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Interactive Mobile Voice and Text Response Prototype for Reducing Maternal & Child Mortality

BY

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A Research project report submitted in partial fulfillment of the requirements of the Degree of Master of Science in Computer Science at the University of Nairobi.

DECLARATION

This project, as presented in this report, is my original work and has not been presented for any other award in any other University.

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This project has been submitted in partial fulfillment of the requirements for the Masters of Science in Computer Science of the University of Nairobi with my approval as the University supervisor.

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ABSTRACT

Recent global focus on healthcare issues has stimulated research and development of innovative technologies which address much unsustainability of the current healthcare provision models. Rapid advances in mobile, wireless and sensing technologies have opened new opportunities in healthcare.

Exploitation of Information and Communications Technologies enables cost-effective and efficient healthcare delivery in home, hospital, assisted-living, and nursing home settings. Remote diagnosis, patient and elderly monitoring, computer assisted rehabilitation and therapy, control of vital parameters of people suffering from chronic diseases such as asthma, diabetes, epilepsy, Parkinson's disease and heart attacks, sensing of individual's health-related activities and vital signals, and smart management of medical records with the help of on/in body biosensors, radio frequency medical devices and intra-body communication systems are just some examples.

This study was aimed at providing a sustainable model of reducing maternal and child deaths through the use of both mobile voice systems and text/SMS among the mothers and the community health workers. The study also aimed to improve learning and behavior change through the use of pre-recorded voice messages among the mothers and CHWs. The system used an integrated voice and text system to improve surveillance and create awareness of syndromes and danger signs among pregnant mothers and under five children who are vulnerable.

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CHAPTER 1: INTRODUCTION

1.1 Background

Maternal morbidity and mortality relate to illness or death occurring during pregnancy or childbirth, or within two months of the birth or termination of a pregnancy. The fifth Millennium Development Goal (MDG) aims to reduce the maternal mortality ratio by 75% between 1990 and 2015. In Kenya, maternal mortality remains high at 488 maternal deaths per 100,000 live births (Ziraba, A., et al, 2009). While this is below the Sub-Saharan average of 640 deaths per 100,000, Kenya experiences a very slow progression in maternal health.

Most maternal deaths are due to causes directly related to pregnancy and childbirth, unsafe abortion and obstetric complications such as severe bleeding, infection, hypertensive disorders, and obstructed labor. Others are due to causes such as malaria, diabetes, hepatitis, and anaemia, which are aggravated by pregnancy. Other factors that hinder adequate health care from reaching the women and newborns that are most at risk include distance to resources, severe shortages of trained health professionals, and lack of investment in public health. To achieve the MDGs and to maintain better MNH beyond 2015, we must critically examine new ways of using existing resources in regions where improvements need to be made.

According the Kenya Demographic and Health Survey (KDHS) 2008-2009, the Government of Kenya's 2009 National Road Map for accelerating the attainment of the MDGs related to Maternal and Newborn Health in Kenya and the Child Survival and Development Strategy 2008 -2015 identified several barriers for program improvement, including: lack of recognition of danger signs in pregnancy; poor accessibility and low utilization of skilled attendance during pregnancy, child birth and post birth period; among others.

The use of mobile phones to improve the quality of care and enhance efficiency of service delivery within healthcare systems is known as mobile health, or mHealth, and is a sub-segment of the broader field of electronic health (eHealth), (Eilish McAuliffe., et al, 2010). WHO has defined

mHealth as the "provision of health services and information via mobile technologies such as mobile phones and Personal Digital Assistants (PDAs)."

mHealth tools have shown promise in providing greater access to healthcare to populations in developing countries, as well as creating cost efficiencies and improving the capacity of health systems to provide quality healthcare. From text message campaigns disseminating information on healthy lifestyles to the use of smart phones as medical devices capable of diagnostics and remote monitoring, mobile technology will permeate every aspect of global health systems. In the process, this technology will cut the costs associated with provision while maintaining and improving quality of care and reaching patients for whom access to healthcare has until now been limited. With over six billion mobile phone subscriptions spread across a world population of over seven billion, mobile technologies are rapidly penetrating even the most remote corners of the world. For women and newborns in many low- and middle income countries (LmiCs), the rapid expansion of mobile technology infrastructure presents an unprecedented opportunity to increase access to health care and save lives, but how exactly can we leverage the power of mobile technology to save the lives of women and newborns?

Maternal morbidity and mortality in Kenya results from the interplay of social, cultural, economic and logistical barriers, coupled with a high fertility rate and inadequate and under-funded health services. Strengthening the health system and improving quality of healthcare delivery is pivotal to reversing the trend of high maternal morbidity and mortality.

Income, education also plays a major role in determining maternal health outcomes, including fertility rates, access to family planning, and antenatal coverage. Women with higher education are much more likely to receive antenatal care from a medical doctor than are those with no education (36 vs. 21%). Similarly, the higher the wealth quintile, the more likely a woman is to get antenatal care from a doctor. Restrictive abortion legislation also contributes substantially to maternal mortality and morbidity in Kenya.

1.2 Maternal and new born Health frameworks

The maternal-newborn continuum of care ranges from pre-pregnancy and extends into pregnancy, labor and delivery, and postpartum or postnatal care, and it naturally includes child health. The purpose of the continuum of care is to map the specific moments along the continuum where proven interventions ought to be delivered (see Figure 1). An analysis of coverage gap' measures, which represent the percentage of a target population not receiving critical services, indicated that the greatest inequities in services fall into the categories of maternal and newborn care and family planning.

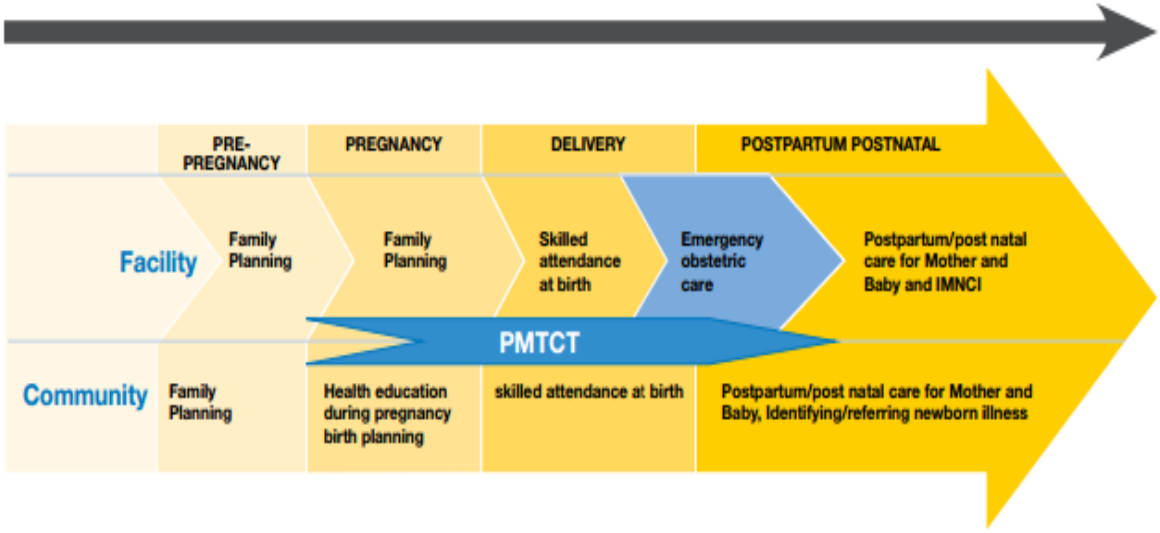


Figure 1: Maternal-newborn continuum of care (source: mhealth alliance, Credit UNICEF:…where is the closing bracket?

1.3 Problem statement

While approximately 92% of women giving birth received some antenatal in 2010, only 47% had the recommended four or more visits to the care centers. 56% of Kenyan women deliver at home, with home births being more common in rural areas and only 44% of births were assisted by a health care professional (doctors, nurses and midwives). These rates of antenatal care and skilled birth attendance have declined over the past 10 years, particularly among the poor.

The people who deliver at home lack education/ awareness on the danger signs needs to be assisted by midwives and community health workers. People in the informal/ rural setting also lack information on how to take care of their children under five years after birth which tend to lead to higher mortality rates in these settlements. Information on early warning signs, disease syndromes and better nutrition and health practices during pregnancy birth and lactation needs to be shared with the productive population to reduce chances of contracting health threatening diseases to the mothers and their children.

1.4 Proposed Solution

Innovative techniques can be used to enable mothers report the danger signs and seek remedial actions or interventions in time to ensure their safety and that of their children. Mobile phones and mhealth applications can play a significant role in reducing mother child mortality. Several countries currently use the mobile applications to identity risk signs or danger signs, communicate and discuss birth plans and promote community based referral systems. The use of mobile banking to promote mother's transport to health delivery facilities and hospitals is gaining momentum especially in donor supported projects. Most caregivers and community health workers can now follow up with family and mothers to ensure continuum of care including post- partum and post-natal care.

The mobile applications are increasingly being used to assist mothers with high risk health conditions to access the right care at the right time. Additionally, mhealth applications can be used to improve identification of pregnant mother's risks; improve decision making for critical referrals during labor; Improve coordination of community and health facility actors to provide high quality labor, delivery & post-partum care; Increase percentage of high risk deliveries assisted by skilled caregivers in facilities; Increase percentage of mothers and newborns attending postpartum care within the first seven days after delivery.

1.5 Objectives

The overall reason for carrying out the research project was to build a system prototype that could be used to reduce mother child mortality.

The project involved the following specific objectives:

i. To build an integrated text-voice response system prototype that is used to collate syndromes and danger signs from mothers through the use of mobile devices.
ii. To build into the prototype capacity to inform mothers of intervention techniques to reduce mortality.
iii. To assess the effect of behavior change patterns among the reproductive population that uses the prototype as an indication of learning among the mothers.
iv. To apply simple statistical techniques to determine the level of system uptake and usability among the reproductive population.
v. To visually display syndrome concentration using GIS in a way to improve disease surveillance among the most at risk population.

1.6 Research questions

Based on the above research objectives, the research questions included:-

i. Can an integrated mobile voice and text system be built to improve learning among mothers and be used to bring behavior that reduces mother child mortality?
ii. Can the use of mobile voice in learning among the reproductive mothers enhance positive behavior change towards reducing mother child mortality?
iii. What are the variables in the dataset provided that would indicate positive change behavior most?
iv. What patterns exhibited by the population indicate system uptake and confidence in the system use?
v. Is it possible to use the model for surveillance to detect of spread of diseases among the at most risk population?

1.7 Justification

The major drivers of the use of interactive text and voice response system among the mothers and community health workers include; improvement of post treatment understanding, greater access to health information, increase in medication compliance and aggregate data-improves population

healthcare. Phone networks for health, not only can frontline health workers carry tools loaded with protocols, but captured data can also flow through a health system in real-time and deliver critical information to support women's and providers' needs in a timely and efficient manner. Additionally, combining mobile technologies with existing health system resources offers opportunities in stimulating demand for available services and expanding access to effective and already existing programs through growing mobile phone networks, both of which can lead to higher levels of efficiency in service delivery, supervision, and management practices.

In particular, for MNH, mhealth can support and strengthen existing efforts along the continuum of care, as well as offer innovative solutions, such as providing women with MNH-related information services by phone, in addition to providing community-based health workers and health.

1.8 Rationale of the study

The mobile phone is a strong contender as a key transforming agent in the future of health and healthcare. There are now more than 5.3 billion cell phone users around the globe, and 90 percent of the world's population is covered by a commercial wireless signal. We now have a pathway to reach the unreached, and to deliver health services where people are, not merely in healthfacilities.

In a world with severe healthcare resource constraints, mobile digital technology can be a major "force multiplier." It can empower both patients and practitioners by providing them with the information they need to make informed decisions about health issues from healthy living habits, health care provision, and monitoring of diseases. The rapid expansion of wireless networks represents a particularly exciting opportunity to reach those who are currently isolated by distance and lack of communication, using "mHealth" (mobile health) programs.

Healthcare systems around the world face unprecedented challenges as healthcare spending surpasses national health budgets. Wireless technology will enable new high value healthcare delivery to mitigate some of these rising costs and embedded wireless devices will provide the platform, to create large market opportunities for a variety of potential players.Embedded mobile

technology and the widespread availability of mobile broadband networks are enabling a transformation of healthcare providing benefits never before imagined. Clearly the mobile industry is accepting the healthcare challenge as carriers, device manufacturers, system integrators, software developers and new start-ups begin to take an active and often leadership role in this transformation.

1.9 Scope of the study

The scope of the project was limited to activities that relate to assessment of the current behavioral patterns exhibited by the targeted group, model building and validation. The model was tested on a targeted population and information on the required indicators was collected. An analysis of the information wasperformed to determine patterns exhibited on the indicators with the aim of studying change in behavioral patterns. A prototype was built as a proof of concept and this included a mobile portal with health messages for the reproductive mothers, a surveillance module for collecting and collating syndromes and GIS component for plotting syndrome concentration. The study was undertaken and recommended further modifications of the framework that could be implemented in any environments to reduce mother child mortality.

1.10 Assumptions of the research

The research made the following assumptions:

i. All the population at risk have smart phones
ii. The targeted mothers are willing to reveal their disease syndromes through the phone
iii. The targeted population is literate and comprehends English

1.11Definition of important terms

Millennium Development goals: these are eight international development goals that were officially established following the Millennium Summit of the United Nations in 2000, following the adoption of the United Nations Millennium Declaration. All 189 United Nations member states and at least 23 international organizations have agreed to achieve these goals by the year 2015. The goals are: Eradicating extreme poverty and hunger, Achieving universal primary education,

Promoting gender equality and empowering women, Reducing child mortality rates, Improving maternal health, Combating HIV/AIDS, malaria, and other diseases, Ensuring environmental sustainability, and Developing a global partnership for development.**Mortality:** ity is the term used for the number of people who died within a population.

Morbidity: Morbidity refers to the state of being diseased or unhealthy.

CHEW: Community Health Workers.

Mhealth: mHealth stands for the provision of health-related services using mobile communication technology

ehealth: e-health simply means the application of the latest information and communication technologies in all health-related fields such as collecting, storing, restoring, analyzing and managing the information, unifying the electronic health records, disseminating and sharing medical information, surgeries and healthcare remotely, in addition to smart e-healthcare cards

MMS: This extends the capability of SMS (which is restricted to 160 characters of plain text). Increasing numbers of mobile phones today allow you to send these types of message. MMS allows you to send 'richer' messages which can include all or any of the following: Text (as with SMS, but with a higher limit - approximately 1,000 characters); Pictures (taken with the phone's camera);Video (taken with the phone's camera); Sound or audio (recorded by the phone)

PDAs: MMS extends the capability of SMS (which is restricted to 160 characters of plain text). Increasing numbers of mobile phones today allow you to send these types of message. MMS allows you to send 'richer' messages which can include all or any of the following: Text (as with SMS, but with a higher limit - approximately 1,000 characters); Pictures (taken with the phone's camera); Video (taken with the phone's camera); Sound or audio (recorded by the phone).

Wireless devices: A wireless device can refer to any kind of communications equipment that does not require a physical wire for relaying information to another device. Wireless headphones fitted with a receiver use either radio frequency (RF) or infrared technology to communicate with a transmitter that is connected to the sound source, say a television. In most cases, however, when someone refers to a wireless device, they are speaking of a networking device that can pass data to other wireless network gear without being physically connected.

Embedded mobile technology: An embedded system is an applied computer system. It constantly evolves with advances in technology and dramatic decreasesin the cost of implementing various hardware and software components.

Mobile broadband network: Mobile broadband is powered by the same technology that makes cell phones work. It's all about radio waves and frequencies. Cell phones and cell-phone radio towers send packets of digital information back and forth to each other via radio waves. In the case of a phone call, the packets of information carry voice data. For mobile broadband, the packets of information would be other types of data like e-mails, Web pages, music files and streaming video.

1.12 List of acronyms

LMICs: Low and middle income countries.

MCH: Mother Child Mortality.

WHO: is a specialized agency of the United Nations that is concerned with international public health. WHO has been responsible for playing a leading role in the eradication of smallpox. Its current priorities include communicable diseases, in particular, HIV/AIDS, malaria and tuberculosis; the mitigation of the effects of non-communicable diseases; sexual and reproductive health, development, and aging; nutrition, food security and healthy eating; occupational health; substance abuse; and drive the development of reporting, publications, and networking. WHO is responsible for the World Health Report, a leading international publication on health, the worldwide World Health Survey, and World Health Day (7th-April of every Year).

MDG: Millennium Development Goals

MNH: Maternal, Newborn and Child health

CHAPTER 2: LITERATURE REVIEW

In this section, a review of existing literature on mobile learning and use in health especially in mitigating mother Child mortality is done. In the view of mobile alliance (2012), the rise in mhealth solutions to improve health outcomes is largely attributable to the ubiquity of mobile phones as well as the convenience, user friendliness, and relatively low cost of mhealth applications. Expanding mobile phone penetration and network coverage can remove traditional geographic and economic barriers to health care, particularly in emergency situations that can be life threatening, as is often the case for MNH.

2.1 mhealth approaches to maternal and child health

2.1.1 Mobile to Mobile Voice communication

According to the findings of OlusolaIsola (2010), the Abiye project in Ondo state, Nigeria is adopting mobile telephones as a telecommunication tool to connect pregnant women in remote rural locations with health extension workers and delivery facilities to reduce maternal mortality and improve live births. Since the commencement of the project, maternal mortality had been reduced in the State by 47% and there is 96% increase in number of live births. There was also 26% reduction in child mortality and a general improvement in mother and child health as a result of the project.

The major challenge faced on the project however, was the unwillingness of the participating pregnant women to surrender the mobile phones given to them and maintained free of charge until after their child delivery. Such phones were meant to be given to other newly registered pregnant women on the project. The problem of project sustainability was also a major challenge.

2.1.2 Problems and Challenges

he first problem that was noticed on the Abiye project was incomplete telephone signal coverage of the rural communities in Ondo state. The mobile telephone service operator which was partnering with the project hadnot been able to achieve 100% coverage of the State and this had precluded a substantial number of women resident in some remote locations to benefit from the

project. This wasa challenge that is replicated in Kenya since some areas are not served with proper network and signals are very weak.

Secondly, the project implementers have revealed that many of the women who have participated in the project were not willing to return the telephone handsets after child delivery. Such telephone handsets are meant to be transferred to newly register pregnant women. This has put more financial burden on the project to acquire more mobile phones which their budget could not immediately accommodate.

Inadequate finance was another major problem being faced on the project. Currently, the participating pregnant women are offered free antenatal and delivery services and free telephony services. This has put enormous pressure on the state health budget.

2.1.3 Multimedia Mobile communication

In india, the Ananya programme, funded by the Bill & Melinda Gates Foundation which aims to reduce child mortality, improve maternal health and reduce infectious diseases in Bihar. The project partner, BBC Media Action adopted a pioneering approach to improve the demand and uptake of life-saving family health behaviors amongst the population of 104 million. Reaching this enormous audience through traditional forms of media is difficult. Only 27% of young mothers have access to any traditional media (TV, radio, newspapers or cinema). With the use of mobile phones, the access went up drastically to 90%.

