better chance even with the missed ANC visits in comparison to the second one. One of the determinants of maternal mortality is the perceived benefit/need (Gabrysch and Campbell, 2009) and one of the factors for this determinant is information availability. Lack of information can be the key between life and death in maternal health and a lack of information caused the participant to lose the baby, which may have been saved had the participant had the relevant information.

There were two additional neonate deaths during the study. All the neonate deaths were at the OHC trial with one on the intervention arm and the other two on the control arms. The participant in the intervention group indicated that the nurses were on strike and therefore could not access the local hospital. The health worker strike was a combination of 100 days doctors strike and a 150 days nurses strike. One of the leading barriers that are a catalyst for mortality includes distance and inadequate services (World Health Organization, 2018). With the strike underway, the participant was unable to access needed services and was required to travel further in search of services which resulted in tragedy. Kenya had several strikes where doctors, nurses and clinical officers all downed their tools (Wanjala, 2017). Inadequate services should incorporate worker strikes as one of the leading causes of maternal mortality in Kenya. Therefore, mitigating factors need to be placed to prevent mortalities during strikes (Fulton, 2017).

The second participant on the control arm ended up with neonate mortality due to inadequate knowledge (World Health Organization, 2018), one of the causes of mortalities, and inadequate services. Un-empowered women are often unable to act on their own behalf to seek care in the event of a complication. This is similar to previous studies (Ahmed et al., 2016; Obare et al., 2016), that have shown empowered women as being unable to know when to seek additional help in the event of a complication. The lady suffered a neonate death due to inadequate services at the health centre which could be attributed to the third delay in the three delays model (Thaddeus and Maine, 1994). This was due to negligence by the health personnel to recognize the complication and a weak referral system (Ministry of Health Kenya, 2016). Additionally, the lack of information (World Health Organization, 2018) was another factor that caused the woman to lose her child. Ideally, if the participant had been in the intervention group and received the message about water breaking as a sign of labour or ask about alternatives via the intervention, she may have sought a second opinion at a different facility and may have saved the baby. Recommendations are made to educate women

better on danger symptoms which may help them in the event they receive inadequate services (Bintabara, Mpembeni and Mohamed, 2017; Hibstu and Siyoum, 2017).

6.5.2. Influence of the Place of Delivery on the Rate of Complications

The ideal place to give birth would have been the local birth centre where the participants attended their ANC clinics or the recommended referral hospital (Ministry of Health Kenya, 2016). This was not the case due to numerous strikes by the health personnel. The main difference between the OHC and NSD location and the place of delivery was the time and length of the health worker strike. The OHC RCT was conducted between November 2016 to March 2017. Within the same period, the doctor strike ran between December 2016 to March 2017. Basically, the trial ran concurrently with the doctors' strike. The NSD RCT was conducted between April 2017 and August 2017. The nurses strike however started a few months into the trial in June 2017 to November 2017.

At the OHC location, the results showed no significant difference between the intervention and the control arm. This meant that the presence of intervention did not affect the rate of complications based on the place of delivery. As indicated most women could not give birth at the local facility and for those who were considered high risk or with complications had to seek services from other missionary hospitals independently. This is the case in Kenya, where studies have shown that any time there is a strike the population will mainly seek care in missionary institutions (Fulton, 2017). This was the case during the control trial where poor families were unable to access private hospitals due to the expense or cost factors. In such cases, the missionary hospitals are overwhelmed by the influx of patients and may not provide quality care to the patients (Fulton, 2017).

Within the NSD location, the place of delivery has a negative and moderate relationship on complications. Participants who gave birth within the NSD location had fewer complications than those who had to seek other alternative hospitals. This was attributed to the intervention which showed an effect on the complication rate. Those who went into labour when there was no strike and had complications, delivered in their recommended referral hospital. Since all women delivered in a hospital, the rate of complications was not and did not influence the place of delivery. Factors that have been found by previous studies to affect the place of delivery have included, physical access, distance, lack of transport and economic capability, woman's perception (Karanja et al., 2018; Kitui et al., 2013) and a lack of education and awareness (Caulfield et al., 2016). None of these factors affected the place of delivery for the participants at both locations.

Health worker strikes as seen in this study affect the outcome of pregnancy, labour, and delivery adversely. In Kenya, when the public hospital staff strike, the women do not achieve the recommended ANC visits and may end up giving birth away from a birth centre due to cost (Wanjala, 2017). Unfortunately, in a developing country, strikes are inevitable because they are the only way labour officials can leverage the government for better working conditions and pay. In 2017, there was a prolonged strike by both the doctors and nurses. During the same period, the maternal mortality rate doubled to 857 when compared to a similar period the year before (Murumba, 2017). It would be advisable when educating the women during the ANC visits to assert the importance of ANC visits and giving birth in the presence of a skilled worker. This would ensure that in the event of a strike the woman can seek services elsewhere. Sensitization needs to be carried out in the community to ensure that they understand the benefits of a health worker. When women understand the benefits, they will seek services regardless of the type of facility.

Conversations during the trial revealed that the messages the women received helped them to act during the nurses' strike. The researcher received calls from several women in the intervention group during the trial asking whether the nurses were still on strike and recommendations on where else they could deliver. Pregnant women expect to receive help from health workers during labour and delivery. Based on this, it would be advisable for the government and the health workers to think creatively on how best to help these women during worker strikes (Fulton, 2017). The advice given by the researcher in conjunction with the nurses pointed towards cheap private and missionary hospitals within the area. This immensely lowered the number of complications and mortalities. However, while this advice was based on necessity, the missionary hospitals were overwhelmed by the influx of women seeking care (Fulton, 2017; Otieno, 2017). The government of Kenya for the fiscal year of 2017/2018 allocated double the budget for the free maternal health care program at KShs4.3 billion compared to the previous year (Otieno, 2017). While this should have helped with the maternal healthcare program, this was not the case as there were prolonged doctors and nurses' strike and as such the monies would have been more effective to assist the missionary organizations. Fulton (2017) indicates that while strikes may not end, it is prudent to assist missionary organizations with their operating costs in the event of a strike. Additionally, it would be ideal to factor in strikes when educating women and sensitize them on when and where to seek care in the event they occur.

6.5.3. ANC visits and Place of Birth influence on the Complication Rate

The health worker strikes inadvertently affected the NSD RCT study. The insignificant effect of higher ANC visits and skilled birth attendance during delivery on complications can be attributed to the health worker strikes. The results showed that while the number of ANC visits were high, and all women gave birth

in the presence of a skilled worker, the presence of intervention did not have any effect on the complication rates. This was due to the unforeseen external factor of the health worker strikes. Further research needs to be conducted to comprehend the significance of strikes not only on mortalities but on maternal health and complication outcomes. Additionally, more needs to be done to address the issue of inadequate services received at government hospitals. Fulton (2017) gives a similar recommendation including extending financial and resource support to missionary hospitals during health worker strikes.

The OHC location showed a significant difference when the three variables are implemented. The significance of the study increased when the place of delivery, the number of ANC visits and intervention were introduced. The study also showed a medium effect size due to the three variables. The place of delivery was seen to have an effect on the complication rate. Place of birth during the study was defined as a local centre, referral hospital or other facilities. Within OHC, the ANC visits had an effect on the complication rate. This was affected by the health worker strikes as the effect of the variable on the complication rate was only 16.9%. Within the study, women who gave birth at the local facilities and attended more than four ANC visits had higher positive outcomes. Increasing the number of ANC visits has been shown to decrease the chance of neonatal mortalities (Thies, Anderson and Cramer, 2012). Women who averaged more than four ANC visits had lower risks of maternal mortality because it improved early detection of complications (Arunda, Emmelin and Asamoah, 2017; Gupta and Talukdar, 2017; Tekelab et al., 2019). Additionally, the timing of the ANC visits was critical in determining the neonatal outcomes (Gupta and Talukdar, 2017). A greater number of ANC visits created a rapport with the nurses at the local facility and led to positive outcomes within the NSD location.

The second variable that had an effect on the complication rate was the place of delivery when linked with the number of ANC visits. During the doctors' strike, the

clinical officers, nurses and head doctors at the referral hospitals were still at work. Women who had complications could be attended to by the doctors in the event they received referrals. Studies have shown that the care a woman receives in a hospital during labour and delivery will determine whether the delivery will end up in mortality or not (Kunkel et al., 2019; Titaley et al., 2012; Tura, Fantahun and Worku, 2013). Factors toward the greater risk of perinatal mortalities within hospitals include delays during the referral process, care received during complicated pregnancies and the poor quality of care in facilities (Kunkel et al., 2019).

The final variable was mother education through the interventional study arm. Mother education has been shown to reduce both maternal and neonatal mortality (Fonseca et al., 2017; Kiross et al., 2019; Pillay, 2019). Within the study, it was observed that while mother education was key, it needed to interact with the ANC visits and ensure that a woman gave birth within a health facility for a positive outcome. The messages sent to the interventional group were key in ensuring that the mothers sought care when they deemed it necessary. In conclusion, it is key to note that while the intervention produced significant effects on the NSD study, the nurse strike hindered a greater effect by the intervention.

6.6. System Effectiveness

Use of the combinational bulk SMS system, ODK and Google aggregate provided a reliable system for the intervention. The system allowed for appointment reminders and mother education to be sent out that was relevant to the participants. In addition, the delivery and log reports allowed for immediate action by the researcher to resend any messages that failed or were undelivered. This also provided the researcher with the option to query the number after subsequent fails. Use of ODK and Google aggregate allowed the researcher to do an analysis

with error-free, clean data. Additionally, it also allowed for availability of the survey results in the event other researchers intended to conduct similar studies.

The data used by the bulk SMS system and Google aggregate was anonymous and only contained participant responses hence could not be identified to match any patient. Participant data were coded, and each participant assigned a participant ID that was used within the system. Anonymity and confidentiality were in line with Kenya's 2011 eHealth strategy which aims to protect consumer confidentiality especially in system development processes supporting eHealth (Kenya National Bureau of Statistics et al., 2015). Additionally, the eHealth strategy recommends that data collected during trials is shared with other researchers while maintaining participants' confidentiality with which the study did.

The system has provision to grow because the Google aggregate server allows for the additional upload of specific data collection forms. Additionally, ODK is open source and can be installed in many Android devices if the aggregate server supports multiple data collection which is supported by the Google aggregate server. In areas where the telecommunications network is poor, the ODK collect tool used on the android phone could store data locally until the internet was available to push the records to the server. The messaging component of the system could be customized to include the user's name if personalization was desired. It also allows for customization of cohort groups in line with the researcher's needs. The initial integration testing failed, hence prompting the researcher to outsource the messaging section of the system. The messaging company selected ensured that targeted messages sent were delivered promptly because they had perfected their system to send customized messages to thousands of users. One of the prominent features of the system was the customization of the message and the grouping of participants into cohorts.

Follow-up with the users when sending messages was also key in success as outlined in the design science methodology.

The mHealth solution designed used a design science research methodology that ensured a rigorous development method. The methodology enabled the researcher to identify various errors and missing components that would be necessary for the success of the RCT. The first iteration only focused on a solution for the participants. Data collection and storage was done manually by the researcher. During the second iteration, the researcher included a solution that would be used to enhance the data collected. The inclusion of tools that focused on the researcher ensured the collection of quality error-free data that required no cleaning. The ODK form that was used to collect the post-test data enabled the researcher to code the data and enforce rules to ensure that data was compulsory was collected. The ODK tool also ensured that data was not lost or destroyed as in the case of a paper form. This agreed with a study conducted by Steiner et al. (2016), which gave recommendations of using ODK as a data collection tool in under-resourced countries.

A combination of the ODK tool with the Google Aggregate server went a step further and introduced a concept of sharing data online with other researchers. The Aggregate server was key in ensuring that the RCT data collected was available in the event a researcher conducted a comparable data. Additionally, the availability of the data would aid in the use of the data set to run further analysis by other researchers. The bulk SMS, ODK tool and Google Aggregate server modules are all freely available are an ideal solution when conducting studies in low-resource settings. The components are also reusable individually or as a whole and could be used for small to large scale studies.

6.7. Objective 6: Propose a Framework to Reduce Complications that may lead to High MMRs.

The findings of the controlled trial presented an opportunity to develop a framework. This section discusses the framework that when implemented would help in increasing ANC visits while ensuring delivery in a health facility. This would translate to a reduction in complications that result in maternal and neonate morbidity and mortalities. Several models and frameworks were discussed in chapter two. These frameworks and models, however, focus on the direct causes of maternal mortality and do not factor in the inclusion of mitigating factors. The framework presented will have the inclusion of a mitigating factor.

