

**A DATA ANALYTIC MODULE FOR NUTRITION SCREENING OF
CHILDREN UNDER FIVE YEARS IN TANZANIA**

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ABSTRACT

Malnutrition is one of the major health problems in the world, and more prevalent in developing countries. The World Health Organisation (WHO) estimates that malnutrition is associated to half of all deaths of children under five years. In Tanzania it is estimated that 43,000 children die and the government loses up to Tsh. 700 billion annually due to the effects associated with malnutrition. Due to its unbearable consequences several international organisation have initiated collective measures to combat malnutrition. Nutrition screening, the process of identifying whether the child is malnourished or not, is a proven and important step towards malnutrition eradication. Regular and effective nutrition screening allows early malnutrition or risk of malnutrition to be identified and proper treatment and malnutrition management to be effected. The whole process of nutrition screening and malnutrition management in Tanzania still requires a lot of improvements. The studies show that the nutrition screening is not effective and it is mostly manual. The process includes the use of papers (clinic card) in recording anthropometrics measurement and that Mid Upper Arm Circumference (MUAC) is the only tool used for nutrition screening despite the already identified shortcomings. In this study, a nutrition data analytic module for nutrition screening for children under five years is proposed and developed. The system will have the ability to store child records after the child is registered, perform nutrition screening to identify if the child is well nourished or malnourished, and establish the current state of malnourished child in order to allow appropriate action to be taken by a health worker. Additionally the progress of malnourished child will be established to allow proper malnutrition management. The module has the ability to create reports which will help researchers, stakeholders and other users to get nutrition related data and information and malnutrition trends. This study puts in place a nutritional data analytic module for nutrition screening. This will facilitate effective nutrition screening of children and hence improve children nutrition health.

DECLARATION

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



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Date

The above declaration is confirmed.

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13/04/2016

Name and signature of supervisor

Date

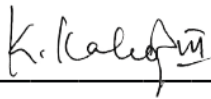
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CERTIFICATION

The undersigned certifies that he has read and found that this dissertation to be acceptable by the Nelson Mandela African Institution of Science and Technology.

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Date

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DEDICATION

I dedicated this work to my daughter, AnnaIvana Kelvin Nzilano.

TABLE OF CONTENTS

DECLARATION	2
COPYRIGHT.....	3
CERTIFICATION	4
ACKNOWLEDGEMENT	5
DEDICATION	6
TABLE OF CONTENTS.....	7
LIST OF TABLES	11
LIST OF FIGURES	12
LIST OF EQUATIONS	13
LIST OF APPENDICES	14
LIST OF ABBREVIATIONS.....	15
CHAPTER ONE	16
Introduction.....	16
1.1Background Information.....	16
1.2Research problem and justification of study.....	17
1.3Objectives	18
1.3.1 General objective	18
1.3.2 Specific objectives	18
1.4Research questions.....	18
1.5Significance of the research	18
1.6 Dissertation Organization	19
CHAPTER TWO	20

Summary	20
2.1 Introduction.....	20
2.2 Methodology	21
2.3 Maternal Newborn and child health care provision in Tanzania	21
2.4 The Nutrition Screening Process in Tanzania.....	22
2.5 Findings and Discussion	24
2.6 Conclusion	25
CHAPTER THREE	26
Summary	26
3.1 Introduction.....	26
3.2 Nutrition Status in Tanzania	27
3.3 System analysis process	27
3.3.1 Requirements Determination	27
3.3.2 Methods used in requirements collection	28
3.4 Functional Requirements	28
3.5 Non-functional Requirements	29
3.6 Requirements Structuring	29
3.6.1 Modelling of a Nutritional Data Analytic Module Requirements	30
3.6.2 Shapes used in drawing DFDs	30
3.6.3 Terminologies used in DFDs	30

3.6.4Context DFD	31
3.6.5 Level – 0 DFD	31
3.7 Conclusion	31
CHAPTER FOUR.....	33
Summary	33
4.1 Introduction.....	33
4.3 System Design	36
4.3.1 System Definition	36
4.3.2 Requirement Specification.....	36
4.4 Nutrition Screening Process flow	37
4.5 Individual components of the nutritional screening process and their contribution to the overall nutritional screening process	38
4.5.1 Process Inputs	39
4.5.2 Calculations of Nutritional Indicators.....	39
4.6 Nutritional Progress Establishment.....	40
4.7 Rule based malnutrition extent	42
4.8 Conclusion	43
CHAPTER FIVE	44
Summary	44
5.1 Introduction.....	44
5.2 Criteria used for nutritional data analytics module evaluation	44

5.2.1 Accuracy	44
5.2.2 Easy Operation and Maintenance	45
5.2.3 Efficiency	45
5.3 Evaluation Process	45
5.3.1 Checking System Accuracy	46
5.3.2 Checking against the requirements specification.....	49
5.3.3 Checking the Users' Responses	49
5.3.3.1 Data Presentation, Interpretation and Discussion of User's Responses	49
5.4 Conclusion	53
CHAPTER SIX.....	54
6.1 General Discussion	54
6.2 Conclusion	55
6.3 Recommendations	55
REFERENCES	56
APPENDICES	61

LIST OF TABLES

Table 1: DFD Shapes	30
Table 4: Specific System Requirements	36
Table 5: Subjective data.....	39
Table 6: Cut-off points.....	39

LIST OF FIGURES

Figure 1: Child clinic card with growth chart	23
Figure 2: MUAC tape	23
Figure 3: Context DFD	31
Figure 4: Level 0 DFD	31
Figure 5: User response graph 1	50
Figure 6: User response graph 2	50
Figure 7: User response graph 3	51
Figure 8: User Response graph 4	52
Figure 9: User response graph 5	52

LIST OF EQUATIONS

Z-SCORE.....	39
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LIST OF APPENDICES

Appendix 1: Login interface	61
Appendix 2: Child registration.....	62
Appendix 3: Child anthropometric data entrance	62
Appendix 3: Nutrition screening.....	63
Appendix 4: Malnutrition Extent Establishment	63
Appendix 5: Nutritional Progress Establishment.....	64
Appendix 6: Nutrition screening sample codes	65

LIST OF ABBREVIATIONS

BMI	Body Mass Index
GOT	Government of Tanzania
FAO	Food and Agriculture Organisation
HIV	Human Immunodeficiency Virus
ICT	Information and Communication Technology
MCH	Maternal and Child Health
MDG	Millennium Development goals
MNCH	Maternal New-born and child health
MOHSW	Ministry of Health and Social Welfare
MUAC	Mid Upper Arm Circumference
NRS	Nutrition Risk Score
NST	Nutrition Screening System
PYMS	Paediatric Yorkhill malnutrition Screening
SGNA	Subjective global Nutritional Assessment for children
SPNRS	Simple Paediatric Nutrition Risk Score
STAMP	Screening Tool for Assessment of Malnutrition in Paediatric
UN	United Nations
UNCEF	United Nations Children's Fund
URT	United Republic of Tanzania
WFP	World Food Programme
WHO	World Health Organisation
NIS	Nutrition Information System
TDHS	Tanzania Demographic and Health Survey
NDAM	Nutritional Data Analytics Module
NBS	National Bureau of Statistics

CHAPTER ONE

Introduction

Currently, prenatal and postnatal nutrition is one of the health challenges facing most countries in Africa. According to Food and Agriculture Organization (FAO), lack of enough health workers and limited access to food and health services needed for healthy life constrain efforts to fight malnutrition in the continent(FAO, 2010). Recent information reveals that malnutrition affects more than half of African children under five years and contributes to about 45 percent of all under five years deaths each year(Agreement & Agreement, 2010;WHO, 2013). The WHO report of 2011 reveals that, in Tanzania the death rates of women and children under five years due to malnutrition are about 15.1 percent. According to the first Millennium Development Goals (MDGs), African countries including Tanzania agreed to halve the number of people suffering from malnutrition and hunger by 2015(MDGs, 2015). In response, international organizations like WHO, FAO, United Nations Children's Fund (UNICEF) and World Food Programme (WFP) have initiated various programmes and campaigns to achieve this goal.

Despite various efforts by the government and other partners, yet there is no reliable national system that collects, analyses, and disseminates data, information and parameters related to malnutrition in Tanzania(Leach & Kilama, 2009). The application of information and communication technology (ICT) in developing information systems and use of computerised tools for malnutrition screening has proven to have significant contribution in combating malnutrition(Bertolini, 2004). However, it has been observed that ICT alone cannot solve the challenge of malnutrition and food security though it can significantly contribute in malnutrition reduction(Bertolini, 2004). There is a need therefore to develop an integrated automated system that screens malnutrition and disseminates data and information about children that are malnourished and in danger and determines the existent of the problem to help the government in the fight against malnutrition in Tanzania.

1.1Background Information

Malnutrition is a major health problem in the world today. It has both health and socio-economic consequences. In the developing countries, the prevalence of malnutrition among under five years children is estimated to be 41 percent (De Onis & Blössner, 1997a). In the Sub- Saharan Africa, the prevalence of malnutrition is still high. The global database on child malnutrition

shows that 10% of children under five years in Sub-Saharan Africa were moderately and severely wasted (Kolsteren, Roberfroid, Huybregts, & Lachat, 2007).

Malnutrition contributes to more than 50% of children under five year's mortality. Death due to malnutrition not only increases when there is an increase in food insecurity, absolute poverty, and famine but these also result into poor maternal nutrition care (UNDP, 2005; Fao, Ifad, & Wfp, 2014; and Haddad & Smith, 1999). Malnutrition survivors are left with delay in mental development, poor school performance and reduced intellectual achievements (Okomo UA, et al. 2011; Bryce, Coitinho, Darnton-Hill, Pelletier, & Pinstруп-Andersen, 2008).

The 2010 statistics shows that 5% of children were wasted and 1% were severely wasted in Tanzania (NBS, 2010). For example, malnutrition is a big problem in Simanjiro district as 25.2% of children were found to be moderately malnourished while 6.0% were severely malnourished (Nyaruhucha, Mamiro, Kerengi, & Shayo, 2006). Furthermore, most hospitals use manual-based nutrition screening approaches, which are relatively ineffective. The need for developing a new system for screening nutrition cases in Tanzania was therefore inevitable. This study therefore aimed at developing an effective and reliable nutrition screening tool that will replace manual screening practices. The developed nutrition screening tool will improve nutrition screening process for early identification of malnourished children to allow treatment and proper malnutrition management.

1.2 Research problem and justification of study

In recent years the world has witnessed information technology contributing significantly in the performance of social sectors such as education and health (Dzidonu, 2010). In rural areas of India, CommCare software is used to help in management and prevention of malnutrition (Medhi et al., 2012). Given this evidence elsewhere in the world, the same is possible to improve management of malnutrition cases in Tanzania given the great pace of ICT development in the country. The current government's efforts in fighting against malnutrition could be fastened by the use of ICT automated systems that will bring about technological means of identifying children who are malnourished, who are at risk and the extent to which the child is affected as well as disseminating information right as it is needed as so contribute in combating malnutrition among children in Tanzania. This study therefore supports the government's efforts in fighting

against malnutrition in Tanzania. The study developed the intended nutritional data analytics module that will facilitate nutrition screening to children under five years.

1.3 Objectives

1.3.1 General objective

The main objective of this research is to develop a nutritional data analytics module for nutrition screening of children under five years in Tanzania.

1.3.2 Specific objectives

- i. To review of the nutrition screening process in maternal, newborn and child health (MNCH) care system Tanzania.
- ii. To identify and analyze user and system requirements for development of the nutritional data analytics module for nutrition screening.
- iii. To design and develop a nutritional data analytics module based on the requirements.
- iv. To evaluate the performance of the nutritional data analytics module.