360-degree approach

BBC Media Action has therefore adopted what has been called 'a 360-degree approach' – a combination of face-to-face communication, Information Communication Technology (ICT), mass media and community work – which is being implemented on an unprecedented scale. These sustainable, scalable, and innovative and multiple channels of communication work together to create a whole that is greater than the sum of its parts.

Mobile Academy

BBC Media Action has developed two innovative mobile phone services for CHWs: a training course called Mobile Academy, and an on-demand service called Mobile Kunji which is supported by a deck of cards illustrated with life-saving messages.

Mass media

Humorous and engaging TV adverts about specific family health behaviors such as birth spacing are accompanied by a long-running radio series about critical maternal and child health issues.

Community Mobilization

According to BBC Media Action, (2011), 10,000 street theatre performances and 6000 women's listener clubs engage and inform families about critical family health issues. All these elements focus on the critical 33-month timeline from when a woman becomes pregnant until her child is two years old. The objective is to shift social norms and empower those who lack the information and power to make informed choices about their health.

2.1. 4 Mobile use: Kenya scenarios

According to a 2010 survey by the Kenya Service Provision Assessment, an estimated 56% of pregnant women deliver at home, most without assistance from a trained provider. This trend is in part responsible for Kenya's high maternal mortality rate which is thought to be approximately 530 per 100,000 live births, one of the highest in the world.

According to Jahonga Ruth, (2012), most of the women who die in pregnancy do so due to complications such as haemorrhages, obstructed labour, hypertensive disease, sepsis and ruptured uterus. "We want to ensure that the lives of both the mother and the child are safeguarded," A pilot mobile project in machakos county – will ensure that pregnant women in the area are registered by health-providers who always call or send an SMS text to patients to check whether their conditions are stable. "Using the SMS platform, the mothers can be reminded to attend antenatal care, and even make individual birth plans,". In the project, Midwives are also supported with relevant and updates as well as giving them airtime to call mothers for follow up care.

2.2 Mobile Technologies

Mobile devices include portable devices such as mobile phones, smart phones, handheld computers, games consoles and personal media players.

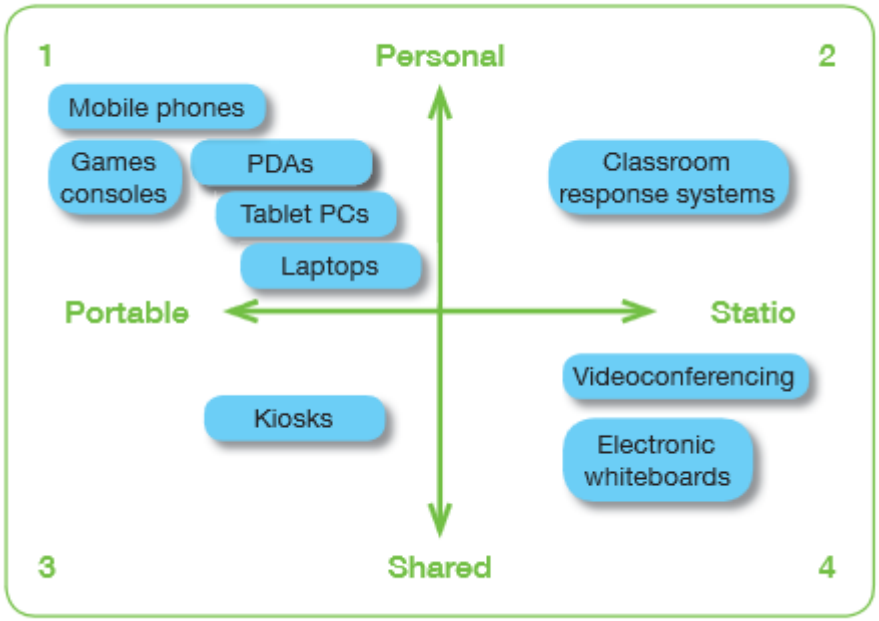


Figure 2: Mobile Technologies

Source: ……

2.2.1 Portable and Personal

Technologies in quadrant include what most people think of as mobile devices (mobile phones, Personal Digital Assistants (PDAs) etc.). These afford communication and information, so while devices themselves may be personal, they allow for information to be easily shared.

2.2.2 Static and Personal

Technologies in quadrant 2 are static (i.e. they can only be used in one location), but they still offer personal interactions with learning experiences because of their small size and allocation to one user (e.g. classroom response systems).

2.2.3 Portable and Shared

Technologies in quadrant 3 can provide learning experiences to users on the move – the users are portable even though the devices themselves are not portable. These technologies are less personal as they are likely to be shared by multiple users (e.g. street kiosks, interactive museum displays).

2.2.4 Static and Shared

Technologies in quadrant 4 include larger devices (which are therefore less portable) which allow more shareable interactions? These are not generally classified as ‘mobile technologies

2.4 Mobile learning devices

2.4.1 Cell phones

This is the simplest of mobile devices all but still fairly powerful. They can be used for group discussions via text messaging, and since so many cell phones have cameras, they are useful for photography-based projects as well. Students can also record themselves reading stories aloud for writers’ workshops or practicing speeches.

2.4.2 E-book Readers

Their fundamental function, of course, is for reading books and storing entire libraries. They also provide easy access to dictionaries. Many students also use their e-book readers as a replacement for the daily paper, since they can read various editions and magazines on it. Well-known brands include Amazon’s Kindle and Barnes & Noble’s Nook.

2.4.3 Mp3 and Portable Media Players

Free lectures and short videos are available for downloading via the iTunes U app, or on the Internet at sites such as Brainpop.com, which has animated educational videos. Apps can also be downloaded onto the devices and many are equipped with cameras students can use to shoot and to post to a website.

2.4.4 Smart phones

A smart phone is a high-end mobile phone that combines the functions of a personal digital assistant and a mobile phone. They can also serve as portable media players and camera phones with high-resolution touch screens, web browsers that can access and properly display standard web pages.

2.4.5 Tablets

Apple's iPad, the Kindle Fire, and the Galaxy are just a few models of tablets, and they can do anything e-book readers can do and then some. Downloadable apps, many educational, make these machines nearly comparable to computers; you can surf the Web, play games, watch (and even make) movies, as well as take photographs.

2.5 Features of mobile phones that change learning

2.5.1 Portability

The small size and weight of mobile devices means they can be carried everywhere. This easy access enables learning activities to be undertaken outside the traditional learning environment, anywhere and at any time.

2.5.2 Connectivity

As well as providing learners with access to content, mobile devices also provide them with connections to other learners. For example, a shared network can be created by connecting to other devices or to a common network

2.5.3 Interactivity

Previously mobile learning has been viewed as an isolated activity. However, mobile devices are social devices by nature and as such they are potential tools for enhancing a cooperative learning environment. In this way, mobile learning can be seen as a rich, collaborative and conversational experience. And a shared, crowd-sourcing model offers opportunity for communal learning.

2.5.4 Context sensitivity

Mobile devices can both gather and respond to real or simulated data unique to the current location, environment and time. This enables learning to take place which can make greater use of a person's immediate context and surroundings and facilitate the application of knowledge, skill development

and communication. In this way, mobile technologies can facilitate learning both in context and learning across contexts (both of which apply to executive education).

2.5.5 Learning in context

A learner exploring a physical or social environment with a mobile device that can provide relevant Information about the environment and engage learners in activities such as interview, data gathering and information sharing.

2.5.6 Learning across contexts

Learning can take place whilst a learner moves between settings. This could be over one day (e.g. when commuting, in the office, at home) or over a lifetime (lifelong learning).

2.5.7 Lifelong

Mobile content consumption is continuous: there is no beginning, middle or end. Learning does not have to be linear, given and received at a fixed time and within a fixed period.

2.5.8 Individuality

'Scaffolding' (i.e. offering appropriate support to facilitate a learner) for difficult activities can be customized for individual learners. As well as being able to customize preferences for how a learner interfaces with materials, there is also the possibility of basing learning on previous learning experiences.

2.6Mobile learning theory and practice

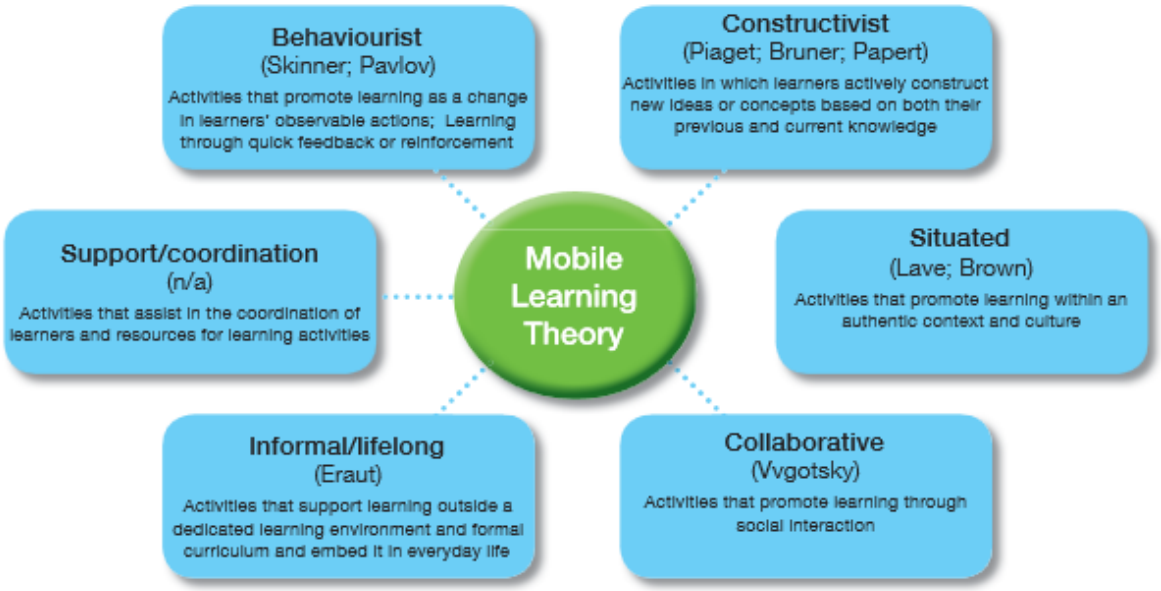


Figure 3: Mobile learning theory

Source: Mike Sharples et al, towards a theory of mobile learning (2005)

i. Behaviourist - activities that promote learning as a change in learners' observable actions.
ii. Constructivist - activities in which learners actively construct new ideas or concepts based on both their previous and current knowledge.
iii. Situated - activities that promote learning within an authentic context and culture.
iv. Collaborative - activities that promote learning through social interaction.
v. Informal and lifelong - activities that support learning outside a dedicated learning environment and formal curriculum.
vi. Learning and teaching support - activities that assist in the coordination of learners and resources for learning activities.

Whilst some initiatives may see mobile learning as a way to foster collaborative interactions, others may foreground more behaviourist approaches. It is possible, of course, to blend several categories of activity (although this may make the initiative more difficult to evaluate).

2.7Types of mobile approaches

2.7.1 Context

Smartphone software that links to GPS enables learning that is truly context-specific to a learner's action. This means that learning which entails geographical know-how can be accessed in the field, so that learning can happen in the course of activity. For example: participants may be asked to take photographs in various locations and situations throughout their working day and make notes to share online; specially equipped locations (e.g. museums and art galleries) can offer additional information about exhibits and displays based on a visitors location within them. Another example is within the context of work itself. There, participants are able to access learning in context and specific to their needs. This enables them to choose the right and relevant time and place – perhaps the participant is the best person to decide that.

2.7.2 Recording Information

Mobile devices provide numerous ways to input information – through touch, stylus and voice. This allows learners to build up a series of personal notes, observations, and collections of evidence and reflections of progress. These can be used to prompt future recall, build a portfolio, or for assisting comprehension and reflection.

2.7.3 Audio

Mobile learning can take place through listening to audio. Podcasts can be downloaded of relevant lectures, interviews, or overviews of the latest research. For example, participants may download an audio (or video) podcast of a session prior to attending a session. The time in the classroom can then spent discussing the key points from the session in more detail

2.7.4 Images

Mobile learning can make use of illustrations, photos, animations and/or videos (through viewing and recording). This is useful on several levels. An image is able to capture information without the need for lengthy description. This can serve as an aide memoire for the individual or as a way to share ideas or information with others in collaboration or evaluation. Images can also be used as supporting evidence for a portfolio. Using imagery also appeals to learners with a visual learning preference. Mobile learning can also take place through using decision trees, which enable visual representations along with inter-connectedness, and mind mapping to help organize thoughts and ideas.

2.7.5 Collaboration

Mobile learners can communicate with other learners and experts through calling, sending messages and using online communities to create and discuss subject matter.

2.7.6 Games/Simulations

Learners may also play educational mobile games, gaming simulations and other interactive applications. Participatory or immersive experiences can add a layer of motivation to learning, engaging users, and can bring scenarios to classroom educators could not otherwise.

2.7.7 Searching

Mobile learning can take place through information gathering and research via search engines; accessing websites to look up information instantly, 'just-in-time'. In this way learning can be intentional (through specific projects) as well as accidental (through acquiring information through various sources).

2.7.8 Reading

Mobile learning can simply be through reading. Learners can easily carry around study materials in order to be able to revisit them (if need to for revision or practice). Again, learning can be intentional or accidental.

2.7.9 Assessment

Assessment through answering multiple choice questions can enable both learners and educators to test knowledge and skills. For example, educators can conduct pre-assessments prior to face-to-face sessions to enable them to determine learners' level of knowledge and plan their sessions accordingly.

2.7.10 Polling

Polling can be used in several ways. One example is for evaluation. Students can be sent a link to a polling website (e.g. Poll Daddy or Survey Monkey) or as a unique URL imbedded onto a website which participants can then access from their mobiles phones. kThis can be as a supplement or alternative to completing the process on paper. Polling can also be used to ask participants to respond to questions (true/false; Likert; multiple choice, word cloud) which can take place inside or outside of the classroom.

2.7.11 Support and Coordination

Mobile devices help organize personal learning schedules, keep track of deadlines, set reminders, monitor attendance and progress. Learners can use mobile devices for storage, to access messages and content, to stay informed about course context, and to review and manage learning activities they engage in during a day.

2.7.12 Apps

Apps have many strands for learning. Apps provide access to information for consumption. There is also opportunity for learning through the creation of apps. On a much simpler level, apps can provide participants with a ‘digital backpack’ which enables them access to tools that they may have physically carried before. The availability of apps for smartphones lets the backpack be anything needed at that moment – just-in-time. The apps available are plenty and include scientific calculators, periodic tables, dictionaries and foreign language lessons.

2.8 Conceptual Framework

Independent Variables

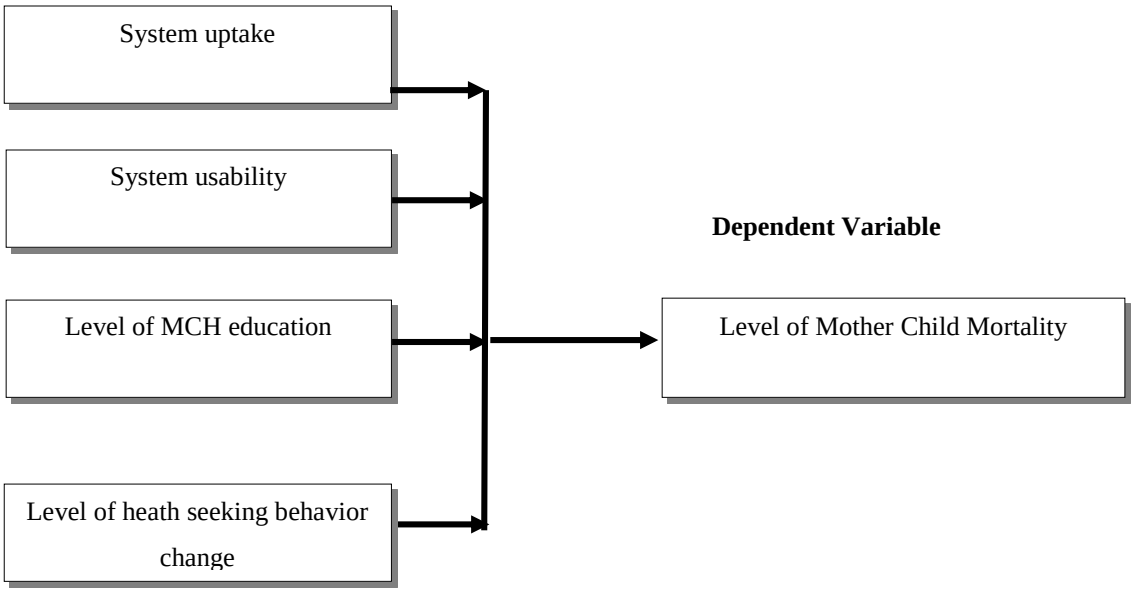


Figure 4: Schematic Presentation of the Framework

Source: Author (2013)

2.9Mobile Health

Mobile health (mHealth) broadly encompasses health related uses of mobile telecommunication and multimedia technologies within service delivery and public health systems. While this definition of mHealth was established in 2003, it has since been expande d to include public health and wellbeing and gained significant momentum through the una nticipated spread of mobile telecommunications infrastructure and uptake of handsets a nd services throughout low and middle income countries (LMICs).

Further, the term "mobile phone" has evolved as the technological capabilities have advance d over the years. In the literature, the term mobile phone, and sometimes cellular phone, is used to denote standard voice, short message service (SMS), and multimedia messaging s ervice (MMS) functionality, and in some cases web browsing and email. The term PDA stan ds for personal digital assistant and refers to the earliest version of a mobile phone with personal organization functionalities such as web browsing, email, and the ability to write easily using pen or

stylus. Despite being almost discontinued, many studies in the literature focus on the use of P DAs, especially for data collection and health information support. Smart phones are the mos t recent technology and combine the functions of a mobile phone and PDA, in addition to ena bling Internet access and imaging and video functionality. Although these phones are gaining popularity in high income countries, for most individuals in LMICs, the cost is prohibitive Nevertheless, the lines between smart phones and mobile phones are increasingly blurring, and the distinction between the two is decreasing rapidly.

Though the mHealth field is still in its early stages, there are indications that it is starting to transform health system demonstrating its potential for extending the reach of health information services to remote populations and promoting a shift toward citizen centered health care and wellbeing. mHealth projects throughout the world are generating benefits including: Increased access to healthcare and health related information, particularly for hard to reach populations; Increased efficiency and lower cost of service delivery; improved ability to diagnose, treat and track diseases;
mely, more actionable public health information; Expanded access to ongoing medical education and training for health workers.

2.9.1 Mhealth benefits to the society

Low network maintenance: The cost of network maintenance is borne by the mobile service provider and not the mothers or doctors using the mobile phones. Remote monitoring in rural areas: There is a greater presence and usage of mobile phones in the rural areas. The use of mobile phones can therefore improve monitoring of disease syndromes in the villages.

Phones are always on, computers are not: Mobile devices have rechargeable batteries and are therefore kept on most of the time unlike computers that require power to operate continuously. There are considerable efforts to encourage the use of solar energy as the main source of power for the mobile devices thus further enhancing mobile devices usage.