The three delays model previously discussed looks at the timing and obstacles that lead to maternal mortality (Thaddeus and Maine, 1994). The first delay is that of deciding to seek care. In one of the neonate mortalities, the lady started labour but was travelling. She decided to seek care once she reached her destination. Her decision to delay seeking care resulted in mortality. While the model explains the decisions made by the pregnant family member and immediate family members, it does not consider the knowledge the members have in identifying complications. The model focuses on complications and considers all complications as emergencies. The second delay is that of reaching the facility while the third one is that of receiving adequate care upon reaching a health facility. The third delay is looked at as a direct consequence of the outcomes and decisions made during the first and second delay. This, however, may not be the case when one of the neonate deaths in the study was attributed to the fact that the pregnant woman was turned away after seeking medical assistance on time after her water broke. While at first glance this could be considered as a delay in receiving adequate care, the woman did see the health worker and arrived at the health facility in a timely manner only not to be turned away. It would be prudent to indicate that the third delay is not always a direct indication of a first and second delay. While the model gives an overview of why most complications lead to mortalities it does not consider other factors of pregnancy and delivery that may lead to mortalities thus would need to be improved upon. It does open the

opportunity that an improvement in the care of the woman before, during and after delivery would lower maternal mortality.

An additional framework that analyses the determinants of maternal mortality works through the weakness of the three delays model (McCarthy and Maine, 1992). There are two determinants (distant and intermediate) that lead either to positive (healthy pregnancy and successful delivery) or negative outcomes (mortality). This model looks at individual factors that affect women and lead to maternal mortality. The model suggests three efforts in the reduction of maternal mortality. The first effort is in reducing the likelihood of pregnancy occurring. The second includes reducing the likelihood of complications occurring while the third is focussed on improving the outcome in the event complications do occur (McCarthy and Maine, 1992). While the first effort did not apply to the study, the second and third efforts applied in different scenarios. Of all the complications only three neonate deaths were recorded. Unfortunately, the three efforts did not apply to the three women because complications occurred, and the outcomes of the complications led to mortality. While the model ideally encourages better outcomes for complications it does not provide any mitigating factors to prevent less than desirable outcomes. The model's main weakness is that it does not provide for mitigating factors, it only provides an understanding of factors that lead to maternal mortality.

The final framework presented is one that shows the interrelated factors that cause maternal mortality (UNICEF, 2008). The framework is an expansion of the framework proposed by McCarthy and Maine and sub-divides and groups each factor that leads to maternal mortality. The framework clearly identifies the basic social problems such as inadequate knowledge and resources. These factors directly impact the underlying causes of maternal mortality. One of the underlying causes of maternal mortality is a lack of knowledge and health education on the part of pregnant women (World Health Organization, 2018). One of the three

neonate deaths, the women could have benefitted from information to help identify when a symptom was a danger sign. This is shown in the framework as the underlying causes at the household level. Similarly, a lack of education and health information will impact the direct causes leading to mortality (UNICEF, 2008). Ideally addressing the basic and underlying causes will lead to lower pregnancy rates. If the woman does get pregnant then the direct causes should be addressed. This would translate to a healthy pregnancy and delivery. Similar to the determinants model by McCarthy and Maine (1992), the conceptual framework has one main weakness. The framework does not address what needs to be done to improve the outcome.

One way to addresses the weaknesses of the three frameworks as outlined in chapter two is to address the barriers that lead to mortality by introducing appropriate mitigating solutions to the framework. Different countries have been able to reduce maternal mortality by empowering women with information and by introducing appropriate technologies to disseminate the said information. In Ghana, there was an increase of 70% of ANC attendance and skilled birth delivery after the introduction of a mobile system (Amoah, Anto and Crimi, 2014). The trial at NSD and OHC showed 81% and 86% adherence to ANC clinic visits respectively as well as a 100% skilled worker delivery. This goes to show that the introduction of a mobile system under the right conditions would not only help empower the woman but also enable the adherence to ANC and ensuring that each woman is attended to by a skilled health worker.

Mobile system interventions have been used successfully to reduce maternal mortality. RapidSMS is one such system that was deployed in Rwanda (United Nations, 2013). The system mainly focused on healthcare workers and did not integrate an application for pregnant mothers. The intervention used in Ondo state, Nigeria, used cell-phones to exclusively track women to ensure they attended ANC clinics and delivered in a hospital (Oyeyemi and Wynn, 2014). The

women were issued with cell-phones which were used to monitor their uptake of services. The greatest limitation was the cost effect. With mobile penetration rates, using the mothers' own phones would be a faster and cost-effective solution.

Building on the frameworks discussed, the researcher developed a framework that introduces mitigating factors that would improve maternal health outcomes hence reducing mortality. The framework is presented in figure 5.1 below. The framework would focus on empowering the women, by introducing an information dissemination system that would help empower women with health-related information. This will increase ANC clinic visits as well as reduce the number of complications thus lowering both maternal and neonate mortality. One of the greatest impediments of the study was the health worker strikes. Factoring the health worker strikes would ensure that regardless of the healthcare situation, women would receive the required care. A combination framework to introduce a mobile intervention while concurrently focusing on extraneous variables such as strikes, would reduce complications, ensure adherence and lower maternal and neonate mortality.

The framework can be implemented in a dispensary, health centre or hospital setting. The framework may also be implemented by home health officers. Once a woman is identified as being pregnant, they are requested for consent and enrolled in a system where they would start receiving messages about pregnancy. The pregnant woman would also have the option of getting in touch with the local centre in the event they had an emergency or had some queries. Messages would be created by the local health centre in consultation with the health officer.

The framework is a three-module information dissemination system. The first module is client-end and is accessed by health workers or researchers. The health workers would input information about the mothers that visit the health facility including their demographic information. The health workers would also record

the mothers contact details that would be used during the entirety of her pregnancy. The health workers would ultimately use the module to add information based on gestation and risk factors on care during pregnancy and childbirth including appointment dates.

The second module is also a client-end that would be accessed by the mother. It is proposed to use an Unstructured Supplementary Service Data (USSD) system, where the mother could access information specific to them. While the study used an SMS system due to cost, a USSD system is more efficient as it would allow users to access previous messages already dispatched. In addition, the users would also receive weekly messages from the system like messages sent during the study. The USSD system would additionally be utilized to conduct any surveys that may be required by the health workers.

The final module would be a backend storage module. This module would be used to store the data acquired by the USSD system, survey data and records involving the expectant women. A recommendation based on the study would be the use of an aggregate or cloud storage to ensure access can be achieved anywhere. With the information dissemination system, the women would be enrolled when they started their ANC visits. This would ensure that the women are empowered throughout the pregnancy.

Based on the extrinsic variables like health worker strikes, then the county health officials could utilize the system to update mothers on where they could visit to seek medical services in the event of a complication. The system would be utilized to send routine notifications to the mothers from their home health facilities.

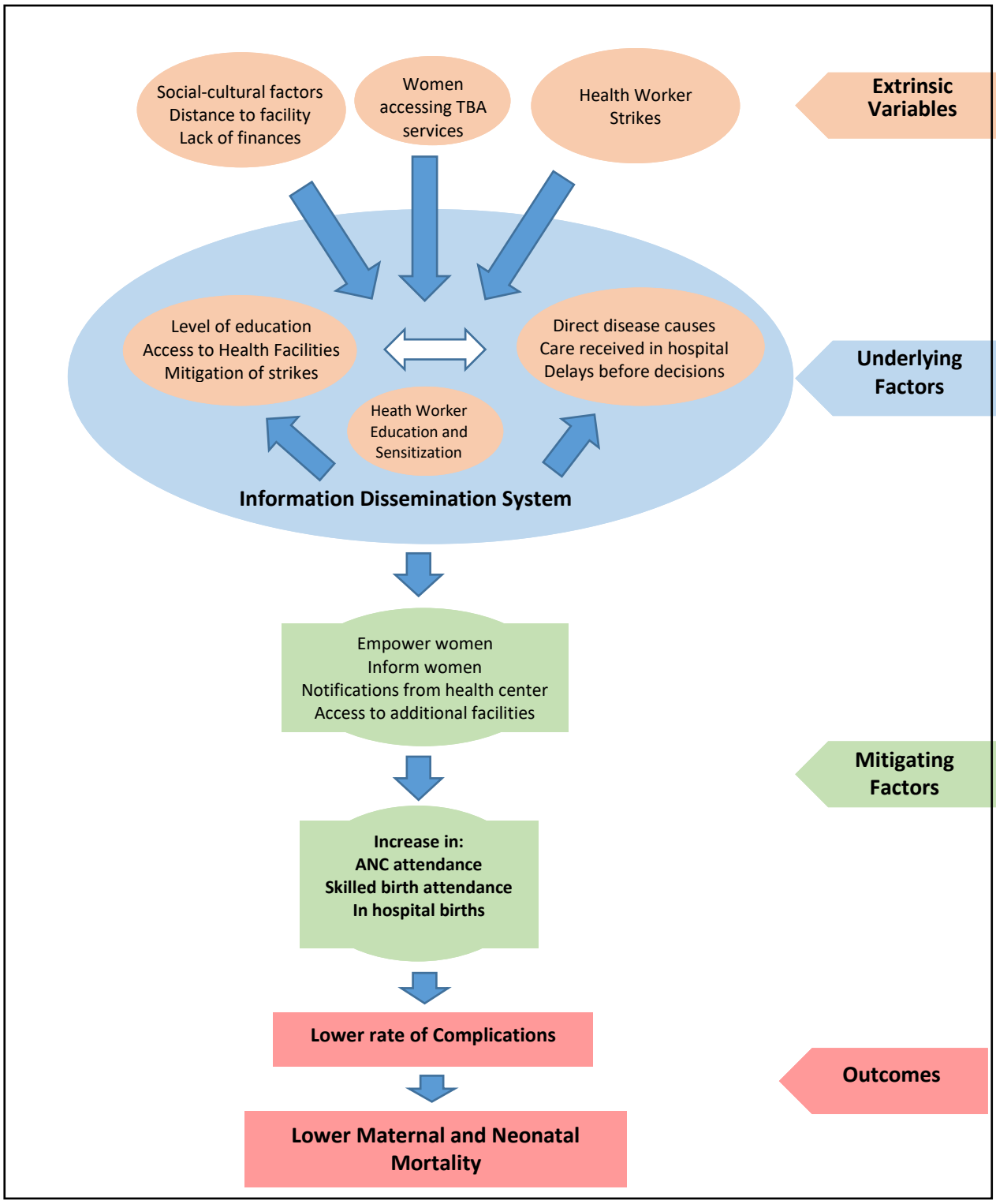

Figure 6.1: A Proposed framework to reduce complications that lead to maternal mortality

6.8. Summary

Chapter six presented discussions of the findings of the study. A framework was formulated that would help replicate results from the study to help reduce complications by increasing ANC visits and instances of skilled worker deliveries. The next chapter will provide a conclusion of the study, recommendations as well as limitations.

CHAPTER 7: CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS

7.1. Introduction

The chapter draws conclusions from the findings of the study in relation to the aims and objectives. It also identifies the limitations of the study and makes recommendations for future research.

7.2. Conclusions

The study focused on proposing a framework through the development and testing of an ICT intervention to reduce maternal and child mortality in a selected community in Kenya. The conclusions are stated in relation to the aims and objectives of the study and are based on the results.

Objective 1: To determine the current status of maternal mortality and morbidity rates within Kajiado North Constituency

The study findings showed a reduction in the number of stillbirths and breech births during the six-month retrospective period. Additionally, during the same period, no maternal mortalities were recorded at both locations. These findings are distorted by the fact that both participating health centres transferred patients with complications during delivery and birth to a higher-level facility. Mortalities that occurred were recorded at the receiving hospital since neither of the participating hospitals had any follow-up mechanism or records of any of their patients that suffered mortality. Both facilities ensured that patients who appeared to be considered as high-risk were transferred or referred to a higher-level hospital during their ANC visits. Additionally, the study showed that both health centres recorded low ANC visit numbers compared to the rest of the country.

Objective 2: To determine the strategies used by pregnant women and health workers, to manage pregnancy and childbirth.

Findings revealed that women started their ANC visits late during pregnancy. This was influenced by advice received by family and friends. The results also showed that some complications during labour and delivery could be avoided if pregnant women attended and met the minimum ANC visits. Findings from the cross-sectional survey found that pregnant women were interested in receiving information in addition to the wellness talks they had with the health workers. The findings also showed the mobile phone as a viable information dissemination tool.

Objective 3: To develop and test a data collection and messaging system to disseminate messages and collect feedback from pregnant women.