1.4 Research questions

- i. What nutrition indicators are involved in nutrition screening in children under-five years?
- ii. What are the requirements for nutrition screening system?
- iii. What design can ensure efficient and effective nutrition screening?
- iv. What is the performance of the designed and developed nutrition screening system?

1.5 Significance of the research

Malnutrition has been frequently mentioned as one of the major challenges in most African countries. In Tanzania for example, Twaweza in the policy note of 2010, mentioned that malnutrition is a major challenge that affects children in rural areas (Note, 2010). Pastoralist societies and regions are particularly more affected as compared to other regions in mainland Tanzania. Arusha has the highest proportion of wasted (acute malnutrition) children (NBS & Calverton, 2011). Empirical evidence reveals that almost all Tanzanian children have suffered from one form of malnutrition during childhood (Survey, 2011). To address this challenge, the Government of Tanzania (GOT) strategized on building capacity of health systems that manages prenatal and postnatal malnutrition statuses and establishing active systems for screening acute

malnutrition in children (Ministry of Health and Social Welfare, 2015). However, the GOT's efforts have been very slow due to incapacity of the health system to manage prenatal and postnatal nutrition status. In this study, nutritional data analytics module is proposed to accelerate the GOT's efforts in eradicating malnutrition among Tanzanian children. The proposed system intends to put in place a nutrition screening system for nutrition screening, analysing nutritional data, and producing useful information for decision making.

1.6 Dissertation Organization

In this dissertation a data analytics module for nutrition screening of children under five years was developed and presented. The dissertation follows a paper based format, therefore the chapter two to five are fully supported by manuscripts. Chapter Two, this chapter presents a review of the nutrition screening process in Maternal, Newborn and Child care system in Tanzania. It consists of a manuscript titled "A Review of the Nutrition Screening Process in Maternal, New-born And Child Care System – Tanzania". Chapter three discusses and present system and Requirements analysis for development of data analytics module for nutrition screening to improve nutrition screening process at health facilities in Tanzania. The chapter consist a manuscript entitled "Developing a Nutrition Screening System to Improve the Nutrition Screening Process at Health Facilities in Tanzania: A System and Requirements Analysis". Chapter Four discusses and present the data analytic tool for performing nutrition screening and extent establishment. Furthermore the chapter presents how the module can quickly and perfectly performs nutrition screening. The chapter consist the manuscript entitled "An Analytic Module to Improve Nutrition Screening for Children Under-five Years at Maternal and Child Health (MCH) Facilities". The final chapter five presents the evaluation of the developed data analytics module, its appropriateness and effectiveness in nutrition screening. This chapter consist of manuscript entitled "Nutrition Screening System to Improve Screening Process at Health Facilities: System Evaluation". The general recommendation and conclusion are presented in chapter six.

CHAPTER TWO

A Review of the Nutrition Screening Process in Maternal, New-born And Child Care

System – Tanzania

Summary

Maternal, new-born and child health (MNCH) care is the health of women during pregnancy, childbirth and postnatal period. In Tanzania, MNCH care includes early and complete antenatal care attendance, prevention of HIV transmission from mother to child, family planning, safe motherhood and nutrition services, and they are provided under the Ministry of Health and Social welfare to ensure coverage, reliability and quality of services provided and better management in order to reduce maternal, new-borns and child deaths. However, not all of these services are provided in good quality and scale. Some of the services are provided under scale and others are not provided at all. Among MNCH care services, nutrition is the one which has not yet been given adequate attention by the government and health workers at Maternal and Child Health (MCH) centres despite the fact that they are the ones who have the mandate to prevent and treat malnutrition. This paper presents an overview of the nutrition screening process in maternal, new-born and child health care system in order to improve malnutrition screening process.

2.1 Introduction

Tanzania is one among ten countries contributing to 61% of maternal deaths and 66% of new-born deaths globally (Bill and Melinda Gates Foundation, 2012; Ministry of Health and Social Welfare, 2008; Mwaikambo, 2010). Among other factors that cause death, malnutrition is the single major factor affecting health and survival of new-borns and children throughout their childhood life (Note, 2010). Due to the threat that malnutrition has to life and general social-economic development of the nation in Tanzania, there is a need for a stable system for nutrition screening and malnutrition management (Leach & Kilama, 2009; Ministry of Health, 1992).

Malnutrition is estimated to contribute to half of all deaths of children under-five years. This is because malnutrition affects children health to the extent that they die due to curable diseases (Note, 2010). The first Millennium Development Goal emphasizes on reducing the number of people with hunger among UN member countries (The Millennium Development Goals, 2015). This will make a considerable step towards eradicating malnutrition. However, this goal

focuses on only one side of the problem because there are other factors such as diseases, problems in food intake and nutrition absorption although hunger is one of the major causes of malnutrition(Garcia, 2012).

Malnutrition can be indicated by a combination of many signs and symptoms, but identifying the extent to which one is malnourished or is at risk needs effective nutrition screening. It is stressed in PABEN report (2008) that, regular malnutrition screening is the only way that malnourished individuals can be identified and appropriate action taken(Russell & Elia, 2008). This allows effective management of malnutrition, which in turn can reduce mortality and morbidity death rates(Blossner M and de Onis M, 2005). Compared to developing countries, nutrition screening in developed countries is given considerable attention. Various screening tools have been developed and used in both adults and children nutrition screening.

2.2 Methodology

A review on nutrition screening process at maternal, newborn and child health care was accomplished using qualitative research methods. Literature review, direct observation and focus group discussion with MCH health workers, nutritional experts, and government officials in charge of nutrition methods were used to gather important data and information needed.

2.3Maternal Newborn and child health care provision in Tanzania

Maternal New-born and Child Health (MNCH) is the health of women during pregnancy, childbirth and postpartum period (Addisse, 2003). MNCH care gains more concern and interest throughout the world and more specifically in developing countries after the World Summit for Children of 1990 which emphasized on the major areas such as detection and prevention of any potential pregnancy complications, new-born care, nutrition, breastfeeding and family planning that need to be addressed when providing MNCH care (UNCEF, 1990). In African countries including Tanzania, MNCH care is not encouraging and maternal mortality is unacceptably high.Among 800 women who die from pregnancy or childbirth complications every day around the world, about 99 per cent are from Africa (WHO, 2014).

The Tanzanian government has made considerable efforts in strengthening MNCH care system to provide better MNCH services and hence reduce maternal, new-born and child deaths (HDT, 2012). Through the MOHSW, the government addresses all matters related to health including MNCH in collaboration with other stakeholders; this ensures the availability of health services up to rural areas (URT, 2011). The government has formulated a number of important policies

and strategies regarding the provision of MNCH services with more emphasis on the recently launched road map “one plan for MNCH,” which integrates all the components of MNCH care to ensure delivery of a set of essential interventions for women, new-borns and children (MOHSW, 2008).

Through the establishment of the desk for Reproductive and Child Health (RCH) at the MOHSW, Tanzania has become a leader in Africa for MNCH planning at the national level. Among other responsibilities, this section has the mandate to serve as a liaison to other ministries and relevant organization dealing with reproductive health and nutrition and to review the list of standard essential equipment and supplies for provision of quality reproductive health care. The RCH section and MNCH structure make the Tanzanian MNCH care to be well tailored to suit the needs of its citizens. However, despite these initiatives of strengthening the MNCH health care, good coverage of health facilities and that MNCH services are all over the country, not all services required for MNCH care are provided in a good quality; some of the services are not provided or are provided below the required standards (URT, 2011; Mwaikambo E, 2010).

2.4 The Nutrition Screening Process in Tanzania

In Tanzania, the nutrition screening process is done at community level specifically in MCH centres. Nutrition screening tools and technics used include anthropometric indicators, which are recommended by WHO and UNICEF (Atukwase, Geoffrey & Bell, 2009). Mid Upper Arm Circumference (MUAC) is an appropriate indicator for the assessment of malnutrition. The indicator is useful for both screening and estimating prevalence of malnutrition at a population level (ACF- International, 2005; Hobss & Bush, 2014). Fig 2 shows the MUAC tape. And the growth monitoring chart in children clinic cards (see Fig. 1 below) is used for monitoring children’s growth. Appropriate and adequate growth in children is considered as a reflection of good health. In some circumstances, growth charts are used to monitor child’s nutrition.

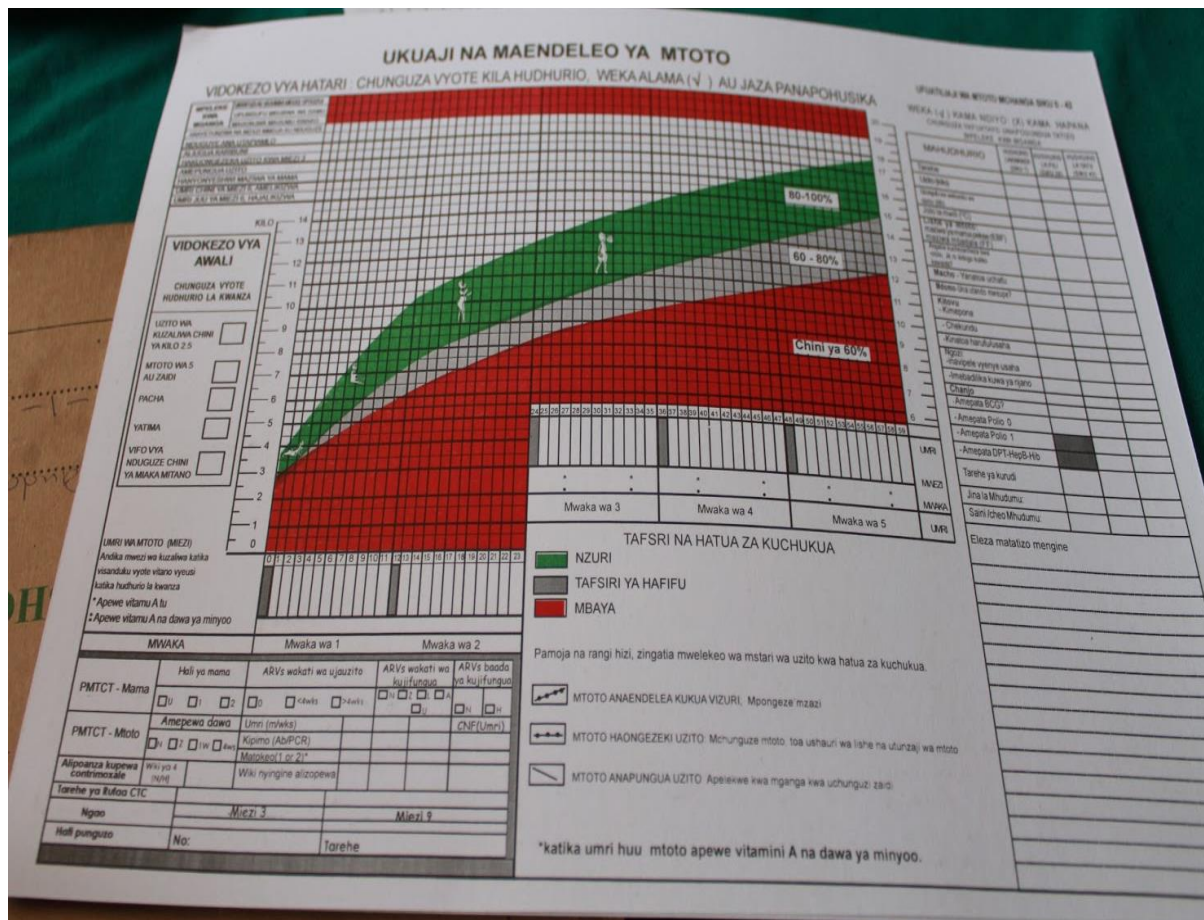


Figure 1: Child clinic card with growth chart

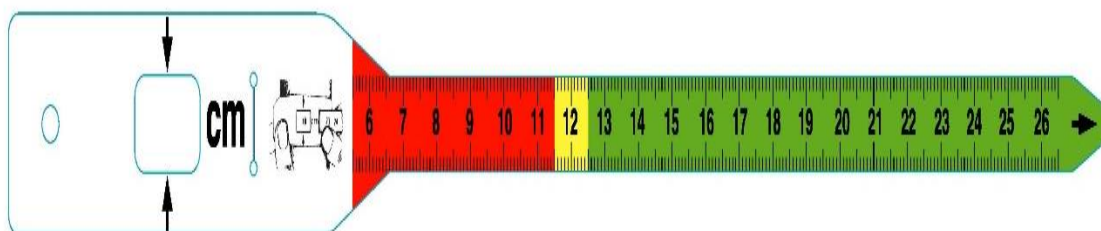


Figure 2: MUAC tape

2.5 Findings and Discussion

Among the services provided by MNCH care in Tanzania, nutrition is given less priority. The Tanzanian National Nutrition Strategy (NNS) of 2011 gives the health workers at MCH centres the obligation to manage malnutrition by preventing and providing its treatment (Ministry of Health and Social Welfare, 2015). However, health workers at MCH centres are still grappling with the basics of how to implement the strategy. This indicates lack of seriousness in implementing the objective of strengthening the health system and establishing an active system for malnutrition screening. There are relatively no dedicated, reliable and effective malnutrition screening and management systems for nutrition in Tanzania, despite the observation that nutrition screening is a very essential step in malnutrition management.

