DEVELOPING A MOBILE DECISION SUPPORT SYSTEM FOR MONITORING CHILD GROWTH FROM 0 TO 23 MONTH OF AGE

BY

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Award of the Degree of Masters of Science (Information Technology and Systems) in the Department of Computing Studies, Mzumbe University

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CERTIFICATION

We, the undersigned, certify that we have read and hereby recommended for acceptance by the Mzumbe University, a Thesis entitled **Developing A Mobile Decision Support System For Monitoring Child Growth From 0 To 23 Month Of Age,** in partial of the requirements for award of the degree of Master of Science Information Technology and System of Mzumbe University.

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I, Debora Fungo, declare that this thesis is my own original work and that has not been presented and will not be presented to any other university for a similar or any other degree award.

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ACKNOWLEDGEMENT

First and foremost I would like to thank almighty GOD for the blessings and grace that has been reason for achieving this study. A special thanks to my supervisor, Dr Mercy M. Komba for his guidance and support throughout the whole study. Big thanks to my class mates. I am lucky to have worked with you in all time during study. Thank you for sharing your experiences, support and advice.

DEDICATION

I dedicate this to my family who has supported me throughout the study.

LIST OF ABBREVIATIONS AND ACRONYMS

ANC	-	Antenatal Care
BP	-	Blood Pressure
CHEW	-	Community Health Extension Workers
CWC	-	Child Clinic Welfare
ECG	-	Electrocardiogram
Fr	-	Functional requirement
GM	-	Growth Monitoring
GPS	-	Global Positioning System
HIV	-	Human Immunodeficiency Virus
HTTP	-	HyperText Transfer Protocol
Ios	-	iPhone Operating System
JSON	-	JavaScript Object Notation
MAMA	-	Mobile Alliance for Maternal Action
MDSS	-	Mobile Decision Support System
mHealth	-	mobile Health
MMS	-	Multimedia Message Services
MOH	-	Ministry Of Health
MUAC	-	Middle Upper Arm Circumference
MySQL	-	My Structured Query Language
NFr	-	Non-Functional requirement
PC	-	Portable Computer
PHP	-	Hypertext preprocessor
SDK	-	Software development kit
SDLC	-	Software Development Life Cycle
SGL	-	Scalable Graphics Library

SIME	-	Sistema Information Monitereory Evaluation
SSL	-	Secure Socket Layer
TCRA	-	Tanzania Communication Regulatory Authority
UN	-	United Nations
UNICEF	-	United Nations Children's Fund
WHO	-	World Health Organisation

ABSTRACT

The application of mobile phone technology is growing rapidly in recent years. It has been adopted, inter-alias, in the health sector where it is growing rapidly worldwide.

This is due to mobility, time efficiency, low cost, reliability, and user friendliness of the mobile healthcare. In Tanzania the adoption of mobile phone technology in healthcare is growing day to day, but still many applications are not oriented towards monitoring a child growth. This study had determine the challenges facing growth monitoring process in children and design a mobile application for monitoring growth in children between 0 and 23 years of age. This is because at this age a child needs special attention as any health problem can affect the future of a child's life. The sample consisted of 30 parents and caregivers selected by purposive sampling procedure from 3 health centers in Morogoro municipality. The data was collected through interview and documentary review. The data collected from this study revealed that the growth monitoring process faces many challenges such as shortage of health personnel, lack of coordination, shortage of expertise in growth monitoring process, and limited number of healthcare centers. Also a distance between residence and the health centers affects the monthly clinic attendance. Moreover the shortage of health workers in most of the health centers causes the growth monitoring process to take a long time. In some of the health centers there is no nutritional expert so it is difficult for parent to get good advice in case of child nutritional problems. Thus, this study presents the design of the Mobile Decision Support System (MDSS) for monitoring growth in children. This system will help parents to monitor growth of their children through smart phone. The system takes short time to complete growth monitoring process and it will be available all times i.e.24/7. The MDSS provides a flexible way of growth monitoring unlike the current method which is limited to be conducted from morning to afternoon. The system is designed and implemented in android platform, so that it can be accessed through android mobile phone. The evaluation of the proposed solution in terms of reliability, functionality and usability suggested that, is a worth and helping idea as 30 interviewed users responded positively.

Keywords: Growth Monitoring, Mobile Health Application, Smart Phone.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

PROBLEM SETTING

1.0 Introduction

This chapter includes the background of the study, a statement of the problem, research questions, research objectives, scope and significance of the study.

1.1 Background of the study

Growth monitoring (GM) is the process of following the growth rate of a child (0-59 months) in comparison to standard by periodic anthropometric measurements in order to assess growth adequacy and identify faltering at early stages (UNICEF, 2008). The growth monitoring process is usually associated with nutrition assessment of a child which is measured on weight-for-age, height-for-age/length-for-age, mid-upper-arm-circumference-for-age, and head-circumference-for-age (Ashworth et al., 2008). The increased adoption of mobile technology devices especially tablets and smartphones, for mobile healthcare (mHealth) delivery is having a great impact in the healthcare globally (Jen-Her et al., 2005). Currently, portable devices such as tablets and smart phones have greater impact in healthcare services (Trevor et al., 2004), this was due to their flexibility and portability. Mobile devices are capable of allowing remote users to synchronize personal databases and provide access to network services such as wireless e-mail, Web browsing, and internet access. The development of mobile phones technology increases the accessibility of information and services easily. The accessibility of health services can be significantly simplified by using mobile phones. In developing countries the number of health centers and health workers is small compared to population. This has led healthcare services to take a longtime. The technology of mobile phones can simplify access to healthcare more easily. This could reduce the existing gaps in healthcare services (Hassan et al., 2011).

During growth, children are passing through different stages which sometimes become challenging to most of the parents or guardians. The growth characteristic from each child may vary from one child to another. There is a lot of information widely available in printed form but usually this information is more general, too lengthy and complicated to some users, and sometimes it is not helpful (Kim et al., 2008). One of the many easy and fast ways to access information about children GM is through the

internet. However, most of the information focused on children in the western world (Kim et al., 2008). This study was based in designing the mobile application that focused on GM standard of Tanzania. The designed application will be helping Tanzanian parents/caregivers to access useful information concerning children's development as well as to monitor their growth without visiting health facilities.

1.2 Problem statement

Among the challenges facing growth monitoring process in developing countries was resource constraints. The research conducted by ministry of health reveals that the ratio of health facilities to population was not directly proportional (MOH, 2004). In Tanzania, GM was conducted at the clinics located in health centers through monthly visits (Morley & Woodland, 1988; Gopalan & Chatterjee, 1989). Parents/caregivers are required to visit clinics at least once in every month. In attending monthly clinic weight of a child was measured and recorded on a clinic card. Health workers plot graph of weight against age on a child's clinic card. This graph was used to indicate if a child growth was normal or there was an abnormality in the child's growth. The limitation of this method of monitoring child growth is said to be: limited number of health workers, few numbers of health facilities and failure of parent to attend monthly clinic due to daily activities. Therefore considering the widely coverage of mobile phone user and improved phone technology (Hassan et al., 2011) a mobile app was designed and implemented in this research. This solution proved to extend the accessibility of growth monitoring service among many parents/caretakers as in recent years, Mobile phone technology has become powerful transformation tool and demonstrated a potential impact in health services delivery all over the global (Qiang et al., 2011).

1.3 Research objectives

The main objective of the research was to develop a mobile decision support system for monitoring child growth from 0 to 23 month of age.

1.3.1 Specific Objectives

Regarding the problems facing parents/caregivers in Tanzania, in order to alleviate the problem as per main objective, this research was focused on the following specific objectives:

1. Investigating the strength and weaknesses of the current methods used in monitoring children growth.

2. Designing and implementing a mobile application for monitoring child growth

1.4 Research questions

In order to achieve the goal of research, the following questions were set to analyze and answer:

1. What are the strengths and weaknesses of the current method that is used in monitoring growth of children?

2. How mobile application decision system in growth monitoring of children can help parents and caregivers?

1.5 Scope of the study

This research preliminary investigated weakness and strengths of the current methods used by parents/caregivers in monitoring the development of children under age between 0-23 months. We concentrated in children of these age because, child growth, at this age needs special attention due to the start of development of special organs. Then based on the results found from the preliminary investigations, a mobile decision support system for monitoring growth was designed. The study scoped on testing some functionalities of the designed mobile application system on compared its efficiency with the old system.

1.6 Significance of the study

The preliminary investigation results provided enough information which led to, the design and implementation of mobile application system. The mobile app is the appropriate solution to growth monitoring process in Tanzania. The usage of the app for growth monitoring solved the challenges aforementioned as it increased the efficiency in growth monitoring process.

1.7 Chapter summary

In setting the problem clear, this chapter described in brief about growth monitoring, the challenges faces the GM process, objectives and research questions for guiding the study. In this regard, limited number of health workers, few numbers of health facilities

and failure of parent to attend monthly clinic due to daily activities was presented as challenges. Then on analyzing the weaknesses and strengths of the said challenge's a mobile application system was designed and implemented which overcome the said problems. The next chapter is literature review.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents the literature review on matters related child of the age below 23months. The chapter includes growth monitoring process, method used to monitor child growth in Tanzania, challenges facing growth monitoring process in Tanzania, the overview of the mobile application system, mobile application in growth monitoring, existing mobile application for growth monitoring in Tanzania, conceptual framework and theoretical framework.

2.1 Growth monitoring process in Tanzania.

Children's growth is determined by good nutrition which is obtained through receiving sufficient nutrition and living in an emotionally supportive environment by following a steady growth pattern which can be monitored through measuring and plotting weight at regular intervals and comparing it to their height centile (Child Growth Foundation, 2009). GM process is an important element in promotion of children growth through measuring and interpreting growth chart according to growth standard. It also facilitates the provision of awareness through: Increased caregivers' awareness about child growth, improved caring practices and increased demand for other services as needed (UNICEF, 2008). GM since then was used as tool for monitoring nutrition status in population worldwide. The effect of poor growth in children can result in delayed mental development, poor school performance and reduce intellectual capacity (WHO, 2003).

The growth disorders in children are detected by measuring height and weight for a particular child (British Society for Pediatrics and Endocrinology, 2009). The monthly measurement of height and weight in child can assist caregivers in diagnosis the challenges which might either be missed or become apparent later in life when treatment may be less successful (British Society for Pediatrics and Endocrinology, 2009). Measuring a child weight will provide caregivers the opportunities to observe the child's general health and will give alert to potential risks. For example, a diagnosis of failure to thrive or increased weight gain in hospital may indicate parental neglect at home and such concerns will need to be explored further (UNICEF, 2008). According to WHO

GM defined as nutrition interventions which are not only to measure child weight but also to provide education to parents in practice that can promote growth of their child. Through GM, an increment in weight in early stage is important before the appearance of physical signs, even before the parents notice anything is wrong with their child (WHO, 1999; Nabarro & Chinnock, 1988; Thaver et al., 1993).