Design science research methodology (DSRM) was used to create a messaging system that was used to disseminate information. During the pilot test, the system faced various challenges and could not be implemented for the main RCT. It was also observed that one key feature of data collection and storage was missing. The second iteration of the DSRM model involved creating a system that not only facilitated the dissemination of information but also catered for the researcher needs by aiding in collection and storage of data. The final test of the system was done through a two-arm two-site randomized control trial (RCT). The system was found to be unique and effective as it not only catered for the needs of the client, it ensured that the RCT data collected was clean and error-free.

Objective 4: To implement a mobile messaging system to increase Antenatal Care (ANC) uptake as well as deliveries by skilled staff within selected facilities

The RCT findings showed a positive relationship between the number and timing of ANC visits and the complication rates. Women who did not achieve the minimum of four visits during ANC tended to have more complications than the

rest. Further, the women who suffered complications but were in the intervention arm of the study did not end up with mortalities. A direct relationship, therefore, can be linked to the impact of the intervention and the complication outcome. Health worker strikes impacted the place of delivery during the study. The strikes meant that women did not give birth at their home facility and instead had to source other facilities to use. With information and access to the researcher during these strikes, the pregnant women were empowered to search for other facilities.

A lack of follow-up after referrals and accountability for the referred women was one area that the study showed a gap that needs to be addressed within the health sectors. Referrals in Kenya have been marred by inappropriate structures that have led to mortalities. Cases have been recorded where patients were transferred to higher-level medical institutions by ambulance and waited for hours in the ambulance for admission to the hospital. In other cases, the patients to be referred have been stuck in the referring facility for lack of transport services. This was evident in the study as participants had to look for personal means to get to the referral hospital. Once at the referral, they were not guaranteed admission as this was dependent on bed space.

Objective 5: To lower the MMR rates that are a result of complications by increasing ANC visits and skilled worker deliveries.

Moderate effect sizes were seen between the ANC deliveries and the complication rate at the OHC location. Within the same site, the effect size of the effect of place of delivery on complication was moderate and statistically significant. However, the three variables were not statistically significant toward a reduction of the complication rate. At the OHC, three variables, ANC visits, place of delivery and the study arm, were shown as having a medium effect toward the complication rate. A regression model showed that the implementation of the three variables leads to a statistically significant model.

Objective 6: To propose a framework to reduce complications that may lead to high MMRs.

In combination with the findings and the gaps identified, a review of frameworks proposed in chapter two was conducted and a framework was proposed. The framework is a medley of previous frameworks with consideration for empowering the woman to reduce maternal mortality. Implementation of the framework in health centres may aid in not only reducing complications that lead to maternal and neonatal mortality but assist in adherence that would lead to the achievement of SDG 3.1.

7.3. Research Contribution

The study resulted in the creation of a framework that forms the foundation of further research in mHealth. Specifically, the research focussed on tools used when conducting RCT's. The key theoretical contribution from the study was a review of frameworks used in analysing what determines maternal mortality (Mukami, Millham and Puckree, 2016), creation and proposal of an ICT framework that mitigates determinants of maternal and neonatal mortality (Mukami, Millham and Puckree, 2019a) and a review of feasible mHealth tools for maternal mortality interventions (Mukami, Millham and Puckree, 2019b). Whetten (1989) created a framework that reviews theoretical contributions during research and was used to guide the key contributions in the study.

Does the study make any significant contribution to current thinking? The research took to consideration previous works within the field of mHealth in maternal mortality and morbidity. Various frameworks were reviewed that led to the creation of a system that was used to disseminate information to pregnant women. The study utilized DSRM to create an artefact that used as the intervention in an RCT. The DSRM method used was rigorous as it was an iterative process that utilized both a pilot study and a multi-site RCT. This resulted

in the creation of a framework that can be used in the mitigation of maternal and neonatal mortality type studies.

Will the research change the practice of mHealth application within pregnant women? One of the key ways of lowering maternal and neonatal mortality is by empowering a woman. The research focused on the information passed on to the pregnant women and was used to empower the women to act and avoid the three delays that lead to mortality. Additionally, discoveries made during the study such as health worker strikes impact on maternal mortality will be key when conducting further studies aimed at reducing maternal mortality. Based on the system effectiveness, the women noted that the messages helped them make empowered decisions regarding their pregnancy.

Is the thesis well written and does it flow logically? A step-by-step process was used from the inception to the conclusion of the study. The study first involved understanding the status of maternal mortality within the study region. This then led to a pre-study that was aimed at understanding how the health workers and pregnant women dealt with pregnancy. Thirdly, a system was developed aimed at educating pregnant women. This was then implemented within an RCT with the aim of reducing complications that led to mortalities. Finally, the culmination was the proposal of a framework aimed at reducing said complications. The thesis flows in the same steps and as final step contributions and recommendations are highlighted.

Is the topic of interest to scholars and other stakeholders in the area? Within Kenya, mHealth is recognized as being key to solving various health challenges. Health is one of the priorities of the government and is listed as one of the agendas towards achieving the Kenya Vision 2030 goals. Some of the specific goals include improving access to referral systems, mainstreaming research and development in health, health product and technologies and community-based information systems. One of the findings of the study was the lack of proper

referral mechanisms during referrals. This would, in turn, inform the government on areas that are lacking and create policies of the same.

Additionally, various solutions have been created for health and range from health strengthening systems to personal wellness applications within the Kenyan scene. With the recently renewed millennium development goals by the sustainable development goals (SDG), maternal health is one of the goals towards sustainability. With that, it is imperative to design solutions targeting the achievement of the SDG goal and relevant toward low resource settings within developing countries. Additionally, the study is relevant as it points out challenges and unexplored areas within maternal health that need addressing and policy formulation.

7.4. Limitations

Several limitations were identified in context with the findings of the study. To begin with, the study was limited because of a low response rate by the women during the post-test survey. While the OHC location had 110 participants and the NSD location had 101 participants initially, the response rate in the post-test was 38% and 36% respectively (only 42 and 37 participants responded to the post-test respectively). This was due to changes in mobile phone numbers and migration of participants. The respondents could only be contacted by phone during the post-test due to ongoing nurses strike that rendered all government health facilities and hospitals inoperable. Considering the nature of the participating cohorts, this kind of response rate may be acceptable.

Secondly, the participants were affected by various inconveniences such as the health worker strikes and as such the findings cannot be generalized to other regions. The mass movement of pregnant women up-country for help nurturing their children by relatives meant inaccessibility of most of the women for the post-test survey. As such the results were limited to a low percentage of the women.

Moreover, the findings of the study were limited to a small population as they were sampled only from one constituency. The inclusion of an additional sample from other constituencies especially the marginalized areas would have presented a more comprehensive picture of the intervention's effectiveness. This may have led to better external validity than was achieved by the study.

One of the delimiters not covered by the study was the use of traditional birth attendants (TBA). While TBA's are illegal in Kenya, they still operate and provide service to women illegally. Access through investigation to TBA's to try and link them as consultants rather than birth attendants may have provided a more beneficial interventional impact to the women who seek out their services.

Lastly, close-out interviews could not be conducted with the health workers due to the health worker strikes. This, in turn, lost perspective, as to the benefits and limitations of the health workers could not be recorded or analysed. These results may have provided a unique perspective in addition to those gathered from the participants.

7.5. Implications of the Study

Based on the results of the analysis several implications about maternal health program implementation and maternal mortality reduction emerged. The findings indicate that there needs to be accountability put in place in the various public hospitals for the SDG-3.1 goal to be met. Strategies towards ending preventable maternal mortality by the Human Reproduction Programme (2015), points towards accountability to improve quality of care and equity. Countries that have been able to reduce their MMRs all bore one similarity; that of accountability at all levels of the health structure (Kuruvilla et al., 2014). The government needs to avail increased resources towards strengthening the systems within the health facilities and to promote accountability.

While the government has exhibited a commitment towards reducing MMRs and promoting maternal health, the progress has been impeded by health worker strikes. The various health worker strikes have unearthed a gap that has not been researched widely. In this regard, the effects of health worker strike specifically on maternal health have not been fully understood. Further research on the implications of the strikes on maternal health and maternal mortality needs to be investigated to gain more ground on how to mitigate those effects.

Additionally, the research has highlighted the complications that women encounter during pregnancy, labour, and birth. The findings showed that the uptake of technology to provide advice on pregnancy matters was positively received. Contributors to a reduction of maternal mortality have been suggested to be the education of women, access to facilities and timely transfers of mothers with complications (Soltani et al., 2015; Ahmed et al., 2016). Programs that use the study as a base for information dissemination, thereafter work towards ensuring access to facilities and timely transfers would help lower maternal morbidity and mortality.

7.6. Recommendations

The following recommendations might advance future similar studies as well as the implementation of the framework. These recommendations identify gaps that were established as a result of the findings. These recommendations are suggested in part by the limitations of the study and in part by the opportunities that can be seized to make future studies more successful.

To begin with, the study did not work with pregnant women who did not visit the health centre for ANC visits. Working with community health officers to recognize pregnant women especially those who do not attend clinics and enrol them in the program is advised. One of the ways that Rwanda was able to reduce maternal mortality was by mobilizing community health workers to work at the village level

(Ahmed et al., 2016). This, in turn, will ensure mother education right at the family and community level.

Second, health centres lacked accountability and follow-up of referrals. One consistent finding was the lack of follow-up and accountability of women referred to other hospitals. Transport or accompaniment to the referral hospital was rare. Additionally, a lack of proper referral procedures, including proper documentation impeded the monitoring of referred patients. Communication and accountability between the health centres and the referral hospitals are required to ensure prompt referrals. As such, a system of accountability from the referring hospital up until the time of patient admission needs to be set up. This with respect to maternal health with ensuring accountability of mortality rates and will reduce referrals of cases that can be handled by the home hospitals.

Third, the lack of adequate care and negligence led to a neonate mortality. One woman was turned away during labour after her water had already broken. This led to the neonate mortality. Had the proper protocol been followed, perhaps the neonate's life may have been saved. Continuous training and sensitization for the nurses and clinical officers need to be done to avoid mortalities due to negligence.

Fourth, because of the prolonged strike, most pregnant women were left to fend for services since their local public hospital was closed. Linkages between the government hospitals and the local missionary and inexpensive private hospitals need to be established for faster referrals. This would be convenient especially during health worker strikes. Additionally, mobilization of resources for the missionary hospitals during strikes would help lower mortalities during pregnancy, labour, and delivery.

During the study, participants called the researcher at odd hours of the night trying to get information about complications and emergencies and how to deal with them thereby saving their lives. A communication module within the system where

mothers can be optionally enrolled to allow communication with health workers round the clock would allow for communication during an emergency. This would be in addition to an interactive module where pregnant mothers can have a dialogue with the health workers.

Participants of the study indicated receiving messages during the study and benefitting from the messages that they requested for additional messages that went beyond pregnancy and childbirth. In turn, recommendations are made for studies to be conducted on facilitating new mothers on childcare and care after pregnancy.

Finally, both hospitals lacked computers and did not have any digital records. This attributes to a lengthy process prone to errors when trying to check patient adherence. Once the hospital has a computerized system, then the system used in the study would be integrated with the hospital system and linked with the participant records to measure adherence more accurately.

In conclusion, the study was impacted significantly due to health worker strikes. The study as such would need to be duplicated so that the real effect of health worker strikes on maternal mortality and morbidity can be evaluated and defined. It will be important to implement and test the framework as ongoing work from this study. It is important to note that in clinical research events are dynamic and can change at any time. Therefore, a reflexive approach is required to mitigate risks and, in this case, a sustainable intervention that could withstand disruptions was developed and implemented.

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ANNEXURES

Annexure 1: DUT Ethics clearance

DUT
DURBAN UNIVERSITY OF TECHNOLOGY

Institutional Research Ethics Committee
Faculty of Health Sciences
Room MS 49, Marshfield School Site
Gate 8, Ritson Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2900
Fax: 031 373 2407
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

4 February 2015

IREC Reference Number: **REC 4/15**

Mrs V M Njoroge
P O Box 37567-00100
Nairobi

Dear Mrs Njoroge

A Framework to Lower Maternal Mortality and Morbidity Rates in Kenya using Feasible Ubiquitous Technology

I am pleased to inform you that Provisional Approval subject to piloting of the data collection tools has been granted to your proposal REC 4/15.

The Proposal has been allocated the following Ethical Clearance number **IREC 011/15**. Please use this number in all communication with this office.

Approval has been granted for a period of one year, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC SOP's. In addition, you will be responsible to ensure gatekeeper permission.

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Please note that you may continue with validity testing and piloting of the data collection tools. Research on the proposed project may not proceed until IREC reviews and approves the final documents. If there are no changes to the data collection tools, kindly notify IREC in writing.