In some circumstances, it was observed that growth charts are used to monitor child's weight and indirectly used to monitor malnutrition as a child with low weight compared to age is considered as undernourished and one with weight that corresponds to age is considered as well-nourished. This practice is supported by the notion that an appropriate and adequate growth in children reflects good health although the case may not be true. As growth monitoring charts rely only on weight and indicators which are affected by various factors such as illness, feeding problems and ethnicity, their use is associated with some challenges such as birth weight being recorded only when delivery was at a health facility; this does not accommodate home delivery and hence this practice is a source of data discrepancy. It was observed that in some instances, the date of weighing and weight of the child are not always recorded on the card. Weight is sometimes also not plotted in the chart. Furthermore, even if the weight is below the curve, which indicates acute malnutrition, it is not a diagnostic feature; however it is used as a sign of acute malnutrition.

MUAC is quick and easy tool for nutrition screening. However, using MUAC is associated with several challenges. The preferential selection of younger children as undernourished, both inter- and intra- observer errors in MUAC measurements and lack of reproducibility of the measurements are some of the challenges that make MUAC not a reliable nutrition screening tool. It is also difficult to determine a child's age when a MUAC is used.

2.6 Conclusion

Generally, nutrition screening tools and malnutrition management systems in Tanzania are poor compared to other countries where computerized screening tools are used for checking nutrition status at hospitals and in community settings. Lack of a reliable nutrition screening tool and shortage of health workers at MCH centres especially in rural areas constrain malnutrition eradication efforts by effective screening and treatment. Various nutrition screening tools exist in the world today because of different nutrition screening needs, diverse malnutrition causes and nutrition screening tools validity and reliability concerns. Adoption and usage of nutrition screening tools developed based on certain screening requirements or developed to suit criteria of certain population is relatively impossible.

This calls for strengthening of health system to manage malnutrition by effective nutrition screening using the current tools as well as development of sophisticated nutrition screening tools and/or systems based on the Tanzanian context. Black et al (2013) argued that, to a greater extent, nutrition has been neglected. Once nutrition is given attention and nutrition screening done in a reliable and effective manner, it will reduce mortality and morbidity rates.

CHAPTER THREE

Developing a Nutrition Screening System to Improve the Nutrition Screening Process at Health Facilities in Tanzania: A System and Requirements Analysis

Summary

Malnutrition is a worldwide challenge and more prevalent in developing economies. To combat it, nutrition screening is a prerequisite step in malnutrition identification and treatment. To get better results, a particular nutrition screening tool has to be developed and used to screen a specific population in its context and settings. Available evidence suggests that a screening tool developed for a particular population cannot suit other populations in different contexts and settings. In similar vein, this paper carries out a system analysis to guide the design and development of a nutrition screening system. Specifically, the system analysis is for development of a computerized system with advanced nutrition screening process that takes in more parameters and ability to generalize cases.

3.1 Introduction

Nutrition screening is the process of identifying if an individual is malnourished or at risk for malnutrition (Mueller, Compher, & Ellen, 2011). The prevalence of malnutrition especially in children under five years has made nutrition screening to receive an increased attention (UNICEF, 2013). Eventually, the demand of nutrition screening tools has also increased. However, finding an appropriate tool for malnutrition screening is still a challenge (van Bokhorst-de van der Schueren, Guaitoli, Jansma, & de Vet, 2014). This challenge is partly contributed by the fact that nutrition screening tools are designed and developed for different objectives, applications and processes (Elia & Stratton, 2011; Van Bokhorst-de van der Schueren, Guaitoli, Jansma, & de Vet, 2014). For a screening tool to work efficiently, it should be applied to the right population or age group (Neelemaat, Meijers, Kruizenga, Van Ballegooijen, & Van Bokhorst-de van der Schueren, 2011). However, given the diverse nature of malnutrition causes, dissimilar needs for screening tool and ethnicity differences, it is difficult to select and use any nutrition screening tool (van Bokhorst-de van der Schueren et al., 2014). Developing a screening tool that suits the context and settings of the population to be screened is a recommended approach for better results.

3.2 Nutrition Status in Tanzania

Malnutrition is a challenge that has faced Tanzania for the past one decade; about 600,000 children aged below five years are estimated to have died due malnutrition (Note, 2010). It has been noted that there is unreliable system for managing child nutrition in Tanzania. This include screening and assessing nutrition statues (Leach & Kilama, 2009; MOHSW, 2011). Thegovernment of Tanzania has strategized to strengthen health system to manage maternal and child nutrition by establishing active system for malnutrition screening, orient the health workers in early signs and dangers of malnutrition and be able to recognize poor child caring practices and take corrective actions, equip health workers with screening tools and appropriate information for referral and follow-up. The government also plansto establish a system for active screening for malnutrition at community and facility level with referral for appropriate treatment (MOHSW, 2015). The strategy aimed at ensuring proper nutrition screening and treatment of malnutrition is scaled up into the health system. This objective is not fully succeeded because implementation of the strategy at community and facility level faces some challenges, such as the use of nutrition screening tools that rely on few nutritional indicators which makes the screening process to be error prone.

3.3 System analysis process

System analysis is the methodical investigation of a problem and the identification and ranking of alternative solutions to the problem. Different tools and techniques can be used in conducting system analysis, and when the structured tools and techniques such as data flow diagrams are used, the system analysis is called structured system analysis.

3.3.1 Requirements Determination

Requirements necessary for system development and implementation were gathered and analysed in this stage. These requirements comprises of functional and non-functional requirements of the nutrition screening system, which were gathered at Maternal and Child Health (MCH) facilities in Simanjiro, Arusha - Tanzania. The methods used in this study based on qualitative methods. And other methods like literature review were also deployed to facilitate the overall process of system analysis and specification. We also used casual talks with health workers and nutritional stakeholders to capture some important data for requirements specification.

3.3.2 Methods used in requirements collection

i. Interviews

We conducted in depth interviews with health workers at Maternal New-born and Child Health (MNCH) care facilities to capture the system functional requirements such as user interfaces and system operations.

ii. Observations

Direct observation method was deployed in this study where by there searcher observed the day to day activities at the MNCH care facility to ascertain requirements specification. The researcher observed the current screening process to identify weaknesses and the areas that need automation.

iii. Focus Group Discussions

This method was deployed to capture stakeholders' views and observations on the module's operations and non-functional requirements.

iv. Literature Review

Various studies on screening tools have been done to collect basic information about this study. The empirical literature review helped in scrutinizing alternatives available to improve the screening process.

3.4 Functional Requirements

Functional requirements describe a system and focuses on the system's logical implementation purpose without considering how the system will be physically implemented such as registrations and report generation. Functional requirements of the nutrition screening system includes:-

3.4.1 Registration

Nutrition screening will start with child registration. The OpenMRS registration module is customized and scaled to ensure the registration module registers information according to the needs of the nutrition screening system. The module allows the user to easily search for records and if not found, register a new record. Additionally, the service dashboard will open up directly when successful match found or the new record is successfully created.

3.4.2 Screening

This module performs nutrition screening. The screening is done by using anthropometric measurements such as body weight, height and mid upper arm circumference. Such body parameters will be accompanied by assessment of other factors like weight loss, illness, ethnicity, growth failure, food intake and choices, unhealthy skin or hair, edema, etc. to decide whether the child is malnourished or not.

3.4.3 Reporting

This module facilitates the dissemination of nutrition related information by producing relevant information in the form of report according to the requirements. The reports may be produced monthly, quarterly or annually depending on the type of report required.

3.4.4 Nutrition Progress Establishment

Nutrition Progress establishment allows monitoring of children nutritional progress to children who are under malnutrition treatment (care plan)

3.4.5 Malnutrition Extent Establishment

Malnutrition extent establishment allows identification of malnutrition magnitude to a child

3.5 Non-functional Requirements

Non-functional requirements are all the descriptions of a system that focuses on how the system will be materially constructed such as security, reliability, and performance.

3.5.1 Availability and Reliability

These are one of the attributes of a nutritional data analytics module that has the ability to deliver services when requested and consistently performs according to its specifications.

3.5.2 Security

The module will have the ability to protect itself against unauthorised intrusion. All users will have to log in the system using usernames and passwords.

3.5.3 Performance

The module is expected to perform efficiently with minimal resources and maximum throughput.

3.6 Requirements Structuring

Requirement structuring is the process of organizing the collected requirements in the meaningful representation of the information system. This includes two processes: process modelling and data modelling of the system requirements.





3.6.1 Modelling of a Nutritional Data Analytic Module Requirements

The nutrition screening system will be modelled using the Data Flow Diagram (DFD) to provide representation on how the data will flow through the system. The relationship among data flows and how data will be stored at a specific location after being processed or transformed to meaningful information. The modelling starts with the whole system as a single process, and then iteratively breaks it into small and smaller processes.

3.6.2 Shapes used in drawing DFDs

Table 1 below shows the shapes used in drawing DFDs.

Table 1: DFD Shapes

Shape	Meaning
	A process
	An internal or external entity
	Data flow
	Data store

3.6.3 Terminologies used in DFDs

- *Process*: Work on Actions performed on data (inside the system)
- *Data Store*: Data at rest (Inside the system)
- *Source/Sink*: External entities that is origin or destination of data (outside the system)
- *Data Flow*: Arrow depicting movement of data.
- *Context DFD*: Overview of the organizational system.
- *Level-0 DFD*: Representation of systems' major processes at high level of abstraction

3.6.4 Context DFD

The context diagram gives a general concept of the nutritional data analytic module. It consists of the main process of nutritional data analytics module and other entities that interact with the system (see Figure 3 below).

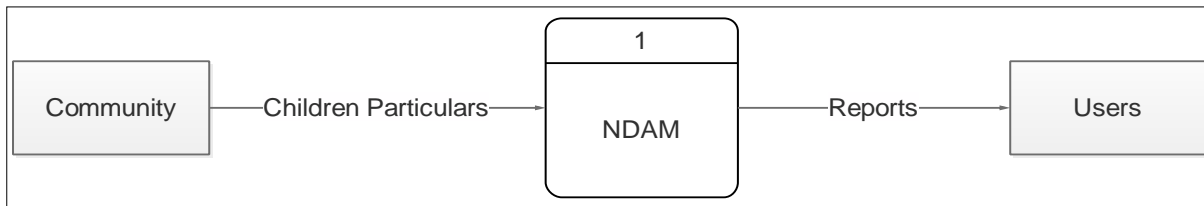


Figure 3: Context DFD

3.6.5 Level – 0 DFD

Expanding the context diagram, the level 0 diagram was created by breaking down the nutritional data analytic module as identified in the context diagram (see Figure 4 below).

