DIAGNOSTIC AND PROGNOSTIC PERFORMANCE OF MID UPPER ARM CIRCUMFERENCE FOR SEVERE AND MODERATE ACUTE MALNUTRITION AMONG UNDER FIVE CHILDREN IN ETHIOPIA

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ACRONYMS

AAH	Action Against Hunger.
AHR	Adjusted Hazard Ratio
AMC	Arm Muscle Circumference
AUC	Area under the ROC Curve
BMI	Body mass index
CDC	Centers for Disease Control and Prevention
CMAM	Community-based management of acute malnutrition
CSA	Central Statistical Agency
DBU	Debere Berhan University
DHS	Demographic and Health Survey
ECD	Early Childhood Development
EDHS	Ethiopian Demographic and Health Survey
FANTA	Food and Nutrition Technical Assistance
FMoH	Federal Minster of Health
GDP	Growth Domestic Product

HAZ	Height-for Z-score
HFA	Height-for-age
HFIAS	Household Food Insecurity Access Scale
HP	Health posts
IMF	International Monetary Fund
IRB	Institutional Review Board
IRR	Incidence rate ratio
IRQ	Intra Quartile Range
JU	Jimma University
MAM	Moderate Acute Malnutrition
MGRS	Multicenter Growth Reference Survey
MTC	Malnutrition Treatment Centre
MUAC	Mid Upper Arm Circumference
NCHS	National Center for Health Statistics
NGO	Nongovernmental organization
OR	Oddis ration
ROC	Receiver Operating Characteristic
SC	Stabilization Center

SAM	Severe Acute Malnutrition
SD	Standard Deviations
SNNPR	Southern Nations Nationalities' and Peoples' Region
SPSS	Statistical Package for Social Sciences
SSA	Sub Saharan Africa
UNICEF	United Nations Children's Fund
USAID	U.S. Agency for International Development
WFA	Weight-for-age
WFH	Weight-for-height
WHO	World Health Organization
WHZ	Weight -for –Height- Z –Score
WLZ	Weight-For-Length- Z- Score
YI	Younden Index

TABLE OF CONTENTS

SUMMARY

Malnutrition refers to shortages, excesses or disparities in a person's intake of energy and/or nutrients leading to two broad groups of conditions including over nutrition and under nutrition. It is an imbalance between the nutrients the body needs and the nutrients it gets and over nutrition or consumption of too much calories or too much of any specific nutrient protein as well as undernutrition or deficiency.

The burden of malnutrition is not equal all over the world and this difference may be linked with more factors like socioeconomic status and health care system. Environmental differences and ethnic variations are may also have an impact on child growth and physical appearance. Many children younger than 5 years in developing countries are exposed to multiple risks. In Africa, the average prevalence of stunting is higher than the global average.

In Ethiopia highest differences on malnutrition in all forms is observed among regions and between residents. There is change in the prevalence of malnutrition however; this change is not uniform across regions showing highest variation. As Ethiopia is home for different ethnic groups, we need to differentiate assessment tools for children from different ethnic backgrounds. The relapse of under nutrition after treatment and time for cure of MUAC is not known for severe acute under nutrition.

Chapter 3; Sensitivity and specificity of mid-upper arm circumference for assessment of severe acute malnutrition among children aged 6-59 months, systematic review and meta-analysis. Search terms used included Sensitivity, specificity of MUAC from April one to nine 2022.

Preferred reporting items for systematic reviews and meta-Analyses (PRISMA) guidelines were followed for this systematic review and meta-analysis. The databases used were; PUBMED, Google Scholar, Jane, and African Journals Online. Joanna Briggs Institute Meta-Analysis and checklist for diagnostic test accuracy studies was used for critical appraisal tools for the studies. The meta-analysis was conducted using STATA 14 software. The pooled sensitivity and specificity were computed to present the pooled sensitivity at a 95% confidence interval.

Results: in this study, eleven individual studies were included in the meta-analysis. The lowest sensitivity of MUAC on detection of SAM was observed as 5% in Vietnam and the highest sensitivity was observed as 57% in Niger.

The pooled sensitivity of MUAC to detect SAM among under-five children was determined as 20.7% (at 95%CI, 13.24- 28.25, P=0.001). Based on the pooled specificity of MUAC in the detection of the severe acute malnutrition is 97.64% (95% CI, 96.34- 98.3 P=0.001), and the pooled optimal cut-off point for diagnosing SAM is determined as 13.23 cm at (95%CI, 12.69-13.76, P =0.001).

The reviews implied that, sensitivity of MUAC is lower compared to the specificity and it also varies from area to area.

Chapter 4; presents frequency of relapse after discharge from management severe acute malnutrition. For this study an institution based retrospective cohort study was done among children admitted to health posts for treatment of SAM from 2014/2015-2019/2020 and all under-five children's after discharge in health post for severe acute malnutrition in the last five years in Hadiya Zone, SNNPR, Ethiopia. Both first admission data and relapse data were abstracted from the records of the SAM children from Aguste 1 – 30, 2020 using a data collection format.

Data were coded and edited manually, then doubly entered into Epi-data statistical software version 3.1 and then exported to SPSS for windows version 26. After checking all the assumptions finally Negative binomial regression for poison has been used, as assumptions for poison regression were not fulfilled. All tests were two sided and P values <0.05 were used to declare statistical significance.

In the last five year the proportion of relapsed cases were 9.6 %(95% CI: 7.7%, 11.7%). On multivariable negative log binomial regression model, after adjusting for background variables relapse of severe acute undernutrition was significantly associated with having edema during admission with (IRR=2.21, 95% CI:1.303-3.732), being in the age group of 6-11 months (IRR=4.74,95% CI:1.79-12.53), lower discharge MUAC for the first admission (P=0.001, IRR=0.37, 95% CI:0.270-0.50) increase the risk of incidence rate ratio(IRR) of relapse case for severe acute under nutrition. In conclusion Frequency of SAM relapse was positively associated with age, having edema during admission, while it was negatively associated with discharge MUAC. The results imply the need for reviewing the discharge criteria considering the recovery of MUAC as a marker for lean tissue accretion, especially in edematous children and those in the younger age.

In Chapter 5, time to relapse after discharge from management severe acute malnutrition was addressed. To identify time of relapse an institution based retrospective cohort study was conducted among children admitted to health posts for treatment of SAM from 2014/2015-2019/2020 and 760 documents were reviewed. Both first admission data and relapse data were abstracted from the records of the SAM children from August one to 30,2020 using a data abstraction form.

The data were coded and edited manually, then doubly entered into Epi-Data statistical software version 3.1 and then exported to SPSS for windows version 26. After checking all the assumptions multivariable Cox regression was fitted. All tests were two sided and P values <0.05 were used to declare statistical significance.

The mean time for relapse of severe acute malnutrition among under five children was determined as 22 at 95% CI, (20.69-24.82) weeks to relapse. On multivariable Cox Proportional Hazards regression model, after adjusting for background variables time for relapse of SAM was significantly associated with edema during admission (AHR,2.02 ,95%, CI: 1.17-3.50), age group of 6-11 months (AHR 5.2,95%, CI:1.95-13.87), less discharge MUAC for 1st admission increase hazard of relapse (AHR 12,95%, CI: 7.90-19.52). In conclusion mean time to relapse was 22 weeks. Edema, age and MUAC were associated time to relapse. The findings suggest the need for following children cured from SAM until for the first 22 weeks.

In Chapter 6; Utilization of mid upper arm circumference as discharge tool for children with SAM in outpatient therapeutic program was determined by using a prospective cohort study among 414 children with severe acute malnutrition under five admitted to 22 selected health posts from February one to August 30,2021 in Habro Worada west Hararghe zone, Oromia, Ethiopia.

Data were coded, entered into Ep-data version 4.2 software and exported to SPSS for windows version 26 software for analysis. After checking all the assumptions, multivariable Cox Proportional Hazards model was fitted to isolate independent determinants of time to cure. All tests were two sided and statistical significance at P values <0.05

In this study the minimum time for cure was 4 weeks, the maximum was16 weeks whereas, and overall mean week to cure from severe acute malnutrition by mid upper arm circumference (MUAC) is determined as 10 weeks at 95% CI (9.65-10.35).

In this study households with family size of six and above were 2.16 times at higher risk of long duration of treatment with (AHR=2.16, 95% CI: 1.53-3.06) compared to those with lower family size. In similar way, children from households with low wealth index were 1.4 times higher hazard of delayed recovery of MUAC. In addition, SAM children from food insecure households were 2.61-time at higher risk of MUAC delayed recovery compared to food secure households.