Yours Sincerely

[redacted]

Professor J K Adam
Chairperson: IREC

Annexure 2: NACOSTI Permit

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471,
2241349,3310571,2219420
Fax: +254-20-318245,318249
Email: dg@nacosti.go.ke
Website: www.nacosti.go.ke
when replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref. No.
NACOSTI/P/16/5620/4983

Date:
13th May, 2016

Victoria Mukami Njoroge
Durban University Of Technology
SOUTH AFRICA.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"A framework to lower maternal mortality and morbidity rates in Kenya using feasible ubiquitous technology,"*** I am pleased to inform you that you have been authorized to undertake research in **Kajiado County** for the period ending **12th May, 2017.**

You are advised to report to **the County Commissioner, the County Director of Education and the County Coordinator of Health, Kajiado County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

[redacted]
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kajiado County.

The County Director of Education
Kajiado County.

The County Coordinator of Health
Kajiado County.

Annexure 3: AMREF Ethics clearance

amref health africa

Amref Health Africa in Kenya

REF: AMREF – ESRC P190/2015

May 11, 2016

Victoria Njoroge
Africa Nazarene University
Phone: 0715579374
Email: vmukami@gmail.com

Dear Victoria Njoroge,

RESEARCH PROTOCOL: A FRAMEWORK TO LOWER MATERNAL MORTALITY AND MORBIDITY RATES IN KENYA USING FEASIBLE UBIQUITOUS TECHNOLOGY

Thank you for submitting your research protocol to the Amref Ethics and Scientific Review Committee (ESRC).

This is to inform you that the ESRC has approved your protocol. The approval period is from May 11, 2016 to May 10, 2017 and is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc) are submitted for review and approval by Amref ESRC before implementation.
c) Death and life threatening problems and severe adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the ESRC immediately.
d) Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to Amref ESRC immediately.
e) Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period (attach a comprehensive progress report to support the renewal).
f) Clearance for export of biological specimen or any form of data must be obtained from Amref ESRC, NACOSTI and Ministry of Health for each batch of shipment/export
g) Submission of an executive summary report within 90 days upon completion of the study. This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/or plagiarism.

Please do not hesitate to contact the ESRC Secretariat (esrc.kenya@amref.org) for any clarification or query.

Yours sincerely,

[redacted]

Prof. Mohamed Karama
Chair, AMREF ESRC

CC: Dr. George Kimathi, WASH Programme Manager, Amref Kenya and Vice Chair Amref ESRC
Samuel Muhula, Monitoring & Evaluation and Research Manager, Amref Kenya

Annexure 4: Consent Letter

Part I: Information Sheet

My Name is Victoria Mukami. I am a PhD student at Durban University of Technology. I am interested in looking at ways to ensure that pregnant women receive proper care so that they deliver their babies in a safe way. We are giving you this information because we would like you to participate in our research project. If you prefer not to participate, you are free to choose to do so. You will continue to receive health services the way that you normally would, with no negative impact.

Why is this Project Important?

Maternal health involves any health procedures done to a woman during pregnancy. Maternal Mortality on the other hand is the death of a woman during pregnancy or immediately after delivery of a child. The main aim of the project is to try and reduce instances of maternal death.

Participation is Your Choice

Your participation in this research is completely voluntary. You will make the choice about whether you will participate or not. If you choose not to take part, you will continue to receive all of the services that you usually get in your community and nothing will change.

What Is Involved in this Project?

The study will be done in Kajiado County: specifically at the Ongata Health Center and at the Ngong Sub District Hospital. The participants of the study will be required to do the following:

1. Answer questions on the questionnaire or interview below
2. Provide contact details
3. Consent to the study
4. Receive Messages via sms

Participants may be required to answer questionnaires throughout the study. The

questionnaires will present closed questions and guidelines on how to answer any of the questions will be included.

How long will the Project Last?

This study is expected to take approximately 6 months.

What are the Benefits?

There will be no direct benefit to you, but your participation is likely to help us find out more about how to lower maternal mortality within your locations and possibly duplicate the findings in other locations to reduce the same.

Can I Refuse to Participate or Withdraw from the Study?

You do not have to take part in this research if you do not wish to do so. If you choose not to participate, you will continue to receive all of the normal services that you usually get and nothing will change. If you wish to stop participating in the study after you begin, you can stop at any time by informing me.

Who Can I Contact?

If you have any questions, you can ask anyone from our team now or later. If you have questions later, you may contact Victoria Mukami at 0715579374 or email vmukami@gmail.com.

Part II: Certificate of Consent

I have read the above information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have been asked have been answered to my satisfaction. I consent voluntarily to be a participant in this study.

Print Name of

Participant	
Signature of Participant	
DD/MM/YYYY	

Annexure 5: Pre-Trial Questionnaire

Pregnant Women Questionnaire

Patient Initials (First letter of each of your names e.g. VMN)			
My Name is Victoria Mukami. I am a PhD student at Durban University of Technology. I am interested in looking at ways to ensure that pregnant women receive proper care so that they deliver their babies in a safe way. To do this, I will need more information about women that are pregnant and the care that they receive. Please help me to complete this questionnaire. Your honest answers will help us to help pregnant women in the future. The questionnaire is private and confidential and all data collected will be accorded the same. Please answer the questionnaire below by either filling in the blank areas or putting a checkmark to the appropriate area.			
Part A: Demographic information			
1. Date			
2. Preferred questionnaire language	2		English
	3		Kiswahili
2. Age			
2. Area of Residence			
3. Gender	1		Male
	2		Female
4. Language Proficiency - Can Read and Write) (Enough to SMS)	1		None
	2		Kiswahili
	3		English

	4		Both English and Kiswahili
	8		Other (Specify in 4a)
4a. Specify other language			
5. Highest Educational Level	1		None
	2		Lower primary(Class 1-7)
	3		Primary School certificate
	4		Form 1-3
	5		High School certificate
	6		College or University
6. Marital Status	1		Married
	2		Single
	8		Other(Specify in 6a)
6a. Specify other			
7. Employment Status (Currently)	1		Formally Employed
	2		Part Time
	3		Self-Employed
	4		Student
	5		Does not work (Dependant)
	6		Unemployed
	8		Other (Specify in 7a)
7a. Specify other employment			
8. Average Household income (Per Month in KES)	2		<2000
	3		2001 - 10,000
	4		10,001 - 40,000
	5		> 40,000
9. How many people live in your household? (Permanently)	2		1
	3		2
	4		3
	5		4
	6		5 or more
11. Average travel time to the prenatal/postnatal clinic?	2		Less than 10 minutes
	3		11-30 minutes
	4		31 – 59 minutes
	5		1 – 2 Hours

	6		More than two hours (specify in 11a)
11a. Specify how long it takes (in hours)			
12. Cost of travel to the clinic? (KES)			
13. Do you Smoke? (During the pregnancy)	1		Yes
	2		No
14. Does anyone in your house hold smoke?	1		Yes
	2		No
15. Do you drink alcohol? (During the pregnancy)	1		Yes
	2		No
Part B: Maternal Health Information			
16. How many pregnancies have you previously had?	1		None **Skip to 18**
	2		1
	3		2
	4		3
	5		4 or more
16a. Specify the number			
17. How many previous births have you had?	1		None **Skip to 18**
	2		1
	3		2
	4		3
	5		4 or more
17a. How many of these were still borns?	1		None
	2		1
	3		2
	4		3
	5		4 or more
17b. How many of these are still alive?	1		None
	2		1
	3		2
	4		3
	5		4 or more
18. How far along are you in your pregnancy?	2		1-4 Weeks

	3		5-12 Weeks
	4		13-26 Weeks
	5		27-40 Weeks
	6		40+ weeks
19. How often do you visit the prenatal clinic (per month	1		None
	2		1
	3		2
	4		3
	5		More than 4
19a. In previous pregnancies how many times did you visit the prenatal clinic?	1		None
	2		1
	3		2
	4		3
	5		More than 4
20. If you do not visit a prenatal clinic where do you get your checkups and advice?	2		Relative
	3		Traditional Birth Attendant
	8		Other
20a. Specify person you go to for checkups			
21. Have you had any complications that required hospitalization in your recent pregnancy?	1		Yes
	0		No
21a. Have you had any complications that required hospitalization in your previous pregnancies?	1		Yes
	0		No
22. Would education about pregnancy help you avoid hospitalizations?	1		Yes
	0		No
	9		Not Sure
Part C: ICT Information			
23. Do you currently own a phone?	1		Yes
	0		No **Skip to 23b**
23a. What is the make and model of the phone			
23ai. Where do you charge your phone?			
23aii. Who is your mobile subscriber?	1		Airtel
	2		Equitel
	3		Orange
	4		Safaricom

	5		Yu
23aiii. How often do you load airtime?	1		Daily
	2		Every 2 days
	3		Twice a week
	4		Once a week
	8		Other (Specify below)
24ab. Please specify how many times!			
23b. Do you have access to another phone?	1		Yes
	0		No
23bi. Whose phone do you have access to? (Check all that apply)	1		Spouse/Partners
	2		Other Household Member
	3		Non Household Member
	4		Simu ya Jamii
	8		Other (Specify)
	7		Not Applicable
23bi. Specify whose phone you have access to			
24. What do you use your phone for? (Select all that apply)	1		Receive calls only
	2		Make Calls
	3		SMS
	4		Internet
24a. Specify other use			
25. Would you like to receive texts relating to pregnancy?	1		Yes
	0		No
26. Would you like to receive voice calls relating to pregnancy?	1		Yes
	0		No
27. When would you like to start receive alerts?	2		During Pregnancy
	3		After Pregnancy
	4		Both
28. Which month of your pregnancy would you like to start receiving alerts?	2		0 - 1 Months
	3		2 - 3 Months
	4		3 - 6 Months
	5		6 - 9 Months
	6		After pregnancy

29. What is your preferred time of day to receive alerts?	2		Morning (8-12pm)
	3		Afternoon (12-4pm)
	4		Evening (4-8pm)
	5		Anytime
30. What is your preferred frequency to receive alerts?	2		1 Per Week
	3		2 Per Week
	4		More than 2 per week
30a. Specify how many more per week.			
31. Which pregnancy information would you like to receive? (Select all that apply)	2		Things to avoid
	3		When to call a doctor
	4		What to look out for
	5		Appointment reminders
	6		Family planning
	10		What to expect at different trimesters of pregnancy
	11		Mental health
	12		Physical activity
	13		Diet and nutrition
	14		Pesticides and harmful substances
	15		Pregnancy & delivery courses
	8		Other

Thank you for taking part in this study. If you need to contact me feel free with the details below.

Name: Victoria Mukami

Cell: 0715579374

Email: vmukami@gmail.com

Annexure 6: End-Survey

Hallo, My name is Victoria. I have been sending you messages about your pregnancy and how to take care of you and your baby. I call today to find out whether the messages were helpful and to find out more about you. I will ask you a series of questions. If you have any question as well do not hesitate to stop me.
Insert the Patient ID
Part A: Demographic Information
Date
How old are you?
What is your Area of Residence?
What is your highest educational level?
What is your marital status?
Specify other status
Are you employed?
What job do you do?
What is your monthly household income?
Part B: Maternal Health Information
How many pregnancies have you previously had?
Specify number of pregnancies
How many other deliveries have you had?
How many of these babies did you lose during pregnancy and delivery?
How many children do you currently have that are alive?
How many total visits did you have before giving birth?
Part B: Maternal Health Information
Has your baby been born yet?
What date was your baby born?
Where was your baby born?

Were there complications during birth?
What were the complications during birth
What was the method of delivery?
Is your baby alive and well?
What are the reasons as to why the baby is not well?
Part C: SMS Intervention
Did the sms's assist you during pregnancy?
Why did they not assist you?
Did the sms's help prepare you for birth and delivery?
How else could they have helped you?
Did they assist with your nutrition during pregnancy?
What other ways should they have helped with your nutrition?
Did you ever call the researcher for additional information?
What information were you requesting from the researcher?
Is there any other information you would like me to know?
What is this information?