Carrying a Phone/Tablet is part of a modern lifestyle: Due to their sizes, most people have no problem carrying their mobile phones around with them. This enables one to be accessible all

the time from anywhere as long as there is network coverage. Using a small portable multi-communication computing device is convenient, economical and practical.

2.9.2 Importance of mhealth as a tool in Mother Child mortality reduction

There are numerous approaches in which mobile devices can be used to reduce mother child mortality in Kenya. Some of these approaches include but not limited to: Education & Awareness – SMS/Text Messaging in support of health programs; Disease & Emergency Tracking – Use mobile Devices to send and receive disease incidence;Data Collection and Record Access – There are applications to enter and access patient data;Health and Administration Systems – Allow access to mHealth and Public Health systems; Monitoring and Medication Compliance – Maintain care giving appointments and medication regime; Analysis, Diagnosis and Consultation – Access to staff or information via mobile devices for diagnosis.

Mhealth greatly improves the activities of different cadres of staff in the health fraternity in many aspects. For instance, or healthcare professionals, it can empower their patients and help them manage chronic diseases, it can help them manage patient prescriptions, ensure accuracy and help with patient compliance, To access instructional information or patient details on-the-go, and To help manage data and make the best use of technology.

Mhealth will assist patients to better manage, understand and track their illness. The government agencies and Non-Governmental Organizations can use mheath to: educate populations on diseases, track / acquire statistical data, advocate / lobby for awareness on diseases.

2.9.3 Challenges of improving maternity mortality

One model that frames the challenges of improving maternal mortality is the Three delays model, which proposes that pregnancy-related mortality is overwhelmingly due to delays in the decision to seek care, access to the appropriate level of care, and receipt of the appropriate treatment and professional care upon arrival at the health facility (see Figure 1).

The maternal-newborn continuum of care provides a general overview of what health systems can do to assure that appropriate services are available to mothers and newborns, but when designing effective interventions, it is equally important to keep in mind factors on the

population side that may prevent the usage of services, regardless of whether they are delivered with high quality or not. In this report, ways mhealth can be integrated to reduce these delays are described using this framework.

2.10.1 Mobile learning

Mobile learning can be defined as, “the processes (both personal and public) of coming to know through exploration and conversation across multiple contexts amongst people and interactive technologies” (Sharples, M., et al, 2007). It involves the "exploitation of ubiquitous handheld hardware, wireless networking and mobile telephony to facilitate, support, enhance and extend the reach of teaching and learning.”

2.10.2 Relationship between mhealth and mlearning

The use of mobile devices in health also known as mhealth offers great opportunities for learning among the reproductive population. Pregnant mothers can report signs that they exhibit and get explanation and directions on the best methods of dealing with their prevailing circumstances. These devices can offer information in different media including text, audio and video that caters for all the categories of the mothers. Mobile access, ownership and use of mobile phones have greatly increased among the poor and the semi-illiterate in the county. The mothers can therefore prompt the clinicians for information based on the observed conditions and experiences. The devices can further be used to search for information and procedures on the internet using the search engines.

2.10.3 Frameworks for implementing mlearning for mhealth

a. Koole’s FRAME model

The study is based on the on the analysis of the behavioral patterns based on the use of mobile devices in promoting good practices in neonatal and post natal care. The Koole’s FRAME model, (2009) is used. This consists of a three-circle Venn diagram comprising the Learner aspect (L), the Social aspect (S) and the Device aspect (D). Taking two or more of these together at the point at which the circles overlap in the Venn diagram:

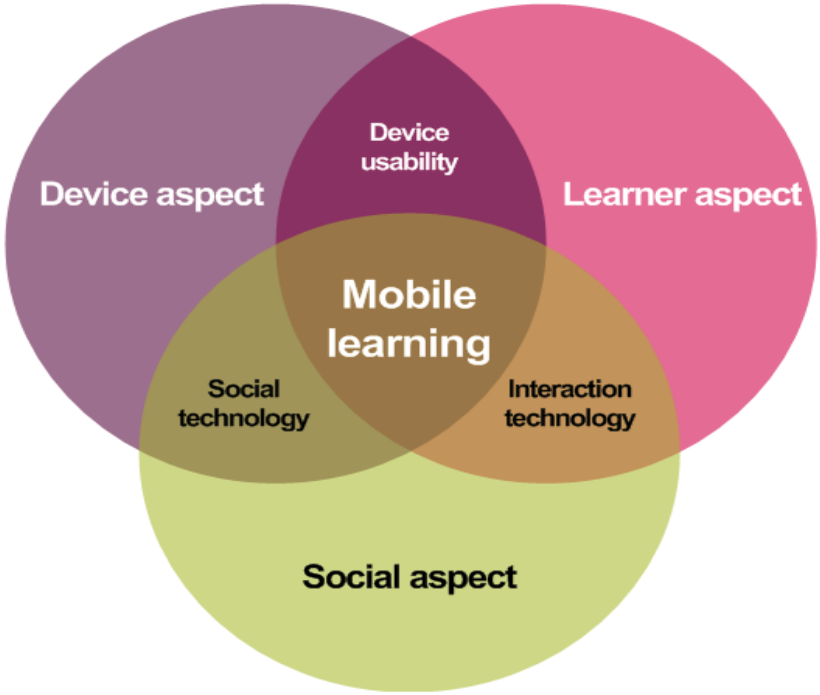


Figure 5:Koole's mobile Learning Framework

The circles represent the characteristics of the device, the learner, and the social. The Device Aspect (D) takes into consideration the physical characteristics, input and output capabilities, file storage & retrieval, processor speed, and error rates. If using this model for other technologies, other characteristics might come into play. The Learner Aspect (L) focuses on the characteristics of an individual such as prior knowledge, personal history, memory, emotions, learning styles (if you subscribe to a belief in learning styles), and ability to transfer skills and knowledge from context to context. The Social Aspect (S) takes into consideration processes of conversation and cooperation, the sharing of signs and symbols, as well as social and cultural beliefs and values.

According to Koole, (2009) mobile learning is therefore a combination of the interactions between learners, their devices, and other people. He provides a helpful checklist for institutions looking to adopt mobile learning, including the following questions that should be considered;

i. How use of mobile devices might change the process of interaction between learners, communities, and systems?

ii. How learners may most effectively use mobile access to other learners, systems, and devices to recognize and evaluate information and processes to achieve their goals?

iii. How learners can become more independent in navigating through and filtering information?

iv. How the roles of teachers (health professionals) and learners will change and how to prepare them for that change?

In line with Koole's mobile learning framework, the study aims to determine the positive change in behavior when using interactive mobile voice and text in learning and forums.

b. Three delays model

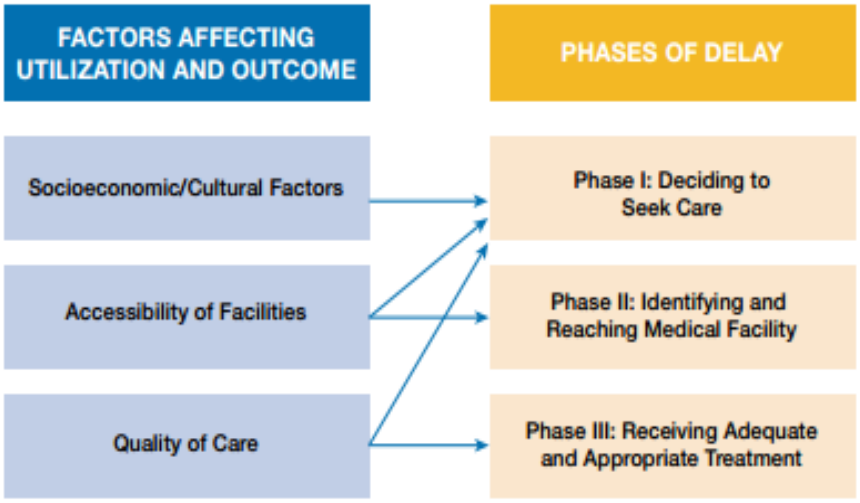


Figure 6: Three delays model for maternal mortality

(source: Thaddeus and maine, 1994)

2.10.4 Lessons in mobile mediated projects

The lessons that have emerged across mhealth interventions in mnh and that highlight what has been learned by the global community include;

Technology design should address user needs. for example, when compared to text messages, voice-based solutions are often more effective in optimizing the reach and impact of mhealth services particularly in an environment where illiteracy levels are high. additionally, it is important to contextualize content of the information being trasmitted, while taking into consideration local cultures when designing interventions.Solutions should leverage available resources to maximize impact. mobile technology solutions should be consistent with local technology and health policy environments to have optimal impact on augmenting established care practices. This improves the likelihood that mhealth solutions will better contribute to health priorities and complement existing practices while minimizing the potential for disruption. in the future, it is probable that advances achieved through mhealth interventions will drive developments in public policy and health practices.Technology is one element of the whole solution. in addition to the technology itself, social factors, market-based incentives, and regulatory frameworks must be considered. Incorporating these will ultimately influence successful user interaction with technology, the benefits to be derived, the rate of adoption anddiffusion, and the degree of impact on health outcomes. failure to achieve adequate attention in the planning phase may lead to mobilesolutions falling short of their potential.

Open solutions minimize the technical and economic risks in design. Open-source software solutions, standardized user and system requirements, and the sharing of resources based on experiences with technology can facilitate greater interoperability among information systems. They can also support the development of costeffective and low-risk approaches to design and development, and increase the prospect for local ownership, adaptation, and management in the implementation of mhealth solutions.

Strong partnerships across sectors breed success for sustaining development efforts. partnerships that engage a broad range of stakeholders across the health system and other sectors are more likely to ensure successful outcomes and the incorporation of a rigorous evaluation framework. for a more conducive policy environment and to assure that projects are consistent with health system priorities and resources, involving the government is particularly important. success also depends

on the development of in-country program capacity in technology development, project management, and monitoring and evaluation.

2.10.5 The Economic impact of mhealth

Mobile health clearly has expanded in number and type of initiatives. It is expected to become a multi-billion dollar field by 2017, Darrel M. West, 2012. According to a report from PwC, annual revenues are projected to reach $23 billion worldwide. This includes $6.9 billion in Europe, $6.8 billion in Asia, $6.5 billion in North Americas, $1.6 billion in Latin America, and $1.2 billion in Africa.

Remote monitoring will comprise about two-thirds of this market as doctors and patients use these devices to manage chronic illnesses. With the ubiquity of mobile devices both in developing and developed countries, there have been innovations in awareness, prevention, diagnosis, and treatment. Mobile technology is especially helpful in regard to chronic health diseases because it frees physicians from routine office visits while still providing data on patient conditions. This helps doctors focus office care on those requiring more detailed medical assistance.

2.10.6 Key benefits of mobile technology to educators

A number of studies have been carried out looking at the key benefits that mobile technology offer educators (Rau, Gao and Wu, 2008; Markett, Sa´nchez, Weber, Tangney, 2006; Peters, 2007; KukulskaHulme and Traxler, 2005). In Kim, Mims, and Holmes (2006) these benefits have been summarized into four main groups:

i. Providing students and educators with freedom of location and time;
ii. Increasing speed in teaching and learning;
iii. Enabling one-to-one learning based on individual educational histories or test results; and
iv. Allowing teachers to keep up the new educational subjects for future education.
v.

2.10.7 Challenges of Adopting Mobile Teaching and learning

According to Naismith, Lonsdale, Vavoula, and Sharples (2005) they highlight a number of new challenges when adopting mobile technology in learning and teaching: Mobility – the 'anytime, anywhere' capabilities of mobile devices encourage learning experiences outside of a teacher-managed classroom environment. Inside the classroom, mobile devices provide students with the capabilities to link to activities in the outside world that do not correspond with either the teacher's agenda or the curriculum. Both scenarios present significant challenges to conventional teaching practices.

Learning over time –learners will need effective tools to record, organise and reflect on their mobile learning experiences. Informality – the benefits of the informality of mobile devices may be lost if their use becomes widespread throughout formal education. Students may abandon their use of certain technologies if they perceive their social networks to be under attack.

Ownership - both personal and group learning are most effectively supported when each student has access to a device. The ownership of the devices is thus a key consideration. According to Perry(2003), both tangible and intangible benefits can accrue through the use of mobile devices. Intangible benefits include a sense of belonging with the device and personal commitment and comfort. Ownership is stated as a prerequisite for engagement, where students have the potential to go "beyond the necessary and play with it to explore its potential". Personal ownership does, however, present a challenge to the institutional control of the technology.

Overall mobile learning is a relatively new technology and how it will impact on the educational environment will be underpinned on whether the instructor sees the possibilities that mobile technology has to offer education. The instructors experience, attitude and previous experiences will possibly all have a role in whether or not the adoption of mobile learning happens. The following section outlines the results of the survey undertaken to identify how these variables play a role in adoption and how educators currently perceive mobile learning.

2.11Proposed solution system architecture

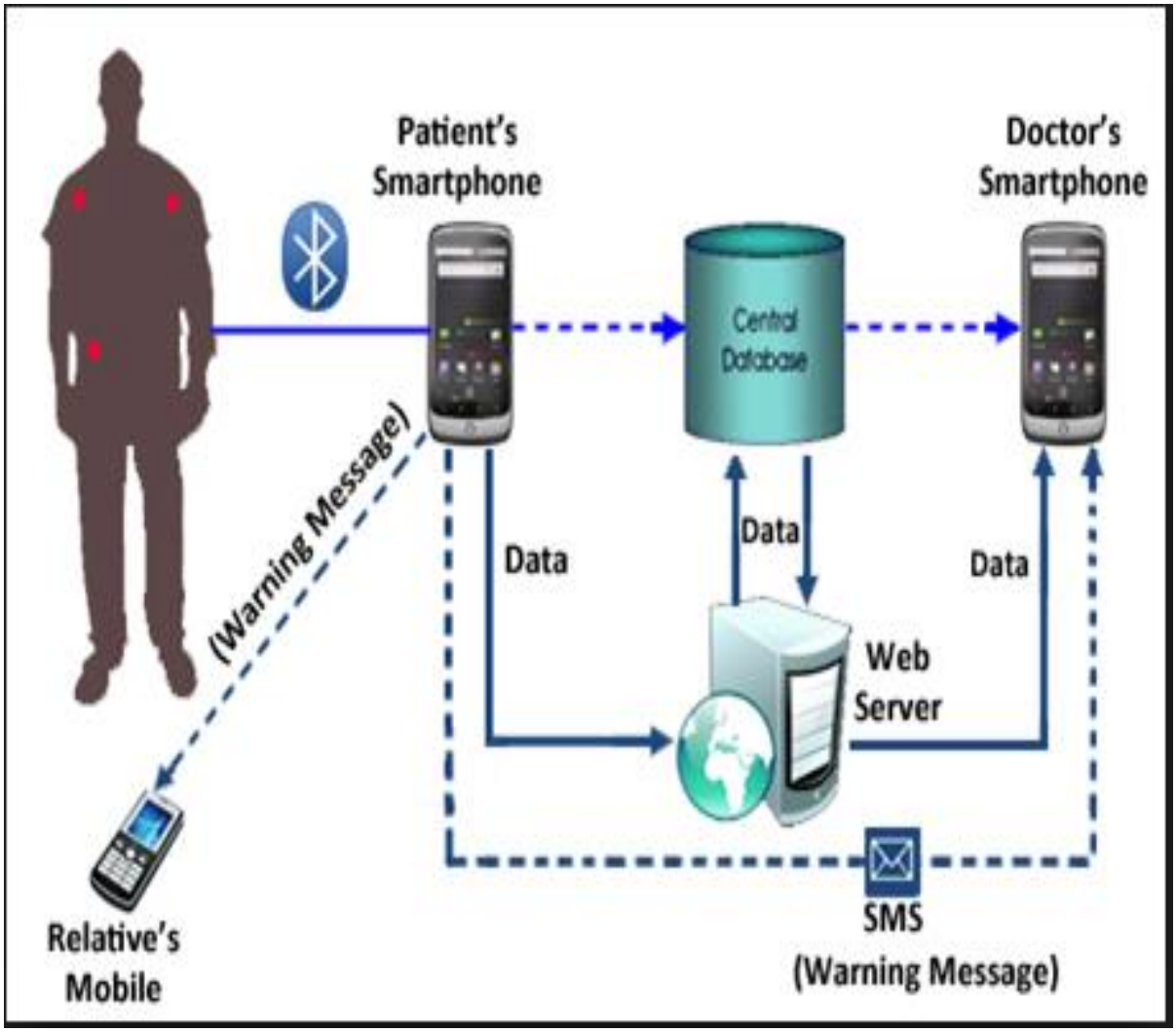


Figure 7: System architecture

2.11.1 Proposed solution model

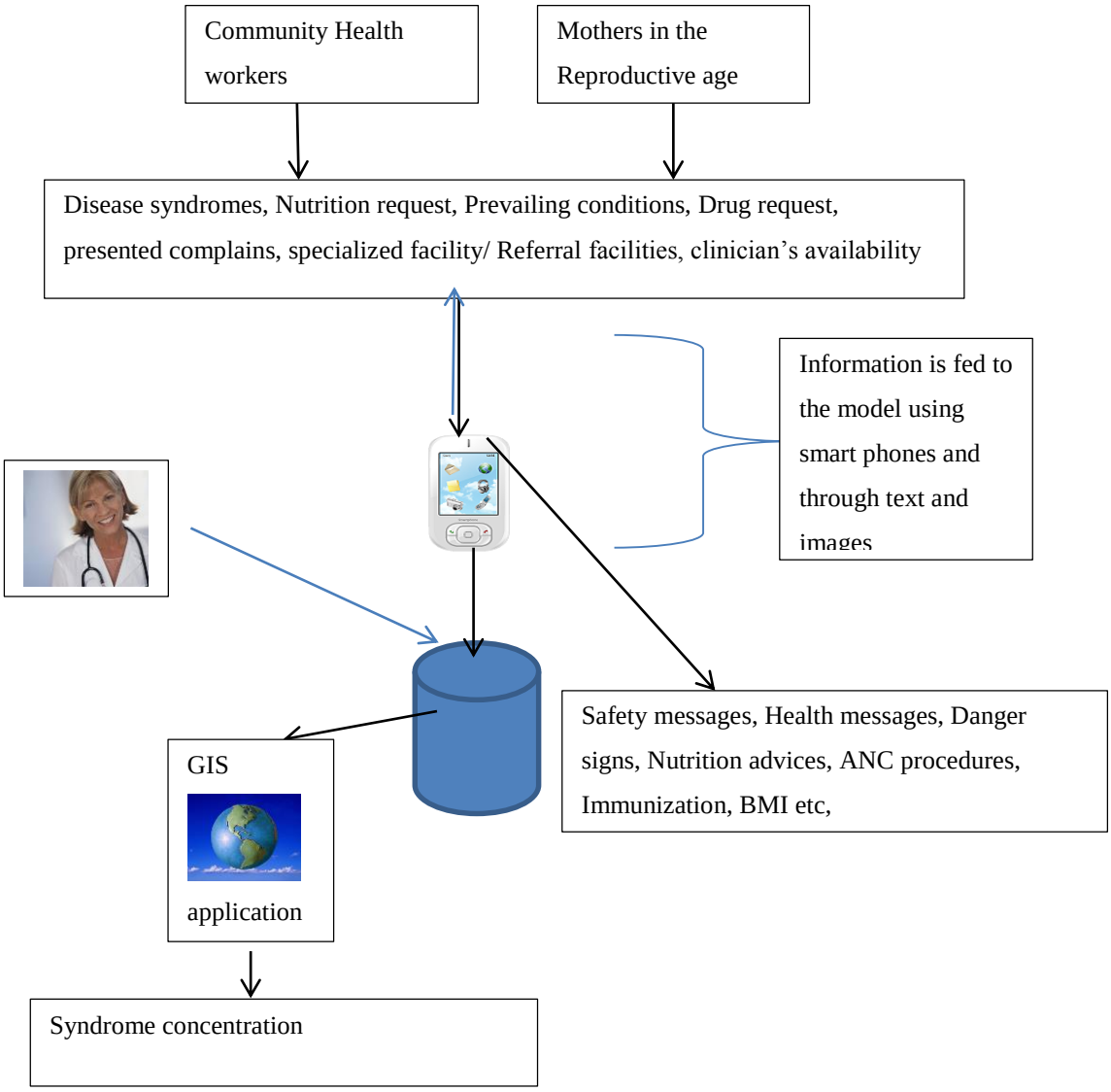


Figure 8: proposed solution

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, the research methodology is outlined. An indication of model type, techniques and tools, data collection and collation and analysis techniques is also outlined. In this project, software engineering model for mobile apps development (SEMMA) methodology is used. The SEMMA model applies ideas from agile development initiatives such as adaptability, iterations, and making heavy use of prototyping and diversified testing as early as possible in the process.