In conclusion the mean time to cure from severe acute malnutrition by mid upper arm circumference (MUAC) is determined as 10 weeks. Families size six and above, low wealth index category and household food insecurity were identified as risk factors delayed recovery of MUAC. From this study, the findings imply the need for using MUAC as diagnostic and discharge criteria for severe acute malnutrition by increasing the treatment week to 10 and above or until MUAC becomes to 12.5 cm for all under five children irrespective of admission criteria.

Chapter 7; presents optimal cut-off values for MUAC as indicators of under nutrition among different ethnic group of under five children in Ethiopia. To determine the validity and suggest an optimal cut-off point a community based cross-sectional study was conducted among under five children of the three regions namely: Somalia, Amhara and Gambella.

The diagnostic performance of MUAC was validated using weight for height Z-score< -2 as a gold standard binary classifier. Test variable was mid upper arm circumference (MUAC).

ROC analysis was performed based on the assumptions of MUAC value lower than the cut-off point indicates the undernutrition. Areas under the curve and validity measures (sensitivity and

specificity) were generated as parameters. The results were presented using tables and ROC curves.

Except in the Gambella Region, there was fair agreement between MUC<12.5cm and Weight for Height Z score<-2 in diagnosing wasting, in Somali (Sensitivity = 29.3%, Kappa = 0.325, P<0.001) and in Gambella regions (Sensitivity =16.7%, Kappa=0.19, P<0.001). In Amhara region there was fair agreement between the two measures in diagnosing MAM (Sensitivity=16%, Kappa=0.216, P<0.001). For the overall sample, the sensitivity of MUAC<12.5cm was (20.6% Kappa=0.245, P<0.001.

Based on ROC analysis, the optimal cutoff value of MUAC for diagnosing moderate acute malnutrition for the two regions namely for Gambella and Amhara was 13.85cm with sensitivity of 0.99 and specificity of 1.00, respectively. However, for Somali Region the optimal cut was 13.75cm (Sensitivity= 0.98 cm and specificity = 0.71).

The findings revealed that the interrater reliability of measurement for MUAC< 12.5cm and WHZ<-2 for diagnosing MAM was low among different ethnic groups with the cut-off varying in each region. The existing cutoff point is less sensitive for diagnosis of MAM. The new cut off points developed for each region are recommended to be used for screening moderate acute malnutrition to prevent relapse of MAM and reduce chronic malnutrition.

In conclusion, the PhD research provides evidence on the diagnostic and prognostic performance of MUAC for children with severe acute malnutrition. **Chapter 8;** presents the general discussion and implications of the findings on nutrition programming, conclusions and recommendations for further research.

1. CHAPTER 1

1.1. General Introduction

An overview

This chapter includes definition of malnutrition, diagnosis of malnutrition, sensitivity and specificity of MUAC, treatment outcome of malnutrition and prognosis during and after treatment of malnutrition.

1.1. Malnutrition

1.1.1. Definition of malnutrition

Malnutrition refers to shortages, excesses or disparities in a person's intake of energy and/or nutrients and it encompasses two broad groups of conditions over nutrition and under nutrition (Fabiansen et al.,2018). It is an imbalance between the nutrients the body needs and the nutrients it gets and over nutrition or consumption of too many calories or too much of any specific nutrient protein, fat, vitamin, mineral, or other dietary supplement, as well as undernutrition or deficiency (John E. Morley, 2021). It occurs when nutrient intake does not meet the needs for normal body functions and as a consequence leads to alterations of growth and development in children (Larson-Nath and Goday, 2019). Impaired growth may result from a combination of inadequate nutrient intake, increased losses (diarrhoeal episodes, vomiting) and increased energy expenditure usually due to infections (Walton and Allen, 2011). However, some author's arguing that during screening for malnutrition in health care has expanded enormously, a gold standard for the optimal definition and operationalization of malnutrition is still lacking (Meijers et al.,2010).

The high mortality and disease burden resulting from these nutrition-related factors make a compelling case (Black et al.,2008). In all forms, it is associated with images of starving children in addition to that it is more often chronic and lifelong, that begins in early childhood and continues into old age, devastating one generation and passing the miserable legacy on to the next (World Bank,2012, Fabiansen et al.,2018, Global Nutrition Report,2018).

Although malnutrition is a common health and social care problem, there is no universal agreement about its definition, prevalence, or method of identification and report (Elia, 2017). Definitions also varied from non-outcome based to those based on functional, physiological, and/or clinical outcomes. Some definitions depend on the pathways, by which malnutrition develops, with one seemingly requiring loss of fat-free mass (Dipasquale et al., 2020).

As summary from the above reference we may conclude malnutrition as follows; Malnutrition occurs when an individual gets too few or too many nutrients, resulting in health problems. Specifically, it is a deficiency, excess, or imbalance of energy, protein and other nutrients which adversely affects the body's tissues (De Onis et al.,1997). Published evidence which suggests that nutritional status conditions the host to infectious disease (Chandra and Newberne,1977). Undernutrition is a lack of nutrients, which can result in stunted growth, wasting, and underweight. Most clinical studies use the term 'malnutrition' to refer to undernutrition (Saunders et al.,2011). However, the use of 'malnutrition' instead of 'undernutrition' makes it impossible to distinguish between undernutrition and over nutrition, a less acknowledged form of under nutrition (White et al.,2012).

1.2. Epidemiology of under nutrition

Globally, nearly one in four children under age of 5 years (165 million or 26 per cent in 2011) was stunted. Stunting, or low height for age, is associated with impaired brain development, which is likely to have long-lasting negative consequences throughout a child's lifetime (UNICEF,2013). Childhood stunting it shows that gradually declining but still 150.8 million children are stunted. In addition, 50.5 and 38.3 million children were wasted and overweight respectively (Global Nutrition Report,2018). Today, there are more stunted children in Africa than other area and most of the health costs linked with under nutrition occur before the child turns 1 year old (COHA,2014).

There were around 795 million undernourished people in the world in 2014, a decrease of 216 million since 1990, despite the fact that the world already produces enough food to feed everyone (FAO, 2020). According to the World Food Programme, 135 million suffer from acute hunger, largely due to manmade conflicts, climate changes, and economic downturns (WFP, 2020).

One or more forms of malnutrition affect every country in the world (WHO,2021). It is a universal problem that affects most of the world's population at some point in their lifecycle. No country is untouched. It affects all geographies, all age groups, rich people and poor people, and all sexes this indicates that it is a truly universal problem (Global Nutrition Report, 2018).

Burden of malnutrition is not equal all over the world and this difference may be linked with more factors like socioeconomic status, health care system. Environmental differences and ethnic variations may have impact on child growth and physical appearance (Grantham et al.,2007). Child undernutrition is highly prevalent in low-income and middle-income countries (Black et al.,2008). Stunting and wasting remain public health problems in low-income countries, where 4·7% of children are simultaneously affected by both, a condition associated with a 4·8-times increase in

mortality (Victora et al.,2021). Some pocket studies suggest that the majority of the under-nutrition burden exists in sub-Saharan Africa and South-Central Asia (Zulfiqar and Rehana,2012, Zulfiqar A. et al.,2017). In Africa, the average prevalence of overweight is 5.3%, which is lower than the global average of 5.7% and prevalence of stunting is 30.7% - higher than the global average of 22.0%. Conversely, the Africa region's prevalence of wasting is 6.0%, which is lower than the global average of 6.7 % (Global Nutrition Report,2021).

In Ethiopia 36.8% of children, under 5 years of age are stunted and 7.2% of children wasted (Global Nutrition Report,2021). Meta-analysis in Ethiopia reveal that overall estimate of wasting prevalence is 10.6% with highest differences among regions and between residents and refugees (Altare et al.,2016). In addition, consecutive Ethiopian demographic health survey reports from 2000-2016 for the last fifteen years among different regions suggest that there is change time to time in nutritional status of under-five children. However, this change was not uniform across regions; for example, there was highest variation among Amhara and Somalia regions for the last 15 years. There was a slow decrement in the percent of children with stunting in Amhara region but raped decline in wasting again in similar manner there is highest decline in percent for stunting and rising for wasting in Somalia region and similar is true for Gambella regions (CS A and ORC Macro,2001, CS A and ORC Macro,2006, CS A and ICF International,2012, CSA and ORC Macro,2017). Based on this evidence, this dissertation research intended to develop cutoff point of MUAC by considering weight for height as gold standard for three regions those are Amhara, Gambella and Somali Regions and to assess the relapse rate of children after discharge from the treatment program for SAM (Figures 1 and 2).