Annexure 7: Pregnancy Messages

Pregnancy week	Day of the week	Message	Category
40	2	Giving birth in the hospital is free of charge. Talk to the nurse if you have not yet done so on what you need to carry with you when you go to hospital. Find out also how you can prepare your home in readiness for the baby.	Pregnancy & delivery courses
40	4	If your baby is not yet here do not worry. Sometimes babies are late. Enjoy this moments like the little kicks before baby is born and you become busy. Make sure to watch out for contractions or your water breaking. If that happens be sure to report to the hospital immediately.	Mental health
38	3	When baby is born it is important that you breastfeed them. The first thick and creamy milk is called colostrum. It is creamy with goodness. Feed this straight away to your baby to give them the best start in life	Diet and nutrition
38	6	Before discharge from the hospital, the nurse will let you know when your next appointment will be. Once you are given a go ahead to have sex then it is recommended that you talk to the nurse about family planning methods you can use. This will help you prevent unwanted pregnancies and give you peace of mind.	Family planning
37	2	Pregnancy hormones cause the ring of muscle that separates the esophagus from the stomach to loosen, causing heartburn. Heartburn does go away as soon as your baby is born. There are food that trigger heartburn and one way to avoid heartburn is to find out what they are and to avaoid them. Try eating a couple hours befor bedtime and if possible try to sleep with your head elevated by 2 or 3 pillows.	Things to avoid

37	7	Pelvic pressure (a feeling that your baby is pushing down), lower back pain (especially if it's a new problem for you), menstrual-like cramping or abdominal pain, or more than four contractions in an hour (even if they don't hurt) needs to be checked out. How to tell you have contractions is if you can time them and can tell exactly when the next contraction is coming. Visit your health center if you have any of these symptoms.	Announcements by the health center
36	2	If you have a persistent headache, abdominal (stomach) pain, blurry vision (cannot see well) and swelling of your body then you urgently need to visit the health center. This is due to a serious condition called Preclampsia that is life threatening.	Announcements by the health center
36	6	By now many of your baby's systems are pretty mature and just about ready for life on the outside. Most probably your baby is head down but if not your doctor and midwife will have some suggestions for you. You may also notice some small cramp like pains called braxton hicks that are considered practice contractions.	What to expect
35	1	This is to remind you that you have an appointment at the Ongata Health Center as from 7:30 AM. Please confirm your record book for your appointment date. Ensure you attend the clinic as it is important for you and your baby's well being.	Appointment Reminders
35	2	Part of your peace of mind is being prepared. You have been preparing for the baby all along but what about yourself? You will require some items after birth. Have you bought sanitary pads, nursing bras? If you are a first time mother talk to other mothers to find out what else you will need.	Mental health

34	5	Pushing your baby through your pelvis and into the world is demanding for you and your pelvic. Ever heard of Kegel exercises? These are exercises for the pelvic muscles. These muscles ensure that you are able to hold your urine in and ensures that your baby is held in. To find your muscles stop the urine mid stream. then start urinating again, then stop it mid stream. Now try doing that when you are not urinating. You can do this anywhere and it is never too early to start.	Phyisical Activity
34	6	When you start labor you may see a mucus like discharge. For most women the main sign is contractions (More painful than cramps). Sometimes the first sign of labor is breaking of waters. The water may be clear with a bit of yellow. It may be blood stained. Once it breaks it is recommended to go to the clinic immediately.	When to call a doctor
33	2	Being prepared is key to less stress. You need to prepare the area where your baby will sleep. Start buying or collecting clothes, bottles, wash basins and other items baby will need. Remember to prepare older children on the arrival of the baby.	Mental health
33	5	Slightly swollen hands and feet are caused by the extra blood in your body. Try to rest with your feet raised. If you have sudden swelling and headaches, go to the clinic. If you get bleeding, headaches or a pain down one side of your stomach, go to the clinic.	What to look out for
32	5	During pregnancy some women get diabetes, even if they have not had it before. Signs of diabetes are being more tired than usual, being very thirsty and blurred vision. You are more likely to get diabetes if you are overweight or other family members have diabetes. Eating well, Exercising and stopping smoking can prevent it.	Diet and nutrition

32	7	Are you sleeping under an insecticide treated mosquito net? Might you need a new one for you and your baby when they are born? Please speak to your health worker to be issued with one for you and your baby.	Pregnancy & delivery courses
31	7	Your womb is warm and cosy. It is warmer than the weather outside, even if it is hot. This means your newborn can get cold easily. Your body will keep him warm. Hold him firmly, lay a clean warm blanket over both of you. Ensure that the baby always has a hat as they loose a lot of their heat through their head.	Miscellaneous
31	6	Your baby is putting longer stretches of sleep which is why you are noticing more defined patterns of wakefulness (movement) and rest (stillness). Your baby is swallowing, practicing to breathe, moving his arms and legs even sucking their thumb. Your baby is also developing their five senses.	What to expect
30	6	This is to remind you that you have an appointment at the Ongata Health Center as from 7:30 AM. Please confirm your record book for your appointment date. Ensure you attend the clinic as it is important for you and your baby's well being.	Appointment Reminders
30	7	Heavy bleeding during pregnancy is never a good sign especially when accompanied with cramping or abdominal pain. If you experience this or if you have any trauma (accident) where the stomach is hurt like a car accident ensure to visit the hospital as soon as you can. You health center will be able to take a look at what is going on and assist you and the baby.	Announcements by the health center
29	6	Are there relatives or friends who live far away that you have not visited in a while? Your chance to do so is closing. It is not recommended to travel far after week 30 or the 7th month of your pregnancy.Ensure that no last minute travels exist to ensure you do not get unforeseen emergencies.	Mental health

29	5	Have you had a cold recently or do you feel like as if a cold is lingering in the background? Not all cold and flu medicine is good for you and your baby. To soothe a cold or sore throat, try drinking hot water mixed with ginger and honey. If you do not mind the taste feel free to add garlic. Ensure to keep drinking fluids to ensure you do not get dehydrated.	Things to avoid
28	4	This is to remind you that you have an appointment this week at the Ongata Health Center as from 7:30 AM. Please confirm your record book for your appointment date. Ensure you attend the clinic as it is important for you and your baby's well being.	Appointment Reminders
28	1	Just half an hour of exercise will benefit you and your baby. Whether it is walking or simple cleaning of the house you should be able to moderate the amount of work to ensure that you do not over tire yourself. You also need to ensure that you do not over exert yourself.	Phyisical Activity
27	3	Avoiding risky foods is only half the challenge, your food is only as safe as your own handling and cooking habits. Avoid eating raw food that you are not aware what water was used to clean them. Avoid using dirty water to clean your vegetables and if possible only eat from places you trust. This will ensure you do not get ill which can be very risky for you and your baby.	Things to avoid
27	1	Your baby may be able to recognize both you and your partner's voices by now. This might be a good time to bond with your baby by starting to sing to your baby (tummy). You may start to fill twinges or shudders on your stomach after eating certain foods. This is your baby having hiccups which are perfectly safe.	What to expect

26	6	Severe ithching at any point of your pregnancy is never a good sign. It could be a sign of a rare liver disorder. Should you experience this please visit the health center to get checked out. Keep listening to your babies movements. If you do not feel the baby moving when you expect them to be moving then get something to eat or drink then lie on your side. If there is still no movement please visit the health center immediately.	Announcements by the health center
26	7	You may be thinking about where to have your baby. You should ensure you give birth in a hospital. The reasons are: it is a clean place hence a lower risk of infection, the nurse who is trained will be able to deal with any problems that can occur and if anything goes wrong the nurse will be able to keep you and your baby safe.	Miscellaneous
25	1	If you feel breathless, tired or dizzy, you may be short of iron. Pale hands, eyelids or tongue are signs of severe anaemia. If you notice these symptoms, go to the clinic. A burning sensation at the top of your stomach is heartburn. Spicy and oily foods can make it worse. A glass of milk may help soothe it.	What to look out for
25	5	Your baby is growing fast. Try to increase the amount of food you serve at every meal. Eat foods to help your baby grow such as Fish like Tilapia, Meat, Beans and Peas(Minji).	Diet and nutrition
24	2	Your body requires higher levels of Iron for you and your baby. You can get iron from meat, lentils, peas, beans and leafy vegetables like sukuma-wiki, managu, terere and spinach. Keep Eating these vegetables as well as taking your IFAS tables. Ensure to refill these with your ANC nurse.	Diet and nutrition
24	1	This is to remind you that you have an appointment this week at the Ongata Health Center as from 7:30 AM. Please confirm your	Appointment Reminders

		record book for your appointment date. Ensure you attend the clinic as it is important for you and your baby's well being.	
23	6	Is your stomach growing big? This is part of the wonders of pregnancy. This is a good time to look for lose fiting clothes or time to buy maternity clothes. Remember to wear comfortable clothes and sensible shoes. If you are comfortable you and your baby are happy!	Miscellaneous
23	2	Your belly will have increased further with your pregnancy now more pronounced. The are more back muscle pains and cramps due to the increase size of your belly. You can start singing lullabies to the baby and reading books such as the bible to them.	Miscellaneous
22	2	Make sure to have lots of calcium rich foods like Milk, Mala, Yoghurt, and vegetables like Sukuma Wiki, Managu, Terere and Spinach. Calcium helps to prevent problems later on in pregnancy.	Diet and nutrition
22	7	Do you feel like you have started gaining to much weight or has your doctor mentioned that you have gained too much weight? Then consider eating more healthy food. Avoid junk food. Eat homemade food that does not have too much artificial ingredients.	Things to avoid
21	7	You may have to start to make modifications on how you sit, stand up and do other physical activities. Exercise is still pretty easy and good for your body , as long as you stick t activities that don’t put you at risk for falling or being hit in the stomach.	Phyisical Activity
21	5	Additional signs to look out for include: if you are thirst and have not been urinating frequently, if it hurts or burns to urinate, it could mean that you are dehydrated (not taking enough water) or are ill. Please go to the health center to have you and your baby checked out.	When to call a doctor

20	2	Ensure to visit the clinic if any when you see any of these signs: A sharp pain in your tummy, A high fever, Any bleeding, if you feel breathless all the time. Vomiting may also mean you are ill especially if you vomit all the time. If you see any of these signs please go immediately to the health center.	When to call a doctor
20	1	The health center offers education to all mothers every weekday before appointments. This is normally done first thing in the morning. Please ensure to get to your appointment early to ensure that you get some education on pregnancy.	Pregnancy & delivery courses

Annexure 8: Nurses Interview

Introduction

My Name is Victoria Mukami. I am a PhD student at Durban University of Technology. I am interested in looking at ways to ensure that pregnant women receive proper care so that they deliver their babies in a safe way. To do this, I will need more information about women that are pregnant and the care that they receive. Please help me to complete this interview. Your honest answers will help us to help pregnant women in the future. The interview is private and confidential and all information collected will be accorded the same.

Interview Questions

Age

_____

Gender

_____

Hospital:

_____

Hospital Role

_____

Length at current hospital

_____

Length of service

_____

Number of births assisted per month:

_____

1. Can you tell us about the unit that you work in?
    a. Types of services
2. Do you think maternal mortality is a problem in Kajiado North?
    a. Why is that?
    b. In what way do you think nurses and midwives can prevent this?
3. What is the situation like (concerning maternal health) at your Health Care Facility?

4. Explain the process that you take when a pregnant woman comes to see you?
5. What difficulties do you see in your work?
    a. Can you give an example?
        i. Staffing
        ii. Availability
        iii. No Time
        iv. Communication difficulties
        v. Decision making
        vi. Referral system
6. What preventive methods do you use in your work?
    a. Do you think they are effective?
7. What is the biggest problem pregnant mothers' face here in Kajiado North?
    a. In what way can you assist them in this problem/s?
8. What kind of problems do you normally handle during antenatal care?
9. What kind of problems do you handle during labor and delivery?
10. What kind of recommendations do you give to mothers about health during pregnancy and delivery?
    a. How do you do this? (Pamphlets, groups, individuals, couples?)
    b. Do the mothers follow your recommendations?
    c. Do you check the baby and woman after birth?
11. What kind of advice do you give women after birth?
    a. Do the women always come for their appointments after? (why/why not?)
12. From where do you get your information on what to recommend to the mothers?
    a. What are these recommendations?
    b. Are you able to follow these recommendations in your work? (why/why not?)
13. Would it be beneficial if the women received notifications during the pregnancy of upcoming appointments?
14. Is there something else you would like to highlight concerning prevention of maternal mortality?
15. Is there anything more you would like to add?

Follow up-questions: Can you explain more/can you give an example/how do you mean?