Prototypes can be exploited in nearly any phase of the engineering of a mobile software solution. They are primarily helpful in eliciting requirements or to get a common understanding with various stakeholders early in the project.

The mobile software engineering process that we introduce here is subdivided into three major phases:

i. Feasibility and economic efficiency analysis phase
ii. Software product realization phase
iii. Distribution phase

3.2 Software Engineering Model for Mobile Application methodology project phases

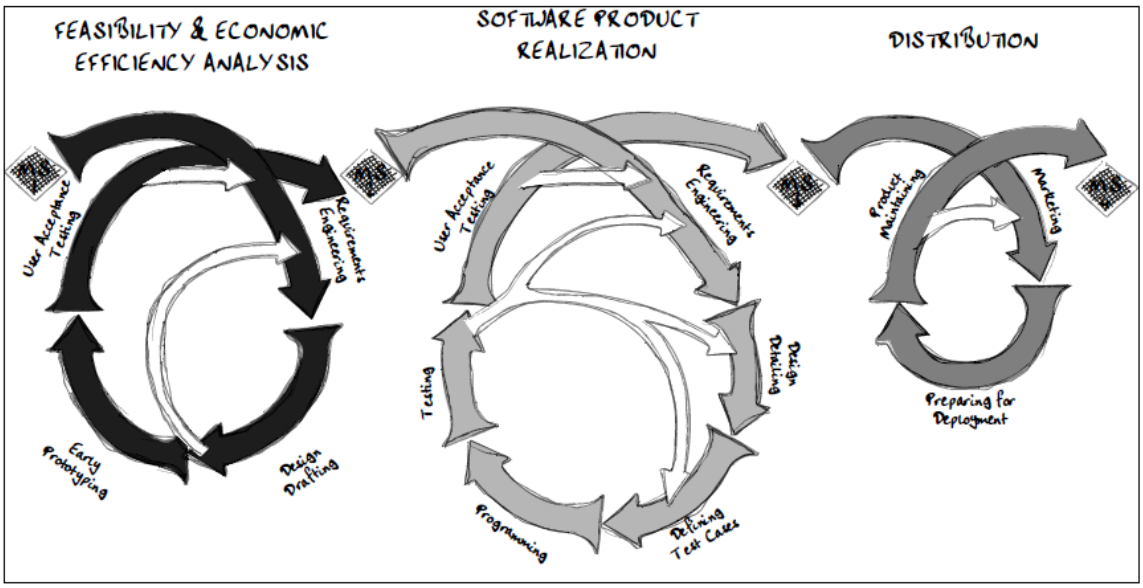


Figure 9: A software engineering process model.

3.2.1 Feasibility and economic Efficiency Analysis

3.2.1.1 Requirements engineering

i. This will involve the identification of the major actors in the mobile application and refining of their roles in structured system functionality.
ii. The development of use cases diagrams and users stories that model what users need from the system and their expectation from the mobile applications system.
iii. Modeling the interactions of the different components of the system.
iv. The focus here is to address the clearly defined problem or need with as little functionality as required.

3.2.1.2 Design drafting

This will involve:-

i. Drawing of the dialog flow logic and the user interface. This will involve the users to get their feel and inputs so as to get their buy in the application being developed.
ii. Software component architecture considerations. The user interface design activities are conducted in various micro- iterations with feedback from stakeholders.

3.2.1.3 Early prototyping

Through the use paper prototypes, interactive slide show and or clickable UI mockup, a good balance between a fast and cost-effective prototype and providing a user experience that comes close to the final product.

3.2.1.4 User acceptance testing

This is an optional stage. However, I recommend planning and executing tests with users that are not involved in the project. These tests can be short in length but should be as close to the real-world context as possible. This way, many problems that would go unnoticed in a lab environment will become apparent, such as bad readability under sunlight or overly complex and confusing user interfaces. These kinds of trials will almost always yield highly valuable feedback about the future acceptance by users and thus potential success in the market. After a test session there may be one or more iterations back to the requirements engineering stage depending on available time, and quality and cost targets.

3.2.2 Software product realization

The second main phase deals with realizing the software solution. It builds on the work in the first phase, and as many of the results as possible should be reused. In following the agile engineering process, this phase is also characterized by many iterations, incremental development (‘first things first’), and a high degree of internal and external communication.

3.2.2.1 Requirements reviewing

Prior to starting with the detailed software design, programming, and testing, the requirements should be reviewed and revised – ideally together with all stakeholders.

3.2.2.2 Design detailing

In this step, the available UI and architecture designs of the first phase are detailed into much more fine-grained levels – down to element and component level. Although, mobile software engineering is a comparatively young discipline, some (mostly vendor-driven) initiatives have emerged that provide guidelines for UI design. Although you are not bound to use these, we strongly recommend complying with these guidelines because it simply increases the usability of your product and its acceptance.

3.2.2.3 Defining test cases

Testing is absolutely necessary in any software engineering endeavor. In mobile software engineering it is more multifaceted and more variables need to be taken into consideration. The definition of test cases is the first activity related to testing. The cases can be derived from the requirements.

3.2.2.4 Programming

During this stage the designs should be transformed into program code that can finally successfully pass all test cases. Although mobile devices are becoming more and more powerful, it is nevertheless highly recommended to write efficient code with an eye on conservative computation to conserve as much battery capacity as possible

3.2.2.5 Testing

In the mobile software engineering process, much emphasis must be placed on the testing stage. It is important to differentiate between the testing platform and the real platform. The testing platform is usually a desktop computer that runs an emulation of the mobile device. Unfortunately, emulators exhibit great discrepancies with real mobile devices. Emulator tests are in ideal lab environments where context factors such as position or light conditions are either not considered or simulated. Hence, it is necessary to test software on the real target mobile device and in the real-world environment where the software is intended to be used. All the 'controllable' variables must be caught by the software, such as behavior according to device capabilities, adapting to screen size, masking network disconnections, or loss of GPS signal.

3.2.2.6 User acceptance testing

User acceptance tests at the end of the second phase are again optional but recommended. This way, engineers can make sure to really meet users' requirements with a software version that increasingly resembles the final state. This type of testing can be repeated and the outcomes can be fed back into earlier steps of this phase. Human–computer interaction techniques such as audio/video recordings, questionnaires, cooperative evaluations, focus groups, or controlled experiments can be deployed and are beneficial

3.2.3 Distribution

This phase mainly deals with bringing the mobile software product into the market to the users. This phase is less iterative than the other two. It is composed of the three stages: marketing, preparing for deployment, product maintenance, and a milestone at the end of the phase.

3.3 Justification of Software engineering model for mobile app development

In many respects, developing mobile applications is similar to software engineering for other embedded applications. Common issues include integration with device hardware, as well as traditional issues of security, performance, reliability, and storage limitations. However, mobile applications present some additional requirements that are less commonly found with traditional software applications, including:

- Potential interaction with other applications – most embedded devices only have factory-installed software, but mobile devices may have numerous applications from varied sources, with the possibility of interactions among them;
- Sensor handling – most modern mobile devices, e.g., "smart phones", include an accelerometer that responds to device movement, a touch screen that responds to numerous gestures, along with real and/or virtual keyboards, a global positioning system, a microphone usable by applications other than voice calls, one or more cameras, and multiple networking protocols;
- Native and hybrid (mobile web) applications – most embedded devices use only software installed directly on the device, but mobile devices often include applications that invoke services over the telephone network or the Internet via a web browser and affect data and displays on the device;
- Families of hardware and software platforms – most embedded devices execute code that is custom-built for the properties of that device, but mobile devices may have to support applications that were written for all of the varied devices supporting the operating system, and also for different versions of the operating system. An Android developer, for example, must decide whether to build a single application or multiple versions to run on the broad range of Android devices and operating system releases
- Security – most embedded devices are "closed", in the sense that there is no straightforward way to attack the embedded software and affect its operation, but mobile platforms are open, allowing the installation of new "malware" applications that can affect the overall operation of the device, including the surreptitious transmission of local data by such an application.
- User interfaces – with a custom-built embedded application, the developer can control all aspects of the user experience, but a mobile application must share common elements of the user interface with other applications and must adhere to externally developed user interface guidelines, many of which are implemented in the software development kits (SDKs) that are part of the platform.
- Complexity of testing – while native applications can be tested in a traditional manner or via a PC-based emulator, mobile web applications are particularly challenging to test. Not

only do they have many of the same issues found in testing web applications, but they have the added issues associated with transmission through gateways and the telephone network

- Power consumption – many aspects of an application affect its use of the device's power and thus the battery life of the device. Dedicated devices can be optimized for maximum battery life, but mobile applications may inadvertently make extensive use of battery-draining resources.

3.4 Tools and infrastructure

The following were used:

i. Eclipse IDE for java and android application development
ii. Apache server for php hosting
iii. MYSQL database to store the data
iv. Cpanel to edit the php codes(cpanel.0fees.net)
v. Filezilla for code buckup
vi. Huawei u8815(ginger bread) to test and test the phone
vii. A domain(tituka.0fees.net)

3.5 Research methodology

3.5.1 Introduction

This chapter presents the methodology, which was used to carry out the study. It further describes the type and source of data, the target population and sampling methods and the techniques that was used to select the sample size. It also describes how data was collected and analysed.

3.5.2 Research Design

Research design is the outline, plan or scheme that is used to generate answers to the research problem. It is basically the plan and structure of investigation. Descriptive research design was used in the study. Descriptive research sought to establish factors associated with certain occurrences, outcomes, conditions or types of behavior. Descriptive research is a scientific method of investigation in which data is collected and analyzed in order to describe the current conditions, terms or relationships concerning a problem (Kothari 2005).

3.5.3 Target Population

Target population as defined by Reinhardt (2003) is a universal set of the study of all members of real or hypothetical set of people, events or objects to which an investigator wishes to generalize the result. The target population of the study was as follows:

Table 3.1 Target Population

Table 1: Target population

Population Category	Target Population	Percentage
Mothers	200	74
CHWs	60	22
Clinical staff	10	4
Total	**270**	**100**

Source: Author (2013)

3.5.4 Sampling Design

According to Kothari (2005) sampling is the process by which a relatively small number of individual, object or event is selected and analyzed in order to find out something about the entire population from which was selected. A sample is a small proportion of targeted population selected using some systematic form. The research used stratified random sampling because it enabled generalization of a larger population with a margin of error that is statistically determinable. The sample size was 50% of the target population. The sample size was as follows:

Table 2: Sample size

Population Category	Target Population	Sample Size 50 %	Percentage
Mothers	200	100	74
CHWs	60	30	22
Clinical staff	10	5	4
Total	**270**	**135**	**100**

Source: Author (2012)

3.5.5 Data Collection

In the study, we will make use of both primary and secondary data sources. There are two major data sources that will be used in this study: Data from the interactive mobile voice/Text model's database. Through the system, I intend to register mothers and CHWs in the target population. The interactions between the registered mothers and the systems will be recorded in the system and monitored. This will form vital data for analysis to show the trends in attitude or behavior change. The system usability and familiarity will be captured based on the use of the system.

Data from Health Information Systems Department. Data from the health information department of the ministry of health that aggregates the number of mothers accessing services will be used to monitor the trends upon the deployment of the systems prototype in the targeted area. The DHIS system used by the department also contains the populations of by administrative boundaries which is vital in this study. Additionally the department provides data on morbidity and mortality that is required for this study. The DHIS system therefore will form baseline for this study.

Data from the community health workers. The information from the community is vital source. The study intends to collate information on the attitude, behavioral patterns, preferences and tastes in regards to the use of mobile phones in learning and education. Additionally I intend to interview

the CHWs on their interaction with the target population to know their assessment of the patterns exhibited by the reproductive population.

Questionnaires were used in the study. Questionnaires were hand-delivered and collected after a few days. The types of questions used included both open and closed ended. Closed ended questions were used to ensure that the given answers were relevant. The research phrased the questions clearly in order to make clear dimensions along which respondents would be analyzed. In open ended questions, space was provided for relevant explanation by the respondents, thus giving them freedom to express their feelings. This method was considered effective to the study in that; it created confidentiality. The presence of the researcher will not be required as the questionnaire will be self-administered.

3.5.6 Data collection methods

- Model reporting

  This will form the main source of data collection, the model usage, interactions and other key indicators to be monitored shall be collected from the system model.

- Direct observation

  Observation on the health seeking behavior for the targeted sample will form the major source of data collection.

- Interviews

  Users of the model will be interview to determine their attitude and taste for the model as an intervention tool.

- Questionnaires

  To reach a larger number of respondents, questionnaires shall be applicable. This will be used to determine the level of usage of the model and to collect information on certain indicators such the number of times for an ANC visit, consultation with professional health providers.

- Key informant interviews

3.5.7 Validity of Research Instruments

The research obtained authority from relevant departmental sections of the organization to circulate questionnaires. To ensure reliability and validity questionnaires were pre tested on three respondents. These respondents were not included in the final study. The questionnaire was then corrected before the final distribution.

3.5.8 Data Analysis Method

According to Kothari (2005), data analysis procedure includes the process of packaging the collected information putting in order and structuring its main components in a way that the findings can be easily and effectively communicated. After the fieldwork, before analysis, all questionnaires were adequately checked for reliability and verification. Editing, coding and tabulation were carried out. The data was analyzed using qualitative and quantitative techniques. Qualitative method involved content analysis and evaluation of text material. Quantitative method involved the use of diagrams such as tables and charts.

CHAPTER 4: SYSTEM ANALYSIS AND DESIGN

4.1 System specification

4.1.1 Overview

Currently, mothers in the reproductive stages rely on the services offered by health professionals often in the health facilities. Most deliveries in the informal settlement still occur in the villages and homes with traditional birth attendance as the only semi-skilled personnel in attendance. The gap in maternal health knowledge among these mothers is huge and there is great need for education and mentorship for them. The mothers currently will seek care after developing a complication and trying different medication often without a doctor's advice. The proposed system will enable the mothers to report the observed syndromes, complications and any complains through a mobile device to a repository using text or video. The health professionals shall review the syndromes and upload their suggestions and/or advice on the web application. The mothers shall then get possible solutions to their issues via their mobile devices.

The system further enables the health professionals and policy makers in the government to know the syndrome concentration in an area. This can enable faster intervention before a catastrophe or spread of epidemics in the targeted locations.

The mothers shall also build their knowledge on reproductive issues by requesting for health safety messages from the repository. These messages shall be available to the mothers through text, audio and video.

4.1.2 Inputs and outputs

4.1.2.1 Inputs

The system will allow mothers to be registered where their phone numbers and location. The mothers therefore form the primary users of the system. Information on maternal and child best practices from WHO, national and program with specific targets on improving mother and child wellness shall also be used. Doctors' pieces of advice including healthy practices, nutrition and

medicinal advice will form some of the inputs. Using GPS, the system will capture as input, the coordinates of the syndrome senders (mothers)

4.1.2.2 Outputs

The system, being an interactive response system, shall output the specific responses to the enquiries by the users based on the categories selected. The mothers will also be able to access a list of best practices in the reproductive stages and post-delivery mother and infant wellness. To enable quick response to epidemics, the system will produce a mapping of the locations from which the syndromes are sent to show syndrome concentration.

4.1.3 Data management

The data used by the system will be stored in a database. The system will save all interactions with the mothers and health professionals. The database shall also be a portal for all the reproductive health best practices. The GPS generated geocodes for the locations of all interacting mothers shall be included in the database.

4.2 System analysis

The mobile software engineering process that is used here subdivided into three major phases namely:-:

i. Feasibility and economic efficiency analysis phase
ii. Software product realization phase
iii. Distribution phase

4.2.1 Feasibility and economic efficiency analysis

This is the first step in the analysis phase, which takes an initial system specification and transforms it into a structured set of system goals.

a) Requirements engineering

The systems major actors were identified and their roles mapped out. The following actors were identified; Mothers whose primary role is to interact with the system through the enquiries and learning, the health professionals who give the pieces of advice and write reproductive health messages to the mothers, the policy makers who uses the system for surveillance.

4.2.2 Applying use cases

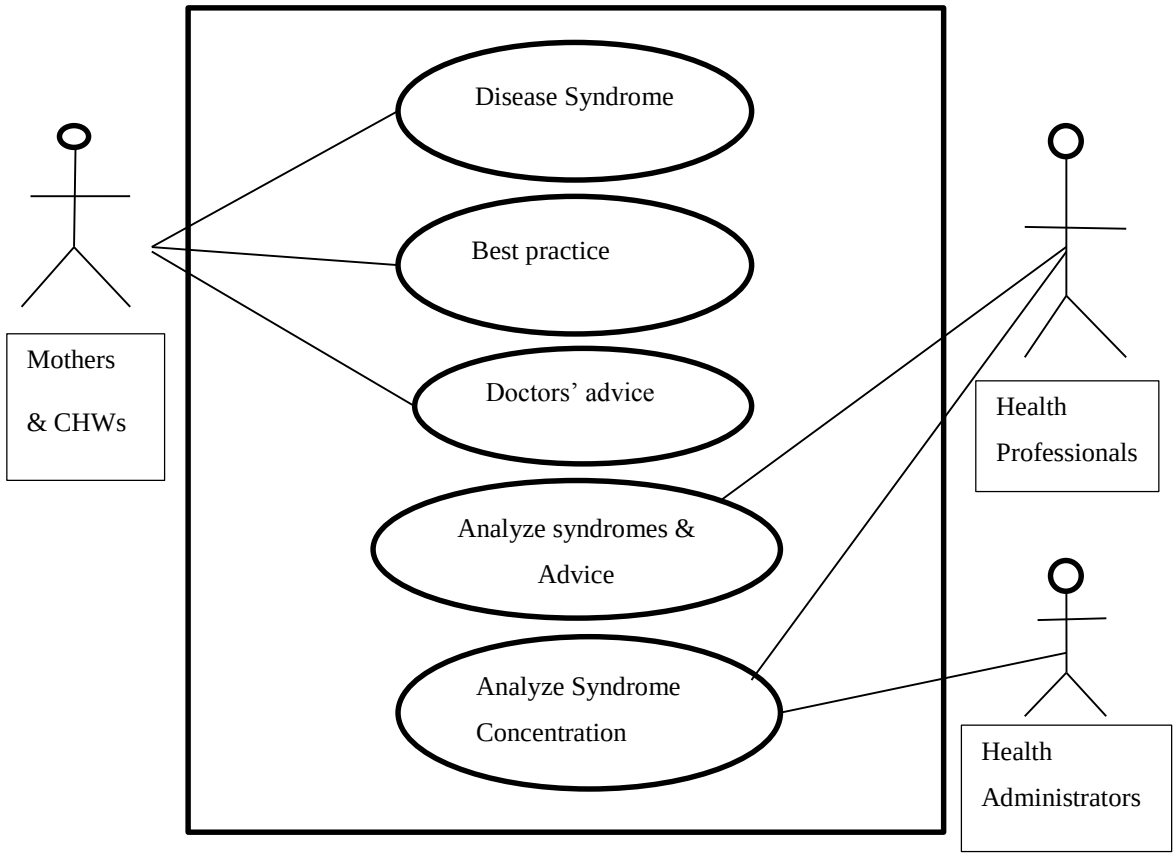


Figure 10: Use case diagram

4.2.3Refining roles

The objective of this step is to transform the structured goals and sequence diagrams into roles and their associated tasks. The tasks are generally derived from the goals for which a task is responsible. These are captured in a role model diagram as shown below.