2.2 Method used to monitor child growth in Tanzania.

The growth chart is one of the methods used to monitor growth in children by regularly measuring and charting children's weight against reference curves (Morley & Woodland, 1988; Gopalan & Chatterjee, 1989). GM of children helps parents to know the nutritional status of their children. It is difficult to notice the changes in children's health at early stage, many malnourished children normally look normal, until their size is compared with other children of the same age and sex (UNICEF, 2008). Growth is dynamic and therefore inadequate growth is reversible in the first two years (1000 days window of opportunity) of life. The GM process in developing countries has many advantages which are: reduction in under-nutrition, morbidity and mortality among young children (Ashworth *et al*., 2008). Other benefits of GM process are: early detection of malnutrition when controlling process is easy; improve nutritional education; families motivated and enabled to take effective action; malnutrition and health counseling tailored to individual needs; opportunity to assess remedial actions; greater self-reliance and self-esteem; greater utilization of preventive health-care services; fewer referrals for curative care; cost savings; and communities mobilized to address underlying socio-economic causes of poor health (Ashworth *et al*., 2008).

2.3 Challenges of the current method used in monitoring child growth in Tanzania

In developing countries the process of growth monitoring faces challenges such as:

i. Lack of coordination

Coordination is an important element among governments, society and healthcare providers. The government must re-allocate resources and promote awareness on child growth monitoring and design a system that will enhance good decision making on adequate monitoring by empowering trained personnel, providing them with resources (Akanbi et al., 2014).

ii. Caliber of personnel

Many health workers lack adequate knowledge on growth monitoring process. To address this problem the government should provide training programmes for health workers. The training should emphasise on the importance of accurate measurement, plotting and interpretation of growth charts for correct identification of growth problems (Akanbi et al., 2014).

iii. Resource constraints

Small number of staff in healthcare facilities and shortage of equipment especially in remote areas is an important factor that cannot be over emphasised as it impedes a successful implantation of growth monitoring (De Onis et al., 2012).

2.4 Mobile application overview

'Mobile health' is the connection between health and mobile device technology, especially smart phones. It is defined as 'medical and public health practice supported by mobile devices (e.g. mobile phones, patient monitoring device and wireless devices) (Sowal *et al.*, 2013), whereas, 10 years ago, it has been defined as wireless telemedicine involving the use of mobile telecommunications and multimedia technologies and their integration with mobile healthcare delivery systems(Arshad *et al*.,2012). Unlike the internet and the medical workstations used in tele-health systems, mobile health uses mobile phones and untethered portable healthcare devices, which are easier to use, less expensive, flexible, and compliant with patient's lifestyle and can easily be upgraded remotely. Due to these distinguished advantages, mobile health can reach large populations and is often presented and studied as a unique sub provision of healthcare services (WHO, 2012). Compared to traditional mobile phones, which were used mainly for voice communications, smartphones have integrated virtually all the core functions of a modern computer, and hence, the available apps have revolutionized ways people now use them in their everyday lives. The functions of smartphone that have enabled its clinical applications include:

Voice/video calling**:** provides a convenient and accepted way for clinicians and patients to remotely communicate with each other as an alternative to face-to-face consultation with patients all time (Augestad *et al.,* 2009);

Short message services (SMS) and multimedia message services (MMS): the ability to transfer text messages and video clips/sound files respectively, offers a convenient and cost-effective way to deliver information in health monitoring or risk factor modification (Martinez-Perez *et al.,* 2013).

Multimedia functions: smartphones has ability to access and play a large range of multimedia content from online multimedia servers, which can be updated as required and can provide intuitive, accessible health education everywhere (Kim *et al.,* 2012)

Inbuilt sensors: inbuilt touch, motion and GPS sensors can obviate the need for additional health devices and provide clinical assessment opportunities, for example quantifying and classifying physical activities and measuring lifestyle and social activities of patient (Garcia *et al*., 2010).

Device connectivity: many tele-monitoring devices such as ambulatory ECG and BP monitors, can be connected to mobile phones or tablet PCs via wireless, to enable automated data transfer that is more practical and less error prone than manual data entry method.

Internet connectivity**:** 3G/4G and Wi-Fi provides greater accessibility to remotely monitored health data, online education materials, and communication with clinicians.

2.5 Growth monitoring in other countries

In 2007-2008 Honduras developed a system for monitoring growth using mobile phone called Monitoring and Evaluation Information System (or Sistema Information Monitereoy Evaluation, SIME). This system was used to collect and monitor nutrition data for the children through measuring growth in various health centers located in Honduras. The health workers were trained to use mobile phone technology to monitor growth where they enter weight, height, sex and age of a particular child. As compared to local method of entering data manually in a hardcopy of a clinic card and manually send data in a local government for evaluation of nutritional status; this system has shown a greater efficiency. This mobile phone technology helped to overcome persistent challenges related to the quality of data, the cost of data collection, processing, and

analysis; the lag time between collection and results; and the use of data for timely decision-making.

Guatemala and Panama run pilot of cell phone technology for nutrition data collection through growth monitoring from various clinics located at different health centers. The health workers were trained to use mobile phone technology in monitoring children's growth. They measure weight, height and head circumference for a child then they enter that data in mobile phone for further processing. After finishing recording data of a child they send that data to a server located at the local government office, the local government uses that data for various decision making process concerning to nutrition status for that area.

2.6 Existing Mobile application in growth monitoring in Tanzania

Wazazi Nipendeni: The application was launched 2012 by Ministry of Health and Social Welfare (MOHSW).This health application is currently operating in Tanzania. It offers remainders notice and information via text messages in Swahili to pregnant women, mothers with newborn babies up to 16 weeks old (continuing through to age 5) and supporters/caregivers of these women. This program promotes healthy pregnancy and early childhood care behaviors in preventing occurrence of maternal death. This service is also used to assist health professionals in the dissemination of information typically shared during antenatal care (ANC) visits. The content from this application promotes improved nutrition practices. For instance, nutritional messages range from information on timely iron and folic acid intake to maintaining health during pregnancy and after giving birth, well balanced diet and drinking clean water, as well as breastfeeding instructions. These messages can include simple instructions information on how to treat early pregnancy nausea, to information on the importance of the first breast milk and how to observe and monitor the milk intake by babies.

ChildCount+ is another mHealth project which was implemented in Tanzania, Kenya and Ghana but it is most actively used in Kenya. It is used in the community health events reporting and alerts platform aimed at empowering communities to improve child survival and improve maternal health. The system uses standard mobile phone, community health extension workers (CHEWs) are communicating through text messages to register patients and send health reports to closely monitor the health of their community and reduce gaps in treatment services.

MAMA (Mobile Alliance for Maternal Action) of which the main objective was to promote Healthy Pregnancy, Healthy Baby- is the Text Messaging Service which offers Tanzanians free text messages in Swahili for pregnant women, mothers with newborns up to 16 weeks old. It provides support to pregnant women and new mothers (partners, friends and relatives) (MAMA, 2013). This project was challenged in monitoring infants growth, by the fact that it does not provide service in which mothers cannot know if her infant grows well or there is a sign of malnutrition.

2.7 Conceptual Framework

This study was aimed to design a mobile application for monitoring child growth, so as to be implemented and to be used by parents/caregivers. The use of such application can increase the attendance of monthly clinic for children hence improve the growth standard in children. Once parents/caregivers are using the mobile growth monitoring, helps them to record weight of the child and the application will plot the graph of age against weight. Also the application will provide the interpretation on graph. See figure 2.7 shows the conceptual framework of the mobile application in growth monitoring.

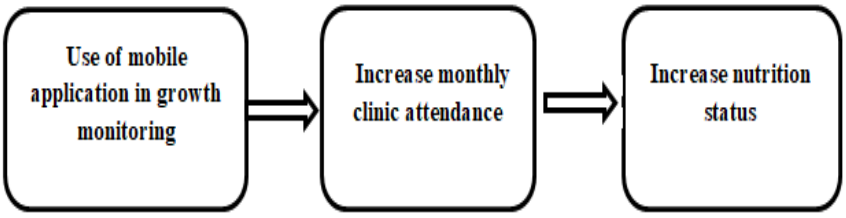

Figure 2. 1: conceptual framework for mobile application system

2.8 Theoretical framework

Theoretical frameworks consist of the structure that can hold and support the theory of the research study. It is responsible to explain the path of the research and ground it firmly in theoretical construct, said Dicson Adom et al (2018). It introduces and describes the theory that explains the reason why the research problem under study exists. According to Abend and Gabriel (2008), the theoretical framework must demonstrate an understanding of theories and concepts that are relevant to the topic of your research paper and that relate to the broader areas of knowledge being considered. In this study, the researcher considered the information theory based on a probability

theory as the main framework to demonstrate the concept of the topic under study since it is characterized by a prediction system.

2.9 Chapter summary

The literature review chapter elaborates various literature reviewed in growth monitoring process. Routine growth monitoring process in children has the potential impact in early detection of malnutrition. Malnutrition is often not recognized by the mother until it has become severe and then reversing the condition becomes expensive and often very difficult. Through growth monitoring and promotion parents/caregivers can get knowledge on how to feed a baby in order to avoid malnutrition and other growth anomalies. Growth monitoring and promotion in Tanzania was provided in healthcare clinics. However, this service faces some challenges such as limited number of health workers, limited number of health facilities, lack of professional health worker and others. Due to expansion of technology in Tanzania, the implemented mobile health application such as Wazazi Nipendeni to some extent helped to overcome the challenges facing provision of health services. This application helps parents/women to access various health information without visiting the health centers. Although Wazazi Nipendeni proves much efficient it lacks other services such as monthly clinic service for children. It does not provide an access where parents can follow growth development of their children. This study therefore addresses the challenges facing parents in monitoring growth of their children by designing and implementing a Mobile Decision Support System which is equipped with the facilities to overcome the presented challenge.

CHAPTER THREE
RESEARCH METHODOLOGY

3.0 Introduction

This chapter presents an overview of the methodology used to conduct the study for the development of mobile application for monitoring children growth in Tanzania. It start by explains the location where the study has been conducted, the approach utilized in the study, the target population, research instruments, data analysis, ethical consideration, sampling techniques and sample size. The study employed qualitative method as a research approach whereas; interview was used to collect data from parents/caregivers about the challenges facing parents in monitoring children growth. In additional information from secondary sources like documentation analysis was also used to collect data as well. The technical methodology employed to design and implement the application was agile method of software development life cycle.

3.1 Research design

This was community based cross-sectional analytical study to determine and identify challenges facing current methods used in child growth monitoring from 0 to 23 months of age. The study design were appropriate for this research since a researcher collect data from the portion of the population at a single point in time and the sample composition reflected the true picture of the whole population. The study design was good for answering research questions so as to meet the research objectives.