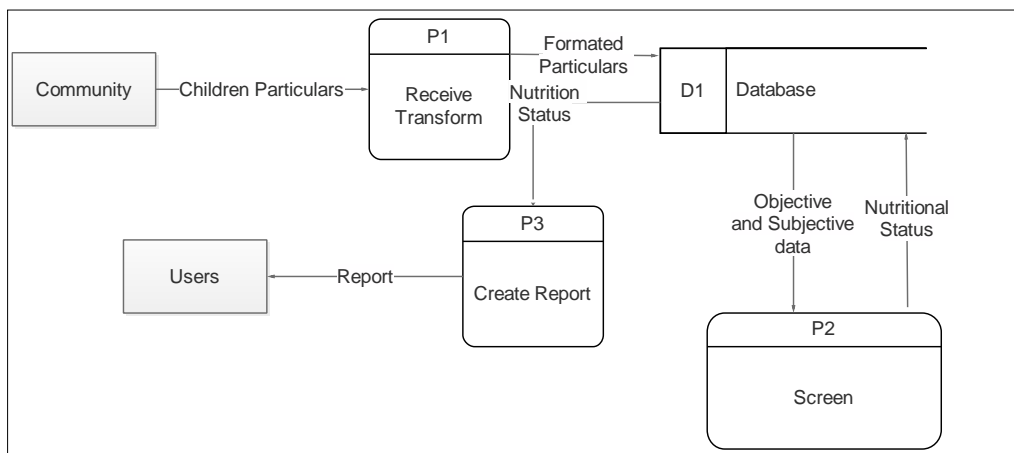


Figure 4: Level 0 DFD

3.7 Conclusion

Effective nutrition screening is the gateway to healthy children and society. However, it remains inaccessible to many children especially in developing countries including Tanzania. Lack of advanced nutrition screening tools and the challenges of using inappropriate screening tools are

major reasons that hinder efforts to combat malnutrition in Tanzania. To partly address this challenge, this system design is proposed to provide efficient and reliable nutritional screening with specific user requirements. This chapter has discussed the system's requirements and design, which provides a foundation for implementing the phases of nutrition screening system with improved feedback from users during phase testing.

CHAPTER FOUR

An Analytic Module to Improve Nutrition Screening for Children Under-five Years at Maternal and Child Health (MCH) Facilities

Summary

For years, we have been witnessing malnutrition taking life of almost half of all children under-five years in the world. Additionally, malnutrition has many effects to individuals including mortality and disability, which are temporary ones, and low intellectual ability and low productive performance, which are permanent. National and international organizations have been struggling to combat malnutrition and its effects. Identification of malnourished children and provision of proper treatment thereafter are important p to be taken. Various nutrition screening and assessment tools have been developed and are used to facilitate the process of identifying malnourished children. Most tools are developed for specific purposes such as identifying nutritional status or to identify the need of nutrition intervention, and for a specific setting such as community, hospital or home care. Due to the diverse nature of nutrition screening, there has been an unnecessary struggle to device nutrition screening tools for the individual communities. In this paper, we propose and design a generic but reliable and effective nutrition screening system for performing nutrition screening and establish extent. When used such a system will quicken and perfect nutrition screening process, improve productivity of nurses, and enhance utilization of anthropometric and other clinical data.

4.1 Introduction

Malnutrition is defined as the condition that hinders good health, which is mainly caused by inadequate or unbalanced food intake or poor absorption of nutrients (FAO, 2008).It can be in form of under-nutrition, where by the overall nutrient intake is low, or over-nutrition where by the overall nutrients intake has exceeded not limits (“Defining Hunger,” 2012). Malnutrition has been mentioned as one of the major health challenges in developing countries(UNICEF, 2009). In sub-Sahara African countries, malnutrition is associated with about 45% of deaths of children under five years (Black et al., 2013; Bhutta et al., 2013).In Tanzania, 42% of children under five years are affected and 600,000 are estimated to have died due to malnutrition (Andrews, 2015; Ministry of Health and Social Welfare, 2008; Survey & Findings, 2010; Note, 2010). Malnutrition is also the leading cause of diseases as it lowers body immunity; this makes

children to die with diseases they could survive if they were nourished (Note, 2010; Matthias, 2003; Foster, Parr, & Wright, 2005). Furthermore, malnutrition retards children's physical and cognitive development, which results to poor work performance in adulthood (Ramani & Souza, 2014). Malnutrition is a major problem in public health; its effects and consequences are a burden to the individual, society and nation as well (Bain L. *Eet al.*, 2013).

Despite the effects malnutrition has to a child, it is often unrecognized and goes untreated (Cao *et al.*, 2014). Effective nutrition screening will not only identify malnourished children for treatment but also reduce the burden of malnutrition on health facilities, society and the nation at large. Nutrition screening, which is the process of identifying individuals who are malnourished or at risk of becoming malnourished, and nutrition assessment, which is the process of establishing nutritional status and energy requirement, are both highly recommended (Santarpia, Contaldo, & Pasanisi, 2011). The two processes therefore are essential processes towards combating malnutrition. Numerous nutrition screening tools have been developed for use in different contexts to facilitate the nutrition screening process. Many of these tools are facility and community specific and offer very limited flexibility in terms of optimizing the parameters. The tools are mostly manual and therefore do little to improve productivity of care facilities which are normally burdened by huge number of patients. There is no golden nutrition screening tool that is accepted worldwide for malnutrition and malnutrition risk identification as well as detecting individuals who need nutritional intervention (van Bokhorst-de van der Schueren *et al.*, 2014). This is a major challenge towards combating malnutrition. This study proposes and designs a nutritional screening system that will facilitate nutrition screening process at health facilities. The system can help to quicken and perfect nutrition screening process at a facility, improve productivity of nurses, and enhance utilization of anthropometric and other clinical data.

4.2 Literature Review

Nutrition Screening Tools (NST) facilitates nutrition screening or nutrition assessment processes. It is argued that NST should be quick and simple to use while maintaining their validity and reliability. Moeeni & Day (2012) identify different categories of NST: there are simple tools such as Mid Upper Arm Circumference (MUAC) and standard deviation that measure the distance between the child's value and the expected value of the reference (z-score), and sophisticated tools such Nutrition Risk Score (NRS), Simple Paediatric Nutritional Risk Score

(SPNRS), Subjective global Nutritional Assessment for children (SGNA), Screening Tool for Assessment of Malnutrition in Paediatric (STAMP), Screening Tool for Risk on Nutrition and Growth (STRONG_{kids}) and Paediatric Yorkhill for Malnutrition Score (PYMS)(Moeeni & Day, 2012).

Z-score is a widely recognized system for expressing anthropometric values in a number of standard deviations. In screening children nutrition, the most common anthropometric nutrition indicators such as weight for height, weight for age and weight for height are interpreted using a z-score (Matthews, Billiet, & Borrell, 1983). However, although z-score is a recognized descriptor of malnutrition, studies show that it has some limitations. The z-score cannot be appropriately use on individual bases; it is sex dependent as it has different values for each sex (De Onis & Blössner, 1997b). Furthermore, the z-score's complex computations make it less usable at most community health facilities.

MUAC is the circumference of the left upper arm; it is useful in screening of nutritional status. MUAC has been in use for some time and it has been recommended as the best for nutrition screening of children under-five years and for adult during famine (Rahma A, 2001; Manary & Sandige, 2008). Its simplicity in use makes it a preferable indicator over other nutritional indicators although it lacks solid cut-off points in reference to age and ethnicity. Also errors arise in MUAC measurements, and lack of reproducibility in measurement makes some health centres and agencies to be sceptical on using it (Ouannes, Shepherd, Goossens, Bekele, & Yun, 2012; Saeed, Mogendi, Akparibo, & Kolsteren, 2015; Collins, Duffield, & Myatt, 2000).

STRONG_{kids} is a nutrition screening tool used for children. A study done by Huysentruyt *et al* (2013) reviewing the validity of STRONG_{kids} in nutrition screening showed that it is an appropriate tool for nutrition screening in hospitalized children. However, another study compared three nutrition screening tools, namely STRONG_{kids}, STAMP and PYMS in evaluation of nutrition status; the study results showed that among the three, PYMS is the most reliable tool (Humphrey, Dinakar, City, Padron, & Hernandez-trujillo, 2014). STAMP is quick and easy tool to use; it is developed for children aged two years and above. A study done by McCarthy *et al*, comparing STAMP with dietetic specialist assessment showed the sensitivity, specificity and positive values shown by STAMP are in line with general expectations results of a screening tool (Wong, Graham, Harini, Grimble, & Forbes, 2012). SGNA successfully screens children nutrition and categorizes screened children into well nourished, moderately malnourished and

severely malnourished categories. Due to its ability of identifying children with malnutrition and categorize according to malnutrition extent, (Secker & Jeejeebhoy (2007) recommend SGNA as the valid tool for assessing nutritional status in children.

Numerous Screening tools have been developed and used for nutrition screening in children. But none of them is adequately capable of screening nutrition. Some scholars argue that development of new NST is redundant and it might not lead to new insights (van Bokhorst-de van der Schueren *et al.*, 2014). However, it is important to consider that nutrition screening tools are designed and developed for diverse purposes, for use by people with different backgrounds, and for application in one or more specific settings and for one or more specific disease groups (Joosten & Hulst, 2014). Also for better nutrition screening results, the nutrition screening tool should be developed specifically for intended group (Phillips *et al.*, 2010). Nevertheless, these nutrition screening tools for children mentioned above were developed in developed countries. Given the differences in nutritional status between developed and developing countries, applicability and validity of these tools in developing countries context like Tanzania may vary substantially and make a tool inappropriate (Van Bokhorst-de van der Schueren *et al.*, 2014). Therefore, the ideal nutrition screening tool for the Tanzanian context that can be quick and reliable in identifying the nutritional status of children is highly recommended.

4.3 System Design

In designing the system Unified Machine Language (UML) were used to design the algorithm/ flowchart of the system. The module were developed using PHP and JavaScript programming languages and MySQL database.

4.3.1 System Definition

Nutrition Screening System is a module based system that will facilitate nutrition screening process at health facilities, and provide real-time results and reports on nutrition status, nutrition progress and malnutrition trend. The development of the nutrition screening system aims to support malnutrition management by facilitating quick and reliable nutrition screening.

4.3.2 Requirement Specification

The nutrition screening system will be used for nutrition screening of children under five years. Therefore, the system should be able to register and maintain child's records, use the child's anthropometric measurements to establish nutrition status, provide real-time nutrition status and nutrition reports. The system requirements are described in Table 2 below.

Table 2: Specific System Requirements

Requirement	Purpose	Rationale
Child Registration	Required for child registration	Registration allows entrance of the child's particulars into the system.
Nutrition Screening	Required for nutrition screening	Nutrition screening allows identification of the malnourished child, establishment of the extent the child is undernourished and the progress the child has made after starting the care plan.
Reporting	Required for report creation	Report creation allows dissemination of nutrition related data and information and malnutrition trend.
Nutrition Progress Establishment	Required for monitoring nutritional progress	Nutrition Progress establishment allows monitoring of children nutritional progress to children who are under malnutrition treatment (care plan)
Malnutrition Extent Establishment	Required for malnutrition magnitude establishment	Malnutrition extent establishment allows identification of malnutrition magnitude to a child

4.4 Nutrition Screening Process flow

Figure 5 shows the nutrition screening process workflow for the proposed nutrition screening system. To accomplish the nutrition screening task, several sub-processes are included as shown in the nutrition screening process workflow.