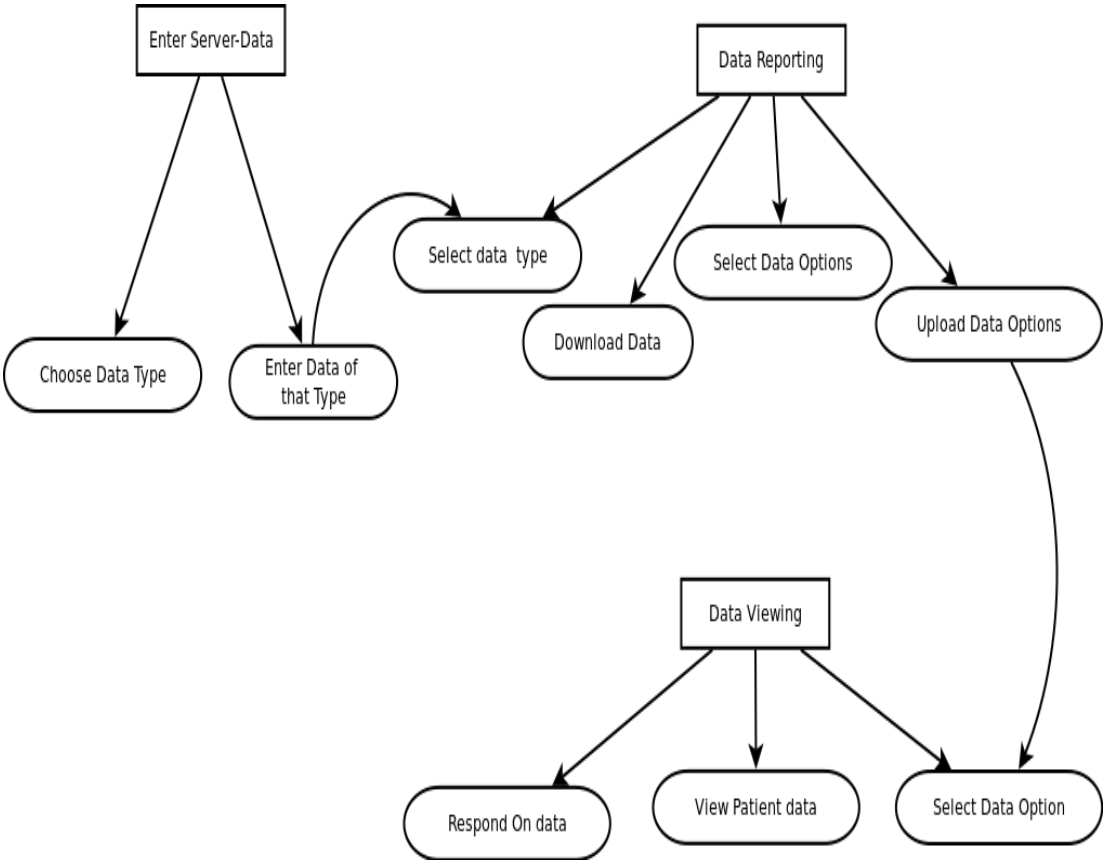


Figure 11: Roles Diagram

4.3 System Design

4.3.1 Overall system architecture

The mothers constantly monitor their conditions and those of their children under the age of five. The mothers then report any syndromes of concern through their mobile phones using the healthcare system prototype. These syndromes are picked via a web application into a database. The mothers can assess the responses to their queries immediately if such a syndrome had been reported before. In the central database, a doctor uses a web application to access the syndromes posted. He/she then analyses and responds with suggestions on the required prescription and/or advice to the mother. The response is stored in the database for future use especially if a similar syndrome response is requested by the mothers.

Whenever a new syndrome request is made, the health professionals are noted on the pending syndromes yet to be responded to. In any event that a professional is unable to respond to a syndrome, it will be kept in a pool until a response to response is given.

The system prompts the mothers to find out a response to their syndromes whenever the system is unable to locate the requested syndrome's request. The system allows the mothers to get feedback in multiple forms i.e. text, audio and video depending on the device used.

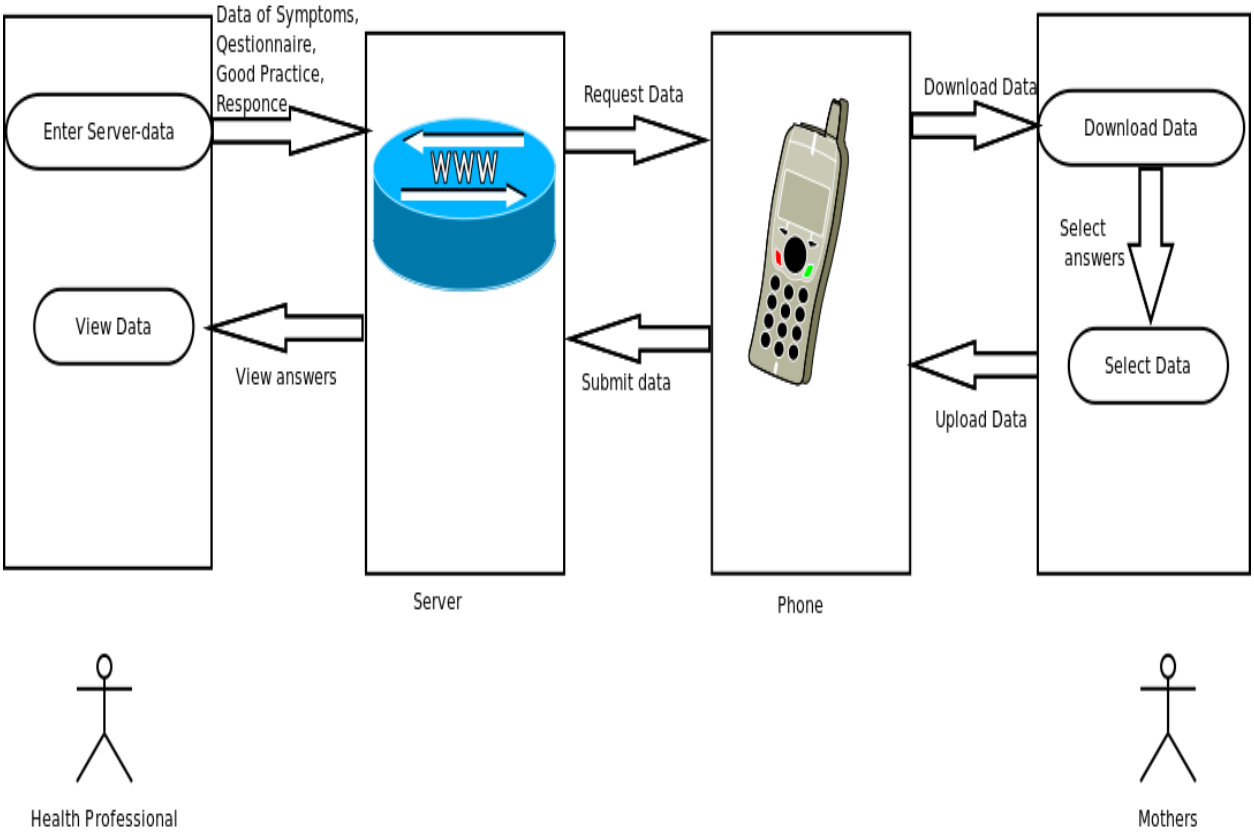


Figure 12: System architecture

To ensure the successful running of the system, the following items are required to be installed into the system; Eclipse for editing android code; MySQL workbench for creating transaction code, tables, relationships; and database design. Filezilla was used for uploading and editing PHP code in the server. The server used is php - MSQL server. Dia application diagram editor was used for modeling the system.

4.3.2 System Classes

The system classes are created from the roles defined in the Analysis phase. The end product of this phase is a system class diagram, which depicts the overall agent system organization consisting of the classes and the conversations between them.

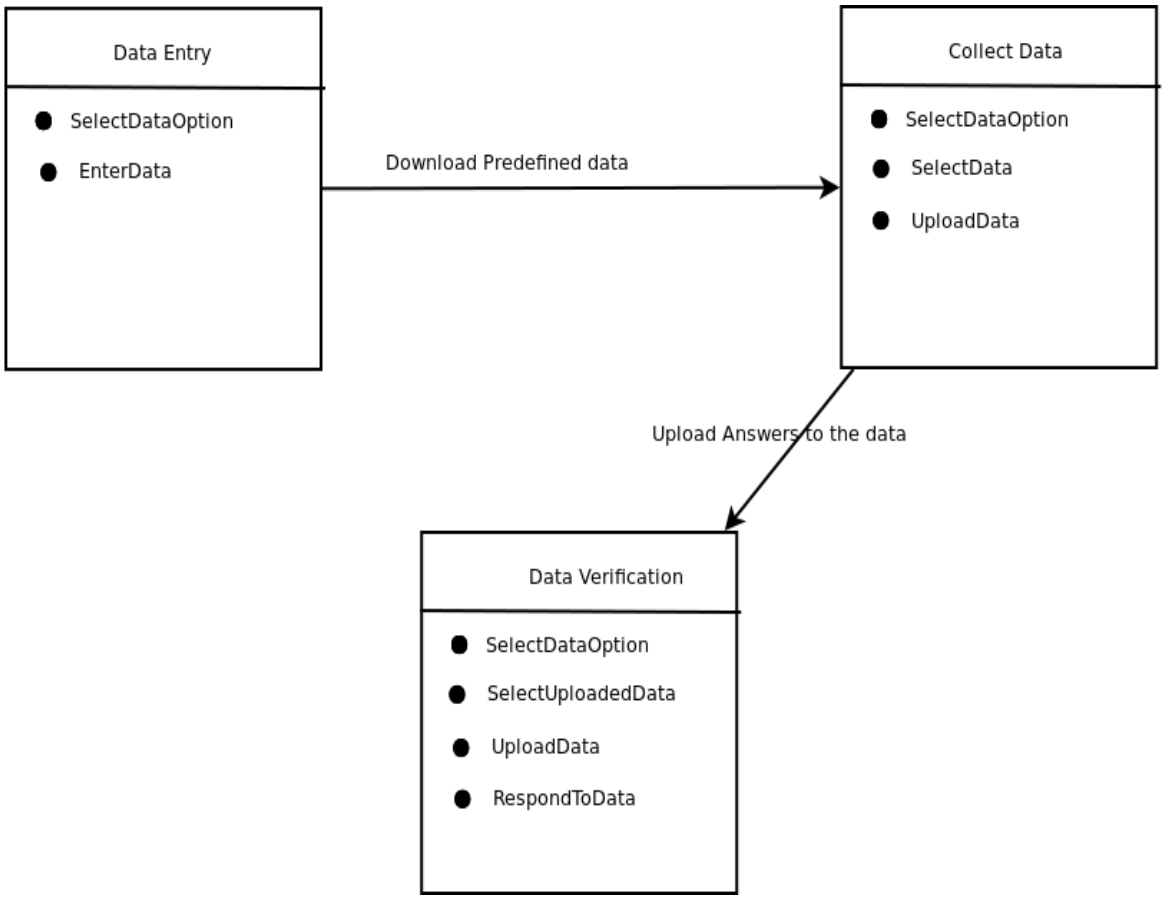


Figure 13: Class Diagram

4.3.3 Communication diagram

The following interactions shall occur between the different system artifacts

Figure 14: Communication diagram

4.3.4 Creating Sequence diagram

A Sequence Diagram depicts the sequence of events that are transmitted between the agent classes. The communications described above are summed up in a sequence diagram.

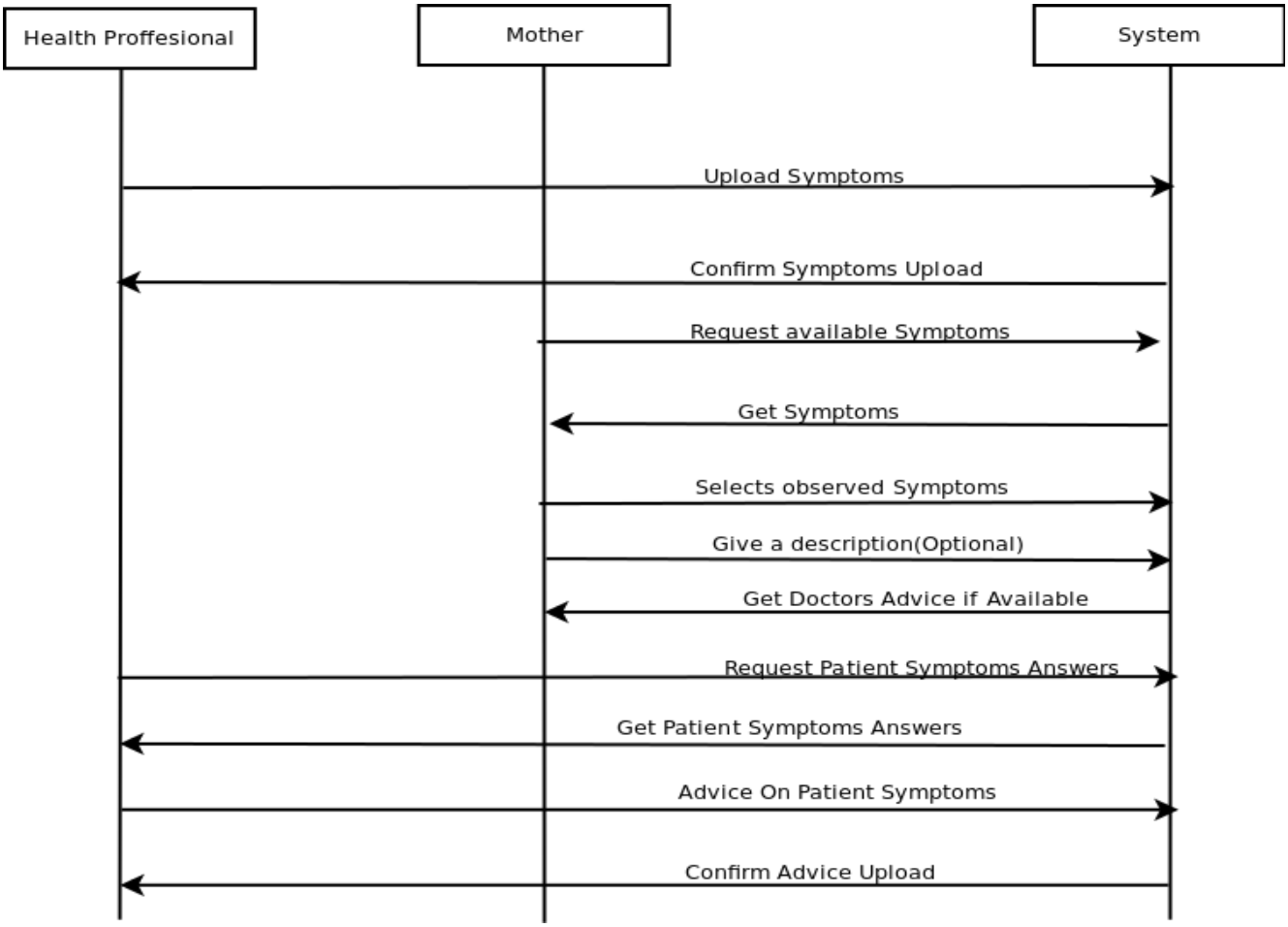


Figure 15: Use case diagram

4.4 Database design

The database will be used to store all the collected symptoms and syndromes from the mothers and the CHWs that report using the healthcare system. In the database as well will be the best practices and doctors' response to the observed syndromes. The geocodes representing the locations from which the syndromes are reported shall be saved to allow plotting. The audio and video links will be stored in that database to allow both mobile and web application to reference them if required.

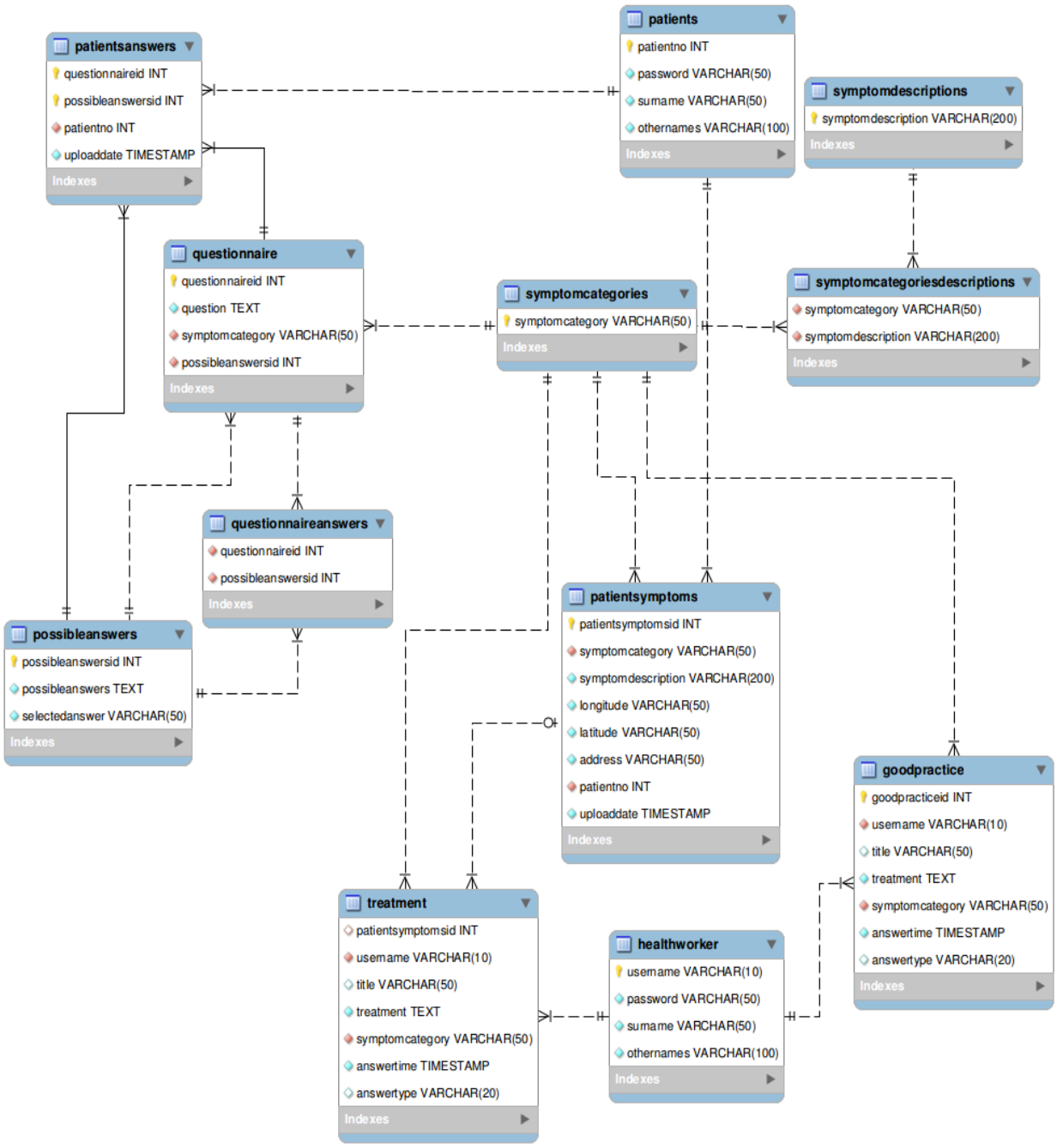


Figure 16: Database Schema

CHAPTER 5: SYSTEM IMPLEMENTATION AND TESTING

5.1 System development

The system is developed using Android and PhP. In the development of the system various tools were used including; Eclipse IDE for android application code editing and debugging tool; Filezilla was used for uploading and editing of Php files; MySQL workbench for table design and creation of the relationships; cpanel for creating the online database.