3.2 Study Area

The study was conducted in Mororgoro municipality located in Mororgoro region. Morogoro municipality has total area of 288 square kilometers which lies at the base of the Uluguru Mountains. The municipality has 19 wards. The population of the people in Morogoro municipality is estimated to be 315,866 people, of which women constitute 52% while men 48%. (Census, 2012). Morogoro municipality has 40 health centers. The language spoken is Kiswahili, though there are tribal languages such as luguru.

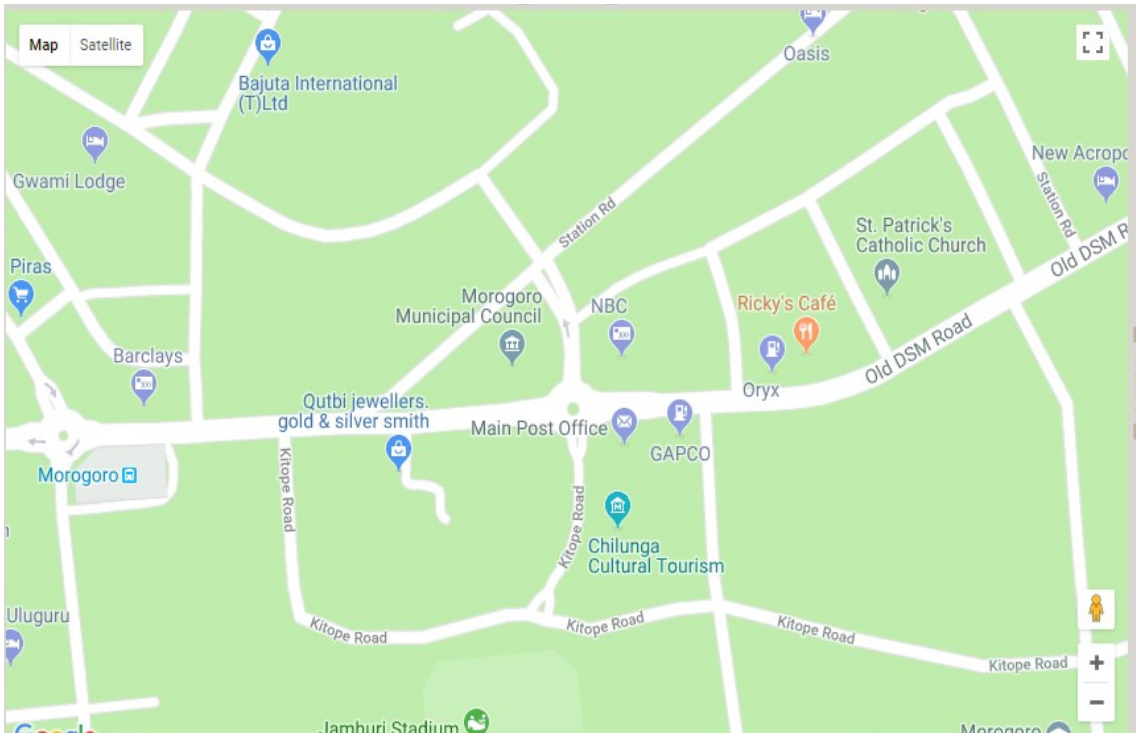

Figure 3. 1: Map of Morogoro municipality (source: https://satellites.pro/Morogoro_map)

According to Tanzania National Nutrition Survey (2014) Morogoro was the one of the region facing challenges in growth monitoring. From this literature its shows that there is no similar study conducted to determine the challenges facing growth monitoring process to this particular area, thus why this study was being carried out in this area. In additional the researcher is familiar with the area for approximately seven years, the familiarity made very easier in data collection stage as well as the interpretation of the data.

3.3 Research Approach

The approach used in this study was the qualitative approach since the interviews and documentation were the ones used as the method of data collection. This approach was chosen because according to Myers (1997), "Qualitative research involves the use of qualitative data, such as interviews, documents, focus-groups, and participant observation data, to understand and explain social phenomena." This qualitative approach methodology enabled the researcher to deeply understand the major challenges facing parents in growth monitoring of children.

3.4 Target group and population

Population is defined as the totality of all subjects that conform to a set of specifications, comprising the entire group of persons that is of interest to the researcher and to whom the research results can be generalized (Polit et al, 1999). The study population in this research includes parents and caregivers. The eligibility criterion in this study was that the selected population was directly beneficial of the research.

3.5 Sample size and sampling procedure

A sample is a subset of a population selected to participate in the study, it is a fraction of the whole, selected to participate in the research project (Brink, 1996); while sampling is the process of selecting a portion of the population to represent the entire population (LoBiondo-Wood et al 1998).

3.5.1 Sample

A study sample is taken from the universe population of the data. According to (Zikmund, 2003) if the sample is adequate it has characteristics as those of the universe population. According to (Martinez_Mesa et al., 2014) among the factors guided in selection of sample size is budget and time limitation. Therefore the sample sizes of this study were obtained from three health centers. In each health centers five parents and five caregivers was purposively selected to make total of 30. See Table 3.1.

Table 3. 1: Sample of the study (Source From field research, 2017)

	Health Center Name	**Number of parents**	**Number of caregivers**
Morogoro Municipal	Nunge	5	5
	Mafiga	5	5
	Sabasaba	5	5
	Sub total	15	15
	Total	30	

3.5.2 Sampling

The sampling is a procedure of selecting a number of individuals for a study in such a way that the individuals represent the larger group from which they were selected and the inference drawn from the sample is extended to the whole group (Cochran, 1953). The study adopts non-probability technique which is purposive sampling. Purposive sampling (also known as judgment, selective or subjective) is a sampling technique in which researcher relies on his or her own judgment when choosing members of population to participate in the study

(Black, 2010). Also in judgmental or purposive sampling a researcher employs his judgment about who to include in the sample. The knowledge and research skills were required in selecting respondents to be sampled. Since the researcher had prior knowledge about the study and sample to be used purposive techniques was selected. The samples selected by using this technique are tabulated in table 3.1.

3.6 Research instruments

A research instrument is what a researcher use to collect information (data) to answer research question such as tests, checklists, structured interview and questionnaires (Seaman, 1991). This study employs document review and interview.

3.6.1 Document reviews

A review of various documents which address children growth monitoring and mobile health was done. The importance of this review was to understand the background, important and operation of various aspects of growth monitoring and mobile health technology. Extensive reading and analysis of written documents on children growth monitoring related issues in both developed and developing countries was carried out regarding mobile health technology. This was done in order to get general understanding on children's growth monitoring and mobile health technology with their limitations. Most of the mobile health applications in Tanzania are SMS based and provide general information on children's growth and maternal health. Most of the applications are used for maternal health and parents cannot do monthly clinic via application. As technology increases, advanced application must be developed to make use of current technologies. Other source of information was TCRA that gives detailed information on mobile technology status in Tanzania and the percentage of the usage. It also contains information on network coverage and mobile operators in Tanzania. Reports from international organizations such as World Health Organization (WHO) and United Nations Children's Funds (UNICEF) that have accurate data on children health and warfare were very useful in providing information for this study. The information from local organizations that deal with children's health was also useful. This was mostly from magazines, newspapers, blogs and websites.

3.6.2 Interviews

This method of data collection was used to collect various information from stakeholders such as parents and health workers. This method helps to determine the altitude of respondent easily. The respondents selected in health facility who attending monthly child clinic and health workers in a particular health center, this is because their familiar with GM process. The Language used was Kiswahili because of its familiarity. The interview questions were both open and closed ended questions which target to collect information on:

- General knowledge on GM processes (the important of GM).
- Challenges on current method used in GM process.
- Knowledge on mobile health application.
- Smartphone ownership.

3.6.3 Data analysis

Data analysis is the process of analyzing, interpreting the data collected during research to produce meaning to them. According to (Patton and Cochran, 2007)) data analysis can be used to look across all the data to identify the common issues that recur and identify the main themes that summaries all the views collected. In this study, the qualitative data were analyzed manually by putting together common explanations and trends into themes. Since qualitative data analysis is a personal process with few rigid rules and procedures, therefore a researches went through a content analysis process which is an analysis of the contents of the interview and document analysis in order to identify the main issues (challenges facing growth monitoring process) that emerge from the responses given by the respondents.

3.7 Ethical considerations

Data collection procedure involving the permission from individuals in authority to provide access to study participants (Creswel, 2002). The permission procedure often involves writing a letter that identifies how long the interview would take, the potential impact and the outcomes of the research. Also a researcher gave respect to participants during data collection.

The researcher understood the culture and norms of the particular population from which the data to be collected. The participant's right must be clearly explained such as rights to participate voluntarily and the right to withdraw at any time, so that they are not being coerced into participating. According to (McNamara, 1994) there are five ethical: voluntary participants, no harm to respondents, anonymity and confidentiality, identifying purpose and sponsor, and analysis and reporting. Therefore during research a researcher took consideration of all these ethical issues.

3.8 System development methodology

In this research the development of technical solution was carried out using agile methodology. The methods were selected due to its distinct advantages. It allows changes in requirements at any stage of development, and accepts incremental releases. The developed system was implemented in android smart phone therefore it requires good design and updated technology. To design the system that would meet the user requirements the system was produced in incremental and each increment was improved from previous system release.

The typical stages in agile Model are:

Requirements specification: What the proposed system is performing was described in this stage, where in the study interview was used.

Design: Describe how the system was implemented to meet specified user requirements and the system architecture. An android technology was used to design a mobile application.

Implementation: Describe code implementation phase of the proposed system, whereas java programming language and SQLite technology was used.

Evaluation and Testing: Testing and evaluation of the developed system to discover some errors.

3.9 Project schedule and milestone

Project schedules contain description on project's milestones, activities, and deliverables which shows start and finish dates. In this study scheduling section describes the milestone for the project activities, sequence of the activities and schedule that support all activities in the research, Refer to Appendix D.

3.10 Chapter summary

A qualitative research-approach method for preliminary investigations and agile methodology for technical development was introduced in this chapter. On the design of research, sample size and sampling procedure, target group and population, data analysis, research instruments, and project schedule and milestone was presented. The study was chosen to be Morogoro municipal and the research instruments were interview and document review. Also ethical and project schedule was introduced. The data collected was analyzed and presented as discussed in next chapter.