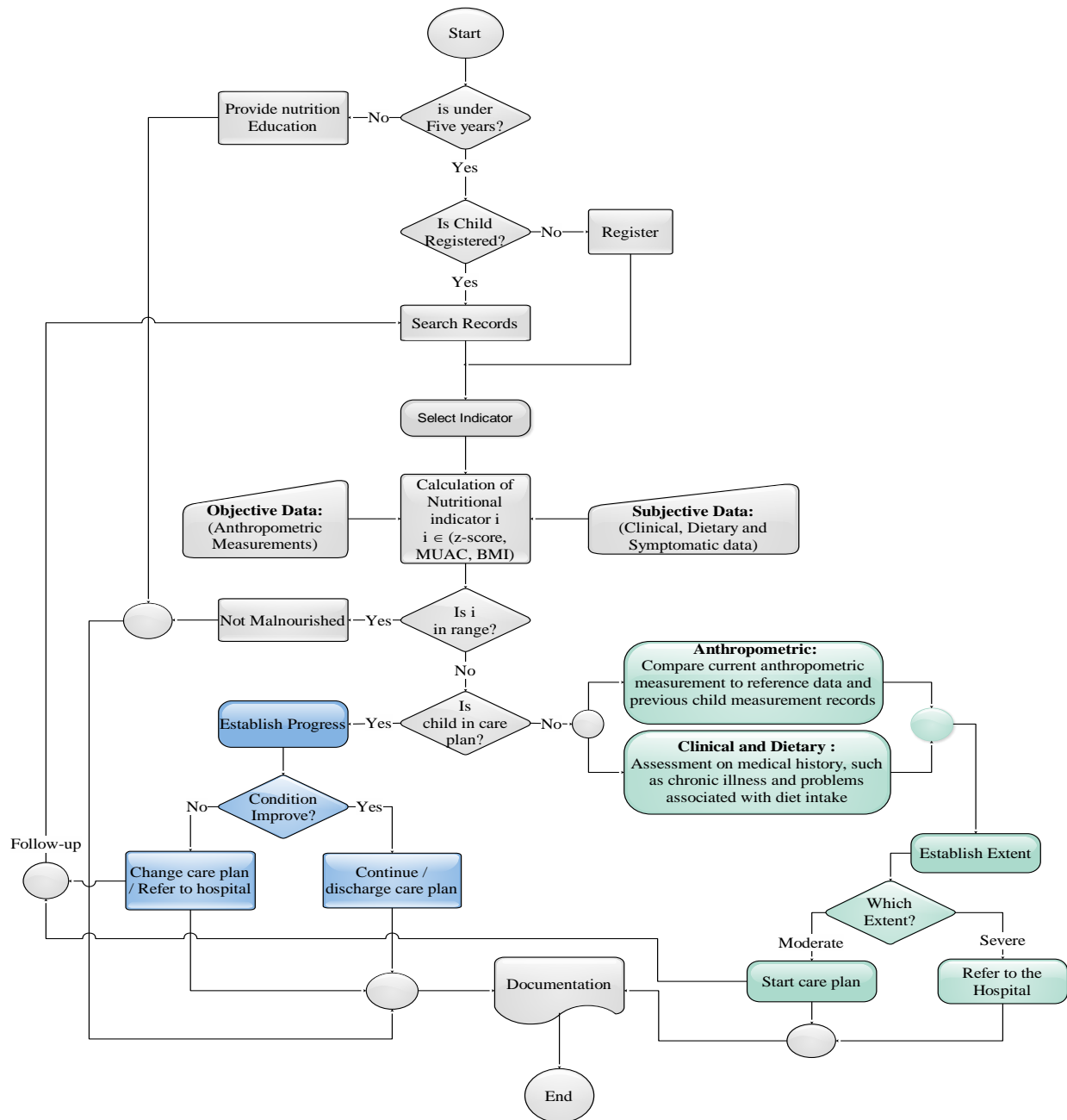


Figure5: Nutrition screening process flow

4.5 Individual components of the nutritional screening process and their contribution to the overall nutritional screening process

Each of the individual components is significantly correlated with the overall nutritional screening process. For nutrition screening, the most important components are measurements, calculation of nutritional indicator score, progress establishment and extent establishment.

4.5.1 Process Inputs

Objective data; The objective data will be obtained from anthropometric measurements, which are weight in kilogram (kg), height in centimetre (cm) and MUAC in millimetres (mm).

Subjective data; the subjective data will be obtained from clinical and dietary records; symptomatic data will also be captured from the child's physical appearance. This data will include clinical, dietary and symptoms information as shown in Table 3 below.

Table 3: Subjective data

Category	Subjective data
Clinical	Chronic illness
Dietary	Problem in food intake
Symptoms	Oedema (water retention)

4.5.2 Calculations of Nutritional Indicators

The main objective of the nutrition screening system is to establish nutrition status. MUAC tape and z-score formula will be used to find the nutritional indicator value, for this case child's arm circumference and z-score value.

Z-SCORE

The following z-score formula will be used:

$$i = \frac{\text{Child's measurement} - \text{Reference median}}{\text{Reference Standard Deviation}}$$

Key:

- i is z-score value obtained
- Child Measurement – weight or height of a child at age X
- Reference Median – Mean or 50th percentile of the reference population at age X
- Standard Deviation – Standard deviation of the reference population at age X
- X – Child's age

Table 4: Cut-off points

Indicator	Severe Malnutrition	Moderate Malnutrition	Adequate Malnutrition
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Mid Upper Arm Circumference(MUAC)	MUAC >110 mm and <115mm	MUAC > 115 and < 125 mm	
Z-Score	Z-score < - 3	-3 < Z-score < - 2	-2 < Z-score < + 2

Source-(CDC&WFP, 2005)

4.6 Nutritional Progress Establishment

To monitor child's condition and to identify whether the child is recovering from malnutrition or not, the system will establish a nutrition progress. Nutrition indicators used in nutrition screening will establish progress whereby running average method will be used. The decision on whether the child is progressing well or deteriorating will depend on the slope of the last two points of the graph. The positive slope of the graph will denote progress, the negative slope of the graph will denote deterioration, and the zero slope will denote that the child is stagnant (see Figure 6 below).

Nutrition Progress Establishment

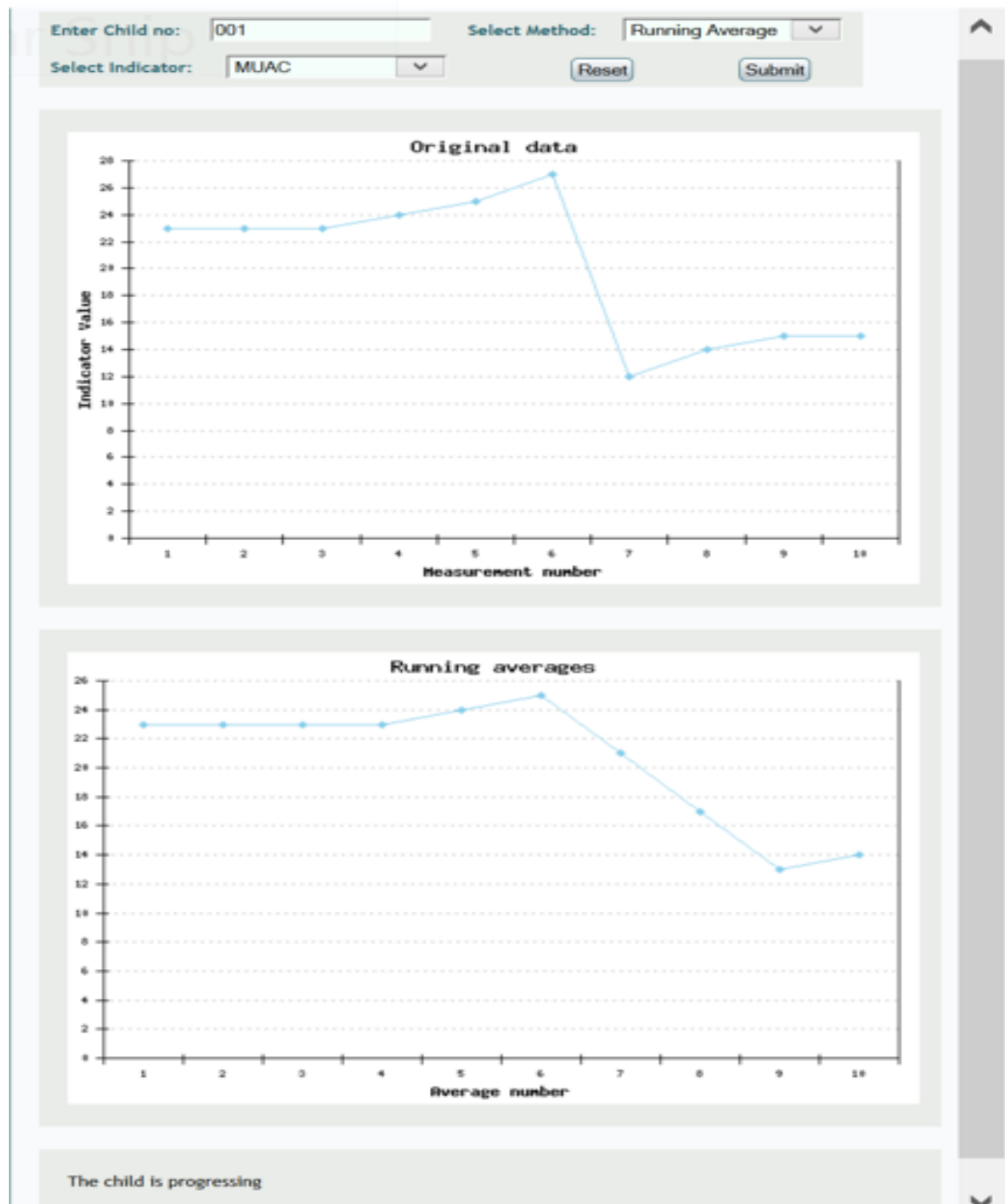


Figure 6: Nutrition progress graph

4.7 Rule based malnutrition extent

To establish magnitude of malnutrition in a child, we use a rule based approach. The decision rules are based on the previous and current anthropometric measurements, clinical data, dietary data, observed symptoms like oedema, and also inputs from local practitioners. In total, the system uses sixty four (64) rules. Below are examples of such rules.

Rule I: If ($AM_P = 0, CD_P = 1, E_P = 1$ && $AM_C = 0, CD_C = 1, E_C = 1$) then the child will be considered as severely malnourished.

Rule II: If ($AM_P = 0, CD_P = 1, E_P = 1$ && $AM_C = 1, CD_C = 0, E_C = 0$) then the child will be considered as moderately malnourished

Rule III: If ($AM_P = 1, CD_P = 0, E_P = 0$ && $AM_C = 0, CD_C = 1, E_C = 1$) then the child will be considered as severely malnourished

Rule IV: If ($AM_P = 1, CD_P = 0, E_P = 0$ && $AM_C = 1, CD_C = 0, E_C = 0$) then the child will be considered as moderately malnourished

Rule V: If ($AM_P = 1, CD_P = 0, E_P = 0$ && $AM_C = 1, CD_C = 1, E_C = 0$) then the child will be considered as severely malnourished

Key:

AM = Anthropometric Measurement

CD = Clinical and Dietary Data

E = Oedema

P = Previous

C = Current

0 = Low and No

1 = Medium and Yes

4.8 Conclusion

This paper describes the design of the nutrition screening system, which will facilitate nutrition screening and assessment. Nutrition screening and assessment are very essential processes for effective malnutrition management. These processes should be simple, easy and rapid to be carried by a health worker. The design combines nutrition screening and assessment because it is of advantageous to have a nutrition screening process combined with nutrition assessment process as it enables identification of not only malnutrition or potential malnutrition risk but also evaluation of nutritional status.