5.2 Modules in the system

5.2.1 Data collection Module

This is an application installed on the user's mobile device. The mothers sign into the application using a simple password and can access an online database with syndromes categorized into prenatal, postnatal, newborn and doctors' advice. The mother can then search for the existing symptoms and select single or group symptoms as observed. The mothers and the CHWs can then save the syndromes which are then transferred to the online database. The module also uses geocoding to identify the location of the sender.

Figure 17: Login screen

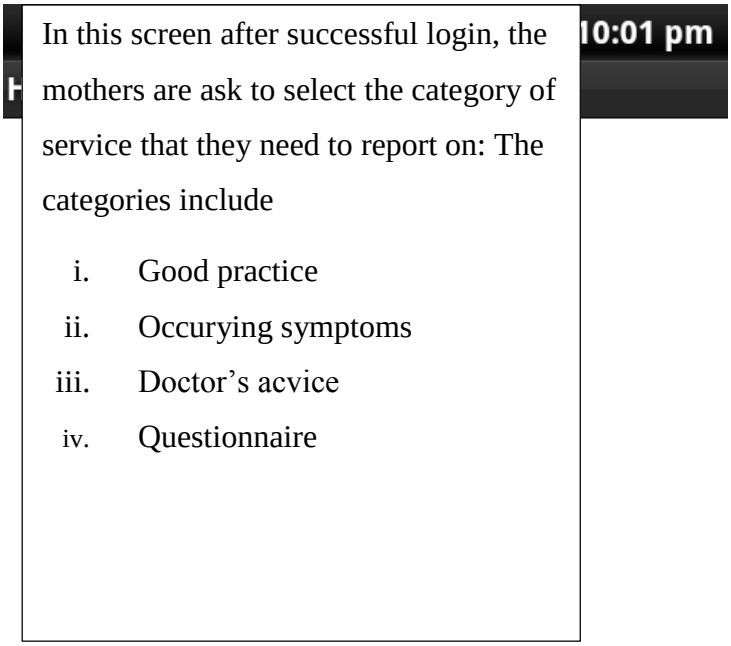


Figure 18: Symptoms window

In this module, the mothers select the occurring symptoms after which the system displays a list of symptoms as structured by the health professionals. The subsequent screen displays a list of symptoms from which the mothers can select from. If the observed symptom is not listed, the mother is provided with a free text box to give a brief description of the conditions exhibited.

The mothers are shown synthesized symptoms arranged with check boxes from which to select from. One or several options can be selected and from the menu option, they are asked to save those that are selected. This action pushes the symptoms to the online database including the sender's location. The system then prompts the mothers on whether to vie the doctor's advice immediately with a yes or no options. The module further allows the mothers to select the media in which they would like the message to be relayed which are text, audio or video. If a text or video is selected, the system loads a URL which then plays on U-tube. For text messages, a message box is shown to the mothers.

In circumstances where the doctor's advice is yet to be uploaded, the mothers are prompted to wait for some time and check on the system after some time or days.

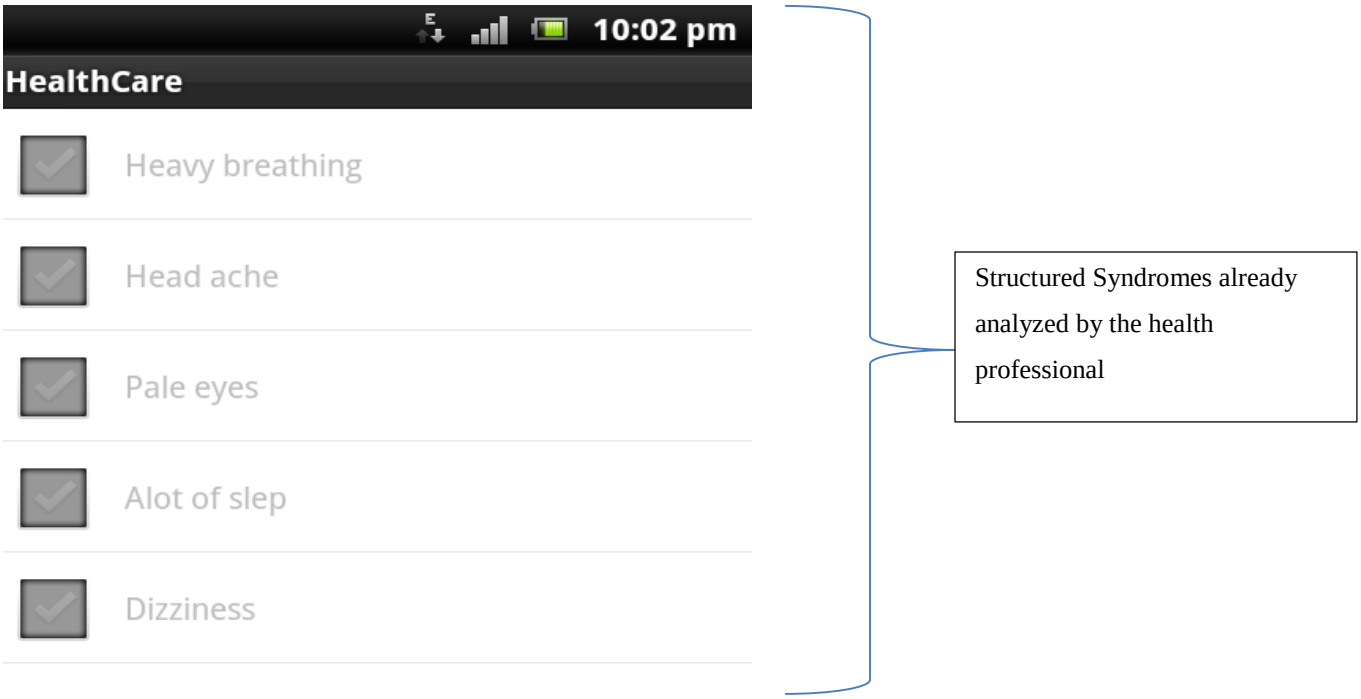
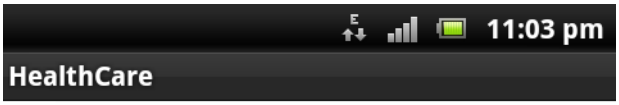


Figure 19: Line list of symptoms

5.2.2 Knowledge enhancement module

This module enables the mothers to access the resources on best practices on the reproductive aspects as well as gain some insights on how to go about the reported syndromes. The mothers use their mobile devices to select the category of interest and select a topic from where they can read, listen to and/or watch a video clip on the some of the world acknowledged practices ranging from breast feeding, lactation, immunization, prenatal care, post natal care, well baby care etc.

The prerequisite for the system is network availability therefore reducing considerably the cost of data transmission for the poor mothers. The module is aimed at increasing awareness among the vulnerable mothers by being in touch with some of the healthy behavior/ health seeking behaviors.



SELECT ADVICE

Click on menu to search

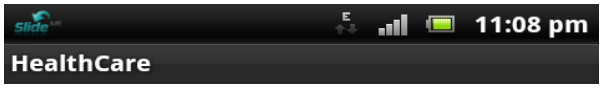
Upon selecting on the menu item, the mothers are presented with the following options

Prenatal

Post natal

Child below 5 years

Selected category



SELECT REPLY

Click on menu to search For
a)Audio Reply
b)Video Reply
c)Text Reply

Three options of media are available for relaying the message ie

Audio

Video

Text

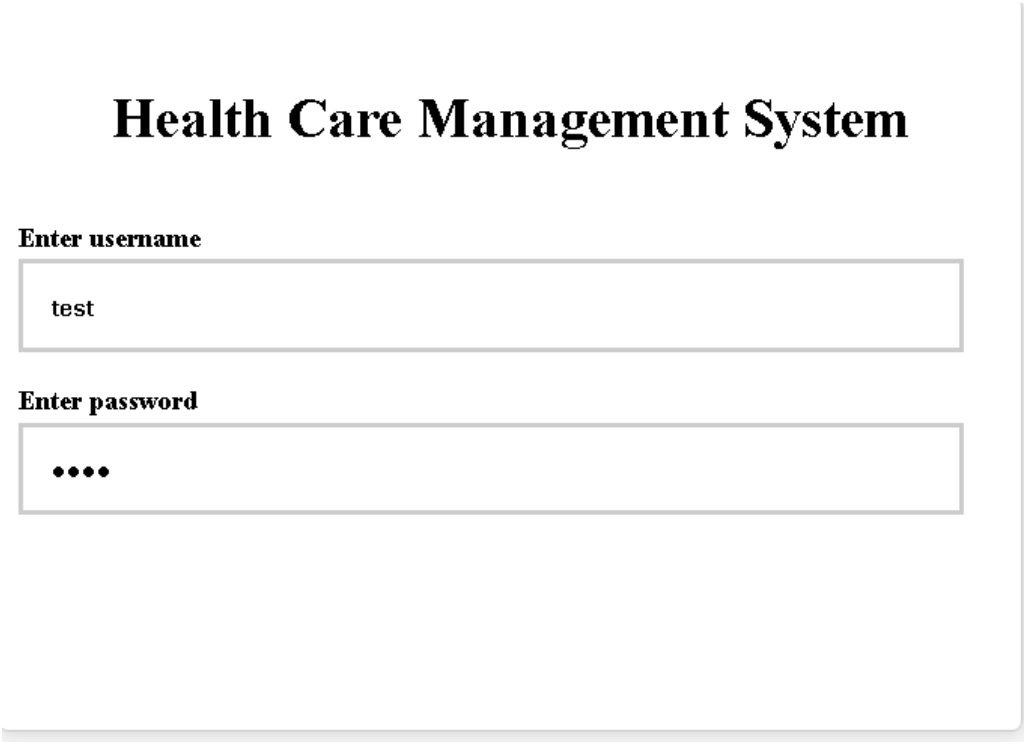
The mothers select an option in which the doctor's advice is relayed.

By presenting the three options, the system improves learning through cognition, affective and psychomotor. This has a greater effect on heath seeking behavior change than the conventional text messaging.

5.2.3 Heath Professionals module –Web application

This module acts as the systems administrators' module in which most of the setups and configurations are done. It primarily provides the interface for the health professional to update the system and respond to the enquiries by the vulnerable population and mothers. Since healthcare and patient information is very private, the doctors gain access to the module through secure login. Upon login the professionals are presented with a wide range of menus from which they can configure the system and respond to pending syndromes. The doctors use the same module to upload good practices for access by the mothers.

Secure login by the administrator



The web application that tracks symptoms from the mothers

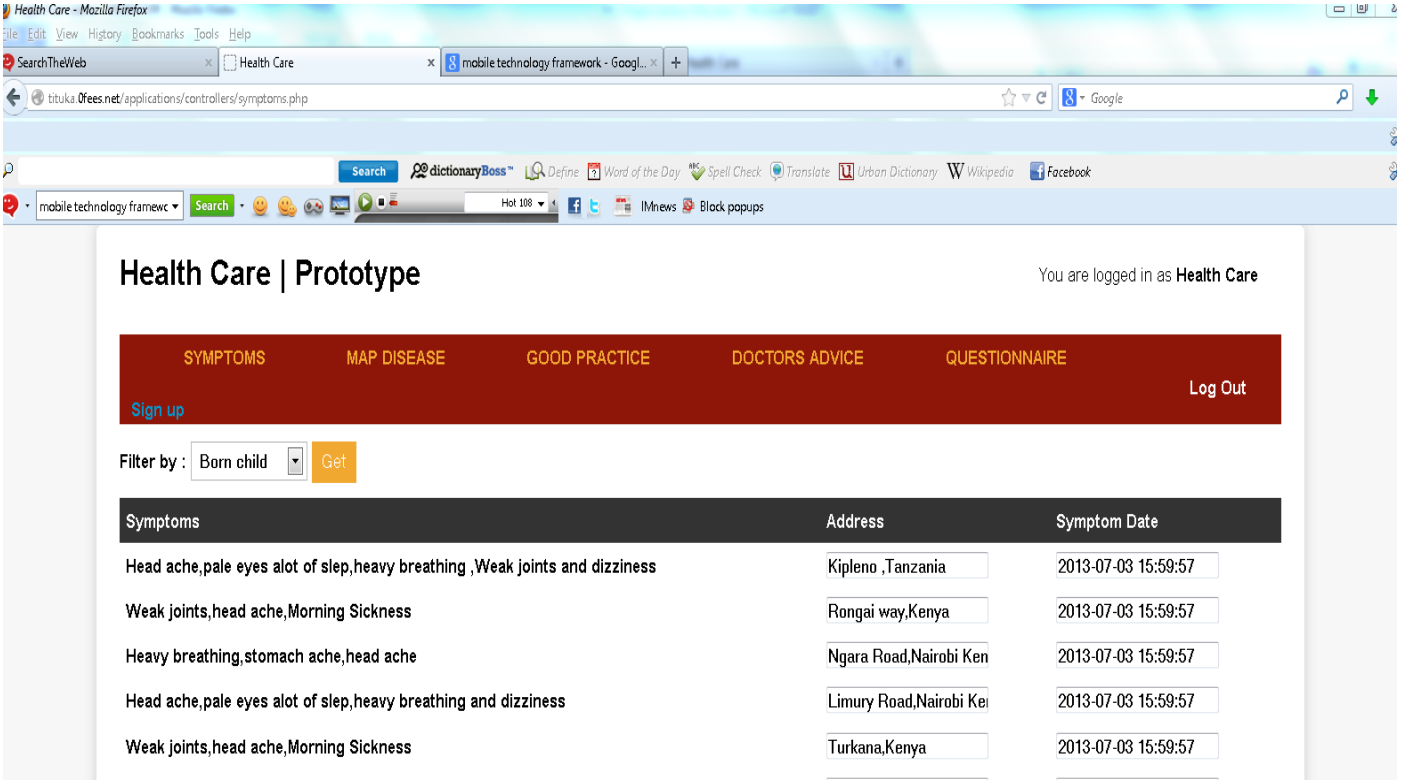


Figure 20: Web site

In this module, the particular location of the sending device is captured and the date in which the syndrome is sent is captured. In the menu, the items include symptoms, map disease, good practice doctors' advice and questionnaire.

The default menu is the symptom that displays all the syndromes organized by dates. The submenus also provide vital functions for the health professionals in combating the Mother Child mortality levels.

a. Mapping syndrome density

This sub menu enables the health professionals especially the policy people to identify syndrome concentration in a particular area so that necessary intervention can be requested proactively. This enables curbing the spread of a disease to a larger population thereby reducing the number of vulnerable exposed to the danger signs. After an intervention, the details can be cleared and new information collected from the mothers.