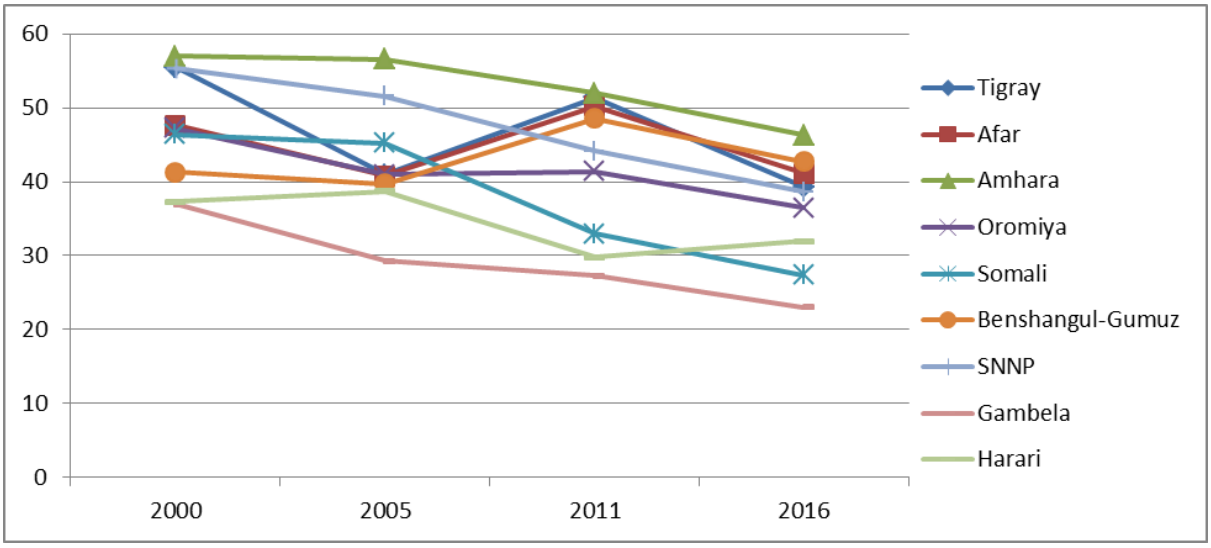

Figure1. Pattern of stunting in different regions of Ethiopia from 2000-2016 EDHS reports (CS A and ORC Macro,2001, CS A and ORC Macro,2006, CS A and ICF International,2012, CSA and ORC Macro,2017).

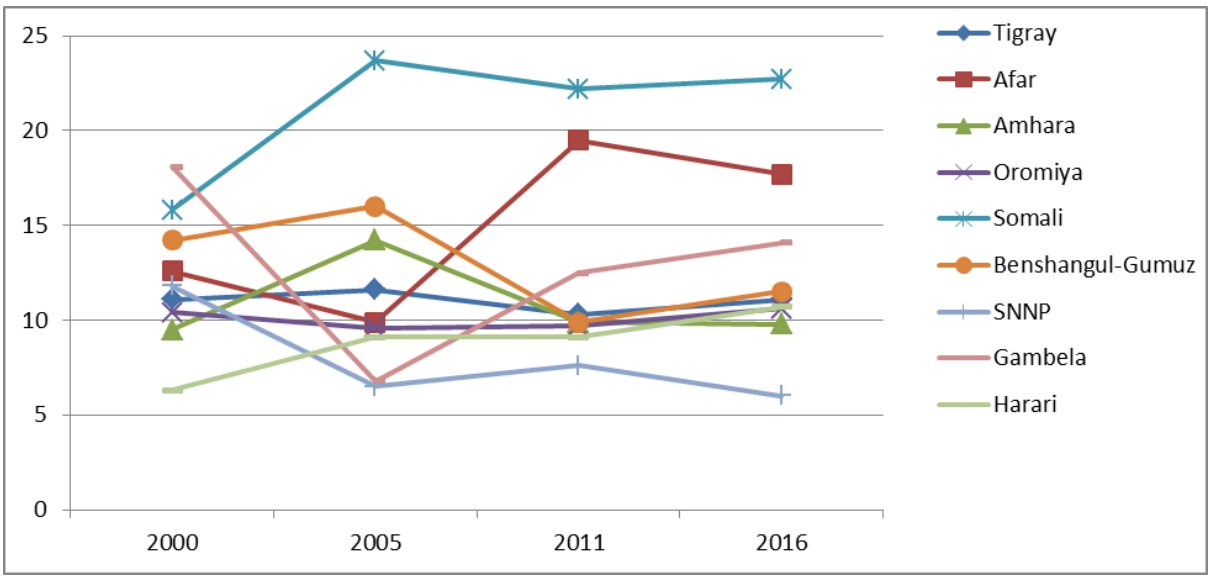

Figure 2. Pattern of wasting in different regions of Ethiopia from 2000-2016 EDHS reports (CS A and ORC Macro,2001, CS A and ORC Macro,2006, CS A and ICF International,2012, CSA and ORC Macro,2017).

1.3. The consequences of malnutrition

The long-term consequences of early malnutrition are now getting increasing attention as better public health measures and medical care ensure the survival of many children with childhood malnutrition who would previously have succumbed (Walton and Allen, 2011). It results in substantial increases in mortality and overall disease burden (Black et al.,2008). It will lead to alterations of growth and development in children eventually to development of chronic disease (Larson-Nath and Goday,2019). It has both a cause and consequence of disease and can lead to increased mortality and morbidity, delayed recovery from illness and impaired body function which can make carrying out activities of daily living difficult (McEvilly,2016). It is characterized by recurrent infections and chronic inflammation, implying an underlying immune defect and these may contribute to intergenerational cycles of malnutrition (Bourke et al.,2016).

Child under nutrition has many unpleasant results on child health during illness and after discharge. Including poverty, malnutrition, poor health, and un stimulating home environments, which detrimentally affect their cognitive, motor, and social emotional development (Grantham et al.,2007). Some studies show that food deficiency affects ability to produce healthy babies, physical performance, mental attitude, and disease experience, irrespective of body size (Calloway, 1982).

Malnutrition during the first years of life has immediate adverse health consequences, including increased mortality risk, and impaired long-term health and capacities and it is an important contributor to poor linear growth, stunting (Neufeld et al.,2020). In addition to that it has long-lasting effects in early life attributed to interconnected biological pathways, involving imbalance of the gut microbiome, inflammation, metabolic dysregulation, and impaired insulin signaling by

imposing a high metabolic load on a depleted capacity for homoeostasis, and in women increases the risk of childbirth complications (Wells et al.,2020). Malnutrition is a direct, immediate cause, not an underlying, indirect cause of death: malnourished children who are ill die because they are malnourished (Habicht,2008).

Poor nutrition or substandard diet quantity and/or quality resulting in under- or over nutrition and the lack of early learning opportunities contribute to the loss of developmental potential and life-long health and economic disparities among millions of children aged <5 years (Hurley et al.,2016). It is associated with lower levels of education that decrease economic productivity and leads to poverty (Rahman and Halder,2021).

Malnutrition is locked in a vicious cycle of increased mortality, poor health, impaired cognitive development, slow physical growth, reduced learning capacity, inferior performance, and ultimately lower adult work performance and productivity (Moench-Pfanner et al.,2016). A vital relationship exists between nutritional status, human capital, and economic standing and it adversely hampers productivity levels, making them and their respective countries more susceptible to poverty (Siddiqui et al.,2020).

1.4. Forms of malnutrition

Malnutrition, in all its forms, includes undernutrition (wasting, stunting, underweight), inadequate vitamins or minerals, overweight, obesity (WHO,2021) and linear growth fiasco is the most common form of under nutrition globally. With an estimated 165 million children below 5 years of age affected, has been recognized as a major public health priority (Andrew J. et al.,2014). The focus of this dissertation is mainly under nutrition or severe acute and moderate malnutrition.

1.4.1. Undernutrition

Undernutrition is a deficiency of calories or of one or more essential nutrients or being unable to properly absorb nutrients from the food one eats to sustain good physical and mental health, for example through illness (Concern Worldwide,2020). Often it is defined as insufficient intake of energy and nutrients to meet an individual's needs to maintain good health (Maleta,2006). There are different forms of undernutrition like, macro nutrient deficiency and micro nutrient deficiency. In addition, under nutrition may be further classified. Sometime deficiencies of vitamins and deficiencies of minerals are considered as separate disorders (John E. Morley 2021).