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF THE FINDINGS

4.0 Introduction

This chapter gives general findings obtained during data collection and analysis. The growth monitoring process was conducted in health facilities such as dispensaries and health centers. The numbers of health facilities were few compared to the population. Therefore some parents were required to work long distance in order to get the services. This section discuss in detail how the growth monitoring currently conducted in Tanzania and to put the objectives of this study into action by trying to answer the questions: what were the strength and weakness of the current method used in growth monitoring process in Tanzania, and how mobile application can help parents or caregivers to monitor growth in children

4.1 Current methods used to monitor growth in children

Currently in Tanzania growth monitoring process falls under Maternal and Child Health (MCH) services. These services also include antenatal and postnatal care, vitamin A supplementation and vaccination for children. MCH clinics are embedded in primary health care system. The growth monitoring process conducted in four different ways; weight for age, height for age, head circumference and middle upper arm circumference. According to data collected in the field the common method that is used in growth monitoring process is weight for age. Few health centers combine two methods; weight for age and height for age. Head circumference and middle upper arm circumference methods are used in referral hospital for children who are in critical health problems. The current methods used in growth monitoring process have some advantages but their disadvantages are many compared to advantages. The next section presents some of the strengths and weaknesses of the current method used in growth monitoring process.

4.2 Strengths and weaknesses of the existing solution

Currently, growth monitoring process was conducted in health centers and dispensaries. Parent/guardian was required to visit in clinic at least once in a month. During visit the weight of child was measured and recorded in child clinic card, the child was also given a vaccine or drops depending on his age.

The current method has the following strength:

- Health worker can physically attend a child and if there is any sign of malnutrition can be easily detected.
- Parents can get advice from health worker physically.
- Parents can exchange their experience concerning child health during meeting.

The weaknesses of the current method are:

- Due to few number of health worker the growth monitoring process can take long time.
- Absence of nutritional expert in some of the health centers.
- The growth monitoring process is always conducted in the morning, therefore due to day to day activities sometimes parents fail to attend monthly clinic.
- The health centers are few compared to population; therefore in some places it takes long distance to reach health centers.
- In the community the growth monitoring process is taken as responsibility of mother, father is not concerned.

4.3 Use of mobile application for monitoring growth in children.

The mobile application system is an application that intended to be stored remotely in the Google play store. Users of the application (parents and caregivers) can get the application simply by downloading it using their smart phone, or tablet that uses Android as the operating system. The system was designed using two tires architecture where by user interface is stored in the Google application server and database is stored in Google data servers.

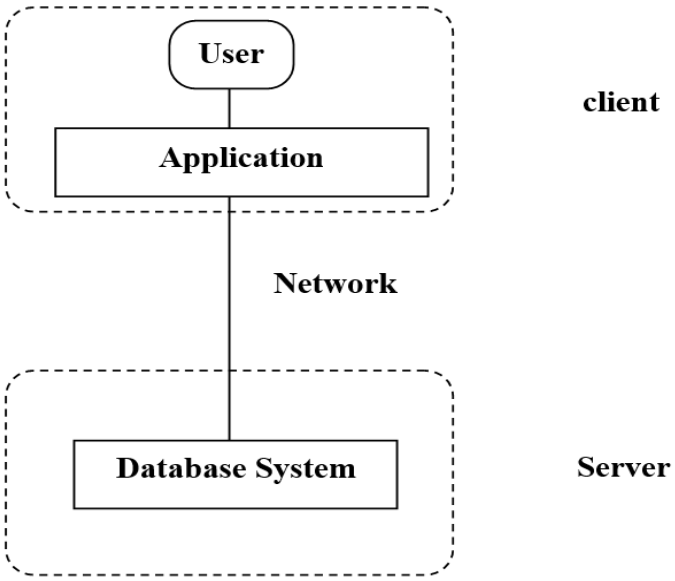

Figure 4.1: Two tier architecture (Source: https://www.google.com/search?q=two+tier+architecture&tbm)

The application for monitoring growth can be downloading by the user through their smart phones or tablets with android operating system. After downloading the application the user is required to register into the system then register his/her child, then continue with the growth monitoring process.

4.4 Chapter summary

Different findings were obtained during study, currently growth monitoring process is conducted in hearth facilities. Parents/guardian is required to visit at least once in every month. This current method helps parents/guardians to get advice physically from health workers and get experience from other parents attending monthly clinic. However the current method has weaknesses such as: few number of health facilities, distance from health facilities and few number of health worker so the clinical service can take long time. According to weakness of current method this study designed a mobile application that helps parents/guardian to monitor growth of their children using smartphone. Due to technological advancement many parents are aware of smart phone usage therefore it is easily to use mobile phone in monitoring child growth. The design was in two tire architecture. The application was designed in simplified form so that can be user friendly to user.

CHAPTER FIVE

ANALYSIS, DESIGN AND IMPLEMENTATION OF TECHNICAL SOLUTION

5.1Introduction

This chapter describes the analysis and design of the technical solution of the mobile application for monitoring growth in children. The chapter presents system planning, system analysis, system design, constructions, installations and system operations.

5.2 System planning

System planning phase, describes the feasibility study of the system. Feasibility study can be considered as preliminary investigation that helps the researcher to take decision about whether study of the system should be feasible for development or not. The feasibility contains three types: economic feasibility, technical feasibility and organizational feasibility.

5.2.1Economic feasibility

The main aim of the economic feasibility was to estimate the economic requirement of the system before investments. The development cost of the system was feasible and assessment of cost and benefits were well planned.

5.2.2 Technical feasibility

Technical feasibility analyses and determines whether the solution can be supported by existing technology or not. It includes technology, project size, compatibility and familiarity with functional area (Denis, 2012). All steps concerning technical feasibility for the mobile application system for monitoring growth in children were considered and well handled. The selected technology such as xml, java and MySQL were familiar to the researcher and system size was manageable.

5.2.3 Organization feasibility

Organizational feasibility analyses whether the user will be affected and accept the system. It also analyses how the organizational goal meet the business objective. Organizational feasibility on mobile application for monitoring growth in children were conducted and aligned with the objectives of designing and developing the system. In development

process researcher must ensure that the system fulfilled the objectives so that to meet user requirement.

5.3 System analysis

Requirements analysis process during software development specifies who will be the main stakeholders. The stakeholders can have direct or indirect interest in the developed system. In this mobile application the main stakeholders are:

- **Primary users**: - the main users of the application. They are divided in two groups:
  - Parents/guardian of the children
  - Health workers
- **Mobile application developer**: - The developer who works in the area of growth monitoring mobile application.

5.3.1 Requirement determination

The application requirements are categorized into functional and non-functional requirements. The functional requirements describe the capabilities and functions that a system must be able to perform successfully. A non-functional requirement describes the qualities that can be used to judge the operation of the system under development.

5.3.1.1 Functional Requirements

A functional requirement describes the function or the major component of the system. The functional requirement usually works together with non-functional requirement. They are expressed by “system must do<requirement>”(I Summaville , 2007).

Table 5. 1: Format used for description of functional requirement of the system

ID:	**The identification number of the system requirement**
Description:	**The requirement**
Explanation:	**Explanation of the system requirement**

Table 5. 2: Description of the Functional requirement of the system

ID	Description	Explanation
Fr01	Users must be able to register in the system	The user must be able to provide personal details required in registration form.
Fr02	Users must be able to login into system	Users must log into the system by using username and password.
Fr03	Users must be able to log out of the system at any time	Users must be able to log out of the system by pressing log out button.
Fr04	The system must be able to provide error message when user fail to follow instructions required by the system.	The system must show the error message and point were the error occur.
Fr05	User must be able to register child in the system	The user must be able to provide necessary information required in registration form of child.
Fr06	The system must show available option of services provided by the system	Users should be able to see the service option shown in button
Fr07	The developer must be able to add new service in the system	The system should provide developer option to add new service.
Fr08	User must be able to attend monthly clinic through system	The system must provide user capability to enter weight of child and date to see child development progress and provide advice
Fr09	User must be able to view vaccine schedule	The system must be able to view schedule for vaccine according to age of a child
Fr10	User must be able to view child diet	The system must be able to provide diet required by a child according the age.
Fr11	User must be able to update vaccine schedule	The system must be able to provide health worker capability to update vaccine schedule.
Fr12	The system must provide dangerous sign to a child	The system should provide user button to see what dangerous signs to their child are and precaution to take.

5.3.1.2 Non-Functional Requirements

The non-functional requirement describes how the system will do functional requirement, for example, system reliability, system availability, system performance, system external interface and design attributes. The function requirement describs “system shall be<requirement>”(I Summarville, 2007).

Below are examples of non-functional requirements

Usability: is the system ease to be operated or learnt by the user.

Portability: the system/component is able to be transmitted to different environment.

Flexibility: the ability of the system to exchange information with the user.

Reliability: the ability of a system to perform a task for a specific time according to a stated condition.

Performance: the system operating speed

Security: user login and password protection.

Table 5. 3 Non-functional requirement (NFr) of the system

ID	Description	Explanation
Nfr01	The graphical user interface must be simple enough for users and all screen must contain similar style	The style for button, menus and layout should look similar throughout the application
Nfr02	The system should not contain any bugs incase user enters wrong operation	The system bugs should be checked before the release. Must provide error message to user to inform what is wrong.
Nfr03	The system must be able to run in all android devices	The system should be able to run in all devices which have android operating system.
Nfr04	The system should be able to show notification to users	The system should display message in popup window.
Nfr05	The system will have faster response.	The system should respond faster so as the user must not wait for long time in performing operation.
Nfr06	The system will request password and username for user to access the system	The user will not access the system before log in.
Nfr07	The system should be able to accept new operations and features	The system must provide developer to add new features.

5.3.2 Functional Modelling

A functional model is a structured representation of the functions (i.e. activities, actions, processes, operations) within the modelled system (Rasmussen & Petersen, 1999). The main purpose of the function model is to describe the functions and processes, assist with discovery of information needs, help identify opportunities and establish a basis for determining product and service cost.

5.3.2.1 Use cases

Use case is used to describe the functionality of a system at high level (Dennis et al., 2012). It defines the interactions between system and the user of the system. The element of use case includes actors, use cases, subject boundaries, and set of relationships among actors, actors and use case. The relation in use case can be association, include, extend and generalization.