Sample map showing the disease concentration is as follows:

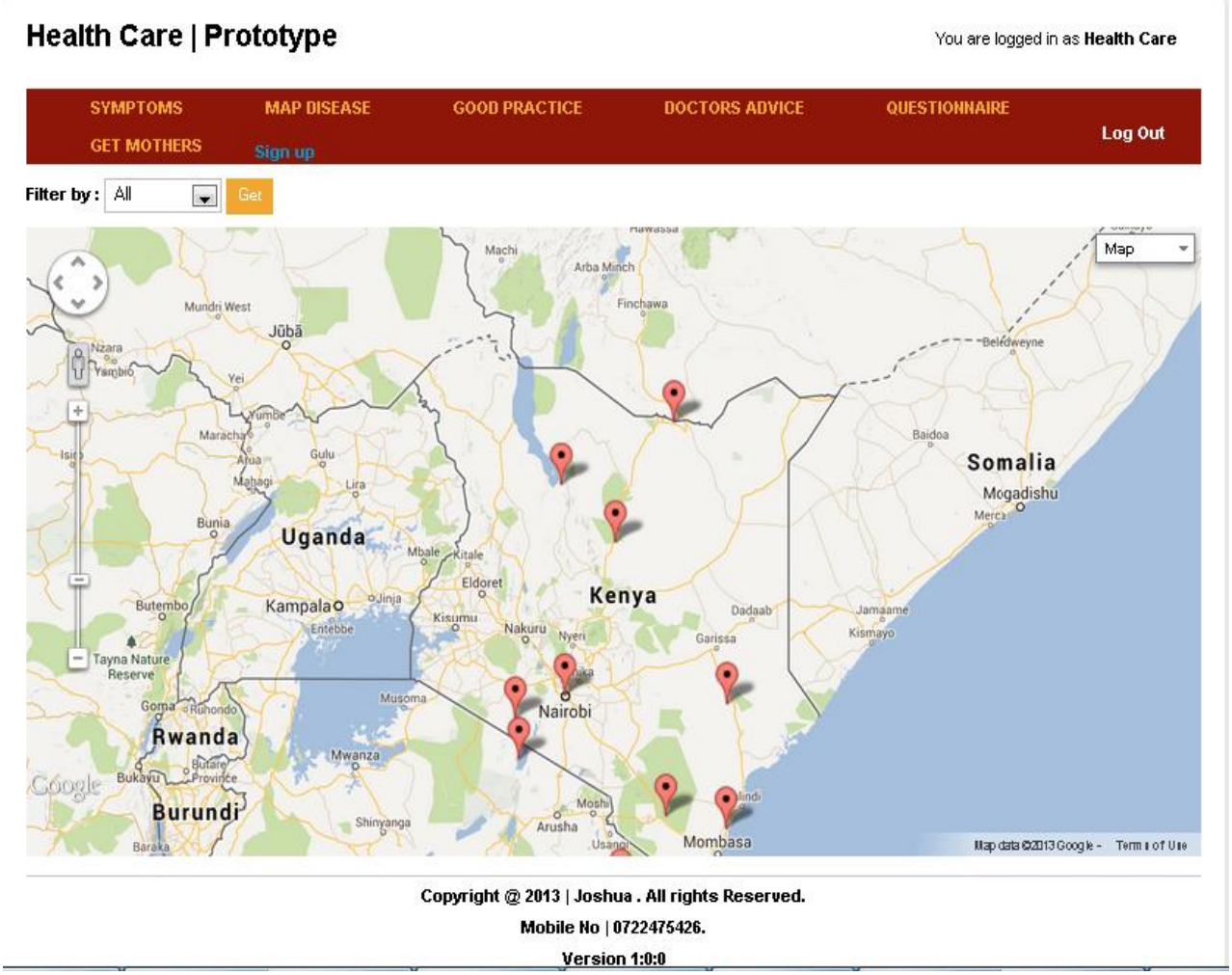


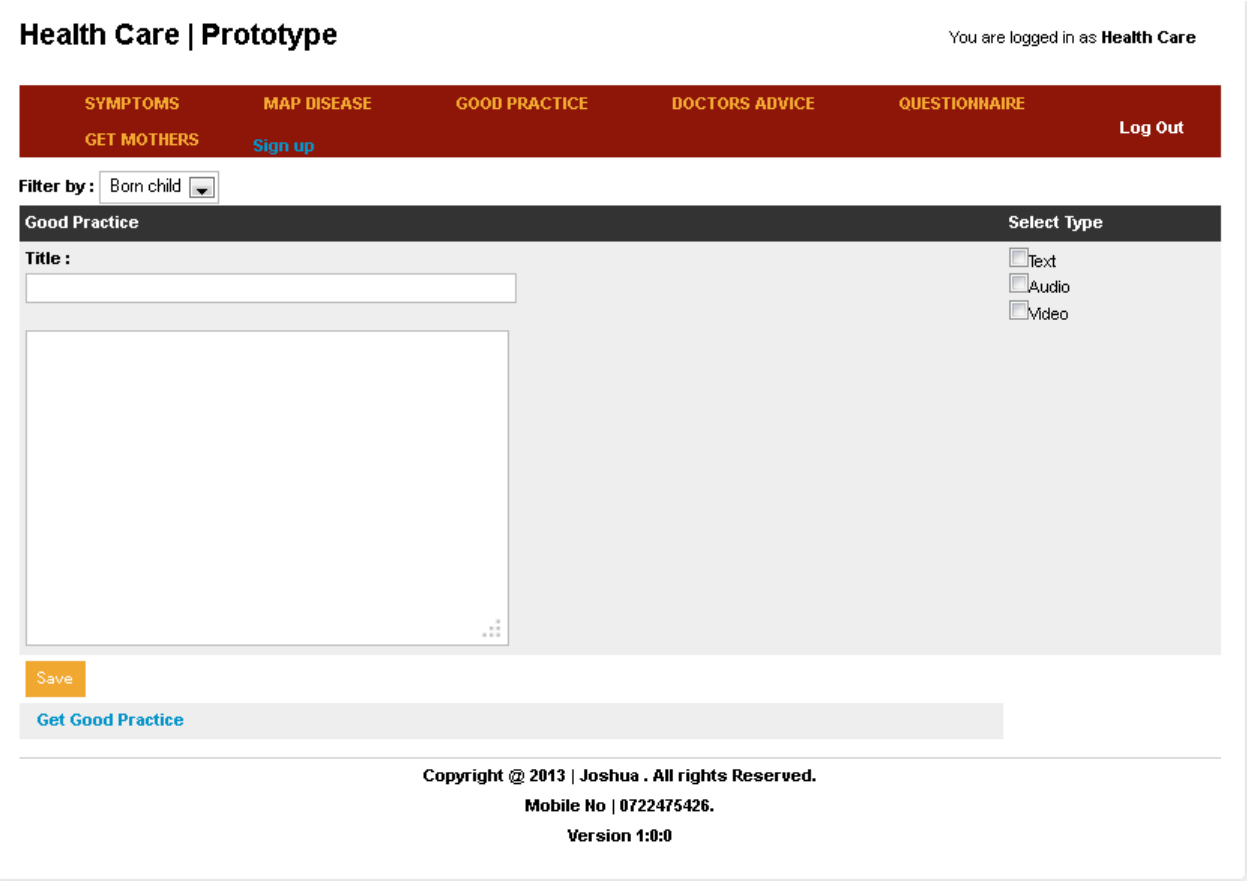
Figure 21: Distribution of syndromes

The use of Google maps to show the distribution enables the policy makers to investigate areas of higher syndrome concentration and avoids any outbreaks that can lead to mass mortality in the population. The mapping can also assist in resource prioritization and intervention mechanisms to the affected areas.

This research made an assumption that the mothers send the symptoms from where they experienced or observed these syndromes. It is important to note that the global positioning system uses public identifiers and landmarks such as roads that may not be very give the exact location of the devices.

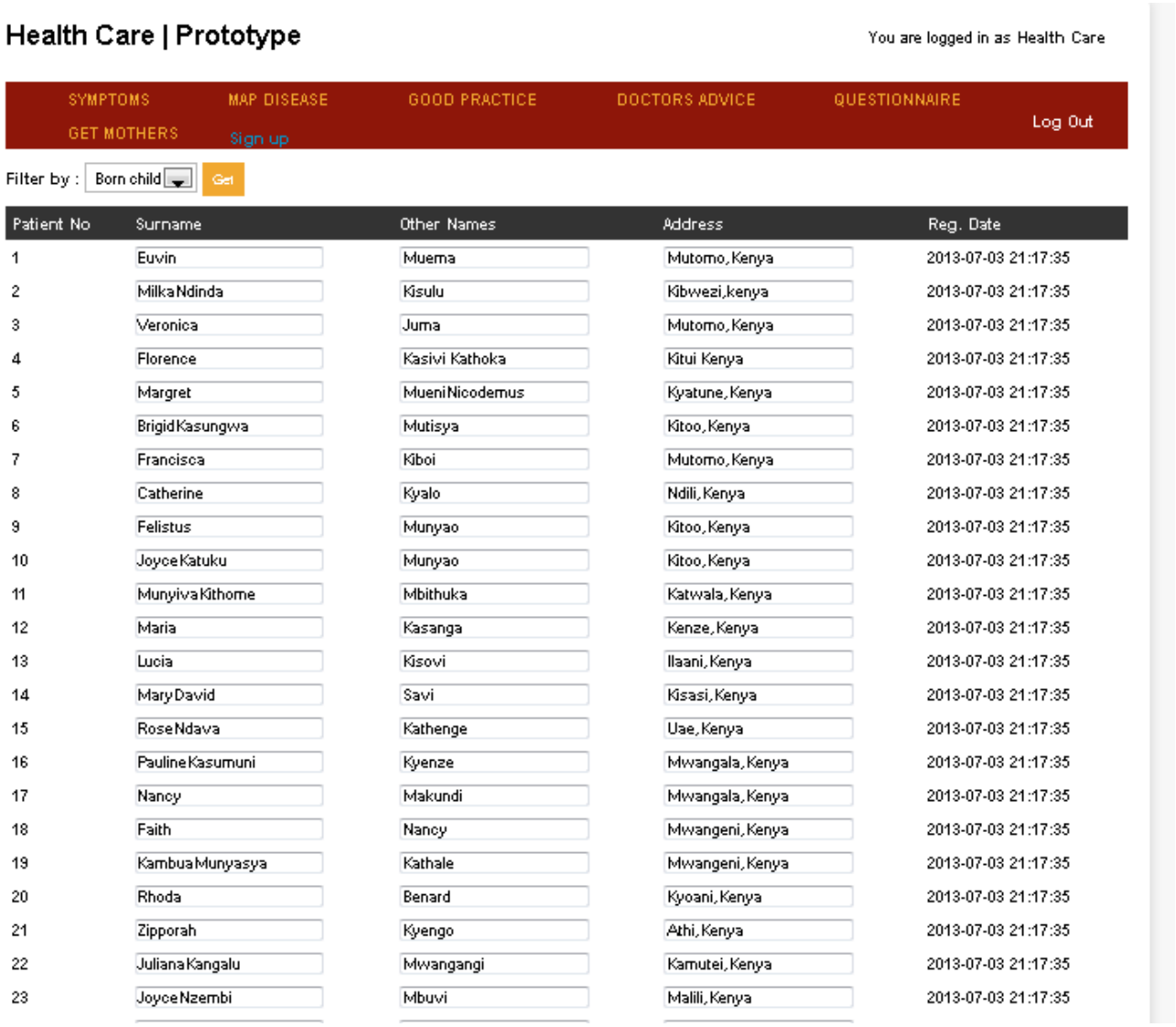
b. Good practice and Doctors' advice

This sub menu allows the health professionals to enter and edit new and existing best practices to be accessed by the users. Doctors may review some of the existing best practices for updates and depending on the changing environment and emerging conditions. They used the menu to specify what medium of information transfer is appropriate for the kind of message they need to pass.



c. Line list of the enrolled mothers

This sub module helps in providing the list of all the mothers enrolled in the system and who are eligible to interact with the system.



Patient No	Surname	Other Names	Address	Reg. Date
1	Euvin	Muema	Mutomo, Kenya	2013-07-03 21:17:35
2	Milka Ndinda	Kisulu	Kibwezi,kenya	2013-07-03 21:17:35
3	Veronica	Juma	Mutomo, Kenya	2013-07-03 21:17:35
4	Florence	Kasivi Kathoka	Kitui Kenya	2013-07-03 21:17:35
5	Margret	Mueni Nicodemus	Kyatune, Kenya	2013-07-03 21:17:35
6	Brigid Kasungwa	Mutisya	Kitoo, Kenya	2013-07-03 21:17:35
7	Francisca	Kiboi	Mutomo, Kenya	2013-07-03 21:17:35
8	Catherine	Kyalo	Ndili, Kenya	2013-07-03 21:17:35
9	Felistus	Munyao	Kitoo, Kenya	2013-07-03 21:17:35
10	Joyce Katuku	Munyao	Kitoo, Kenya	2013-07-03 21:17:35
11	Munyiva Kithome	Mbithuka	Katwala, Kenya	2013-07-03 21:17:35
12	Maria	Kasanga	Kenze, Kenya	2013-07-03 21:17:35
13	Lucia	Kisovi	Ilaani, Kenya	2013-07-03 21:17:35
14	Mary David	Savi	Kisasi, Kenya	2013-07-03 21:17:35
15	Rose Ndava	Kathenge	Uae, Kenya	2013-07-03 21:17:35
16	Pauline Kasumuni	Kyenze	Mwangala, Kenya	2013-07-03 21:17:35
17	Nancy	Makundi	Mwangala, Kenya	2013-07-03 21:17:35
18	Faith	Nancy	Mwangeni, Kenya	2013-07-03 21:17:35
19	Kambua Munyasya	Kathale	Mwangeni, Kenya	2013-07-03 21:17:35
20	Rhoda	Benard	Kyoani, Kenya	2013-07-03 21:17:35
21	Zipporah	Kyengo	Athi, Kenya	2013-07-03 21:17:35
22	Juliana Kangalu	Mwangangi	Kamutei, Kenya	2013-07-03 21:17:35
23	Joyce Nzembi	Mbuvi	Malili, Kenya	2013-07-03 21:17:35

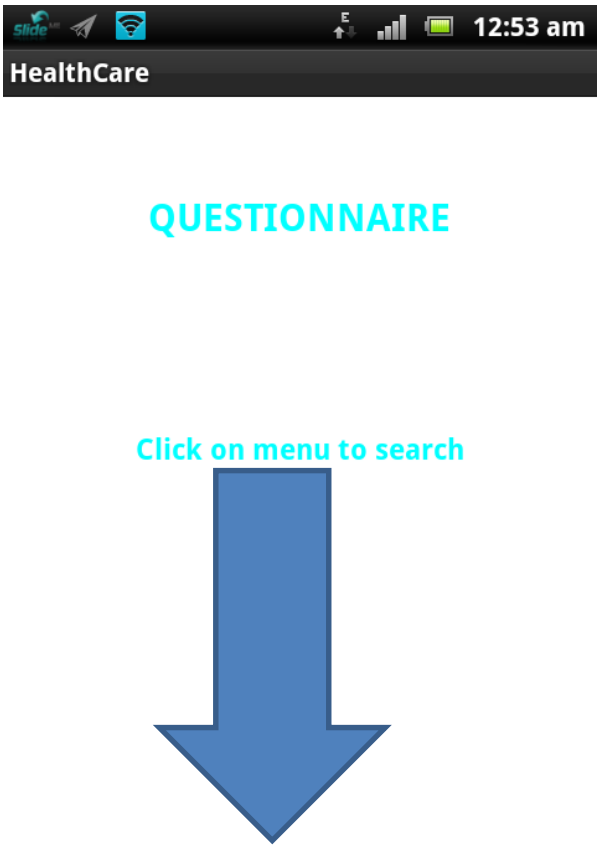
Figure 22: Enrolled Mothers and users

5.3 Questionnaire/ Self-test module

This module has a sole purpose of enabling users to do a self-evaluation and to determine their level of understanding of basic reproductive danger signs and best practices. This is the only way to enable the mothers to know whether there is knowledge transfer or not. The system randomizes the questions each time that a user requests to undertake an examination. Upon completion of the examination, the system displays the score for the user to see how she faired on the exams.The

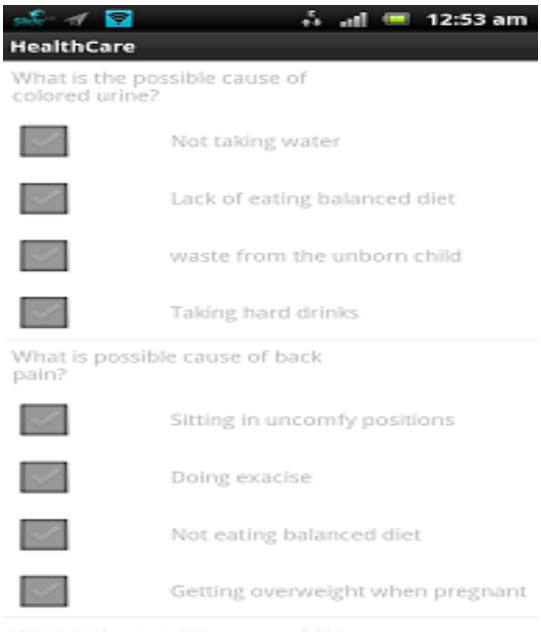
examination is accessed through the mobile device while the updates and modification of the questions can be done through the administrator on the website.

The process steps include:



Select the questionnaire from the mobile device.

Choose the category for which you want to examine yourself.



The mothers will only select the multiple choice questions. Based on the answers, the system displays the score by the user.

A re-run of the questionnaire generates randomized questions.

CHAPTER 6: DATA ANALYSIS, PRESENTATION INTERPRETATION AND EVALUATION

6.1 Introduction

This chapter analyses the findings, interprets and presents data in line with the objectives of the study. The data obtained is presented in tabular form, percentages and in descriptive statistics such as pie charts, line and bar graphs. The chapter is further sub divided into several sections that are pertinent to the subjects under study.

A combination of both printed and online questionnaires were distributed to the registered mothers and the CHEWs. Additionally information was obtained through observation and analysis of trends in the DHIS2- the government reporting system. In the survey, a mixture of both structured questions and open ended questions were given to the users of the prototype. On a scale of 0-4 representing strong disagree to strongly agree, the users were expected to provide an honest evaluation of the system to determine among others; willingness to use them system, simplicity, appropriateness or the relevance of the system. The systems were given an option of writing free form their suggestions for improvement of the systems to increase acceptability.

6.2 Presentation of Data Analysis

6.2.1 Response Rate

The analysis of the response rate was as follows

Table 3: Response Rate

Response Rate	Frequency	Percentage
Response	112	83
Non response	23	17
Total	**135**	**100**

Source: Author (2013)

Table 6.1 above and figure 6.1 below indicates how the sampled respondents participated in the study. The total numbers of the respondents who successfully filled and completed the questionnaires to the required satisfaction of the research were 112 which comprised 82% while 23 comprising 18% of the respondents did not participate effectively. Based on the analysis it can be concluded that the response rate was high.

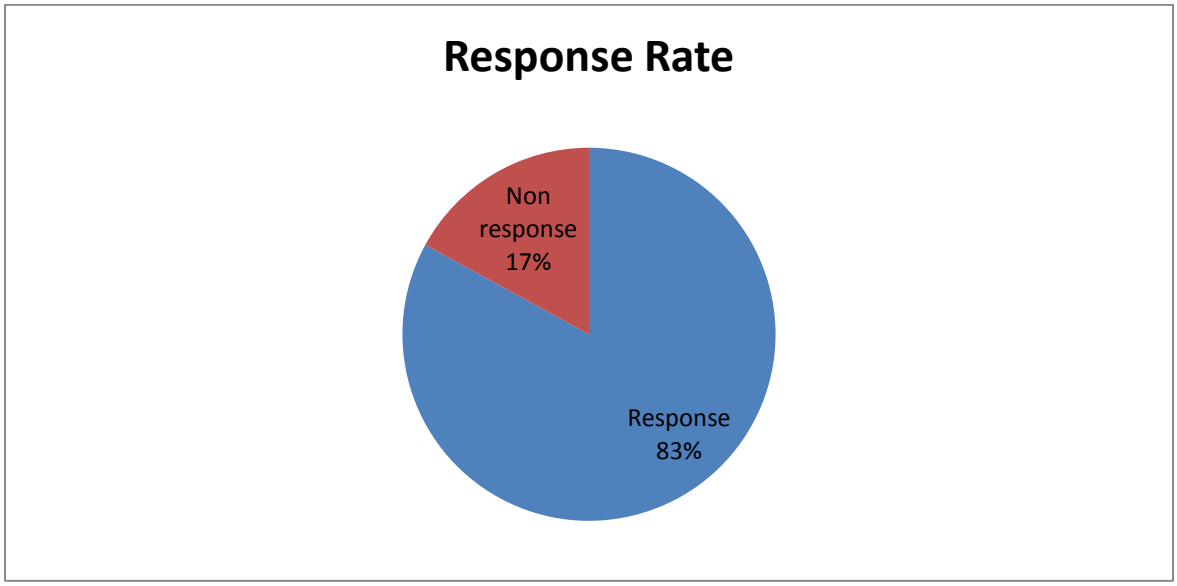


Figure 23: Response rate

6.2.2 Satisfaction with the system

Table 4: Level of satisfaction with the system

Rating	Frequency	Percentage
Strong Agree	20	18
Agree	45	40
Not sure	20	18
Disagree	10	9
Strongly Disagree	17	15
Total	**112**	**100**

Source: Author (2013)

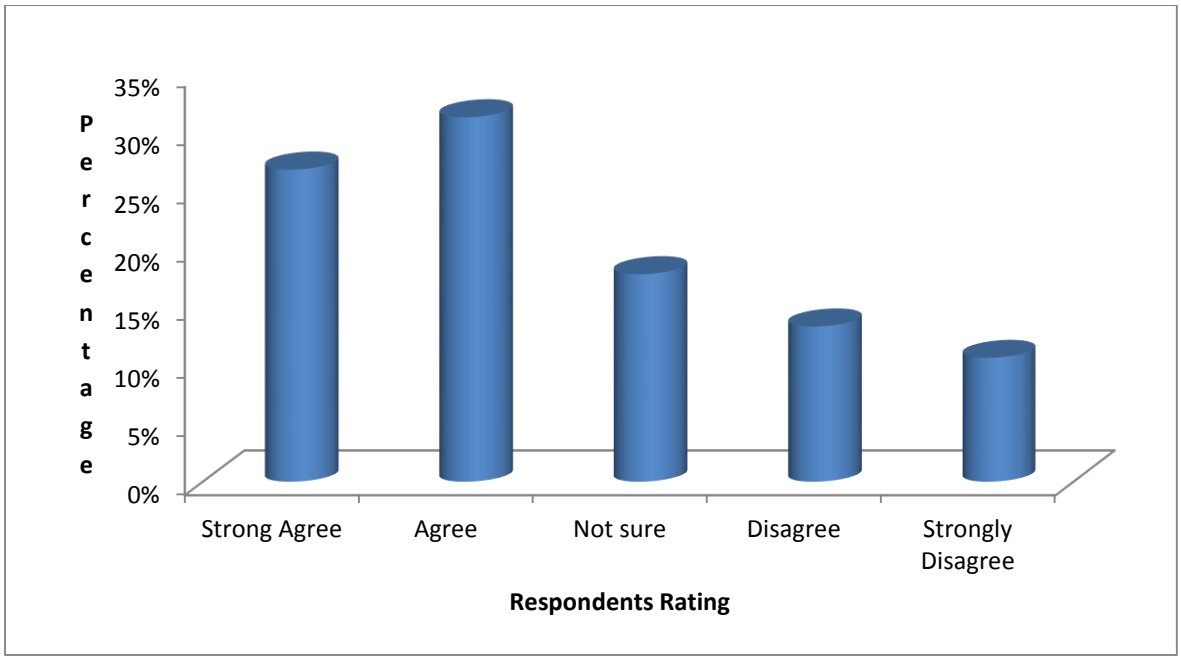


Figure 24: Satisfaction Survey

From the analysis, a higher number of respondents (58%) are satisfied with the system. The analysis also shows tha 24% disagree with the system. This can be attributed to the ICT capacity among the users of the system.