1.4.2. Moderate Acute Malnutrition

Moderate acute malnutrition (MAM), also known as wasting, is defined by a weight-for-height indicator between -3 and -2 z-scores (standard deviations) of the international standard or by a mid-upper arm circumference (MUAC) between 11 cm and 12.5 cm (AAH,2021).

Moderate acute malnutrition (MAM) or Moderate wasting; as a classification of acute malnutrition and defined by low weight-for-length/height or MUAC (WHO,2009). Measurement of weight for Length or Height (WFL/H) shows how a child's weight compares to the weight of a child of the same length/height and sex in the WHO standards (WFP,2016).

1.4.3. Severe Acute Malnutrition

Children with severe acute malnutrition are among the most vulnerable people in the world because most their fat and muscle has been used by their bodies to stay alive (OCHA,2013).

It manifests by either marasmus, Kwashiorkor, marasmic kwashiorkor or non-edematous malnutrition. Moreover, it may be with the form of severe undernutrition, the child is severely wasted and has the appearance of “skin and bones” due to loss of muscle and fatty tissue. The child’s face looks like an old man following forfeiture of facial subcutaneous fat, but the eyes may be watchful and the ribs are visible (WHO,2022).

Kwashiorkor or edematous malnutrition is another form of severe under nutrition, the child’s muscles were wasted, but wasting may not be apparent due to generalized edema or swelling from excess fluid in the tissues (WHO,2009, UNICEF,2014). Historically Kwashiorkor is from the Ghanaian Kwa language meaning ‘the deposed child’ and relates to the child being displaced from the breast by a newborn sibling (Walton and Allen, 2011).

Children with severe acute malnutrition with loss of appetite or any medical complication have complicated severe acute malnutrition and children who have a good appetite and no medical complication (Pocket Book,2013).

1.5. Nutritional Assessment

The report on prevalence of undernutrition in pediatric patients varies considerably. This disparity is partly due to the diversity of methods for its detection and assessment, as well as to the lack of consensus regarding its definition. Several methods, based on varied combinations of morphology characteristics, estimated nutritional intakes and medical conditions have been developed during the last 25 years (Delvin et al.,2019).

Nutritional assessment is taking anthropometric measurements and collecting information about a client’s medical history, clinical and biochemical characteristics, dietary practices, current treatment, and food security situation and making interpretation (FANTA,2016). Nutritional

assessment is the interpretation of anthropometric, biochemical (laboratory), clinical and dietary data to determine whether a person or groups of people are well nourished, malnourished, over-nourished, or under-nourished (Gibson,1993). In other words, nutritional assessment is critical to determine whether a person is at nutritional risk or not and best strategy to monitor responses to nutrition- and lifestyle-based treatment (Lee and Nieman,1996).

Child under-nutrition is currently assessed by body mass index for age and MUAC is considered as cornerstone of assessment in different groups (Lazarus et al.,2017). Good nutrition maintenance starts with good assessment or measurement and classification of nutritional status and nutrition assessment is a critical first step in improving and maintaining nutritional status (USAID,2015).

As the aims of nutritional assessment is to promote a realistic approach on identification and management of undernutrition in the community (Merrick,2014). Moreover, early, rapid, and accurate diagnosis of SAM is crucial in deterrence of deaths of SAM cases in the community and MAUC has been considered a valid and simple and rapid screening measure for wasting in children between 6 months and 5 years of age (Manoj R. and Bishan S.,2016).

Humble and reliable anthropometry is helpful for early finding to increase the number of children accessing treatment for under nutrition. However, because of partial biomedical evidence, researchers are doubtful to agree on using MUAC as the only tool for detection under nutrition and this doubt is a serious barrier to decision-making for policy change to accelerate coverage of more effective, feasible and sustainable quality services at scale (Hammond et al.,2016). Anthropometric measures are widely used to assess nutritional status and as indicators of growth and development in children. Very little is known about the reliability of anthropometric measurements in children (Hardy.J et al.,2018). For assessment of nutritional status of under-five

children various anthropometric indices are being used indiscriminately and so the estimated prevalence of malnutrition varies in different methods (Harshal T. and Samir A., 2012).

We can use diverse measurements, depending on the anthropometric indicators selected. For example, weight for-height or wasting is useful for screening children at risk and for measuring short-term changes in nutritional status but not appropriate for evaluating changes in a population over longer time periods (Bruce,2003). In general, it is used to provide important indicators of nutritional status in both children and adults; in children, measurements reflect general health status, dietary adequacy, and growth and development over time. In adults, body measurements are used to evaluate health and dietary status, disease risk, and body composition (Fryar et al.,2016).

1.5.1. Anthropometry

Anthropometry is the study of the measurement of the human body in terms of the dimensions of bone, muscle, and adipose tissue (ISAK,2001). It is the scientific study of the measurements and proportions of the human body and word anthropometry is actually combination of two Greek words ἄνθρωπος and μέτρον or measure (Boulevard,1988). In medical dictionary anthropometry, defined as; anthropos + metron=refererring to the science of measuring the human body as to height, weight, and size of component parts, including skinfold thickness, to study and compare the relative proportions under normal and abnormal conditions (Kainz et al.,2015). Moreover, it is as any other area of science depends upon adherence to the particular rules of measurements determined by national and international standards bodies (WHO, 2017).

Anthropometric measurement is one of nutritional assessment tool that allow judgement to population standards or to values collected over time in the same individual. Several markers of

somatic growth are typically used to track children to adolescence (Hume and Ackland,2017). Anthropometric measurements are preferred methods and are a widely used because it is economical and non-invasive measure of the general nutritional status of an individual or a population group (Bruce,2003). In addition to this height- and weight-based anthropometric measurement is an excellent tool to instrument general nutritional status in a population (WHO, 2007). It is commonly accepted that for practical purposes anthropometry is the most useful tool for measuring the nutritional status of children (WHO,1986). Economic role of anthropometric indicators are relatively precise, readily available for most countries, reflect the preferences and concerns of many poor people, consistent with reckoning the phenomenon directly in the space of functioning's, intuitive, easy to use for advocacy, and consistent over time and across subgroups (Heltberg,2009).

Growth charts are an essential component of the pediatric toolkit and their values exist in serving to determine the degree to which physiological needs for growth and development are met during the important childhood age (WHO,2006).

1.5.2. Height of children

Growth is a consequence of micro growth at the cellular level in the growth plate. The height, weight, and body proportion consider macro growth, the culmination of the effects of micro growth of various body segments and the total individual (Dimeglio,2001). Height is a summary of the dynamic processes carried out by the growth plate cellular machinery. As these cell-level mechanisms unfold in an individual, time-specific manner, there are many critical points at which a genetic growth program can be enhanced (Lampl and Schoen,2017).

Linear growth delay or linear growth faltering is failure to reach one's linear growth potential and linear growth delay implies that an individual or groups of children are too short for their age, but does not imply that they are stunted (Jef l L. and Edward A.,2019).

Important contributory factors to growth failure include increased energy needs, increased energy loss, malabsorption, decreased energy intake, anorexia, pain, vomiting, intestinal obstruction, and inflammatory cytokines (Kyle et al.,2015).

Changes in height over time indicates that secular trends in different countries, particularly in those undergoing economic development counters, are one form of evidence that reflected the environmental effects of height (Reynaldo and Amanda,2012).

As the above indication that the MGRS of WHO or July 1997/December 2003 population-based study took different areas like in the cities of Davis, California, USA; Muscat, Oman; Oslo, Norway; and Pelotas, Brazil; and in selected affluent Neighborhoods of Accra, Ghana, and South Delhi, India (WHO,2009).

In addition, the new WHO growth standards confirm prior explanations that the effect of ethnic variances on the growth of infants and young children in populations is small compared with the effects of the environment but there are genetic differences among individuals (WHO,2009). Insufficiency in growth is not necessarily the most sensitive indicator of inadequate nutrition in fact, that a slightly inadequate energy intake may cause a reduction in physical activity before there is any impairment of growth. It is also known that the extent to which genetic factors, both within and between populations, affect growth (WHO,1986). As some authors suggest that physical characteristics result from the interaction of heredity and environment it may not always ne due to

nutritional state. Based on this fact, body measurements may not always be used safely for comparing the nutritional status of genetically different populations (Fidanza,1991).