The design incorporates both objective and subjective data; this will enable the system to yield reliable screening results and be applicable in both settings. Most nutrition screening tools assess the risk of malnutrition to a child by using subjective data such as recent weight loss, food intake, disease severity and other measurements of predicting malnutrition risk. These tools left out objective data (anthropometric measurements such as height, weight or MUAC). For this matter, these tools are more appropriate to be used for hospitalized children whose malnutrition condition is due to disease they are suffering from or due to hospital stay and less appropriate to the rest.

CHAPTER FIVE

Nutrition Screening System to Improve Screening Process at Health Facilities: System Evaluation

Summary

The evaluation of the nutritional data analytic module for its appropriateness and effectiveness is an important part of this study. The evaluation process assesses the performance of the module in terms of its ability to identify a malnourished child and the extent to which the child is malnourished. Evaluation will base on the appropriateness, effectiveness and ease of operation of the module. Evaluation results will be regarded as an estimate of the module benefits and success in fulfilling the specified requirements.

5.1 Introduction

System evaluation is the process of assessing the developed system to see if it does what it was supposed to do and if it is working well and it satisfies user requirements. The system should be designed and developed to meet the system and functional requirements specified by the user. Once the system is designed and developed in compliance with the predefined requirements, the next step is to carry out an evaluation of the system to ensure its effectiveness and applicability in performing the projected objective. The main objective of carrying out this evaluation is to verify how well the system fulfils the intended requirements. In order to perform a comprehensive evaluation of the system, the evaluation criteria that address system performance issues need to be developed. This paper identifies and describes the criteria that were used in evaluation process of a nutritional data analytic module.

5.2 Criteria used for nutritional data analytics module evaluation

5.2.1 Accuracy

This criterion refers to evaluating how well the system meets the predefined requirements. As per the functional requirements, the system should be capable of identifying whether the child is malnourished or not. If the child is malnourished, it should be capable of identifying the extent to which a child is malnourished. This criterion also ensures that the system is functionally sound and successfully performs the required manipulations to detect the malnourished child, extent to

which a child is malnourished and the child's nutrition progress. When evaluating the functionality of this module, the features concerned with the module appropriateness were verified. The evaluation checked the following: first, is the module suitable for nutrition screening of children under five years? Secondly, does the system meet the requirements?

5.2.2 Easy Operation and Maintenance

The operation and maintenance of the system is an important factor that was considered during evaluation. The module once installed at MCH centres should be easy to use and maintain. All operations that need to be performed should be simple and obvious. Basically, the system should be user friendly, uncomplicated and designed in such a way that it is hard to make mistakes when using it. When evaluating the operation and maintenance criteria of this module, features relating to easy to use were verified. These features are: first, are all users able to use the module easily and effectively? Secondly, can new users understand and use the module with minimal training?

5.2.3 Efficiency

The efficiency of the system is another important criterion that needs to be evaluated. The efficiency of the system can greatly enhance the adaptability and usability of the system. In evaluating this module, features relating to efficient criteria were used. These are: does the module operate quickly, smoothly and with minimal taskforce? Is the module saving time and resources?

5.3 Evaluation Process

All systems are developed to satisfy certain requirements. These requirements may be easy to state but difficult to measure. In some scenarios, the level to which the system meets the stated requirements can be effectively determined by comparing the before and after states of the scenario. Checking system accuracy, checking against the requirements specification and checking the users' responses are the techniques used in evaluation of the nutrition data analytic module.

5.3.1 Checking System Accuracy

We wanted to evaluate the system using real anthropometric measurements. However, getting such data from hospitals became a challenge. Instead we used synthetic data to evaluate the system.

5.3.1.1 Objectives of system accuracy evaluation

- To test the accuracy and precision of the system in establishing the progress of a malnourished child.
- To test the accuracy and precision of the system in establishing the extent of malnutrition.

5.3.1.2 Data

In collaboration with health facilities, we drafted twelve (12) records (one year period) of anthropometric measurements for eight (8) children. The experts at the facility manually helped to interpret the data by doing the following:

- Stating whether a child's trend constitutes a progress (positive or a negative or a stagnant progress case).
- Stating whether a child is moderately or severely malnourished.

Table 4 below shows sample records of one child for evaluation. A single record contains a record number, the current anthropometric score (i), chronic disease or difficult in food intake status, and confounding factor (oedema). Against each record, the experts provided the two interpretations stated above.

Table 4: Expert Record Interpretation of One Child in a Year

Record No	Score (i)	Confounding factor (oedema)	Chronic disease / difficulties in food intake	Extent	Progress
1	Low	Yes	Yes	Severe	Deteriorate
2	Low	Yes	No	Severe	Stagnant
3	Low	Yes	Yes	Severe	Stagnant
4	Medium	Yes	No	Severe	Stagnant
5	Low	Yes	No	Severe	Progress
6	Low	No	No	Severe	Progress
7	Low	No	No	Severe	Progress
8	Medium	No	No	Moderate	Progress
9	Medium	No	No	Moderate	Progress
10	Medium	No	No	Moderate	Progress
11	Medium	No	No	Moderate	Progress
12	Medium	No	No	Moderate	Progress

Of the eight children five (5) had moderate malnutrition and three (3) had severe. The number of children progressing positively was six (6), while those progressing negatively were two (2).

5.3.1.3 Method and results

The proposed system was used to interpret the data records. That is, when each child's record data were fed into the system, the system suggested the extent of malnutrition and whether there was a progress. We then compared the results against the recommendation by the expert by establishing accuracy and precision using the below formulas.

$$\text{Accuracy} = (\text{TP} + \text{TN}) / (\text{TP} + \text{FP} + \text{TN} + \text{FN})$$

$$\text{Precision} = \text{TP} / (\text{TP} + \text{FP})$$

For extent:

TP = Number of moderate cases by the system which are also moderate by the expert.

TN = Number of severe cases by the system which are also severe by the expert

FP = Number of moderate cases by the system but are severe by the expert.

FN = Number of severe cases by the system but are moderate by the expert.

For progress:

TP = Number of positive progress cases by the system which are also positive progress cases by the expert.

TN = Number of negative progress cases by the system which are also negative progress cases by the expert

FP = Number of positive progress cases by the system but are negative progress by the expert.

FN = Number of negative progress cases by the system but are positive progress by the expert.

The results were as shown in Table 5 below.

Table 5: Accuracy and Precision Results

Indicator	Accuracy %	Precision %
Progress	100	92.3
Extent	100	100

5.3.2 Checking against the requirements specification

Under this technique, we used the requirements specification document, going through the requirements one by one to check if they have been met. We also used validation and verification tests to verify if the system is performing the required functionalities and if the intended functionalities are performed in the right way. To achieve this, a series of tests such as function, integration and system tests were done.

- **Function Test**

The three sections of the system, registration, nutrition screening and report creation, were tested separately. The aim was to ensure if each function works well and performs what it was supposed to do.

- **Integration Test**

Each section was integrated into the large system and integration testing was conducted. This was conducted purposely to check if all sub-systems were communicating effectively.

- **System Test**

The entire system was tested to ensure it functions efficiently as a single unit and displays sensible outputs. In general, this test was to ensure that the system performs its functions as intended in fulfilling the requirements.

5.3.3 Checking the Users' Responses

To get feedback from the users, qualitative methods were used. Specifically, we deployed the questionnaire method in data collection and Microsoft Excel software in data analysis. The feedback was collected from sixteen (16) health workers and two (2) information technology specialists. Health workers are from five different MCH centres.

5.3.3.1 Data Presentation, Interpretation and Discussion of User's Responses

Nutritional data analytic module was evaluated to check whether it is suitable for nutrition screening of children under five years. A total of 10 respondents, which is equivalent to 55.6% of all respondents agreed, 6 respondents equivalent to 33.3 % of all respondents strongly agreed, 1 respondent equivalent to 5.6% of all respondents disagreed and 1 respondent equivalent to 5.6% of all respondents was neutral. The interpretation shows that 88.8% of all respondents agreed that

this system is suitable for nutrition screening of children under five years. This means that the module is suitable for nutrition screening in children below five years in the Tanzanian context.

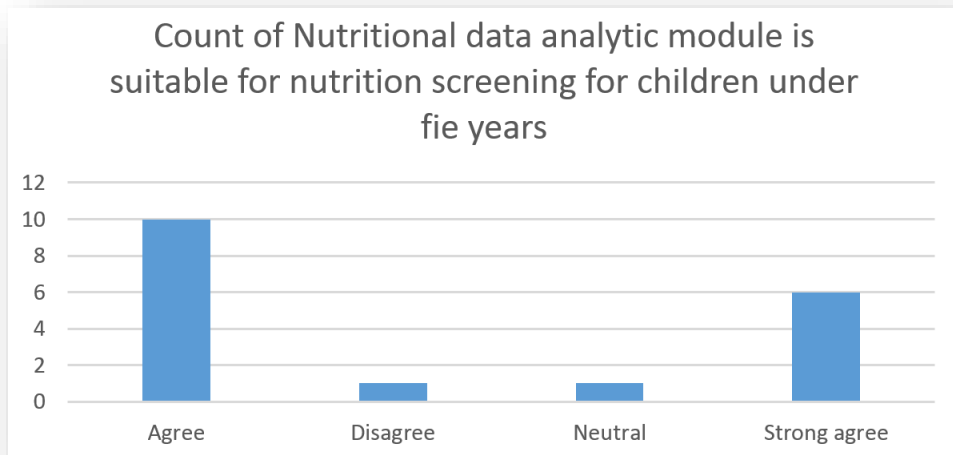


Figure 5: User response graph 1

A total of 17 respondents, which is equivalent to 94.4% of all respondents, agreed that a nutritional data analytics module can identify malnourished children. Only 1 respondent equivalent to 5.6% of all respondents disagreed. This means that the module is functionally sound and successfully performs the required manipulations to detect the malnourished children also it satisfied user requirements.

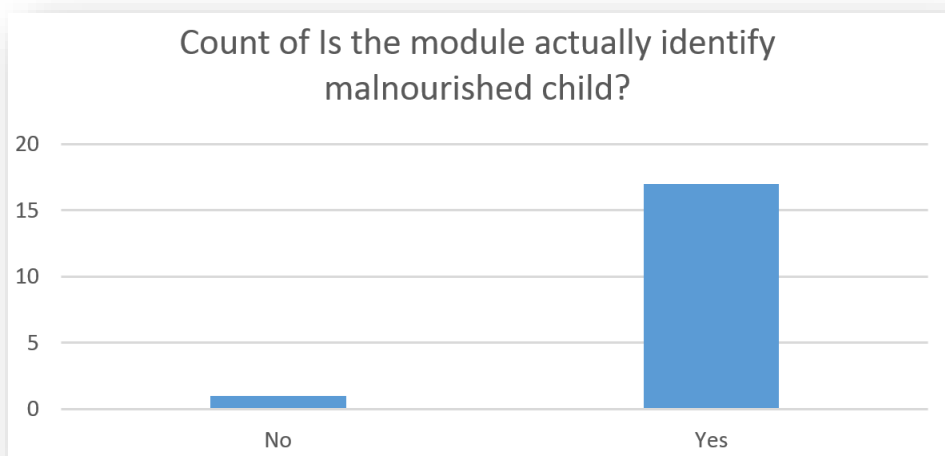


Figure 6: User response graph 2

Figure 9 shows that 11 respondents equivalent to 61% of all respondents, thought that by using this module they will be able to perform nutrition screening process of 50 children and above every day. This means that the nutrition data analytics module is efficient; it operates quickly, smoothly and with minimal taskforce. This also means that the module saves time and resources.