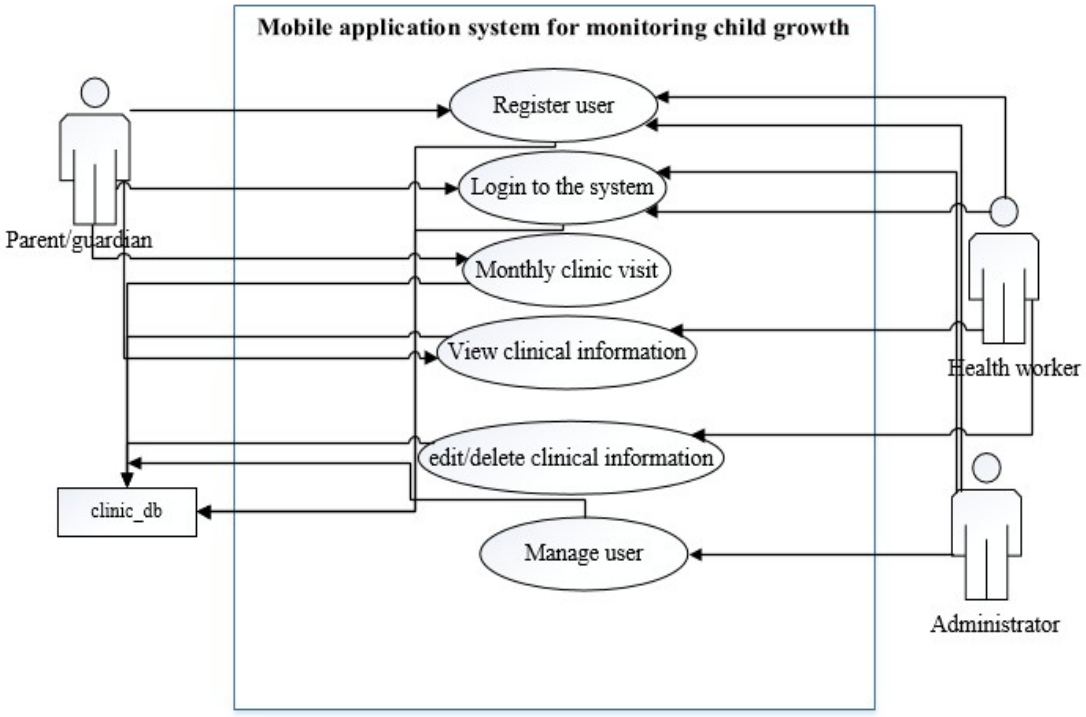

Figure 5. 1: Use case diagram for MDSS

5.3.2.2 Use case description

This section contains only two use case descriptions, one for each use case actor. The first use case in Table 5.4 describes the way user register in a system. The second use case description in Table 5.5 describes how user is deleted from the system and the other shown below.

Table 5. 4: Register user use case description

Use Case Name	Register user
Context	Register new user
Primary Actor	User
Precondition	Application is running, user select register button
Success Post Condition	New user registered successfully
Trigger	User want to register in a system
Main Success Scenario	1. User press on register button 2. System displays user registration form 3. User enters all required fields and press register 4. System closes the form and shows messages about the action a) If username exists a message is displayed to user Exception b) If there is a problem with the internet connection an error message is displayed to the user Exception

Table 5. 5: Use case description for monthly clinic visit

Use Case Name	Monthly clinic
Context	Monthly clinic visit
Primary Actor	Parent/guardian
Precondition	Application is running, Parent/guardian is logged on, user select Monthly clinic visit.
Success Post Condition	Monthly record entered
Trigger	Parent/guardian want to record child weight in a month
Main Success Scenario	1. Parent/guardian press on monthly clinic button 2. System displays monthly clinic form 3. Parent/guardian select child identification number, enters all required fields and press submit 4. System closes the form if Parent/guardian has recorded correctly and shows messages about the action a) If there is a problem with the internet connection an error message is displayed to the user Exception

Table 5. 6: Use case description for viewing clinical information

Use Case Name	View clinical information
Context	View clinical information
Primary Actor	User
Precondition	Application is running, user is logged on, user select clinical information can be vaccination, growth standard or nutritional information.
Success Post Condition	User has view clinical information
Trigger	User want to clinical information
Main Success Scenario	1. User press on vaccination/growth standard/nutrition information 2. System displays the page 3. User select child identification number, and press view 4. System opens the new page and shows messages about the action a) If there is a problem with the internet connection an error message is displayed to the user Exception

Table 5. 7: Edit/Delete clinical information use case description

Use Case Name	Edit/delete clinical information
Context	Edit/delete clinical information
Primary Actor	Health workers
Precondition	Application is running, user is logged on, Health worker select Edit/delete clinical information.
Success Post Condition	Successfully message
Trigger	Health workers want to delete user
Main Success Scenario	1. Health workers press on Edit/delete clinical information 2. If there is a problem with the internet connection an error message is displayed to the user Exception

Table 5. 8: Use case description for managing user

Use Case Name	Manage user
Context	Manage user
Primary Actor	Administrator
Precondition	Application is running, administrator is logged on, administrator select growth standard.
Success Post Condition	Administrator manage user
Trigger	Administrator want to manage user
Main Success Scenario	1. Administrator press on manage user 2. System displays user description 3. Administrator select edit/delete user information 4. System opens the user information and shows messages about the action a) If there is a problem with the internet connection an error message is displayed to the user Exception

5.3.2.3 Activity diagrams

Activity diagrams, as part of behavioral UML diagrams, are used to describe the sequential or concurrent flows of activities in the system (France et al., 1998). It displays a sequence of activities, beginning from the starting point of the activity until the finishing point, by describing in detail the decisions along the progress of the events in the activities and the overall flow of control.

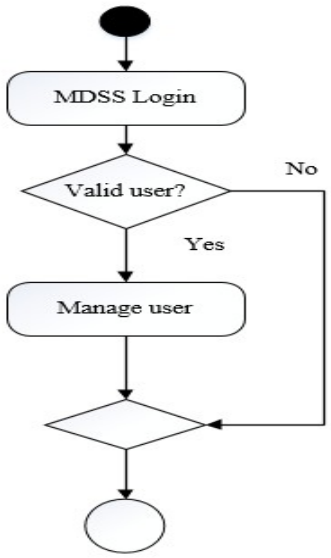

Figure 5. 2: Activity diagram for manage user

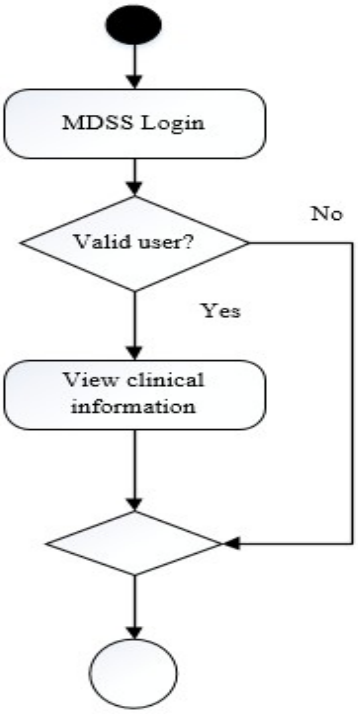

Figure 5. 3: Activity diagram for viewing clinical information

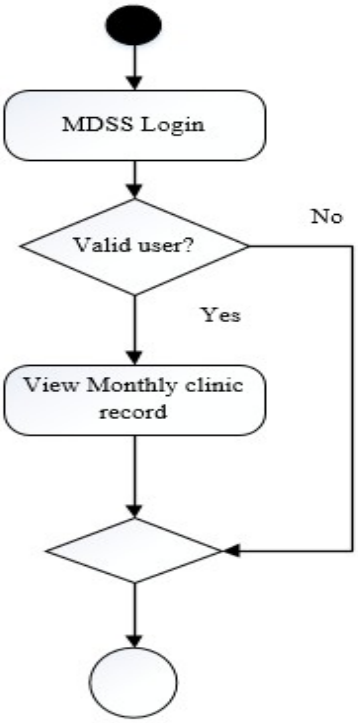

Figure 5. 4: Activity diagram for viewing monthly clinic record

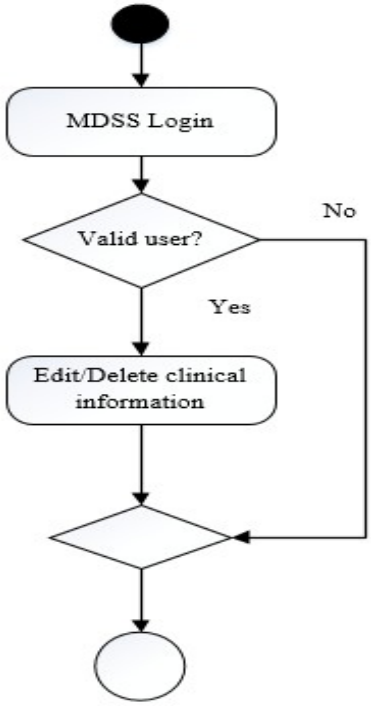

Figure 5. 5: Activity diagram for edit/delete clinical information

5.3.3 Behavioral Modeling

Behavioral models describe the internal behavioral of a system it include sequence and communication. These diagrams shows how objects collaborate to provide the functionality defined in the use cases. It focuses on dynamic view of the system not on how it is implemented.

5.3.3.1 Sequence diagram

Sequence diagrams describe the flow of messages, events, actions between objects (Dennis, 2012). They are used to show time sequences that are not easily depicted in other diagrams.

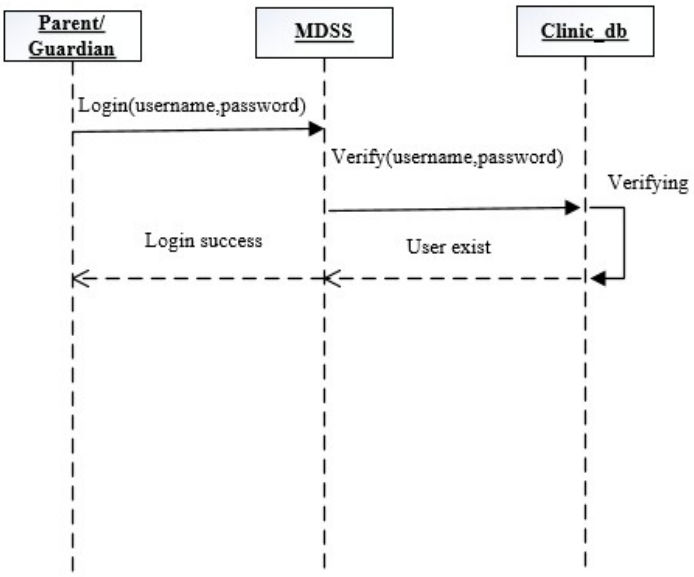

Figure 5. 6: Sequence diagram for login

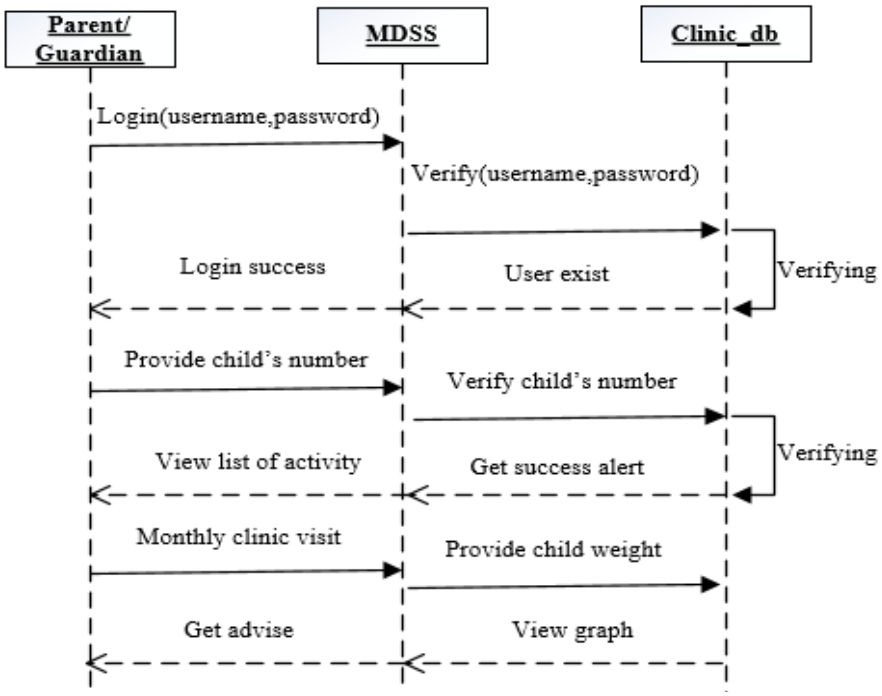

Figure 5. 7: Sequence diagram for monthly clinic visit

5.3.4 Structural Modeling

Structural Modeling describes the structure of the objects, including their classifiers, relationships, attributes and operations.