Therefore, this study aimed to consider ethnic variation of Anthropometric tool for different ethnic background in Ethiopia as national.

1.5.3. Weight

Weight is defined, the force with which a body is attracted to Earth or another celestial body and which is equal to the product of the object's mass and the acceleration of gravity (THE AMERICAN HERITAGE,2001). A carefully measured weight and height remain the most easily performed and useful determinants of nutritional status and predictors of mortality for the general population (Kushner,1993).

There are some factors affecting weight gain among children. Twins had lower birth weight and slower early growth rate than those born as single but had a higher post-weaning growth rate. Phenotypic and genetic correlations among the different body weights were positively associated with weight gain (Thiruvenkadan et al.,2009). There are some other factors operating on child weight gain during pregnancy and early life; parental weight status and smoking habits, both were modifiable risk factors (Griffiths et al.,2010).

1.5.4. Weight for height

A weight-for-length/height z score (WHZ) compares a child’s weight to the weight of child of the same length/height and sex to classify nutritional status (Kristen Cashin and Lesley Oot,2018). It is mostly used during emergency to measure Global Acute Malnutrition (GAM) in refugee children

aged between 6 and 59 months to classify children as low weight-for-height (UNHCR,2019). Weight-for-Height standards corresponding to the height range 65 cm to 120 cm. The lower limit of the weight-for-length standards (45 cm) and the upper limit for the weight-for height standards was influenced by the need to accommodate the tallest children at age 60 months (WHO,2006). However, World health organizations on its 2013 severe acute management Guide line suggests that there is no difference for weight for height and mid upper arm circumference; for program using mid-upper arm circumference weight gain is15–20% after edema disappears and for program using weight-for-height: weight-for-height >–11 standard deviation or weight gain is 15–20% after edema disappears (WHO,2013). In Ethiopia weight measurement considered as diagnosis and follow-up tools with its limitation and difficulties (FMOH,2007).

1.5.5. Mid Upper Arm circumference (MUAC)

Mid-upper-arm circumference (MUAC) is a simple method of assessing nutritional status in children above 6 months of age (WHO, 2007). It is one of anthropometric tool and effective as the body mass index-for-age Z score for assessing mortality risks associated with under-nutrition among African school aged children (Lazarus et al.,2017). It is a decades-old anthropometric measurement of the amount of muscle in the arm, which theoretically reflects the total amount of muscle or protein in the body and the clinician measures the upper arm circumference, by using a flexible tape measure (Steven McGee,2018).

MUAC acts more as a composite index of poor growth indexing and assessment (Eternod et al., 2015).

In moderate acute malnutrition programs, MUAC bids the advantages of easy-to carry, even to geographically hard to reach areas because it needs slightest preparation and it is effective in the

assessment of nutrition status when measured with care and precision (WHO,2006, Jeyakumar et al.,2013). On other hand, study in Senegal suggests that MUAC is better than WHZ to identify high-risk children in the community and using both WHZ less than -3 and MUAC less than 115 mm increases specificity but decreases sensitivity to identify high-risk children (Briend et al.,2012) and MUAC<115 mm identified more severely malnourished children with a higher risk of mortality (Grellety et al.,2015).

In the resource, limited settings where malnutrition is common, accurate measurement of weight and height may be a challenge. Mid-upper arm circumference is easier to measure and interpret and it is similar in boys and girls and is relatively constant from 6 months to 5 years that leads to avoid the requirement to calculate exact age (Kramer and Allen,2015).

However, there are doubt about sensitivity and specificity of MUAC< 115 mm on identification of more severe malnutrition among children and it only captures only a small proportion of all children with SAM cases (Grellety .E et al.,2015, Manoj R. and Bishan S., 2016). Another challenge for Mid-upper-arm circumference is the fact that it is based on a single cut-off value for all the children less than 5 years of age. However, whether MUAC is age- and sex-independent has recently been questioned (WHO, 2006).

1.5.6. Sensitivity and specificity of MUAC

The existing WHO cut off for MUAC captures only a small proportion of the total number of wasted children and has poor sensitivity and specificity of MUAC observed compared to WHZ in diagnosing malnutrition (Lamsal et al.,2021). Inefficient testing can lead to increased costs as well as unnecessary or unwanted treatment for patients. Using evidence to guide diagnostic testing can

become part of the shared decision-making process (Bartol,2015). The accuracy of the test validity is measured by sensitivity and specificity of the test (Parikh et al.,2008).

Sensitivity is the proportions of people with some disease; that have a positive test. A test that is 100% sensitive means all diseased individuals are correctly identified as diseased (Cochrane UK,2019). The sensitivity and specificity of a quantitative test are dependent on the cut-off value above or below which the test is positive (Lalkhen and McCluskey,2008).

Some evidence from India reveals that cutoff point for MUAC < 11.5 cm with sensitivity and specificity of 13.6% and 99.3% captures only a small proportion of all children with SAM cases (Manoj R. and Bishan S., 2016). Another study that is conducted among infants to determine appropriate mid upper arm circumference cutoff to identify severe acute malnutrition reveals that the cutoff of 11.0 cm had sensitivity of 82.5% and a specificity of 80.3% (Chand and Shah,2015). A similar study suggests that cut-off of <11.5 cm is not enough to detect SAM children and to ensure early diagnosis of SAM children and to reduce the risk of death of under nutrition more sensitive cutoff point MUAC is needed (Stobaugh et al.,2019).

As evidence from papers, among the aged of 6 to 23 months with a MUAC between 115 and 125 mm and a weight-for-height z score ≥−2 suggests that short children with low MUAC. Do not gain excessive fat during supplementation (Fabiansen et al.,2018). Study from Africa that conducted in rural Senegal suggests that MUAC less than 115 mm increases specificity but decreases sensitivity (Briend et al.,2012).

As the above literatures suggests the sensitivity of MUAC differs the existing cutoff MUAC at 115mm may fail to identify children with severe acute under nutrition and it may be compromised with some environmental and genetic factors and to overcome the overwhelming problems of

malnutrition more sensitive MUAC is needed as it is easy to conduct and affordable. In Ethiopia although there are different ethnic groups at different environmental settings, there is no study that addressed the sensitivity and specificity of the MUAC among under five children to identify the undernutrition cases.

This may lead to an urgent need to revise cutoff value of MUAC to higher value to improve its sensitivity for detecting children with under nutrition. MUAC is better than weight for height to find out high-risk children in the community.

1.5.7. Factors affecting Sensitivity and Specificity of MUAC

The MUAC and weight-for-height Z score or WHZ or weight-for-length Z score or WLZ have different associations with body composition, and MUAC acts more as a composite index of poor growth indexing (Eternod et al., 2015). Study in Iran shows that there is sex and ethnicity difference among subjects. These consisted of 51.1% boys and 48.9% girls. Some 1685 or22.2% cases were fars-natives, 2917 or38.5% Turkmans and 2973 or39.3% Sistanis (Veghari, 2015). A similar study in India among 6-60-month children's reveals that the sensitivity and specificity of MUAC < 11.5 cm was 13.6% and 99.3%, respectively and the best cutoff for screening SAM was obtained at MUAC < 12.8 cm where the sensitivity and specificity was 50% and 90.8%, respectively (Manoj R. and Bishan S., 2016). Similar cross-sectional study in Northern district of India reveals that the prevalence of SAM was 2.2% (Bhadoria et al.,2017). Retrospective cohort study in Israel among different ages and sex showed that, girls had significantly higher mean HAZ than boys. Increasing birth year also positively associated with HAZ different ages (Bilenko and Belmaker,2019).

Other study, among 92 children aged 24-36 months who attended the municipal early childhood education network in a town in the Vale do Jequitinhonha region of Brazil reveal that prevalence of stunted growth was 14.1%; cognitive and language development were below average at 28.6% and 28.3%, respectively (Neves et al., 2016). In Ethiopia EDHS, 2016 data show that 38 percent of children under five are considered short for their age or stunted or below -2 SD, and 18 percent are severely stunted or below -3 SD,10% were wasted and 24 percent of all children are underweight or below -2 SD (CSA and ORC Macro,2017). This national prevalence is varied among different regions in progress for two indicators stunting and wasting and again survey is not considered mid upper arm circumference or MUAC considers only weight for height. Across-sectional study among children aged 6–59 months in Hadaleala district, Afar Region reveals that the prevalence of acute malnutrition was 11.8 % (Gizaw et al.,2018).