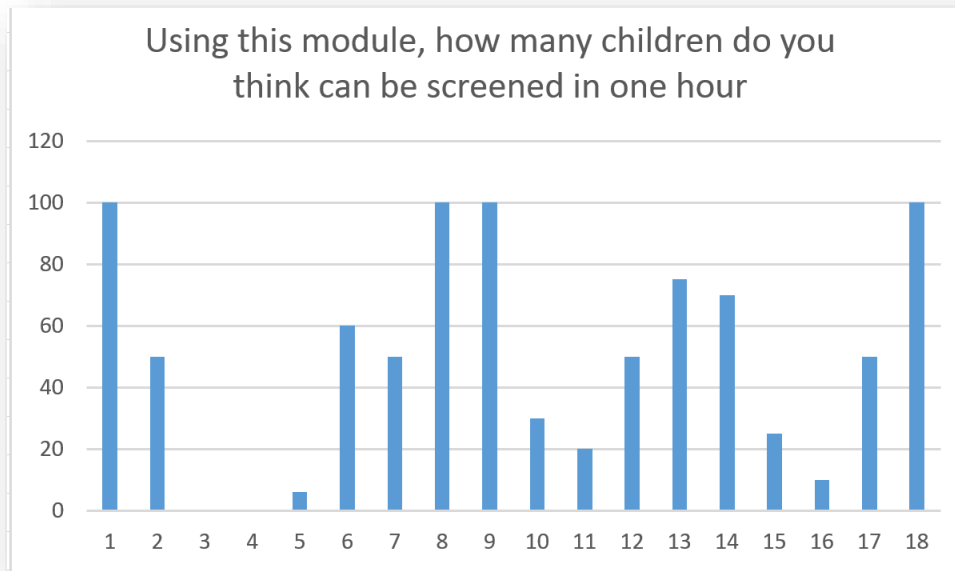


Figure 7: User response graph 3

In Figure 10, we see that 11 respondents equivalent to 61% of all respondents found it is easy to use the module, 6 respondents equivalent to 33.3 % of all respondents found it difficult to use the module while 1 respondent equivalent to 5.6% of all respondents found using the module is neither difficult nor easy. This means that the users will be able to use the module easily and effectively.

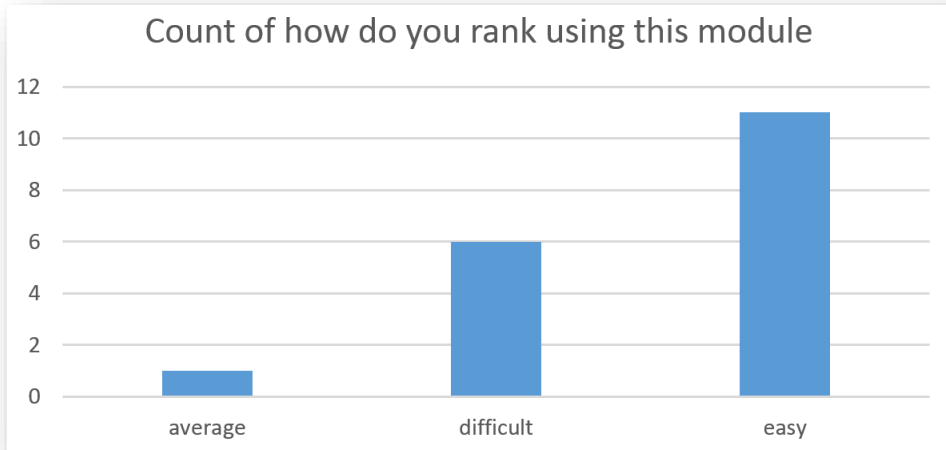


Figure 8: User Response graph 4

Figure 11 shows that 11 respondents, which is equivalent to 61% of all respondents, were able to complete screening process to a child within ten minutes. This means that the nutrition data analytics module is efficient; it operates quickly and smoothly.

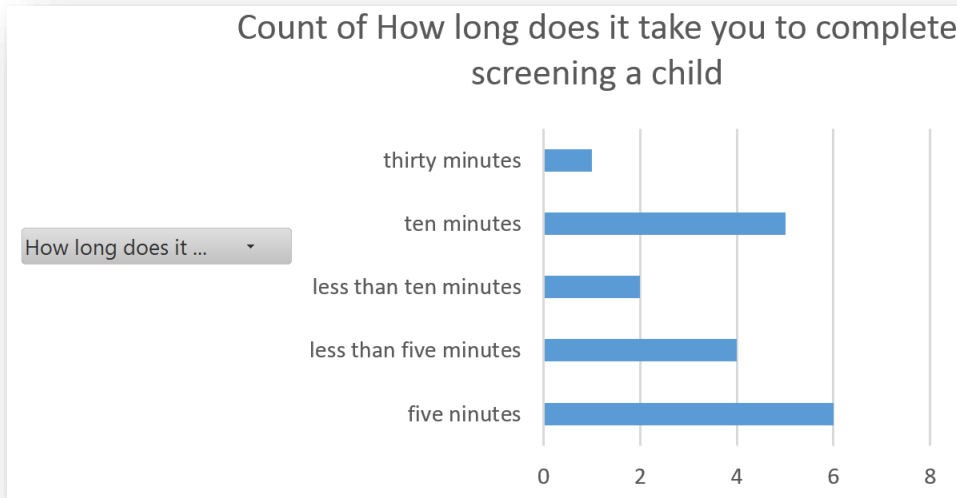


Figure 9: User response graph 5

5.4 Conclusion

The aim of this paper was to test the usability of the developed nutritional data analytics module for nutrition screening. A series of tests were done and user responses on the use of the system were collected and analysed. Interpretation was done and the overall results show that the module is suitable for nutrition screening of children under five years in Tanzania.

CHAPTER SIX

GENERAL DISCUSSION, CONCLUSION AND RECOMMENDATIONS

6.1 General Discussion

Early diagnosis of malnutrition is a crucial step in effective malnutrition management. In this study, we have found that nutrition is neglected in maternal, newborn and child health care despite the rate of malnutrition being unacceptably high in Tanzania. The study also found that systems for malnutrition management are relatively unstable and MUAC is almost the only means of nutrition screening used in malnutrition identification. We understand that nutrition screening is important and strengthening the nutrition screening process by introducing new sophisticated tools is challenged by the limited development in technology especially in the rural parts of Tanzania. But the sophisticated system with simple and affordable technology can be effective and reliable in nutrition screening. And this study has discussed the design and development of a nutrition screening system that is effective and reliable in screening nutrition status and malnutrition management of children under five years at health facilities in Tanzania.

When the prevalence of malnutrition in children under five years especially in developing countries like Tanzania is relatively high, the risk of malnutrition increases dramatically in communities and even in hospitalized children. Malnutrition has high impact on children's health. However, experience reveals that children who are malnourished when admitted to the hospital tend to have longer hospital stay, experience more complications and have high risk of morbidity and mortality than those whose nutrition state is good.

By identifying children who are malnourished or at risk of malnutrition either in the hospital or community settings, the developed nutritional data analytic module will allow health workers to intervene as early as possible to provide adequate nutritional support, prevent further deterioration and improve children's health.

The literature reveals that biochemical measurements can contribute to nutritional assessment but none are always a reliable measure of nutritional risk. Furthermore, the studies reveal that there is no alternative to measurements of weight and height along with other anthropometric measures in nutrition screening and assessment.

6.2 Conclusion

The study presented Information and Communication Technology (ICT) based means of nutrition screening. With this analytic for nutrition screening process has simplified and yet improved. The analytic module so improved has the capability of nutrition screening and assessment also the system is capable of establishing the extent to which a child is affected by malnutrition. Moreover the progress of a child who is under care plan can be established this allows the health worker to have a right decision on the care plan they are providing to a child. Different data, information and reports can be extracted from the module, this includes annual, quarter, monthly and weekly data and reports on malnutrition trend, this will help health practitioners, government and other stakeholders to have right information for decision making.

6.3 Recommendations

With regard to the findings of the study, we highly recommend nutritional data analytic module for nutrition screening of children to be implemented in Tanzania. Malnutrition prevalence in children under five years is unacceptably high, the impacts of malnutrition on children's health are visible and the burden to health centers is unbearable. The nutritional data analytic module developed in this study is capable of identifying the child who is malnourished and categorizes the extent to which the child is affected by malnutrition, hence give health workers better chance to intervene and provide treatment. The module uses objective data (anthropometric measurements) in nutrition screening and assessment for valid and reliable screening results. Furthermore, the module uses subjective data which accommodates all other factors left out by objective data and hence provide better interpretation of the malnutrition results and more ability to generalize the screening results.

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APPENDICES

Appendix 1: Login interface



Appendix 2: Child registration

The screenshot displays a web browser window with the URL `127.0.0.1/nutritionprogress/register.php`. The page title is "Data Analytic Module for Children Nutrition Screening". On the left, a sidebar menu contains links: Home, Registration, Add Anthropometric Data, Progress Monitor, and Reports. The main content area is titled "Registration" and contains a form with the following fields: "Child No:" (012), "Full Name:" (Annalvana Nzilano), "Date of Birth (dd/mm/yyyy):" (27/05/2016), and "Address:" (Moshi). Below the form are "Reset" and "Add" buttons. The Windows taskbar at the bottom shows the time as 12:20 PM on 14-Apr-16.

Registration	
Child No:	012
Full Name:	Annalvana Nzilano
Date of Birth (dd/mm/yyyy):	27/05/2016
Address:	Moshi
<input type="button" value="Reset"/> <input type="button" value="Add"/>	

Appendix 3: Child anthropometric data entrance

The screenshot displays the same web browser window with the URL `127.0.0.1/nutritionprogress/add_data.php`. The sidebar menu is identical to the previous screenshot. The main content area is titled "Add Anthropometric Data" and contains a form with the following fields: "Child No:" (012), "Height (cm):" (26), "Weight (Kg):" (14), and "MUAC Value (mm):" (115). Below the form are "Reset" and "Save Data" buttons. The Windows taskbar at the bottom shows the time as 12:24 PM on 14-Apr-16.

Add Anthropometric Data	
Child No:	012
Height (cm):	26
Weight (Kg):	14
MUAC Value (mm):	115
<input type="button" value="Reset"/> <input type="button" value="Save Data"/>	

Appendix 3: Nutrition screening

The screenshot shows a web browser window with the URL `127.0.0.1/nutritionprogress/save_test_data.php`. The page title is "Data Analytic Module for Children Nutrition Screening". On the left is a sidebar menu with links: Home, Registration, Add Anthropometric Data, Progress Monitor, and Reports. The main content area is titled "Add Anthropometric Data" and contains the following fields and controls:

- Child No:
- Height (cm):
- Weight (Kg):
- MUAC Value (mm):
- Buttons:

Below the input fields, a red message states "Data saved Successfully!". To the right of this message, it says "Test no: 9".

Under the "Z-score:" heading, it displays: "The Z-score value is: 0" and "The initial interpretation indicates: Adequate!".

Under the "MUAC:" heading, it displays: "The MUAC value is: 125" and "The initial interpretation indicates: Adequate!".

The Windows taskbar at the bottom shows the time as 7:10 AM on 20-Nov-15.