5.3.4.1Class Diagram

The diagram below represents the classes contained in the application.

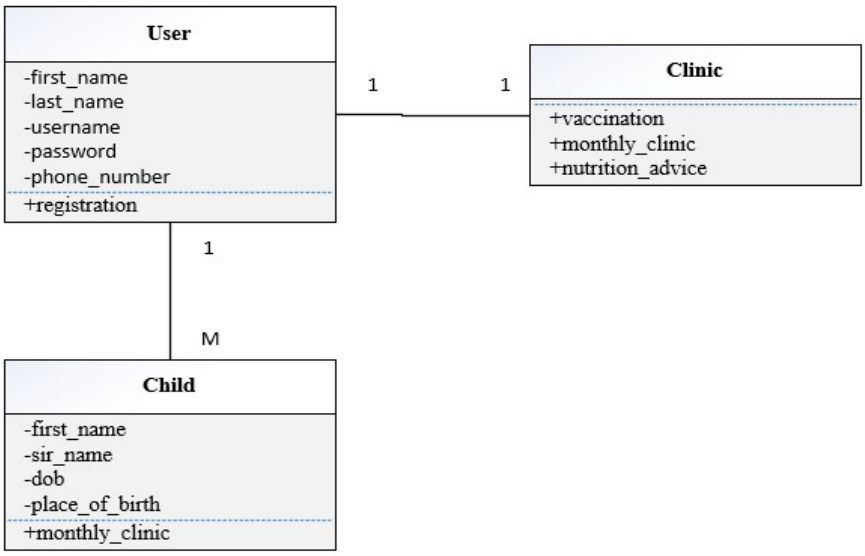

Figure 5. 8: Class diagram for MDSS

5.3.4.2 CRC (Class responsibility collaboration) cards

CRC cards provides the information on responsibilities and collaborations of a class.

Table 5. 9: CRC cards for register user

Front:

Class Name: User	**ID**: 1	**Type:** Concrete
Description: User can be administrator, parent, guardian or health workers, who is using the system. teacher at school.		**Associated Use case:** Register user
Responsibilities: - Monthly clinic visit - Viewing clinic information - Manage user		**Collaborators:** Child,clinic

Back

Attributes: First_name (Varchar) Last_name Varchar) username (Varchar) password Varchar)

phone_number (Varchar)
Relationship: Association :child and clinic

Table 5. 10: CRC card for Monthly clinic visit

Front:

Class Name: child	**ID**: 2	**Type:** Concrete
Description: Child who is attending monthly clinic		**Associated Use case:** Monthly clinic visit
Responsibilities: - Monthly clinic visit		**Collaborators:** user, clinic

Back

Attributes: First_name (Varchar) Last_name Varchar) Place_of_birth (Varchar) Address Varchar) DOB (date)
Relationship: Association :user and clinic

Table 5. 11: CRC card for viewing clinic information

Front:

Class Name: clinic	**ID**: 3	**Type:** Concrete
Description: Clinic contain information about monthly clinic, vaccination and nutrition information		**Associated Use case:** View clinic information

Responsibilities:	Collaborators:
- Vaccination - Monthly clinic - Nutrition information	User , Child

Back

Attributes:
Relationship: Association :user and child

5.4 System design

This section explains briefly how the system is functioning and operating. It includes the architecture, database, algorithm for decision support system, web server design and user interface design of the system.

5.4.1 Architecture design of the system

This application needs communication between the application and the web server in order to exchange message to support enough communication between all mobile phones that will be using MDSS. To achieve this client server architecture will be selected. The client server architecture is an architecture whereby clients request service to the server and receive information from the server. The application services will be running in the server on known ports that are application identifiers, and the client must know the address of the server in order to access the system. However, the server does not know address of the client. The clients will act as active device which initiates the communication whereas server will act as passive wait request initiated from client side. The description of the system structure is described below. The figure shows the components of the system each component will be analyzed.

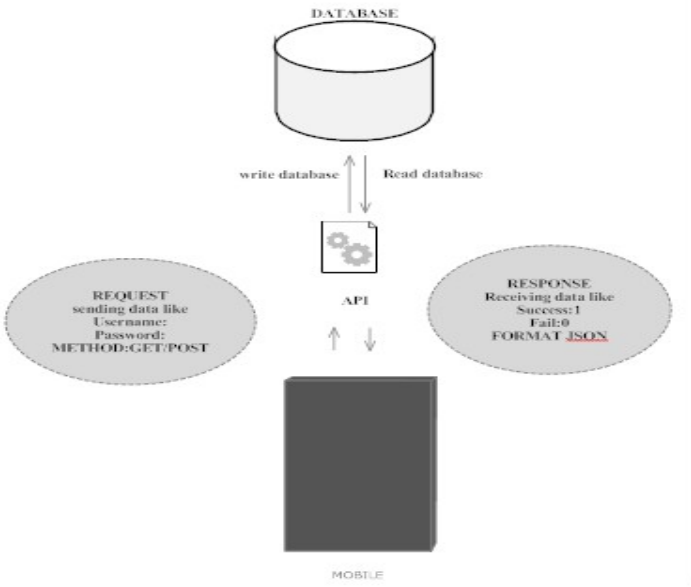

Figure 5. 9 : Compornet view of a mobile application

The request from user is sent to web server using parser and the responses are coming from the web server using HTTP GET/POST requests and responses. The request must contain the information which elaborates which method is invoked and the arguments for the called method. The response coming from the server must contain the result of a service method which is invoked. The application server uses connection to establish communication with the database which is used to store and retrieve data. The web server contains PHP files that contain methods for processing database query and communication between the server and the application.

5.4.2 Technologies

5.4.2.1 Android Studio

It is the current integrated development environment which was launched by google for the android operating system. It is open source tool for application development. The language used in development is java programming language, it enables developers to write, edit and save projects. Android studios contain built-in SDK (Software Development Kit) that enables a developer to access it. Java is the language used to write the program and SDK is used to run programs in android.

Android studio enables developers to visualize changes that occur in a real time, and you can see how the application will be deployed in different devices each of different configuration and resolution. It allows developers to drag and drop system component throughout the user interface, to simplify development process.

5.4.2.2 Java Programming Language

Java is a high-level programming language released in 1995 by Sun Microsystems. It is the most popular programming language used in development of different systems; this is due to its features such as: built-in security features, platform independent, object oriented and class-based. It is available for free. This language is simple, easy to design, compile debug and easy to write code (Amold et al., 2001). In this application android platform will be used, and the application is written by Java programming Language.

5.4.2.3 MySQL Database

MySQL is the most popular Open Source SQL database management system which is developed, distributed, and supported by Oracle Corporation. It has distinct features such as: scalable, reliable, and high performance web based database. The MYSQL database can be easily connected to several programming languages such as PHP, ruby, python, visual basic etc. (Greenspan et al., 2001). In the development of MDSS the MySQL database is used as database server. All application data (users, monthly clinic, vaccination information, growth standard) are stored in this database server. The database table will be used to store the application information.

5.4.2.4 PHP

PHP (Hypertext Preprocessor) is an open source scripting language. It secures data by providing encryption mechanism (Welling *et al.,* 2003). In the development of MDSS the PHP is used to provide communication between MySQL database and android application.

5.4.2.5 JSON Format

JavaScript Object Notation (JSON) is derived from JavaScript scripting language which is used to represent data in a simple human readable format (Bray *et al.*, 2017). JSON represents complex data in textual format which is more readable. It has four types of data: Strings, Numbers, Boolean, Null. JSON format is used in the development of MDSS to interchange data between web server (http) and android application.

5.4.3 Algorithm for decision support

The algorithm used in the development of the MDSS was rule based. In this algorithm the different rules will be defined that will help in providing decision. The rule base consists of:

Rule: this describes the rule which will be required.
Working memory: used to store data.
Matching scheme: this part decides which rules are applicable to the system.
Conflict resolution scheme: it used to decide when more than one rule is applicable.

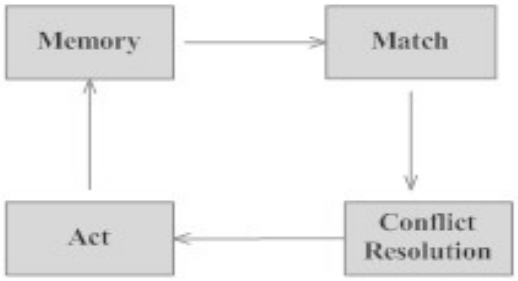

Figure 5. 10: Rule base system components

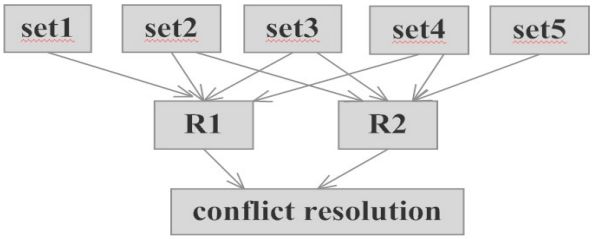

Figure 5. 11: Rule base system implementation

The rule bases in detection of change in weight (Δw) was described below:

R1: If Δw<0 and dose=yes then feeding_advice=yes

R2: If Δw<0 and dose=no and disease_sign=yes then see_doctor=yes

R3: If Δw<0 and dose=no and disease_sign=no then feeding_advice=yes

R4: If Δw=0 then feeding_advice=yes

R5: If Δw>0 and standard=yes then progress=good

R6: If Δw>0 and standard=no and family_history=yes then progress=good

R7: If Δw>0 and standard=no and family_history=no then see_doctor=yes

5.4.4 Database Structure

The figure below shows the entity relation diagram for web server database. This application contains the following tables:

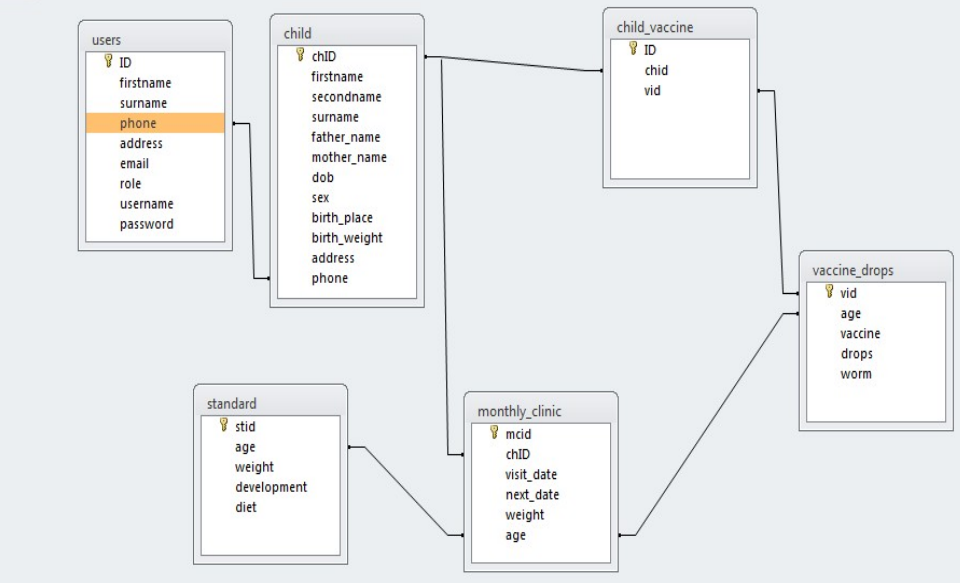

Figure 5.12: database diagram for MDSS

In each table there was primary key which contains unique value. The connection between tables represents foreign key, the foreign key from one table must point to the primary key of another table. The foreign keys in a table are used to prevent incorrect insertion of data and speedup deletion of data from the database. That means when a primary key is deleted, all the rows that have foreign key point to that primary key will be deleted also. Table 5.12 shows all attributes of the table child and all other tables are described in Appendix A:

Table 5.12: Description of child table

Child		
Attribute	**Type**	**Description**
chId	varchar	The child unique id
Firstname	varchar	First name of the child
Secondname	varchar	Second name of the child
Surname	varchar	Surname of the child
Father_name	varchar	Father's name of the child
Mother_name	varchar	Mother's name of the child
Dob	date	Date of birth of the child
Sex	varchar	Sex of the child
Birth_place	varchar	Birth place of a child
Birth_weight	double	Birth weight of a child
Address	varchar	Address of a child
phone	varchar	Phone number of the child Parent/guardian

Users: this table was used to store user information

Child: this table was used to store child information obtained from child registration form.

Monthly_clinic: this table was used to store record for monthly visit

Vaccine: this table contains vaccine information

Growth_Standard: this table was used to store standard for growth in a child.

5.4.5Web Server Design

Web server structure contains the following files:

DatabaseConfig: this file provides the connection to the database, it also disconnects the application from the database.

UserRegistration: this file contains query to insert user data into a database. It includes DatabaseConfig file. The user information such as name, address, phone number is inserted into a table user.

UserLogin: the information about user login was obtained in this file. This file includes DatabaseConfig file. It verifies the user login details from login page with that obtained in database. If user inputs wrong username and password it will display error message.

ChildRegistration: this file contains query which submits child data obtained from child registration form into a database. The information given must be correct in order to successfully submit child information into child table. If the inputs are not correct then it will show popup error message.

VacRegistration: in this file the vaccine information was registered into vaccine table. The file contains DatabaseConfig file. The insert query was used to submit data into vaccine table. The inputs must be correct in order to be successfully inserted.

Getdata: this file was used to retrieve child data from child table. It contains DatabaseConfig file.

Search_vaccine: this file contains query for retrieving vaccine information from the database. The information was retrieved according to child identification number.

Summary_monthlyclinic: this file contains query which retrieves summary of date and weight of monthly clinic visits from database.

Monthly_clinic: this file contains query which is used to record monthly visits data into the monthly clinic table.

Search advice: this file was used to retrieve summary of the weight gain of a child. It contains query which finds the weight difference between current month and previous month.

5.4.6 User interface design

In application to extend the usability and to meet user requirements much effort must be put in interface design, this will enhance the usability of a system. The basic principle of user interface design must be followed.

5.4.7 Structure layout

Application layout must follow the user interface design principle standard. The MDSS three layouts are employed in interface design. Scrolling layout is used for device with small screen to enable visibility. Relative and linear layouts are also used in interface design.

5.4.7.1Theme and icons

All screens use the same theme this will help users to easily learn the system. The color used in all screens is the same and user friendly to attain visibility. Button has the same color in all the application screens. Icons are used in menu control buttons to represent the content of the navigation to the system. Figure 6.5 shows the theme and icons that are used in application first page. The first screen can redirect user to login or register in a system.

5.4.7.2 Navigation and controls

Screen in application has navigation from one screen to another. The login and register screens (activities) contain navigation screens that are used to redirect users to main screen. Main screen uses navigation buttons to redirect user to another application activities. Figure 6.6 shows an example of navigation button; from the main screen the user can navigate to monthly clinic, vaccine schedule, growth stages, child registration, and dangerous sign activities.

5.4.7.3 Feedback and alert dialogs

Feedback and alert dialogs are important elements in application design. Alert dialogs are used to show what is going on in case the application takes a long time to execute the request. This will help to avoid users to panic. In this application toast are used instead of alert dialog box. The feedbacks are displayed in a small popup.

5.5. System implementation

The last stage was the implementation phase, during which the MDSS was built. This section contains two steps:

5.5.1 Constructions

The implementation phase starts with construction step. The MDSS was built and tested to ensure it performs as designed. The Java, PHP, Mysql, JavaScript were used in construction of MDSS. The following is screen shot of MDSS. See the figures below. The home page of MDSS allows user to login or to register into the system. The new user must click register to register into the system, for registered user must inter username and password to login into the system.

Figure 5. 13: MDSS login form design

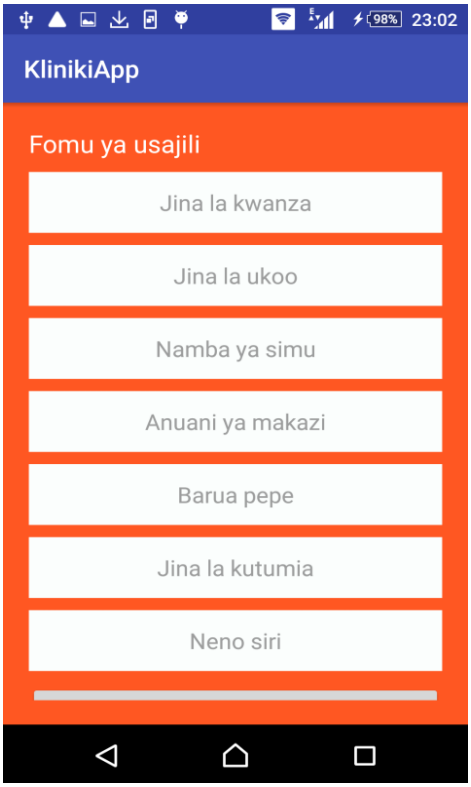

Figure 5. 14: MDSS registration form

Figure 5. 15: MDSS Home page

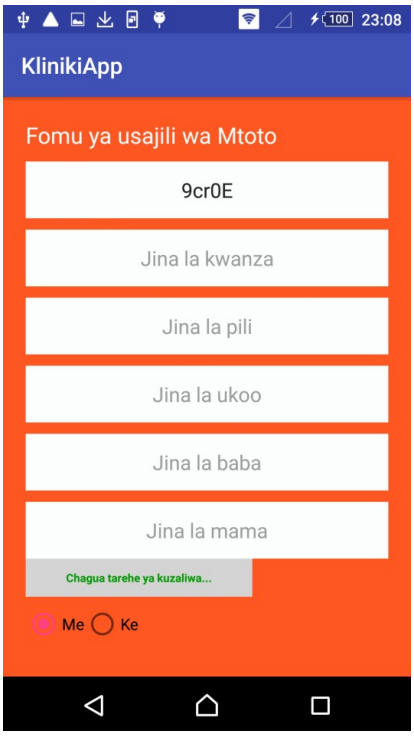

Figure 5. 16: MDSS child registration form

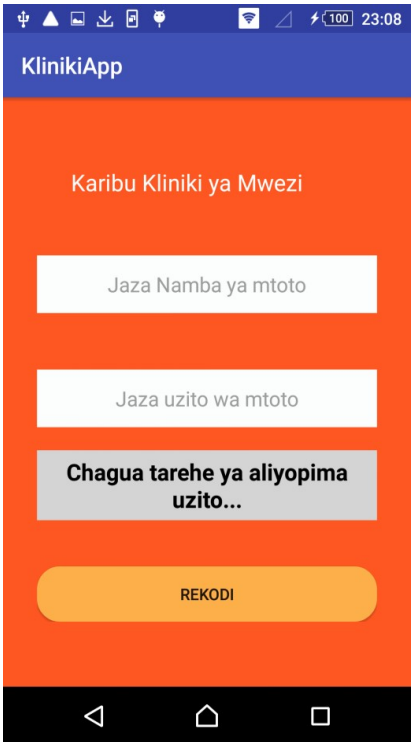

Figure 5. 17:MDSS monthly clinic form

Figure 5. 18: MDSS monthly clinic visit summary

Figure 5. 19: MDSS monthly clinic advice

5.5.2 Testing

After completing construction phase, the system was tested to discover any bugs. The following were the testing cases of the MDSS. See table 5.13 and table 5.15

Table 5. 13: Login with valid credential test case
Project Name: MDSS

Test Case	
Test Case ID: MDS01 **Test Priority (Low/Medium/High)**: medium **Module Name**: MDSS login screen **Test Title**: Verify login with valid username and password **Description**: Test the MDSS login page	**Test Designed by**: Debora Fungo **Test Designed date**:21st march, 2018 **Test Executed by**: kihonda dispensary **Test Execution date**: 24th march, 2018
Pre-conditions: User has valid username and password	

Table 5. 14: Steps and outcomes of test case
Steps and Outcome

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1	Navigate to login page	Username: kihonda	User should be able to login	Login successful	Pass	Done
2	Provide valid username	Password:kliniki				
3	Provide valid password					
4	Click on Login button					
Post-conditions: user is validated with database and successfully login to account.						