Sensitivity; is defined as the probability of a positive diagnostic test in a patient with the illness or injury for which the test serves as a diagnostic tool (Drake and Levine,2005).

Specificity (negative in health); the ability of a test to correctly classify an individual as disease-free is called the test′s specificity (Skaik,2008).

Without more sensitive and specific tools and with many factors that are environmental and genetic factors the prevalence of under nutrition may be affected for different genetic groups in different environments. The above studies are dependent on only weight for height status of the children but no studies addressed nutritional status of the children using MUAC at the end of this study we may use MUAC as diagnosing tool for severe and moderate acute undernutrition among children with different ethnic background in Ethiopia.

1.6. Diagnosis of undernutrition

Because of children's rapid periods of growth and development, early diagnosis, prevention, and management of malnutrition are paramount (Larson-Nath and Goday, 2019). Moreover, the diagnosis of malnutrition is based on measurement of body size (anthropometry) and clinical signs (Walton and Allen, 2011).

Under nutrition; which includes stunting or low length/height-for-age, wasting or low weight-for length/ height, acute malnutrition or low weight-for-length/height or low MUAC or bilateral pitting edema and underweight or low weight-for-age (Fabians, 2018).

Stunting; it is the impaired growth and development that children experience from poor nutrition, repeated infection, and inadequate psychosocial stimulation and they are stunted if their height-for-age is less than two standard deviations (WHO,2015).

Wasting; it is defined as low weight-for-height and it often indicates recent and severe weight loss. It usually occurs when a person has not had food of adequate quality and quantity and/or they have had frequent or prolonged illnesses (WHO,2022).

Severe acute malnutrition; It diagnosed by weight for- height below -3 SD of the WHO standards, by a MUAC cut-off of 115 mm and by Clinical sign (WHO and UNICEF,2009).

Marasmus; it is a severe deficiency of calories and protein. It tends to develop in infants and very young children. It typically results in weight loss, loss of muscle and fat, and dehydration. Breastfeeding usually protects against marasmus (John E. Morley, 2021).

Kwashiorkor; it is a severe deficiency of more protein than of calories and it is less common than marasmus. Moreover, the term is derived from an African word meaning “first child–second

child" because a first-born child often develops kwashiorkor when the second child is born and replaces the first-born child at the mother's breast (John E. Morley, 2021).

Criteria for identifying children with severe acute malnutrition for treatment;

In primary health-care facilities and hospitals, for children who are 6–59 months of age have a mid-upper arm circumference <115 mm or a weight-for-height/length <–3 Z-score1or have bilateral oedema; will be immediately admitted to a programme (WHO,2013).

1.7. Management of malnutrition

Malnutrition is a leading cause of ill health in the world today, more effective treatment and prevention of malnutrition must be a priority for the global healthcare community to tackle the problem (Walton and Allen, 2011).

Managing malnutrition in the community involves identifying malnutrition using a universally validated screening tool and implementing appropriate care plans according to the degree of malnutrition (McEvilly,2016). Severe acute malnutrition is a life-threatening condition requiring urgent treatment. Until recently, the recommendation was to refer these children to hospital to receive therapeutic diets along with medical care (WHO,2022). Nurturing care and protection of children during gestation and early childhood are necessary for the development of trillions of neurons and synapses necessary for healthy development and ECD requires access to good nutrition and health services from gestation, responsive caregiving according to the child's developmental stage, social protection, child welfare, and early stimulation and learning opportunities (Rafael et al.,2017).

Children who are identified as having severe acute malnutrition after assessed with a full clinical examination to confirm whether they have medical complications and whether they have an

appetite failed with one or more Integrated Management of Childhood Illness (IMCI) will be treated as inpatients (WHO,2013).

There some problems children may face during treatment and after treatment. For example, cross sectional study in Mwanza, Tanzania among malnourished children's reveals that the prevalence of bacteremia was significantly higher among severely malnourished children than in children with moderate or mild malnutrition or18.0 vs. 10.7%, (Ahmed et al.,2017).

Another cohort study among aged 6-59 months old with complicated SAM admitted to Zambia University Teaching Hospital's stabilization center reveals that the majority of the children, 67.3%, presented with diarrhea (Irena, 2011). A hospital-based cross sectional study in teaching hospital in Pune, India reveals that co-morbid illnesses contributing to morbidity in the malnourished child were acute diarrheal diseases, acute respiratory infection, anemia, and septicemia(Debnath and Parulekar,2014).Pooled analyses of results from different countries shows that, the relative risks of mortality among young children 6-24 months after they had been identified as having mild-to-moderate or severe malnutrition with mild-to-moderate malnutrition 60-80% of the median weight-for-age of the reference population had 2.2 times the risk of dying during the follow-up period than their counterparts of 80% of the median reference weight-for-age (Schroeder and Brown,1994).

In similar way cohort study in Bangladesh shows that common morbidities following discharge included fever (26%), cough (24%) and diarrhea (20%) (Ashraf et al.,2012). Retrospective cohort Study in Dire Dawa, Ethiopia among different health instructions suggests that the most common co-morbidities accompanied with SAM at admission were diarrhea or 31.1%, anemia or 25.4%, fever or10.2%, vomiting or 8.6%, superficial skin infection or skin peeling or 0.7%, HIV infection or 0.5% and TB or 0.2% (Atnafe and Roba,2019).

Based on the above facts we may say that co-morbidity among SAM children is high but as the above literatures were retrospective studies and less prospective or observatory studies are relatively good to identify more common morbidity and plan for future admission.

Another tricky that encountered is sever acute malnutrition managements during treatment follow-up admission criteria for severe acute under nutrition is based on children with a weight-for-height below -3 SD and MUAC <11.5cm. However, in most of the time discharge of SAM based on target weight.

Criteria for discharging children from treatment; a. Children with severe acute malnutrition should only be discharged from treatment when their:

I. weight-for-height/length is ≥–2 Z-score and they have had no oedema for at least 2 weeks,
II. Alternatively, mid-upper-arm circumference is ≥125 mm and they have had no oedema for at least 2 weeks (WHO,2013).

1.7.1. Survival from severe acute malnutrition

A cohort study in rural Jharkhand and Odisha, eastern Indian among under five children on treatment suggests that there were 36 deaths from them 12 among children with MAM and six among children with SAM. Case fatality rates were 1.1% or12/1,098 for MAM and 1.2% or6/513 for SAM. In total, 99% of all children with SAM at 6 months of age were alive 3 months later, 40% were still SAM, and 18% had recovered or WLZ= -2 standard deviation SD; MUAC = 12.5; no edema (Prost et al.,2019). Moreover, retrospective quantitative review of hospital-based records among the children aged 0-60 months admitted to the University Teaching Hospital in Zambia

reveals that Overall mortality was at 46% with children with marasmus having the lowest survival rates on Kaplan Meier graphs (Munthali et al.,2015).

In Ethiopia study done in Dire-Dawa shows that the overall recovery rate 79.8% Eighty or11.2% defaulted, 27 or3.8% were non-responders, 4 or0.6% died and 15 or2.1% were transferred-out (Atnafe and Roba,2019). Similar retrospective cohort in Hiwot Fana specialized University reveals that the fatality rate of 2.1%, the case recovery rate is 36% defaulter from the treatment is or 61.9% (Abate et al.,2019). Retrospective cohort study in Jimma University Specialized Hospital shows that an improvement, death and defaulter rate are as follows, respectively 77.8, 9.3 and 12.9 % (Jarso et al.,2015).

A retrospective cohort study among under-five children who were admitted for SAM at the University of Gondar comprehensive specialized hospital shows that at the end of the follow-up the mortality rate was 12.52% (Wagnew et al.,2018) and another retrospective cohort study in South Wollo Zone, northeast Ethiopia, reveals that 75.4% of children were recovered and discharged, 10.3% were defaulters, 3.4% died, 7.4% were non-responders, and 3.4% were unknown with mean or ±SD (Legesse et al.,2019)

Facility based prospective follow up study in North Gondar zone, Northwest Ethiopia among children with the age of 6–59 months reveals that 65.3%of SAM children are recovered (Mamo et al.,2019). Study done in Boloso Sore district in Southwest Ethiopia reveals that the overall recovery rate was 396 or68% and from edematous children; 235 or79.9% recovered, 18 or6.1% transferred,6 or2.0% defaulted, 3 or1.0% died, and 32 or11% remained none-respondents and the treatment outcomes among the none-edematous children were 161 or 55.9%, 12 or4.2%, 4 or1.4%, 3 or 1.0%, and 37.5% in similar order another study done in Wolisso St. Luke catholic

hospital, south west Ethiopia suggests that about 83% were cured(Banbeta et al.,2015, Kabalo and Yohannes,2018).