Annexure 9: Sample SMS logs

Destination country	Destination network	Ported	SMS count	Sent date	Delivery report time	Status
Kenya	Safaricom	No	3	06.02.2017 17:00:01	07.02.2017 09:00:25	Delivered
Kenya	Safaricom	No	3	06.02.2017 17:00:01	06.02.2017 17:35:52	Delivered
Kenya	Safaricom	No	3	06.02.2017 17:00:01		Expired
Kenya	Safaricom	No	3	06.02.2017 17:00:01	06.02.2017 17:00:18	Delivered
Kenya	Safaricom	No	3	06.02.2017 17:00:01	06.02.2017 17:00:17	Delivered
Kenya	Safaricom	No	3	06.02.2017 17:00:01		Expired
Kenya	Safaricom	No	3	06.02.2017 17:00:01		Expired
Kenya	Safaricom	No	3	06.02.2017 17:00:01		Expired
Kenya	Safaricom	No	3	06.02.2017 17:00:01	06.02.2017 17:00:12	Delivered
Kenya	Safaricom	No	3	06.02.2017 17:00:01	06.02.2017 17:00:16	Delivered

Kenya	Safaricom	No	3	06.02.2017 17:00:01	06.02.2017 17:00:16	Delivered
Kenya	Safaricom	No	3	06.02.2017 17:00:01	08.02.2017 08:20:02	Delivered
Kenya	Safaricom	No	3	06.02.2017 17:00:01	06.02.2017 17:00:23	Delivered
Kenya	Safaricom	No	3	06.02.2017 17:00:01	07.02.2017 17:00:54	Failed (Message sent, not delivered)
Kenya	Safaricom	No	3	06.02.2017 17:00:01	06.02.2017 17:00:17	Delivered
Kenya	Safaricom	No	3	06.02.2017 17:00:01	06.02.2017 17:00:16	Delivered
Kenya	Safaricom	No	3	06.02.2017 17:00:01	06.02.2017 17:00:35	Delivered
Kenya	Safaricom	No	3	06.02.2017 17:00:00	06.02.2017 17:00:20	Delivered
Kenya	Safaricom	No	3	06.02.2017 17:00:00		Expired
Kenya	Safaricom	No	3	06.02.2017 17:00:00	06.02.2017 17:00:16	Delivered
Kenya	Safaricom	No	3	06.02.2017 17:00:00		Failed (Message sent, not delivered)

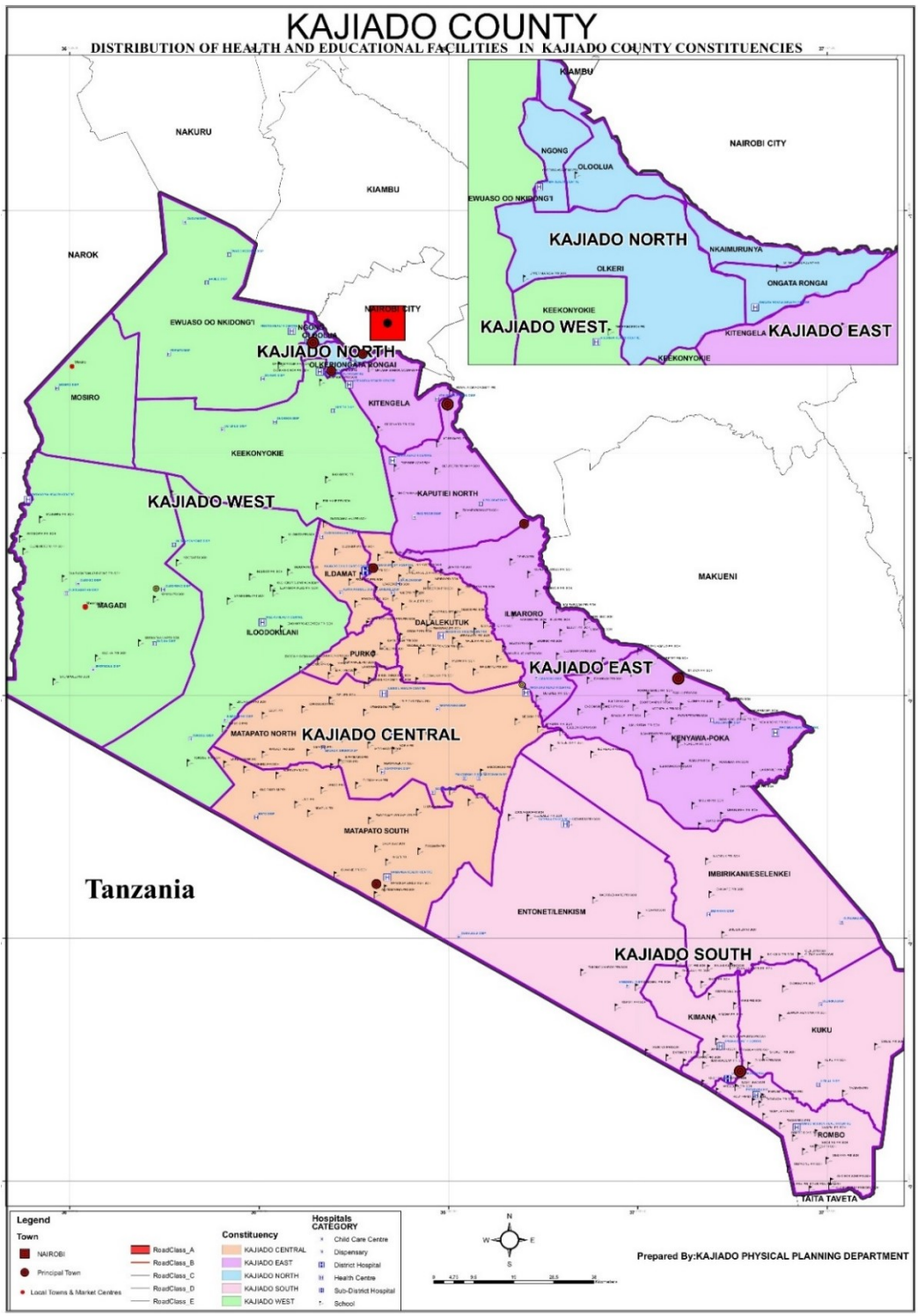
Kenya	Safaricom	No	3	06.02.2017 17:00:00	07.02.2017 17:00:18	Failed (Message sent, not delivered)
Kenya	Safaricom	No	3	06.02.2017 17:00:00	06.02.2017 17:00:16	Delivered
Kenya	Airtel Kenya	No	3	06.02.2017 17:00:00	06.02.2017 17:00:10	Delivered

Annexure 10: Kajiado Ciounty and Kajiado North Constituency details

Kajiado County as shown in figure 10.1 has 21,901 Km^2 with a total population estimated at 687,312 with 342,166 being female and 345,146 being male as of the 2009 statistics (Kenya National Bureau of Statistics, 2013:8). The population that is of reproductive age (15-49) within the county is 178,547 (County Government of Kajiado 2013:9).

Map of Kenya showing Kajiado County

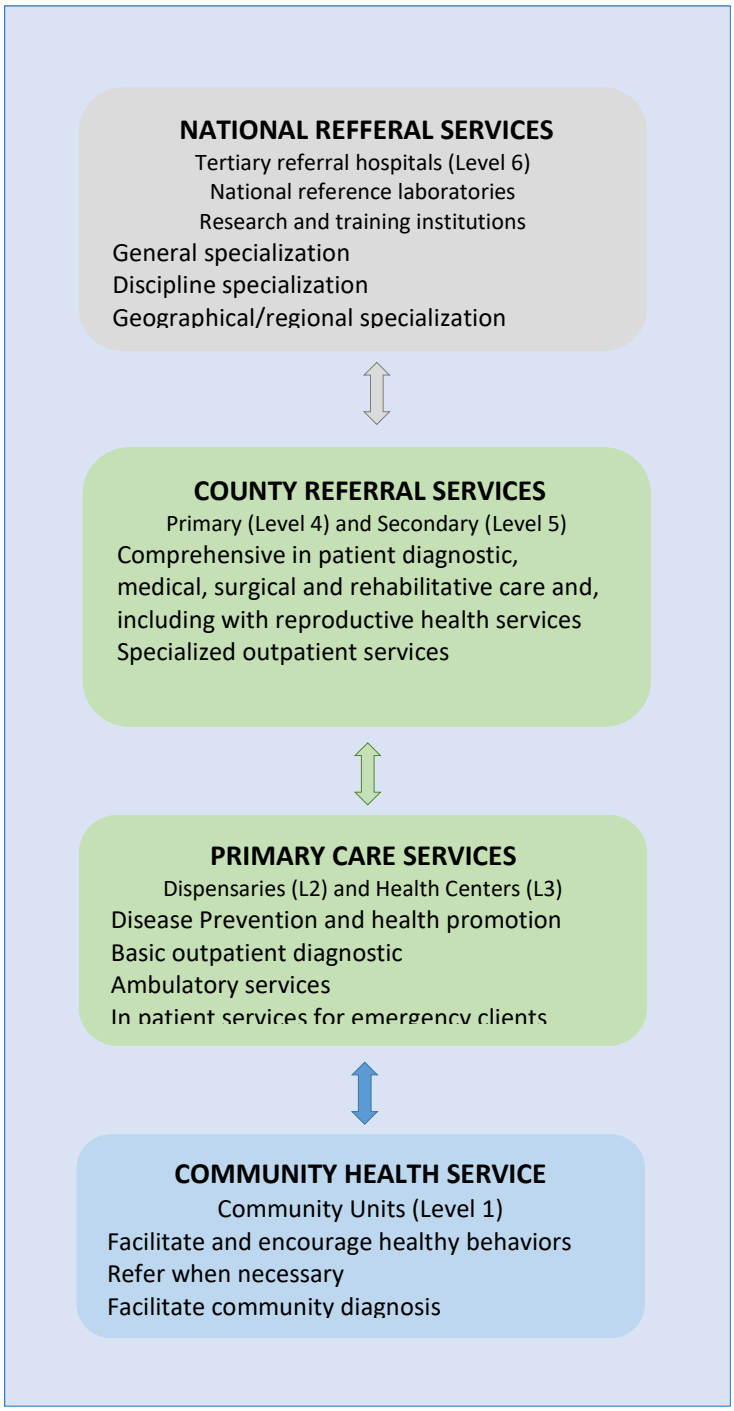
Kajiado-North constituency as shown in figure 10.2 is the smallest constituency in the county at 7,400Km^2, however is the most populated with more than half the population at 387,538 people as of the 2009 statistics. Of these 195,955 are male while 191,583 are female (Kenya National Bureau of Statistics, 2013:13).



Map of Kajiado county list of constituencies (County Government of Kajiado 2016:1)

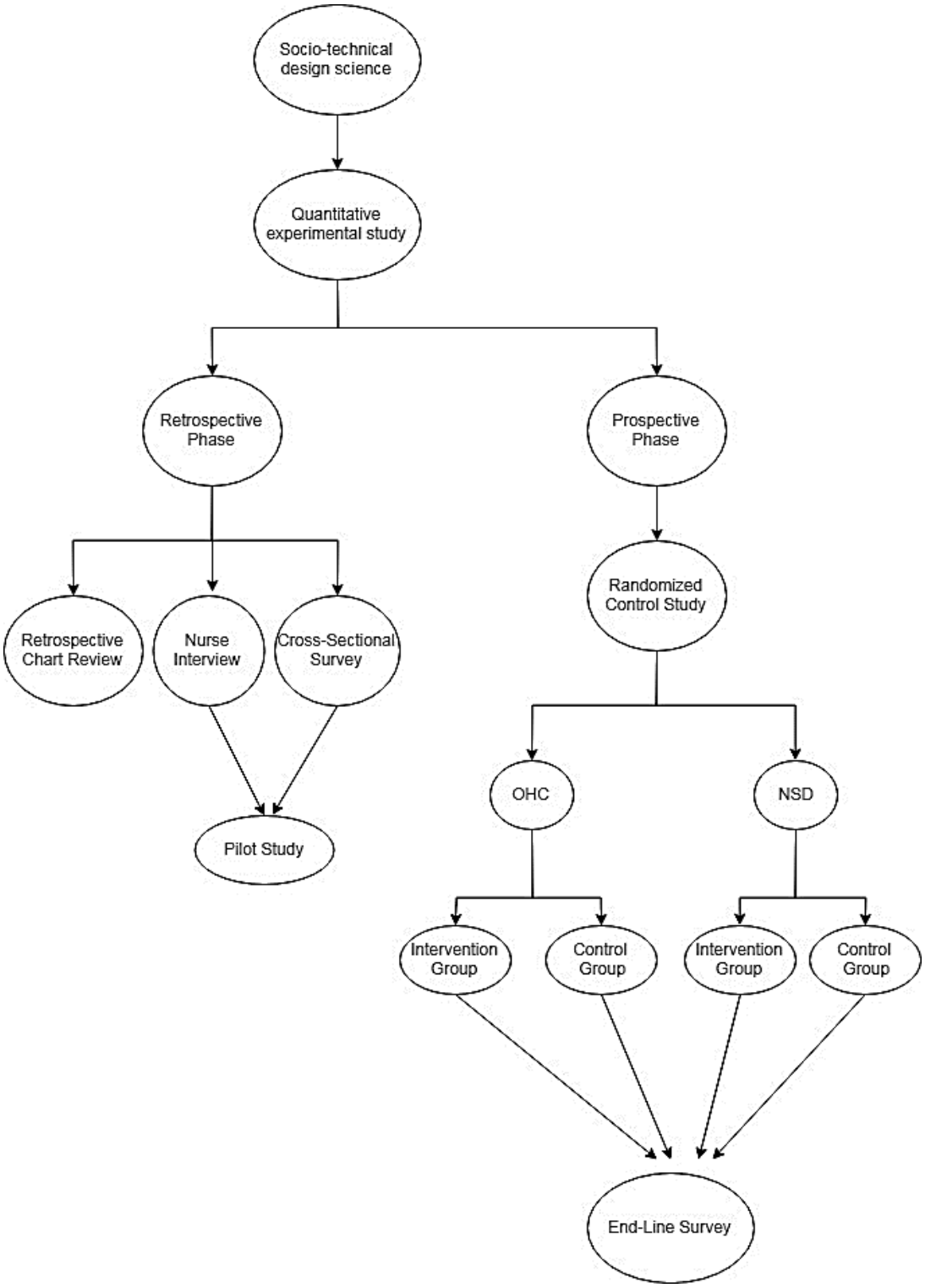
Annexure 11: Organization of health services