Table 5. 15: Login with invalid credential test case
Project name: MDSS

Test Case	
Test Case ID: PS02 **Test Priority (Low/Medium/High):** Medium **Module Name:** MDSS login screen **Test Title:** Verify login with invalid username and password **Description:** Test the MDSS login page	**Test Designed by**: Debora Fungo **Test Designed date**:21st march, 2018 **Test Executed by**: kihonda dispensary **Test Execution date**: 24th march, 2018
Pre-conditions: user has invalid username and password	

Table 5. 16: Steps and outcome of test case
Steps and Outcome

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/Fail)	Notes
1	Navigate to login page	Username:honda	User should not be able to login	Login fails	fail	Done
2	Provide valid username	Password: kihonda				
3	Provide valid password					
4	Click on Login button					
Post-conditions: user is validated with database and unsuccessfully login to account.						

5.5.3 System evaluation

The mobile application for monitoring child growth developed to provide monthly clinic service, vaccine information and nutritional information. The development of this system was discovered in order to overcome challenges facing parents during child growth. The use of mobile application in monitoring child growth will help parents or caregivers flexibility in monitoring child growth. This is because parents can monitor child growth at any time. Before using this system parents were required to visit health facilities in order to get monthly clinic services. Therefore the attendance was not good enough.

Table 5. 17: System evaluation

Users	System reliability	System functionality	System usability	Suggestion
1	More reliable	Functioning well	Good	Allow it to run in IOS
2	Reliable	Not bad	Good	Put emergency contact number
3	Stable	Good	Good	Put emergency contact number
4	Reliable	Functioning well	User friendly	Allow it to run in IOS
5	Stable	Good	User friendly	Put emergency contact number
6	More reliable	Good	Good	Allow it to run in IOS
7	Reliable	Not bad	Good	Allow to send alert message on vaccination date
8	Reliable	Not bad	User friendly	Allow to send alert message on vaccination date
9	More reliable	Good	User friendly	Put emergency contact number
10	Reliable	Not bad	Good	Put emergency contact number
11	Stable	Functioning well	User friendly	Allow it to run in IOS
12	Reliable	Functioning well	Good	Allow it to run in IOS
13	Reliable	Functioning well	Good	Allow it to run in IOS
14	Reliable	Not bad	Good	Allow to send alert message on vaccination date
15	More reliable	Not bad	User friendly	
16	More reliable	Not bad	User friendly	Allow to send alert message on vaccination date
17	Stable	Good	User friendly	
18	Reliable	Functioning well	Good	Allow it to run in IOS
19	More reliable	Good	Good	Put emergency

Users	System reliability	System functionality	System usability	Suggestion
				contact number
20	Reliable	Good	User friendly	Allow to send alert message on vaccination date
21	Reliable	Functioning well	User friendly	
22	Stable	Functioning well	User friendly	Allow to send alert message on vaccination date
23	Stable	Good	Good	Put emergency contact number
24	Stable	Not bad	User friendly	Allow it to run in IOS
25	Reliable	Good	User friendly	Allow to send alert message on vaccination date
26	Reliable	Functioning well	User friendly	Put emergency contact number
27	Reliable	Good	Good	Put emergency contact number
28	Reliable	Not bad	User friendly	Allow to send alert message on vaccination date
29	Reliable	Not bad	User friendly	Allow to send alert message on vaccination date
30	Reliable	Functioning well	Good	Put emergency contact number

The result from the Table 5.17 above shows that the mobile growth monitoring application is helping parents or caregivers to monitor growth of their children more efficiency. The comments obtained from the users suggest that some features must be included. Therefore the application is really needed to monitor child growth and it is easy to use as it is using swahili language which is common almost to all people in Morogoro municipal.

5.5.4 Chapter summary

The system analysis design and implementation of MDSS chapter elaborates what the system will perform and how will meet the user requirements. The analysis section shows the description of requirement determination, functional, non-functional requirements, and system modeling which includes use cases, activity, and sequence. The design of MDSS is represented by class diagrams, database diagram, interface and the web server design. After complete the analysis and design of the system the last part of the chapter is system testing and evaluation. The next chapter is the conclusion and recommendation of the study.

CHAPTER SIX
CONCLUSION, RECOMMENDATION AND FETURE WORK

6.1 Conclusion

The growth monitoring in children has greater impact on the development of children. It is noticed that the future of child is determined by the health history during growth. The growth monitoring process helps the early detection of health abnormalities in children. Early detection of health problems reduces the cost of treatment. The development and use of mobile phone technology in Tanzania have increased currently. The mobile network is available in many of the areas and many people are aware of using smart phones. This technology is used to provide various information such as agriculture, education, health and economic. However, in Tanzania the growth monitoring process is still done in health facilities. Findings show that the distance between residence and health facilities can affect the attendance in monthly clinic. The health sector affected by challenges such as limited number of health workers, shortage of health facilities and lack of qualified personnel. The application of mobile phone technology in provision of various services can help to alleviate those challenges. Thus, this study implemented a mobile application that is used to monitor growth of children. This application will enable parents to attend monthly clinic using smart phones. The method will help parents to save time and cost in monitoring growth of their children.

6.2 Recommendations

On the bases of the findings of this study and the proposed design of mobile application, this study recommends the following:

- The ministry of health should promote the growth monitoring process through smart phones; this is because it will help to improve growth monitoring process.
- The government through the ministry of communication should make sure that the network is available in many places and the tariffs are low.
- The society should be ready to accept new technology in attaining the development. Since the technological changes are inevitable, it is important to accept new changes so as to address new challenges that crop up now and then in societies and the country at large.

6.3 Suggestions for future work

- The application was developed to be used in Android smart phone, in the future the application must be able to run in iOS smart phones.
- The application was able only to monitor growth; in the future the application must be able to detect common diseases in children.
- In this application the weight of a child is measured separately and entered in the system for further processing, in the future the application must be able to connect with weight measure device and read the weigh for further processing.
- In case of emergence the application should be able to connect parents with health facilities.

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APENDICES

APPENDIX A

Database table's description

Vaccine_drops		
Attribute	**Type**	**Description**
VId	Int (AI)	The unique id of vaccine/drops
Age	Int	Required age of a child
vaccine	Varchar	Name of a vaccine
drops	Varchar	Name of a drop
worm	Varchar	Name of worm

Appendix A. 1: Vaccine drops database table description

User		
Attribute	**Type**	**Description**
Id	Varchar	The user unique id
Firstname	Varchar	First name of the user
Surname	Varchar	Surname of the user
phone	Varchar	Phone of user
address	Varchar	Address of user
email	Double	Email of user
role	Varchar	Role of user
username	Varchar	Username of user
password	Varchar	Password of user

Appendix A. 2: User database table description

Standard		
Attribute	**Type**	**Description**
stId	Int (AI)	The unique id of standard
Age	int	Required age of a child
weight	double	Required weight of a child
development	varchar	Required development stage of a child
diet	varchar	Required diet of a child

Appendix A. 3: Standard database table description

Monthly_clinic		
Attribute	**Type**	**Description**
mcId	Int (AI)	The unique id of monthly clinic
chID	varchar	Required age of a child
date	date	Date of measuring weight
Next_date	date	Next date visit
weight	double	Weight of child
age	int	Age of a child during measurement

Appendix A. 4: Monthly clinic database table description

APPENDIX B

Letter of introduction

My name is Debora Fungo. I am an MSc Student at Mzumbe University and carrying out a research on **“Developing A Mobile Decision Support System for Monitoring Child Growth From 0 To 23 Month Of Age**”. I am kindly asking for permission to collect information on the above topic. The interview will take approximately 30 to 45 minutes and all information treated will be treated with greater confidentiality. The findings of the study will be used in designing of the mobile application system for child growth monitoring.

APPENDIX C

DEVELOPING A MOBILE DECISION SUPPORT SYSTEM FOR MONITORING CHILD GROWTH FROM 0 TO 23 MONTH OF AGE

Interview Guide Questions

Dear Valued Respondent,

I am pursuing a Master's of Science Information Technology and Systems at Mzumbe University. I am conducting a research whose theme is "**DEVELOPING A MOBILE DECISION SUPPORT SYSTEM FOR MONITORING CHILD GROWTH FROM 0 TO 23 MONTH OF AGE**". The data collected will be used for writing my dissertation. For this case, I will be more grateful if you respond to these interview questions. The information gathered will be used for Academic work only, nothing else.

Section 1: general knowledge on growth monitoring process

1.1 Is it important for your baby to be taken for weighing regularly?

Yes/No

1.2 If yes, why?

1.3 If no, why?

1.4 Do you know what information is displayed on the child health card?

Yes/No

1.5 If yes, what it means?

1.6 Is this information useful?

1.7 In which way this information is useful?

1.8 What are the benefits of GM process?

Section 2: challenges facing current method of child growth monitoring process

2.1 Are there health facilities available around your residence?

Yes/No

2.2 How far is the health facility from your residence?.....km

2.3 For what services do you usually take your children to the health facility?

2.4 Are the monthly clinic services offered full time?

Yes /No

2.5 How long do you take to go through the whole process of GM……. Minutes

2.6 How do you rate the services offered in the facility

Good /Poor

2.7 If the answer is good, why?

2.8 If the answer is poor why?

2.9 How do you rate the staff's performance?

Committed /not committed

2.10 If committed why?

2.11 If not committed why?

Section 3: Methods used in child growth monitoring processes

3.1 What method used in growth monitoring process?

Weight for age/Height/length for age/Middle upper arm circumference/Head circumference

Section 4: mobile phone ownership

4.1 Do you have a mobile phone?

Yes/No

4.2 If yes what type of mobile phone?

Smart phone/Ordinary phone

4.3 Do you know how to use smart phone?

Yes /No

4.4 If yes what is your main usage of smart phone?

Section 5: knowledge on mobile health application

5.1 Do you know any mobile health application?

Yes/ No

If yes, what mobile health application do you know?

Where do you get healthy information?

Does health information useful?

Yes/ No

APPENDIX D

APPENDIX D: Schedule and research milestones

Milestones	Description	Milestone Criteria	Planned duration
M0	**Concept note development**		11th Nov,2016 to 3rd Dec,2016
	Identification of problem, goals and the scope of the research.	Concept note developed	
M1	**Proposal Writing**		4th Dec,2016 to 30th Apr,2017
	Development the introduction, literature review, and the methodology of the research.	Proposal developed	
M2	**Data collection**		
	Conducting interviews and document review	Data gathered	4th Apr,2017 to 30th May,2016
M3	**Analyzing data**		2nd June,2017 to 30th June,2017
	Analysis of data corrected to get relevant information	Data analysis completed	
M4	**Technical solution**		1st July 2017 to 25th July 2017
	Design and development of mobile application	Use case, activities, sequences, class, interface design, create the application	
M5	**Report Writing**		30th July 2017 to 28th Aug,2017
	Final report preparation	Developed report	
M6	**Report presentation**	Presentation	30th Aug, 2017