Cured; Children with severe acute malnutrition when their: mid-upper-arm circumference is ≥125 mm and they have had no edema for at least 2 weeks (WHO,2013).

But, all of the above studies were done based on the survival status of children by using weight for height ratio at hospital level but there is no a single study that was done using mid upper arm circumferences survival measure at health post at community level for SAM and MAM cases and as we stated above MUAC is good indicator of child mortality however there is study that suggest survival rate by using MUAC.

1.7.2. Time to cure

Study in rural Malawi reveals that children treated for SAM and discharged in 8 weeks compared with children treated until they reached WHZ >-2, children treated for 12 weeks were more likely to remain well-nourished or71% vs. 63%, (Trehan et al.,2015). A cohort study among children aged 6-59 months old with complicated SAM admitted to Zambia University Teaching Hospital's stabilization center reveals that the median length of stay of the cohort was 9 days (IQR, 5-14 days); 30.6% (53/173) of the death occurred within 48 hours of admission (Irena, 2011).

According Ethiopian federal minster of health (FMOH) March 2007 guideline state time to cure for SAM in outpatient is considered as 21 days (FMOH,2007). However, a study in similar country showed that the median time to recovery was 16 days and Female gender being edematous having pneumonia, tuberculosis, HIV/AIDS, having anemia were notably associated with time to recovery (Baraki et al.,2020). In similar study the median time-to-recover was 36 days and maternal illiteracy, severe household food insecurity and practicing sharing of ready to use therapeutic food

(RUTF) were associated with slower propensity of recovery from SAM (Teshome et al.,2019). Other study done in Wolisso St. Luke catholic hospital, south west Ethiopia suggests that the median time-to-cure from SAM cases was 14 days with the maximum of 63 days of which about 83% were cured (Banbeta *et al*., 2015, Kabalo and Yohannes, 2018).

Study conducted in Dire Dawa among different health instructions suggests that there were significantly different in time to recovery among children who were treated in rural health centers and urban health centers and children with marasmus were 56% less likely to achieve nutritional recovery compared to children with edema according to the Ethiopian national protocol for management of SAM. The median recovery time was 8.7 weeks weeks (Atnafe and Roba,2019) and another facility based prospective follow up study in North Gondar Zone, northwest Ethiopia reveals that the median time to recovery was 14 days(Mamo et al.,2019) in similar area a retrospective cohort study among under-five children who were admitted for SAM at the University of Gondar comprehensive specialized hospital shows that the overall, the median follow-up period was 10 days with interquartile range (Wagnew et al.,2018).

A retrospective cohort study in Southern Ethiopia shows that recovery rate is 3.61 per 100-person day observations and median nutritional recovery time is 22 and 29 days for edematous nutrition and severely wasted children respectively, (Gebremichael,2015). Retrospective cohort study in Jimma University Specialized Hospital reveals that the median duration from admission to death was 7 days and the average length of stay in the hospital and average weight gain were 17.4 days and 10.4g/kg/day, respectively (Jarso et al.,2015).

Retrospective cohort study in South Wollo Zone, northeast Ethiopia, reveals that time to recovery was 12 ±5.26 days, whereas the median time to recovery was 11 or IQR of 8–15 days (Legesse et al.,2019). Similarly, retrospective cohort study among < 5 years of age admitted to SCs in Gedeo

Zone reveals that the survival rates at the end of the first, second and third weeks were 95.3%, 90% and 85%, respectively, and the overall mean survival time was 79.6 days (Girum et al.,2017). Facility based prospective follow up study in North Gondar zone; Northwest Ethiopia among children with the age of 6–59 months reveals that the median time to recovery was 38.5 ± IQR of 14 days (Mamo et al.,2019).

However; all of the above recovery rates were done by using weight for height ratio after cure at hospital level. As admission of severe and moderate acute undernutrition admission at health posts is by using weight for height ratio and mid upper arm circumference. However; discharge from the program is based on weight gain or based on target weight only and mid upper arm circumference is not considered for discharge. Cure time of mid upper arm circumference is not known as MUAC is good indicator of child mortality cure time for MUAC is better than weight is more sensitive to change and it may not indicate change in body composition.

1.7.3. Relapse of Severe Acute Malnutrition

A systematically review and secondary data analyses suggests that relapse after treatment of severe acute malnutrition or SAM is poorly defined and scarcely measured across programs and of children following SAM treatment, with the highest proportions occurring within 6 months post discharge (Stobaugh et al.,2019). In addition, relapse is encountering problem during SAM management among children 6 to 59 month's old (Trehan et al.,2015). And it is an occurrence of an event of SAM repeatedly, or deterioration of nutritional status from non-SAM to SAM, in children who were initially admitted to SAM treatment and then discharged as free of SAM, with WHZ≥-3 and MUAC ≥ 115 and no nutritional edema (Guesdon et al.,2021).

Other studies reveal that malnourished children during flow up after sustained recovery throughout the 12-month follow-up period, 36% of them relapsed to MAM and 5% to SAM (Stobaugh and Manary,2018). A study in rural Malawi reveals that children treated for SAM and discharged in 8 weeks compared with children treated until they reached WHZ>-2, children treated for 12 weeks were more likely to remain well-nourished or 71% vs. 63%, and maintain more normal anthropometric indices during 12 months of follow-up (Trehan et al.,2015). Another study from Nigeria Jigaw state reveals that six months post-discharge from outpatient treatment in result in deaths 16 and it occurred within the first 3months of post-discharge (John et al.,2018). A prospective, observational cohort trial in Pakistan reveals that most relapses occurred within 3 months of discharge or mean time to relapse 73·4 days. At enrolment, 90 % had moderate acute malnutrition or MAM and 10 % were not malnourished. By the end of 6 months, 35 % persisted with MAM and the remaining were not malnourished (Dale et al.,2018). Another prospective cohort study in Bangladesh, among severely malnourished children revealed that from those who treated for severe malnutrition and discharged by weight for height but not for MUAC; 7% required re-admission to the nutrition program because of: MUAC dropping to 115 mm, weight loss 10% children and severe medical complications children, of whom one died while 27% maintained a WHZ at normal nutritional state (Ali et al.,2013). A cohort study among under six months infants admitted to Kilifi County Hospital in Kenya suggests that 1405 infants were followed up after discharge. Of these, or 5.3% died within one year during 1318 child-years of observation. MUAC and weight-for-age z score or WAZ predicted inpatient and post discharge mortality better than did WLZ A single MUAC threshold of <11.0 cm performed similarly to MUAC thresholds that varied with age and performed better than WLZ <-3 for both inpatient and post discharge mortality (Mwangome et al.,2017).

The above different studies suggest that there is more relapse case after treatment for severe acute under nutrition. Moreover, as more case load in Ethiopia there is no study that addressed the rate of the relapse in Ethiopia and the rate of relapse is may related with discharge status or discharge weight and mid upper arm circumference.

1.7.4. Time to relapse

Relapse rates are reported over the whole six months follow-up as well as during different periods or in the first 3 months period (Guesdon et al.,2021). In addition, similar prospective study reveals that children who successfully recover from MAM after receiving treatment in an SFP are likely to relapse during of 12 months (Stobaugh and Manary,2018). Another study in Nijeria reviles that in community-based control study there is relapse of SAM after 6-month (Adegoke et al.,2021).

A prospective, observational cohort trial in Pakistan reveals that most relapses occurred within 3 months of discharge or mean time to relapse 73·4 day. At enrolment, 90 % had moderate acute malnutrition or MAM and 10 % were not malnourished. By the end of 6 months, 35 % persisted with MAM and the remaining were not malnourished (Dale et al.,2018).