Tiers of care	Levels of care
Tier 1: Community	Level 1: Community
Tier 2: Primary Care	Level 2: Dispensaries and Clinics Level 3: Health Centers
Tier 3: Secondary Referral	Level 4: Primary Care Hospitals Level 5: Secondary Care Hospitals
Tier 4: Tertiary Referral	Level 6: Tertiary Hospitals



Organization of Health Services (MOH 2014:42)

Annexure 12: Methodology Flow Chart



Annexure 13: Chart Review Instrument

Chart Review Data Collection						
Name of Facility						
Type of Facility						
Report Indicators	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
ANC Ward						
First Visit						
Revisit						
Completed 4th Visit						
0 - 14 Year Olds						
15 - 19 Year Olds						
Delivery Ward						
Indicators						
Live Births						
Referral						
FSB (Fresh Still Birth)						

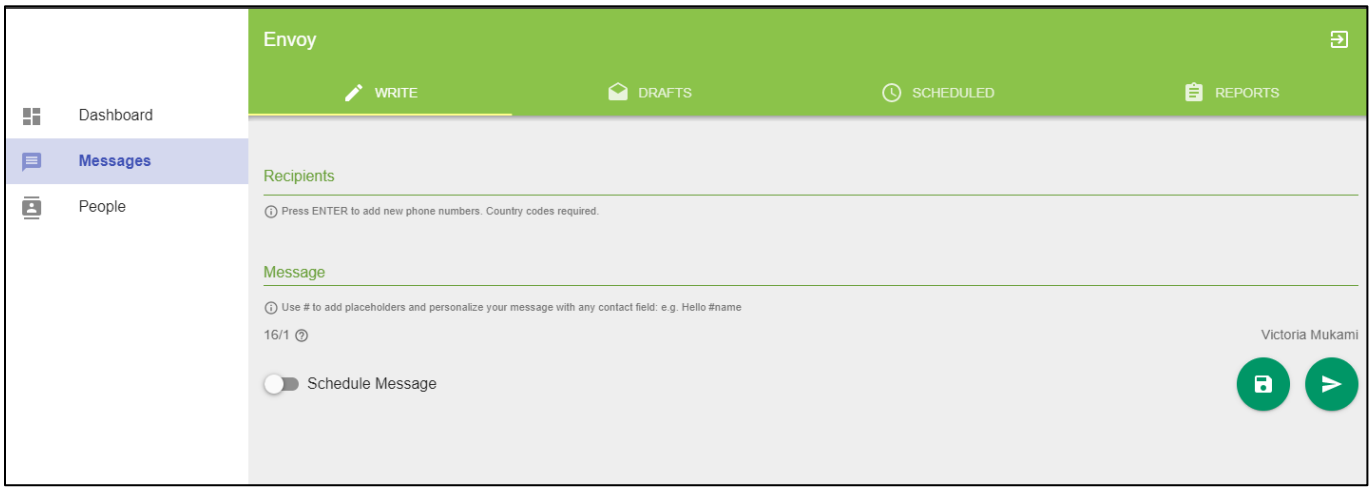
Annexure 14: Response CSV file – Intervention group

participant_id	**q1_date**	**q3_age**	**q4_area**	**q6_edu**	**q7_marital**	**q7a_marital**	**q8_employ**	**q8a_employ**	**q9_income**	
Paruticipant's ID	Day's Date	Participant's age	Area the participant lives in	Education level of the participant	Marital Status	Explanation of other marital status	Employent status	Other employement status	Income level	
s2_maternal	**q10_preg**	**q10a_preg**	**q11_births**	**q11a_births**	**q11b_alive**	**q12_visit**				
Second Section on Pregnancy	Pregnancy status	Pregnancy status other status	Number of previous births	Additional births	How many still-borns	Number of ANC visits				
s3_birth	**q13_delivery**	**q13a_datebirth**	**q14_born**	**q15_compl**	**q15a_compl**	**q16_type**	**q17_baby**	**q17a_baby**		
Third Section on Delivery	Delivery status	Date of delivery	Where was the delivery	Any complication	Name of complication	Type of delivery	Baby alive and well?	Additional information		
s4_sms	**q18_sms**	**q18a_sms**	**q19_smsbirth**	**q19a_smsbirth**	**q20_nutrition**	**q20a_nutrition**	**q21_call**	**q21a_call**	**q22_info**	**q22a_info**
Fourth Section on SMS	Assistance of SMS	Additional Information	Aid during pregnancy and Birth	Additional information	Aid with nutrition	Additional information	Whether participant called the researcher	Information requested	Additional information	What is the information?
s_end	**start**	**start_time**	**end**	**end_time**	**deviceid**	**deviceid_output**	**meta:instanceID**			
Last section on device details	Starting time		Ending time		Device used to collect information		Instance ID			

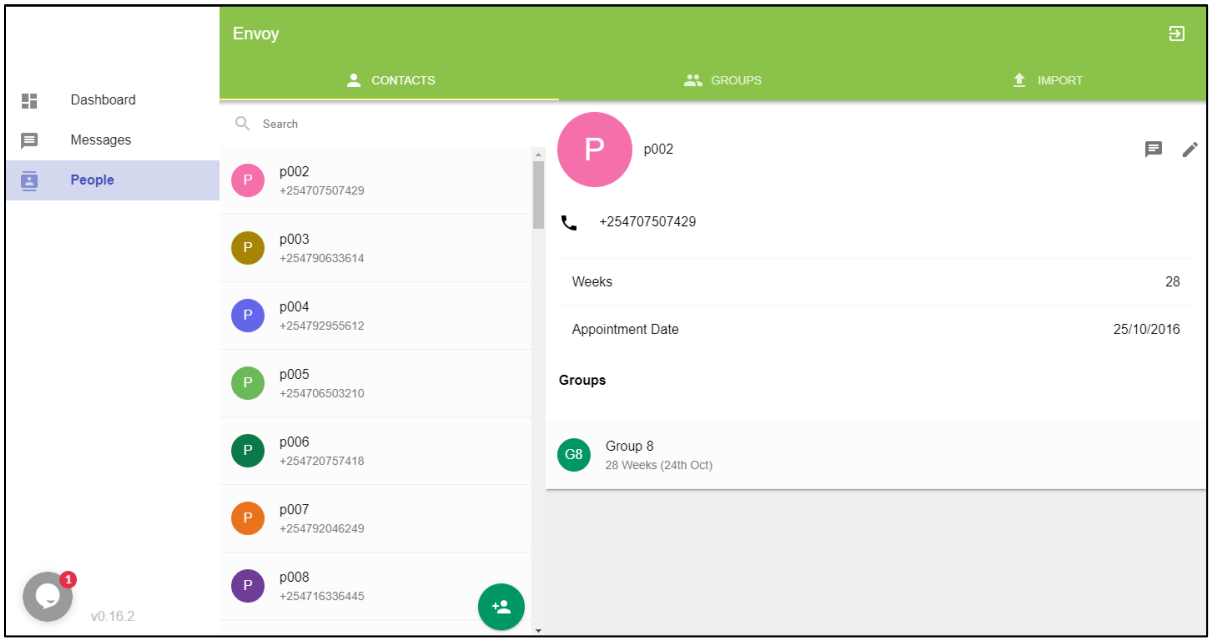
Annexure 15: Response CSV file – Control group

participant_id	**q1_date**	**q3_age**	**q4_area**	**q6_edu**	**q7_marital**	**q7a_marital**	**q8_employ**	**q8a_employ**	**q9_income**
Paruticipant's ID	Day's Date	Participant's age	Area the participant lives in	Education level of the participant	Marital Status	Explanation of other marital status	Employent status	Other employement status	Income level
s2_maternal	**q10_preg**	**q10a_preg**	**q11_births**	**q11a_births**	**q11b_alive**	**q12_visit**			
Second Section on Pregnancy	Pregnancy status	Pregnancy status other status	Number of previous births	Additional births	How many still-borns	Number of ANC visits			
s3_birth	**q13_delivery**	**q13a_dateb irth**	**q14_born**	**q15_compl**	**q15a_compl**	**q16_type**	**q17_baby**	**q17a_baby**	
Third Section on Delivery	Delivery status	Date of delivery	Where was the delivery	Any complication	Name of complication	Type of delivery	Baby alive and well?	Additional information	
s_end	**start**	**start_time**	**end**	**end_time**	**deviceid**	**deviceid_output**	**meta:instanceID**		
Last section on device details	Starting time		Ending time		Device used to collect information		Instance ID		

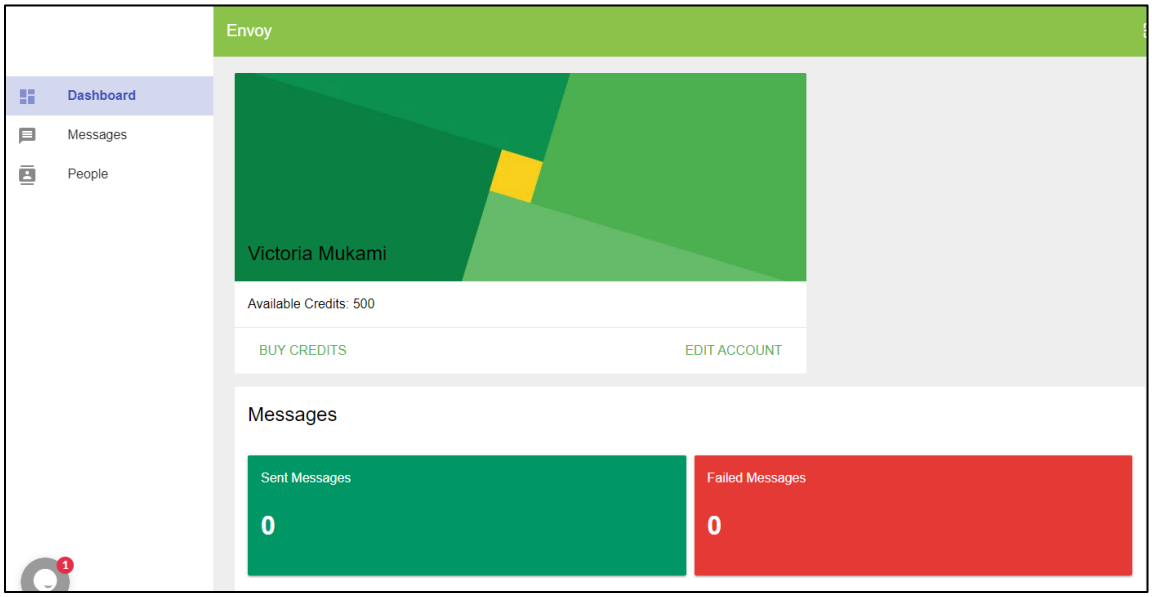
Annexure 16: Web Application – Pilot Test