6.2.3 System Usability

Table 5: System Usability

Rating	Frequency	Percentage
Strong Agree	30	27
Agree	50	45
Not sure	10	9
Disagree	8	7
Strongly Disagree	14	13
Total	**112**	**100**

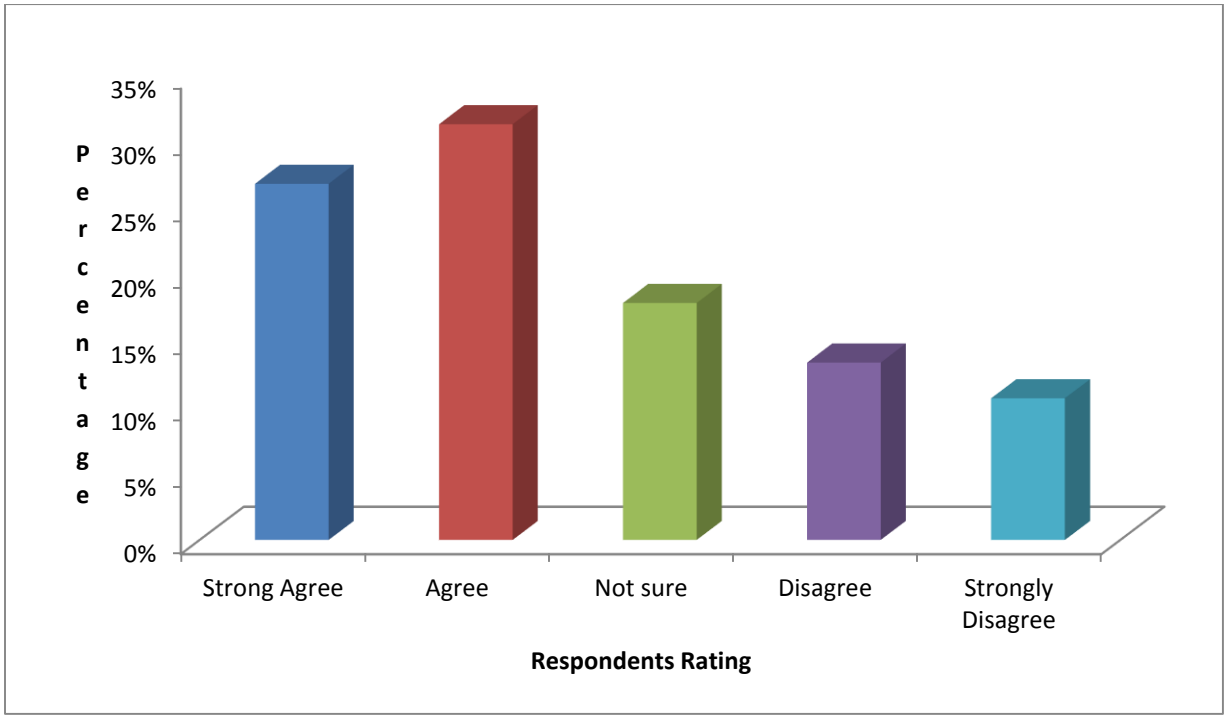


Figure 25: Systems usability

Source: Author 2013

From the data over 70% use and continue to use the system, there is a lot of enthusiasm in the use of the system indicating willingness by the users to acquire information and knowledge from the doctors using the system. This is partly because of the the proximity to health faclities and the need to get good care by the users. A smaller percentage (less than 25%) of the users stillare unwilling to use the system. This can be attributed to low income to sustain the cost of using a smart phone.

6.2.4 Systems effectiveness in education

Table 6: System effectiveness in education

Rating	Frequency	Percentage
Strong Agree	56	50
Agree	40	36
Not sure	1	1
Disagree	9	8
Strongly Disagree	6	5
Total	**112**	**100**

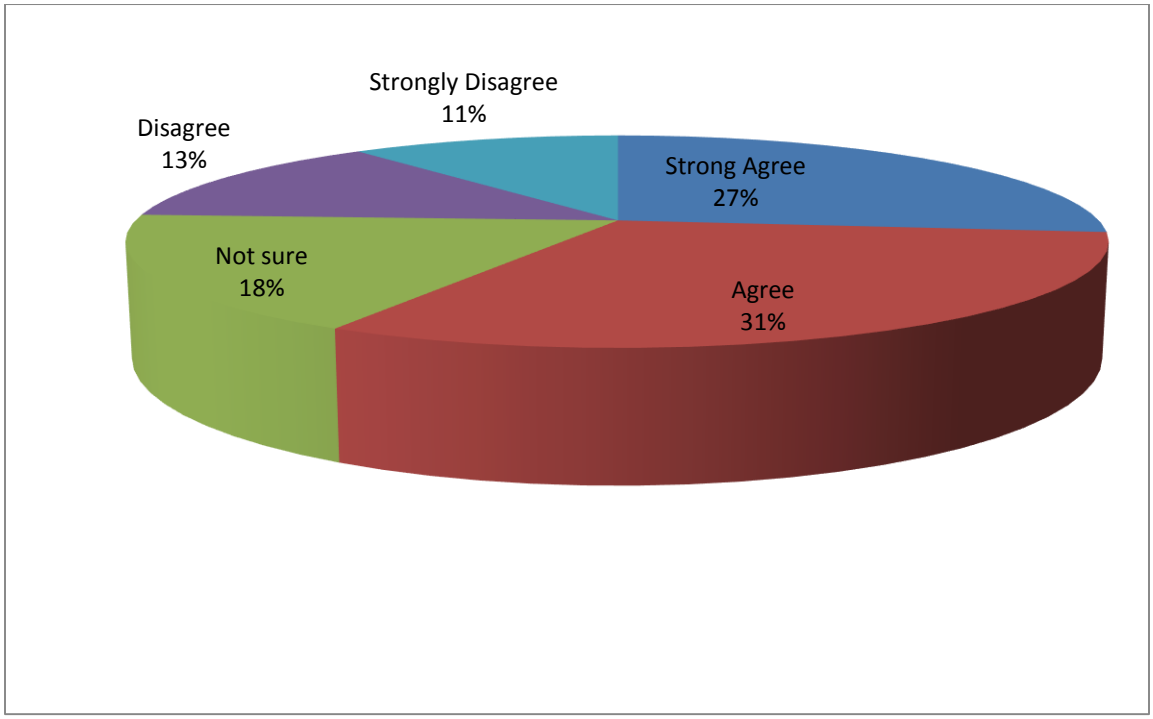


Figure 26: Systems Effectiveness

Source Author 2013

From the analysis, there is consensus that the system is effective in knowledge and information sharing with an approval rating of over 75%. There is concurrence that system can be used to build knowledge on reproductive matters among the most at risk population. This analysis also shows that the mothers are cautious about their wellbeing.

6.2.5 Systems capability in lowering Mother Child Mortality

Table 7: Systems ability in lowering mortality

Rating	Frequency	Percentage
Strong Agree	30	27
Agree	35	31
Not sure	20	18
Disagree	15	13
Strongly Disagree	12	11
Total	**112**	**100**

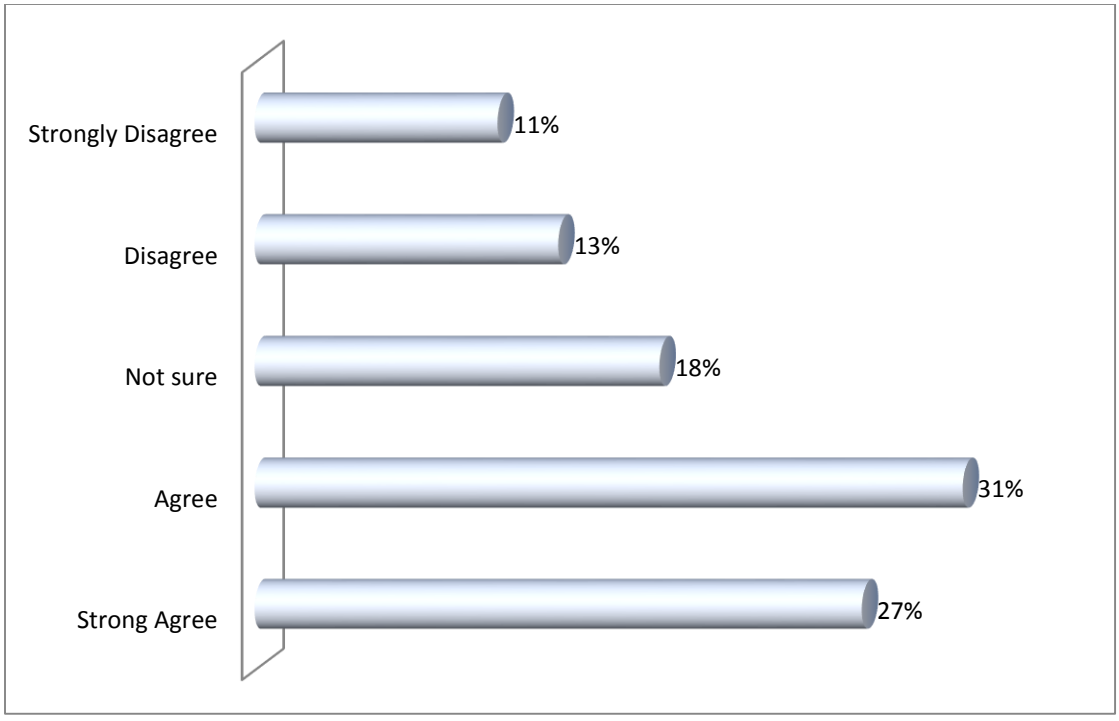


Figure 27: Ability to reduce level of mortality

The study investigated the feelings of the respondents on the role of the system in reducing Mother Child mortality which was the focus of the study. From the above data in the table, the study found that respondents are optimistic that with the interaction of the system, they can improve the level of mortality. 58% of the respondents hold this view.

6.2.6 Average performance in system generated exam {Befor, During and at completion of the research}

Table 8: Examination Scores from the system

Cadres	Before	During	Completion
CHWs	25	35	45
Mothers	10	25	30

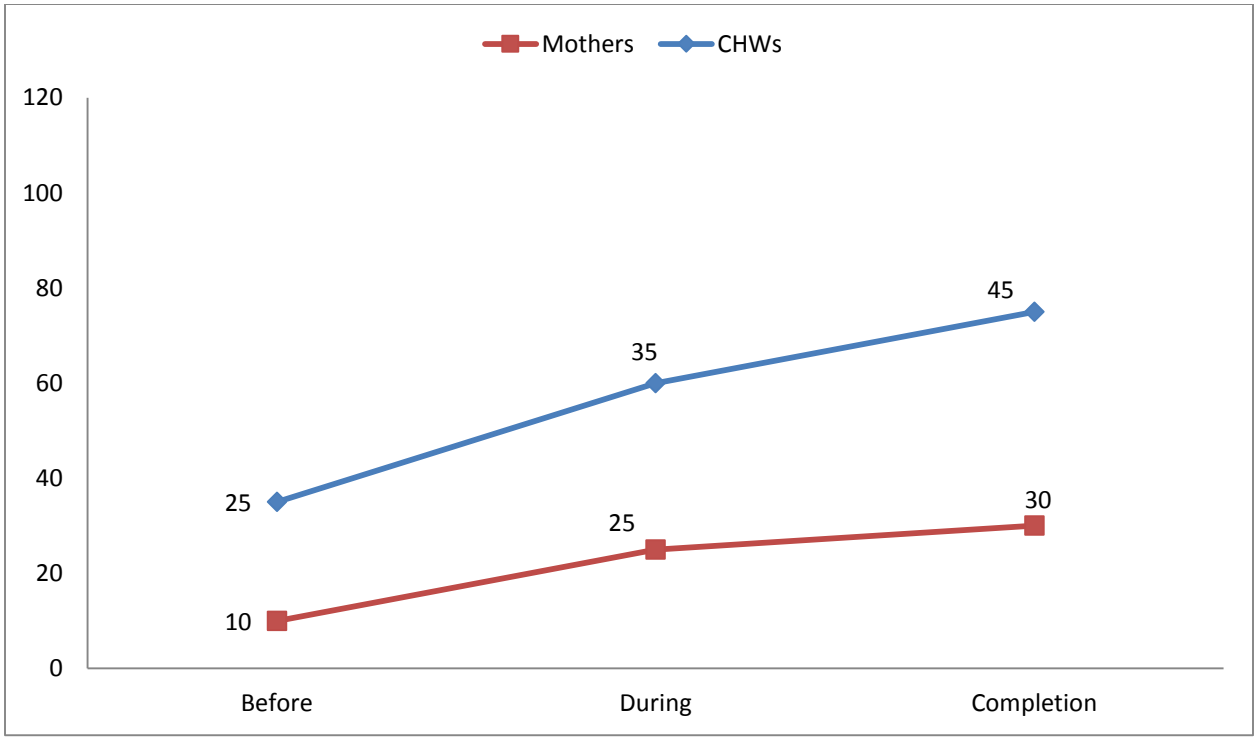


Figure 28: Performance in system test over time

Source: Author 2013

From the data, it is clear that there is some knowledge transfer as time went by. The CHWs were faster in learning while the mothers did as well improve their skills in reproductive health.

6.27 Suggestions for improvement by the respondents

In the open ended questions, the respondents did suggest areas that could improve the uptake of the system. Some valid suggestions included; the use of a native language in the system, users to record the symptoms using voice and sending to the database and reverse geocoding.

6.3 Summary findings

Majority of the respondents (over 70%) did like and used the system. They feel the system is effective in information sharing and knowledge improvement among the mothers in the reproductive age group.

6.4 Conclusion

Mobile applications can be used to improve information sharing between the health professionals and parents there by creating awareness on dangers both mothers and their children are exposed to. With improved knowledge, more parents sought attention from health professionals – positive health seeking behavior. Finally the complexity of the system greatly affects usability of the system.

6.5 Limitations of the research

During the research, the following were determined as the major barriers to successful conduction of the research;

- Literacy levels among the mothers especially language barrier- this limited the sample
- Most parents in the rural do not have smart phones
- Usability issues especially among the rural folks
- High cost for the compensation of health professionals for their service

6.6 Recommendations for further research

I encourage other scholars to find out whether the use of native language in the system can improve system usability and to determine what extent will the use of local content increase system uptake and health seeking behavior.

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Appendix 1: Online Questionnaire for ……..

INTERACTIVE TEXT/VOICE REPONSE SYSTEM TO REDUCE MOTHER CHILD MORTALITY –ONLINE SURVEY TOOL

Mother Child mortality remains a major concern in our country with 488 out of 100000 mothers dying as a result of pregnancy and birth related complications. The government and the development organizations have channeled a lot of resources to curb the high rates. Technology provides opportunities for mitigating some of the challenges through learning and knowledge sharing with the doctors and health professionals. Please take some time us your opinions and concerns on the effectiveness and relevance of the interactive voice and text response system in improving your wellbeing by answering the following questions with utmost honesty.

The first section of this questionnaire requires you to review and give your opinion on a scale of 0 to 4. "0" represents "STRONGLY DISAGREE", “1” represents “DISAGREE”, “2” represents “PARTIALLY AGREE”, “3” represents “AGREE” and "4" represents "TOTALLY AGREE".

The last section of the question is an open question where you are expected to give your thoughts about the system.

1. Overall, I am satisfied with how easy it is to use this system

○ 0 ○ 1 ○ 2 ○ 3 ○ 4

2. The information (such as online help, on-screen messages, and other documentation) provided with this system is clear and helpful

○ 0 ○ 1 ○ 2 ○ 3 ○ 4

3. I found the system very cumbersome to use and frustrating

○ 0 ○ 1 ○ 2 ○ 3 ○ 4

4. I would imagine that most people would learn to use this system very quickly

○ 0 ○ 1 ○ 2 ○ 3 ○ 4

5. My interaction with the systems has improved my knowledge and understanding of safety during pregnancy, the danger signs to watch out for and how to mitigate them

○ 0 ○ 1 ○ 2 ○ 3 ○ 4

6. I use and would continue using the system frequently

○ 0 ○ 1 ○ 2 ○ 3 ● 4

7. I found the various functions in this system were well integrated

○ 0 ○ 1 ○ 2 ○ 3 ○ 4

8. The system can help reduce the mortality levels among the reproductive mothers and their children

○ 0 ○ 1 ○ 2 ○ 3 ○ 4

9. The use of the system has made me change my health seeking behavior for me and to be more observant on the pediatrics

○ 0 ○ 1 ○ 2 ○ 3 ○ 4

10. I would recommend this systems to other people

○ 0 ○ 1 ○ 2 ○ 3 ○ 4

11. What are your thoughts about the effectiveness of the prototypesystem in improving education, knowledge sharing among mothers?

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12. What suggestions would you make to improve the acceptability, uptake and usability of the system?