Appendix 4: Malnutrition Extent Establishment

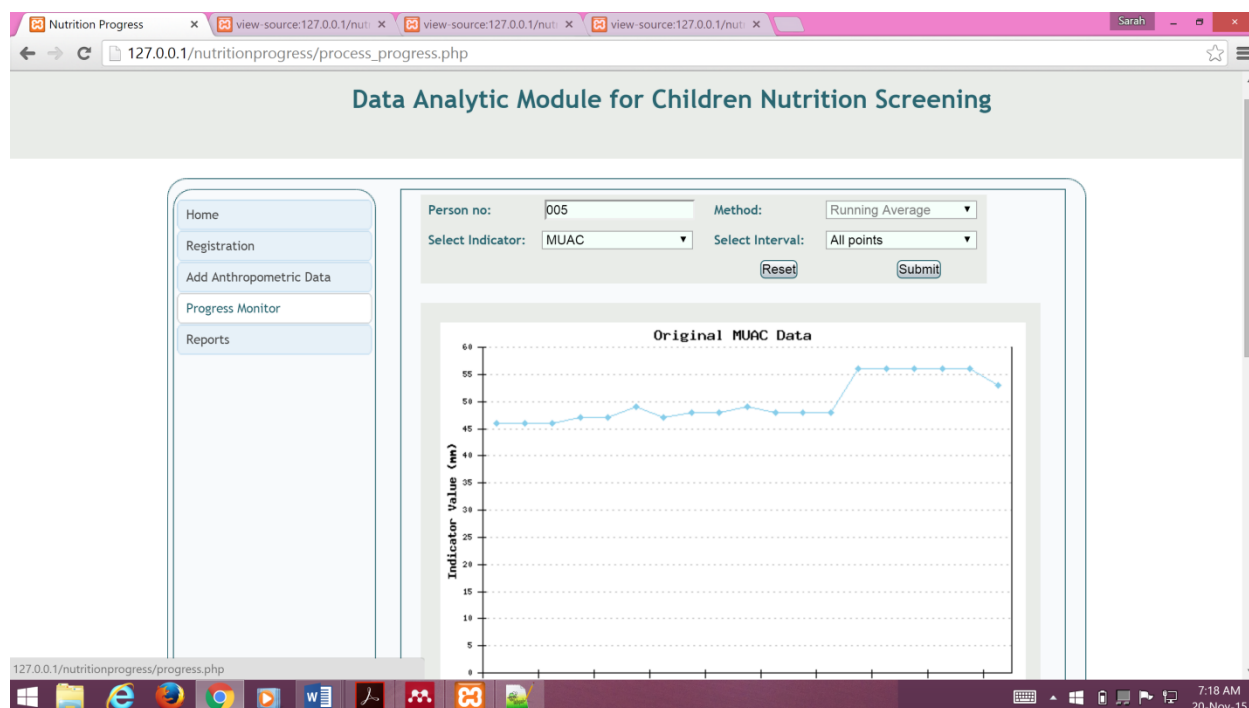
The screenshot shows a web browser window with the URL `127.0.0.1/nutritionprogress/extent.php`. The page title is "Data Analytic Module for Children Nutrition Screening". The sidebar menu is identical to the previous screenshot. The main content area is titled "Clinical and Dietary Data" and contains the following fields and controls:

- Edema?:
- Chronic Disease or Problems in Food Intake?:
- Buttons:

Below these fields is a "Comments" section with a text area containing the text: "Severe Malnutrition" and "Please take immediate care of the disease(s)!".

The Windows taskbar at the bottom shows the time as 7:13 AM on 20-Nov-15.

Appendix 5: Nutritional Progress Establishment



Appendix 6: Nutrition screening sample codes

Appendix 6.1 Home Page

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Nutrition Progress</title>

<link rel="stylesheet" type="text/css" href="styles/styles.css" />
<script type="text/javascript" src="javascript/ajax.js"></script>
<script type="text/javascript" src="javascript/curvycorners.js"></script>
<script type="text/javascript">
    addEvent(window, 'load', initCorners);
    function initCorners() {
        var settings = {
            tl: {radius: 20},
            tr: {radius: 20},
            bl: {radius: 20},
            br: {radius: 20},
            antiAlias: true
        };
        var settings2 = {
            tl: {radius: 20},
            tr: {radius: 20},
            bl: {radius: 20},
            br: {radius: 20},
            antiAlias: true
        };
        curvyCorners(settings, "#main");
        curvyCorners(settings2, "#menudiv");
```

```

        //curvyCorners(settings3, "#slogan");

    }
</script>
</head>
<body>
<div id="banner">
<div id="nembo"></div>
<div id="HD1">
<table width="auto" border="0">
<tr>
<td><div align="center">
<strong>
<h2>
Data Analytic Module for Children Nutrition Screening
</h2>
</strong>
</div>
</td>
</tr>
</table>
</div>
<div id="main">
<div id="menudiv">
<div id="menu10">
<ul class="menu" id="menu">
<li>
<a id= "" href="http://127.0.0.1/nutritionprogress/" class="menulink">Home</a>
</li>
<li>

```

```

<a id= "" href="http://127.0.0.1/nutritionprogress/register.php"
class="menulink">Registration</a>
</li>
<li>
<a id= "" href="http://127.0.0.1/nutritionprogress/add_data.php" class="menulink">Add
Anthropometric Data</a>
</li>
<li>
<a id= "" href="http://127.0.0.1/nutritionprogress/progress.php" class="menulink">Progress
Monitor</a>
</li>
<li>
<a id= "" href="http://127.0.0.1/nutritionprogress/reports.php" class="menulink">Reports</a>
</li>
</ul>
</div>
<script type="text/javascript">
    var menu = new menu.dd("menu");
    menu.init("menu", "menuhover");
</script></div>
<div id="content">

</div>
</div>

<div id="footer">

    Copyright &copy; 2015. All rights reserved.
</div>
</body>
</html>

```

Appendix 6.2: Anthropometric calculation codes

```
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Nutrition Progress</title>

<link rel="stylesheet" type="text/css" href="styles/styles.css" />
<script type="text/javascript" src="javascript/ajax.js"></script>
<script type="text/javascript" src="javascript/curvycorners.js"></script>
<script type="text/javascript">
    addEvent(window, 'load', initCorners);
    function initCorners() {
        var settings = {
            tl: {radius: 20},
            tr: {radius: 20},
            bl: {radius: 20},
            br: {radius: 20},
            antiAlias: true
        };
        var settings2 = {
            tl: {radius: 20},
            tr: {radius: 20},
            bl: {radius: 20},
            br: {radius: 20},
            antiAlias: true
        };
        curvyCorners(settings, "#main");
        curvyCorners(settings2, "#menudiv");
//        curvyCorners(settings2, "#footer");
```

```

        //curvyCorners(settings3, "#slogan");

    }
</script>

</head>

<body>

<div id="banner">
<div id="nembo"></div>
<div id="HD1">

<table width="auto" border="0">
<tr>
<td><div align="center">
<strong>
<h2>
    Data Analytic Module for Children Nutrition Screening
</h2>
</strong>
</div>
</td>
</tr>
</table>
</div>
</div>
<div id="main">
<div id="menudiv">

```

```

<div id="menu10">
<ul class="menu" id="menu">
<li>
<a id= "" href="http://127.0.0.1/nutritionprogress/" class="menulink">Home</a>
</li>
<li>
<a id= "" href="http://127.0.0.1/nutritionprogress/register.php"
class="menulink">Registration</a>
</li>
<li>
<a id= "" href="http://127.0.0.1/nutritionprogress/add_data.php" class="menulink">Add
Anthropometric Data</a>
</li>
<li>
<a id= "" href="http://127.0.0.1/nutritionprogress/progress.php" class="menulink">Progress
Monitor</a>
</li>
<li>
<a id= "" href="http://127.0.0.1/nutritionprogress/reports.php" class="menulink">Reports</a>
</li>
</ul>
</div>
<script type="text/javascript">
    var menu = new menu.dd("menu");
    menu.init("menu", "menuhover");
</script></div>
<div id="content">
<fieldset>
<legend>
    Add Anthropometric Data
</legend>

```

```

<form action="save_test_data.php" method="post">
<table class="normal">
<tr>
<td><label>Child No:</label></td>
<td><input name="person_no" type="text" value=""/></td>
<td style="color: red"></td>
</tr>
<tr>
<td><label>Height (cm):</label></td>
<td><input name="height" type="text" value=""/></td>
<td style="color: red"></td>
</tr>
<tr>
<td><label>Weight (Kg):</label></td>
<td><input name="weight" type="text" value=""/></td>
<td style="color: red"></td>
</tr>
<tr>
<td><label>MUAC Value (mm):</label></td>
<td><input name="muac" type="text" value=""/></td>
<td style="color: red"></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><input class="button" value="Reset" type="reset"/>
<td><input class="button" value="Save Data" type="submit"/></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>

```



```

<td colspan="2" style="color: red">
</td>
<td style="color: red">
</td>
</tr>
</table>
</form>
</fieldset>
</fieldset>
</div>
</div>
<div id="footer">
Copyright &copy; 2015. All rights reserved.
</div>
</body>
</html>

```

Appendix 6.3: Nutrition Progress Codes

```

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Transitional//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-transitional.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<meta http-equiv="Content-Type" content="text/html; charset=utf-8" />
<title>Nutrition Progress</title>

<link rel="stylesheet" type="text/css" href="styles/styles.css" />
<script type="text/javascript" src="javascript/ajax.js"></script>
<script type="text/javascript" src="javascript/curvycorners.js"></script>
<script type="text/javascript">
    addEvent(window, 'load', initCorners);
    function initCorners() {

```

```

var settings = {
    tl: {radius: 20},
    tr: {radius: 20},
    bl: {radius: 20},
    br: {radius: 20},
    antiAlias: true
};
var settings2 = {
    tl: {radius: 20},
    tr: {radius: 20},
    bl: {radius: 20},
    br: {radius: 20},
    antiAlias: true
};
curvyCorners(settings, "#main");
curvyCorners(settings2, "#menudiv");
//curvyCorners(settings3, "#slogan");

}
</script>
</head>
<body>
<div id="banner">
<div id="nembo"></div>
<div id="HD1">
<table width="auto" border="0">
<tr>
<td><div align="center">
<strong>
<h2>
Data Analytic Module for Children Nutrition Screening

```

```

</h2>
</strong>
</div>
</td>
</tr>
</table>
</div>
</div>
<div id="main">
<div id="menudiv">
<div id="menu10">
<ul class="menu" id="menu">
<li>
<a id="" href="http://127.0.0.1/nutritionprogress/" class="menulink">Home</a>
</li>
<li>
<a id="" href="http://127.0.0.1/nutritionprogress/register.php"
class="menulink">Registration</a>
</li>
<li>
<a id="" href="http://127.0.0.1/nutritionprogress/add_data.php" class="menulink">Add
Anthropometric Data</a>
</li>
<li>
<a id="" href="http://127.0.0.1/nutritionprogress/progress.php" class="menulink">Progress
Monitor</a>
</li>
<li>
<a id="" href="http://127.0.0.1/nutritionprogress/reports.php" class="menulink">Reports</a>
</li>
</ul>

```

```

</div>
<script type="text/javascript">
    var menu = new menu.dd("menu");
    menu.init("menu", "menuhover");
</script></div>
<div id="content">
<fieldset>
<legend>

                Progress Monitor
</legend>
<form action="process_progress.php" method="post">
<table class="normal">
<tr>
<td><label>Child No:</label></td>
<td><input name="person_no" type="text" value=""/></td>
<td><label>Select Method:</label></td>
<td><select name="method">
<option value="">--Select--</option>
<option value="run_avg" >Running Average</option>
<option value="slope_diff" >Slope Difference</option>
</select>
</td>
</tr>
<tr>
<td colspan="2" style="color: red" align="center">
</td>
<td colspan="2" style="color: red" align="center">
</td>
</tr>
</table>

```

```

<table class="normal">
</tr>
<tr>
<td><label>Select Indicator:</label></td>
<td><select name="indicator">
<option value="">--Select--</option>
<option value="muac" >MUAC</option>
<option value="zscore" >Z-score</option>
<option value="bmi" >BMI</option>
</select>
</td>
<td rowspan="2" align="center">
<input class="button" value="Reset" type="reset"/>
<input class="button" value="Submit" type="submit"/>
</td>
</tr>
<tr>
<td colspan="2" style="color: red" align="center">
</td>
</tr>
</table>
</form>
</fieldset>
<div id="clearfloats"></div>
</div>
<div>
<div id="footer">
</div>
</body>
</html>

```

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