Message Scheduling dashboard



Contact Scheduling



Main Dashboard

Annexure 17: Questionnaire Automation - Sample

```
<?xml version="1.0"?>
<h:html xmlns="http://www.w3.org/2002/xforms"
xmlns:ev="http://www.w3.org/2001/xml-events"
xmlns:h="http://www.w3.org/1999/xhtml"
xmlns:jr="http://openrosa.org/javarosa"
xmlns:orx="http://openrosa.org/xforms"
xmlns:xsd="http://www.w3.org/2001/XMLSchema">
 <h:head>
  <h:title>Pre-Study questionnaire for Pregnant Women
V5</h:title>
  <model>
   <itext>
    <translation default="true()" lang="default">
     <text id="/PregnantWomenQstv5/q17a_births:label">
      <value>How many of these were born dead?</value>
     </text>
     <text id="/PregnantWomenQstv5/q20a_advice:hint">
      <value>Person's Role</value>
     </text>
     <text id="/PregnantWomenQstv5/q10_house/5:label">
      <value>4</value>
     </text>
     <text
id="/PregnantWomenQstv5/q2_language/3:label">
      <value>Kiswahili</value>
     </text>
     <text
id="/PregnantWomenQstv5/q23b_access/2:label">
      <value>No</value>
     </text>
     <text
id="/PregnantWomenQstv5/q23a_specs/generated_table_list
_label_42:label">
      <value>What are the phone specifications?</value>
     </text>
     <text id="/PregnantWomenQstv5/q31_info/8:label">
      <value>Other</value>
     </text>
     <text id="/PregnantWomenQstv5/q23bi_access:hint">
      <value>Check all that apply</value>
     </text>
     <text id="/PregnantWomenQstv5/q11a_travel:hint">
      <value>In Hours</value>
     </text>
     <text id="/PregnantWomenQstv5/q10_house:hint">
      <value>Permanent residents</value>
     </text>
     <text
id="/PregnantWomenQstv5/q23aiii_airtime/4:label">
      <value>2 times a week</value>
     </text>
     <text id="/PregnantWomenQstv5/q11_travel/4:label">
      <value>31 – 59 minutes</value>
     </text>
     <text id="/PregnantWomenQstv5/q31_info/10:label">
      <value>What to expect at different trimesters of
pregnancy</value>
     </text>
     <text
id="/PregnantWomenQstv5/q23aiii_airtime/3:label">
      <value>3 times a week</value>
     </text>
     <text id="/PregnantWomenQstv5/q18_along/5:label">
      <value>27-40 Weeks</value>
     </text>
     <text id="/PregnantWomenQstv5/q26_voice/1:label">
      <value>Yes</value>
     </text>
     <text id="/PregnantWomenQstv5/q26_voice:label">
      <value>Would you like to receive voice calls relating to
pregnancy?</value>
     </text>
     <text id="/PregnantWomenQstv5/q28_month:label">
      <value>Which month of your pregnancy would you like
to start receiving alerts.</value>
     </text>
     <text id="/PregnantWomenQstv5/q17a_births/3:label">
      <value>2</value>
     </text>
     <text id="/PregnantWomenQstv5/q31_info/12:label">
      <value>Physical activity</value>
     </text>
     <text id="/PregnantWomenQstv5/q20_advice:label">
      <value>If you do not visit a prenatal clinic, where do
you get your checkups and advice?</value>
     </text>
     <text id="/PregnantWomenQstv5/q23_phone:label">
      <value>Do you currently own a cell phone?</value>
     </text>
     <text id="/PregnantWomenQstv5/q18_along:label">
      <value>How far along are you in your
pregnancy?</value>
     </text>
     <text id="/PregnantWomenQstv5/q30_freq/3:label">
      <value>2 Per Week</value>
     </text>
     <text id="/PregnantWomenQstv5/q28_month/4:label">
      <value>3 - 6 Months</value>
     </text>
     <text id="/PregnantWomenQstv5/q29_day/2:label">
      <value>Morning (8-12pm)</value>
     </text>
     <text
id="/PregnantWomenQstv5/q23bi_access/8:label">
      <value>Other (Specify)</value>
     </text>
     <text id="/PregnantWomenQstv5/q6_edu/4:label">
      <value>Form 1-3</value>
     </text>
     <text id="/PregnantWomenQstv5/q15_alcohol/2:label">
      <value>No</value>
     </text>
     <text id="/PregnantWomenQstv5/q11a_travel:label">
      <value>Specify how long it takes to the clinic</value>
     </text>
     <text
id="/PregnantWomenQstv5/q2_language/2:label">
```

```
        <value>English</value>
      </text>
      <text id="/PregnantWomenQstv5/q29_day/3:label">
        <value>Afternoon (12-4pm)</value>
      </text>
      <text id="/PregnantWomenQstv5/q30_freq/2:label">
        <value>1 Per Week</value>
      </text>
      <text
id="/PregnantWomenQstv5/q21_complications:label">
        <value>Have you had any complications that required
hospitalization in your recent pregnancy?</value>
      </text>
      <text id="/PregnantWomenQstv5/q19a_visit:label">
        <value>During previous pregnancies, how many times
did you visit the prenatal clinic</value>
      </text>
      <text id="/PregnantWomenQstv5/q24_use/2:label">
        <value>Make  Calls</value>
      </text>
      <text id="/PregnantWomenQstv5/q13_smoke:label">
        <value>Do you Smoke?</value>
      </text>
      <text id="/PregnantWomenQstv5/participant_id:hint">
        <value>The patient ID is made up of 3
characters</value>
      </text>
      <text id="/PregnantWomenQstv5/s2_intro:label">
        <value>This section allows the researcher to learn the
habits of the interviewee in regards to maternal care and
information relating to pregnancy</value>
      </text>
      <text
id="/PregnantWomenQstv5/q21_complications/2:label">
        <value>No</value>
      </text>
      <text id="/PregnantWomenQstv5/q11_travel/6:label">
        <value>More than two hours (specify)</value>
      </text>
      <text id="/PregnantWomenQstv5/q7_marital/2:label">
        <value>Married</value>
      </text>
      <text id="/PregnantWomenQstv5/q10_house/2:label">
        <value>1</value>
      </text>
      <text id="/PregnantWomenQstv5/q31_info/15:label">
        <value>Pregnancy &amp;amp; delivery courses</value>
      </text>
      <text id="/PregnantWomenQstv5/q11_travel/5:label">
        <value>1 – 2 Hours</value>
      </text>
      <text id="/PregnantWomenQstv5/q13_smoke/1:label">
        <value>Yes</value>
      </text>
      <text
id="/PregnantWomenQstv5/q23aiii_airtime/9:label">
        <value>Once a month</value>
      </text>
      <text id="/PregnantWomenQstv5/q5_prof:label">
        <value>Language Proficiency - Can Read and
Write</value>
      </text>
      <text id="/PregnantWomenQstv5/q19a_visit/5:label">
        <value>4 or more</value>
      </text>
      <text id="/PregnantWomenQstv5/q24_use/4:label">
        <value>Internet</value>
      </text>
      <text id="/PregnantWomenQstv5/q19_visit/7:label">
        <value>None</value>
      </text>
      <text id="/PregnantWomenQstv5/q8_employ/9:label">
        <value>Unemployed</value>
      </text>
      <text id="/PregnantWomenQstv5/q22_help:label">
        <value>Would education about pregnancy have helped
you avoid hospitalizations?</value>
      </text>
      <text id="/PregnantWomenQstv5/q17a_births/5:label">
        <value>4 or more</value>
      </text>
      <text id="/PregnantWomenQstv5/q27_alert:label">
        <value>When would you like to start receiving
alerts?</value>
      </text>
      <text id="/PregnantWomenQstv5/q23b_access:label">
        <value>Do you have access to another cell
phone?</value>
      </text>
      <text
id="/PregnantWomenQstv5/q23a_specs/q23a_model:label">
        <value>Model:</value>
      </text>
      <text id="/PregnantWomenQstv5/q12_cost:hint">
        <value>In Kenya Shilling</value>
:
:
:
:
    <instance>
     <PregnantWomenQstv5 id="PQW" version="5">
      <q2_language/>
      <intro/>
      <participant_id/>
      <s1_demo/>
      <q1_date/>
      <q3_age/>
      <q4_area/>
      <q5_prof/>
      <q5a_prof/>
      <q6_edu/>
      <q7_marital/>
      <q7a_marital/>
      <q8_employ/>
      <q8a_employ/>
      <q9_income/>
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      <q11a_travel/>
      <q12_cost/>
      <q13_smoke/>
      <q14_smoke/>
      <q15_alcohol/>
      <s2_maternal/>
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        <s2_intro/>
        <q16_preg/>
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        <q17a_births/>
        <q17b_alive/>
        <q18_along/>
        <q19_visit/>
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        <q20_advice/>
        <q20a_advice/>
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        <q21a_complications/>
        <q22_help/>
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        <s3_intro/>
        <q23_phone/>
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        <q23ai_charge/>
        <q23aii_subscr/>
        <q23aiii_airtime/>
        <q23b_access/>
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        <q24a_use/>
        <q25_text/>
        <q26_voice/>
        <q27_alert/>
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        <q31_info/>
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readonly="true()" type="string"/>
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jr:constraintMsg="Only input the participants 3 initials. Only
Letters can be used."
nodeset="/PregnantWomenQstv5/participant_id"
required="true()" type="string"/>
    <bind nodeset="/PregnantWomenQstv5/s1_demo"
readonly="true()" type="string"/>
    <bind nodeset="/PregnantWomenQstv5/q1_date"
required="true()" type="date"/>
    <bind nodeset="/PregnantWomenQstv5/q3_age"
required="true()" type="int"/>
    <bind nodeset="/PregnantWomenQstv5/q4_area"
type="string"/>
    <bind nodeset="/PregnantWomenQstv5/q5_prof"
required="true()" type="select1"/>
    <bind nodeset="/PregnantWomenQstv5/q5a_prof"
relevant=" /PregnantWomenQstv5/q5_prof ='8'"
type="string"/>
    <bind nodeset="/PregnantWomenQstv5/q6_edu"
type="select1"/>
    <bind nodeset="/PregnantWomenQstv5/q7_marital"
type="select1"/>
    <bind nodeset="/PregnantWomenQstv5/q7a_marital"
relevant=" /PregnantWomenQstv5/q7_marital ='8'"
type="string"/>
    <bind nodeset="/PregnantWomenQstv5/q8_employ"
type="select1"/>
    <bind nodeset="/PregnantWomenQstv5/q8a_employ"
relevant=" /PregnantWomenQstv5/q8_employ ='8'"
type="string"/>
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type="select1"/>
    <bind nodeset="/PregnantWomenQstv5/q10_house"
type="select1"/>
    <bind nodeset="/PregnantWomenQstv5/q11_travel"
type="select1"/>
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relevant=" /PregnantWomenQstv5/q11_travel ='6'"
type="int"/>
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type="int"/>
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type="select1"/>
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type="int"/>
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/PregnantWomenQstv5/q16_preg ='4' or
/PregnantWomenQstv5/q16_preg ='3' or
/PregnantWomenQstv5/q16_preg ='2'" type="select1"/>
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relevant=" /PregnantWomenQstv5/q17_births ='5' or
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/PregnantWomenQstv5/q17_births ='3' or
/PregnantWomenQstv5/q17_births ='2'" type="select1"/>
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relevant=" /PregnantWomenQstv5/q17_births ='5' or
/PregnantWomenQstv5/q17_births ='4' or
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/PregnantWomenQstv5/q17_births ='2'" type="select1"/>
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type="select1"/>
    <bind nodeset="/PregnantWomenQstv5/q19_visit"
type="select1"/>
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relevant=" /PregnantWomenQstv5/q17_births ='5' or
/PregnantWomenQstv5/q17_births ='4' or
/PregnantWomenQstv5/q17_births ='3' or
/PregnantWomenQstv5/q17_births ='2'" type="select1"/>
    <bind nodeset="/PregnantWomenQstv5/q20_advice"
relevant=" /PregnantWomenQstv5/q19_visit
=&amp;quot;1&amp;quot;" type="select1"/>
    <bind nodeset="/PregnantWomenQstv5/q20a_advice"
relevant=" /PregnantWomenQstv5/q20_advice ='8'"
type="string"/>
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nodeset="/PregnantWomenQstv5/q21_complications"
type="select1"/>
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nodeset="/PregnantWomenQstv5/q21a_complications"
relevant=" /PregnantWomenQstv5/q17_births ='5' or
/PregnantWomenQstv5/q17_births ='4' or
/PregnantWomenQstv5/q17_births ='3' or
/PregnantWomenQstv5/q17_births ='2'" type="select1"/>
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relevant=" /PregnantWomenQstv5/q21_complications
=&amp;quot;1&amp;quot; or
/PregnantWomenQstv5/q21a_complications
=&amp;quot;1&amp;quot;" type="select1"/>
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readonly="true()" type="string"/>
    <bind nodeset="/PregnantWomenQstv5/s3_intro"
readonly="true()" type="string"/>
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type="select1"/>
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nodeset="/PregnantWomenQstv5/q23a_specs/q23a_make"
type="string"/>
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nodeset="/PregnantWomenQstv5/q23a_specs/q23a_model"
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:
:
:
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  </input>
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ref="jr:itext('/PregnantWomenQstv5/q11_travel/3:label')"/>
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:
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:
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ref="jr:itext('/PregnantWomenQstv5/q31_info:label')"/>
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ref="jr:itext('/PregnantWomenQstv5/q31_info:hint')"/>
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  <input ref="/PregnantWomenQstv5/end_time">
    <label>Survey end time: <output value="
/PregnantWomenQstv5/end "/></label></input>
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