1.7.5. Factors associated with time to cure

Cross- sectional study in Northern district of India shows that age with OR: 0.97, nuclear family OR: 1.25, lower occupation of head of family OR: 1.29, and lower paternal education OR: 1.49, as independent predictor of SAM(Bhadoria et al.,2017) another cohort study in rural Jharkhand and Odisha, eastern Indian among under five children's on treatment suggests that the adjusted HRs using all anthropometric indicators were 1.43 for MAM and 2.56 for SAM and both WLZ; -3 and MUAC =11.5 and; 12.5 were associated with increased mortality risk respectively(Prost et

al.,2019).Another a cohort study among aged 6-59 months old with complicated SAM admitted to Zambia University Teaching Hospital's stabilization center reveals that children with diarrhea on admission had two and half times higher odds of mortality than those without diarrhea and the odds of mortality for children with HIV infection was higher than children without HIV infection (Irena, 2011). Another systematic review on relapse of severe acute under nutrition suggests that lower anthropometric measurements on admission to and discharge from SAM treatment are consistent risk factors for relapse (Stobaugh et al.,2019). The prospective study of children with SAM admitted into 10 OTPs s in Jigawa state, Nigeria demonstrates that good post discharge survival rate and improved nutritional status for SAM patients managed in OTP (John et al.,2018).

A retrospective cohort study among under-five children who were admitted for SAM at the University of Gondar comprehensive specialized hospital indicates that Anemia, shock no intake of antibiotics, IV-Fluid, no intake of F75 and no intake of F100 were independent predictors of mortality among SAM children's (Wagnew et al.,2018). Similar retrospective, descriptive cross-sectional study in Hiwot Fana Specialized University Hospital among aged 6-59 months children admitted to, Nutrition Rehabilitation Unit over the period of 2013-2015 reveals that diarrheal disease (Acute Gastroenteritis) commonest cause of mortality among with Severe Acute Malnutrition that is present in 14 of the 15 deaths in the study period (Abate H.K. et al.,2019).

Another retrospective cohort study among under five children admitted for SAM reveals that age <24 months, altered pulse rate, altered temperature, shock, anemia, nasogastric tube feeding, hypoglycemia or and treatment at hospital stabilization center, were independent predictors of mortality (Girum et al.,2017) and children with an admission weight of 7kg, children who were dewormed (Atnafe and Roba,2019). Study done in Boloso Sore district in Southwest Ethiopia reveals that the treatment outcomes of severely undernourished children in the two arms that means

between edematous severely under nourished and non-edematous were statistically different. Severely malnourished children with edema were highly likely to recover as compared to those without it (Kabalo and Yohannes,2018). A retrospective cohort study in Southern Ethiopia shows that the independent predictors of nutritional recovery rate were stabilization center or, malnutrition status or = weight or, mid- upper arm circumference or, inpatient complications or and did not lose edema within four days of inpatient treatment or (Gebremichael,2015). According to the finding of the cohort study in Jimma University Specialized Hospital the main predictors of earlier hospital deaths were age less than 24 months or, hypothermia or, impaired consciousness level or dehydration or palmar pallor or and co-morbidity/complication at admission or (Jarso et al.,2015) another facility based prospective follow up study in North Gondar Zone, Northwest Ethiopia tells that children having diarrhea, taking amoxicillin and have vomiting at admission were significant predictors of time to recovery from SAM (Mamo et al.,2019). Another retrospective cohort study that conducted among children aged 0-59 months who were admitted for complicated severe acute malnutrition at Sekota hospital reveals that; the most frequently associated co-morbid was diarrhea. Moreover, predictors of mortality were Malaria, severe anemia and TB (Desta, 2015). The above all study suggests that post discharge status determines the survival status of the SAM and MAM children. Moreover, there are many factors that linked with child relapse. However, there is no study done to suggest the factors and that are linked with post discharge status of severe and moderate acute malnutrition.

1.8. Why this PhD Dissertation? And what are the gaps?

Height and weight curves may not optimal fits in all cases. The differences between national or ethnic group head circumference by using the WHO charts would put many children at risk for misdiagnosis of undernutrition (Natale and Rajagopalan,2014). Birthweight varies according to

ethnic group and there are clear ethnic differences in birthweight but it is not clear why such differences exist (Kelly et al.,2009). In another study among presumably well-nourished children with different ethnic background indicates that there were differences in height and weight (Habicht et al.,1974).

Ethnicity refers to common sets of traditions, ancestry, language, history, society, culture, nation, religion, or social treatment within their residing area (Hamer et al.,2018). Ethiopia is home for diverse ethnicity, the most important differences on the basis of linguistic categorization. The vast majority of languages belong to the Semitic, Cushitic, or Omotic groups, all part of the Afro-Asiatic language family. A small number of languages belong to a fourth group, Nilotic, which is part of the Nilo-Saharan language family.

So; this study aimed to asses' regional variations on the rate under nutrition by using mid upper arm circumference (MUAC) and weight for height (WHZ) as standard among different regions as regions in Ethiopia are demarcated based on ethnic background this study may help to know the cutoff points of MUAC for different ethnicity.

This may help us to have new cutoff points for different ethnic groups and regions of Ethiopia to improve our diagnosis and management of severe acute under nutrition among in children from different ethnic background. In addition to the above this study also intended to determine cure time or discharge time of severe and moderate acute under nutrition by using MUAC, and relapse of severe and moderate acute under nutrition after cure and discharge at community level or health posts; as we know that in National treatment guide line admission of SAM and MAM is based on WHZ and MUAC but discharge is based on the WHZ or target weight and other related medical complications. However; no one knows about MUAC status of children's during discharge ether they have improved or not so, this study aimed to know median cure time of

MUAC for management under nutrition. So; this study intended to determine time for treatment of severe and moderate acute under nutrition using mid upper arm circumference criteria.

Policy support and cost benefits; as we know that Ethiopia has planned to eradicate all forms of malnutrition in 2030 so to achieve National Goal, appropriate and easy tool is needed to early detect nutritional problems among diverse ethnic groups of Ethiopia. However statistical evidences from national EDHs and other meta-analysis show that the validity of mid upper arm circumference in screening under nutrition among under five children of Somali and Gambella Regions is low, children have disproportionately had high severe acute undernutrition while they are normal.

Frequency of relapse of severe acute undernutrition is another challenge and needed to get response by this study. Therefore, this study will fill this gap by determining the diagnostic and prognostic utility of MUAC for children with severe and moderate acute malnutrition in different regions with different ethnic groups.

1.9. Aims of the study

1.9.1. Overall aims of the study

To assess the diagnostic and prognostic performance of mid-upper arm circumference (MUAC) for severe and moderate acute malnutrition among under five children from different ethnic groups and regions in Ethiopia.

1.10. Specific objectives of the study

- To generate global evidence on Sensitivity and specificity of Mid Upper Arm Circumference for Assessment of Severe acute malnutrition among Children Aged 6-59 Months.
- To quantify the frequency of relapse for severe acute malnutrition and associated factors among under five children admitted to health posts in Hadiya Zone, South Ethiopia.
- To determine time to relapse of severe acute malnutrition and associated factors among under-five children treated in the health posts of Hadiya Zone, Southern Ethiopia.
- To determine mean time of recovery from severe wasting and utilization of MUAC as discharge tool from SAM at selected health posts of West Hararghe, Oromia, Ethiopia.
- To validate the diagnostics performance of MUAC for determination of wasting and suggesting new cut-offs of MUAC for under five children from different ethnic background compared to WHZ in selected regions of Ethiopia.

1.11. Hypotheses of the study

- Existing cut off point of MUAC is does not equally detect wasting for all regions and all ethnic groups in Ethiopia.
- There difference in time to recovery from wasting among children with SAM and MAM by using MUAC.
- There is relapse of severe acute wasting after cure and discharge among under five children.

1.12. Outline of the Dissertation

In this study 7 chapters were addressed sequentially. **Chapter 1** mainly focuses on definitions, epidemiological distribute on, consequence, management, treatment outcome, and relapse of malnutrition. **Chapter 2** outlines the study area, sample size of the study for different objectives, study designees, measurements and ethical issues. **Chapter 3**; focus on global evidence on Sensitivity and specificity of Mid Upper Arm Circumference for Assessment of Severe acute malnutrition among children aged 6-59 Months.

Chapter 4 presents the frequency and number of relapses of severe acute malnutrition and factors contributing to relapse. **Chapter 5** describes the mean time to relapse and factors contributing to relapse. In **Chapter 6,** utilization of mid uper arm circumference as discharge tool for children in outpatient therapeutic program, **I**n **Chapter 7** this chapter addresses the diagnostic performance or sensitivity and specificity of MUAC for diagnosis of malnutrition among deferent ethnic background children were assessed and optimal cut-off MUAC for diagnosis of malnutrition for different ethnic background was suggested. **Chapter 8** integrates the findings from the different studies, presents the policy, research and pragmatic intimations of the findings for nutrition programming. Schematic outline of the dissertation is displayed in Figure 3.

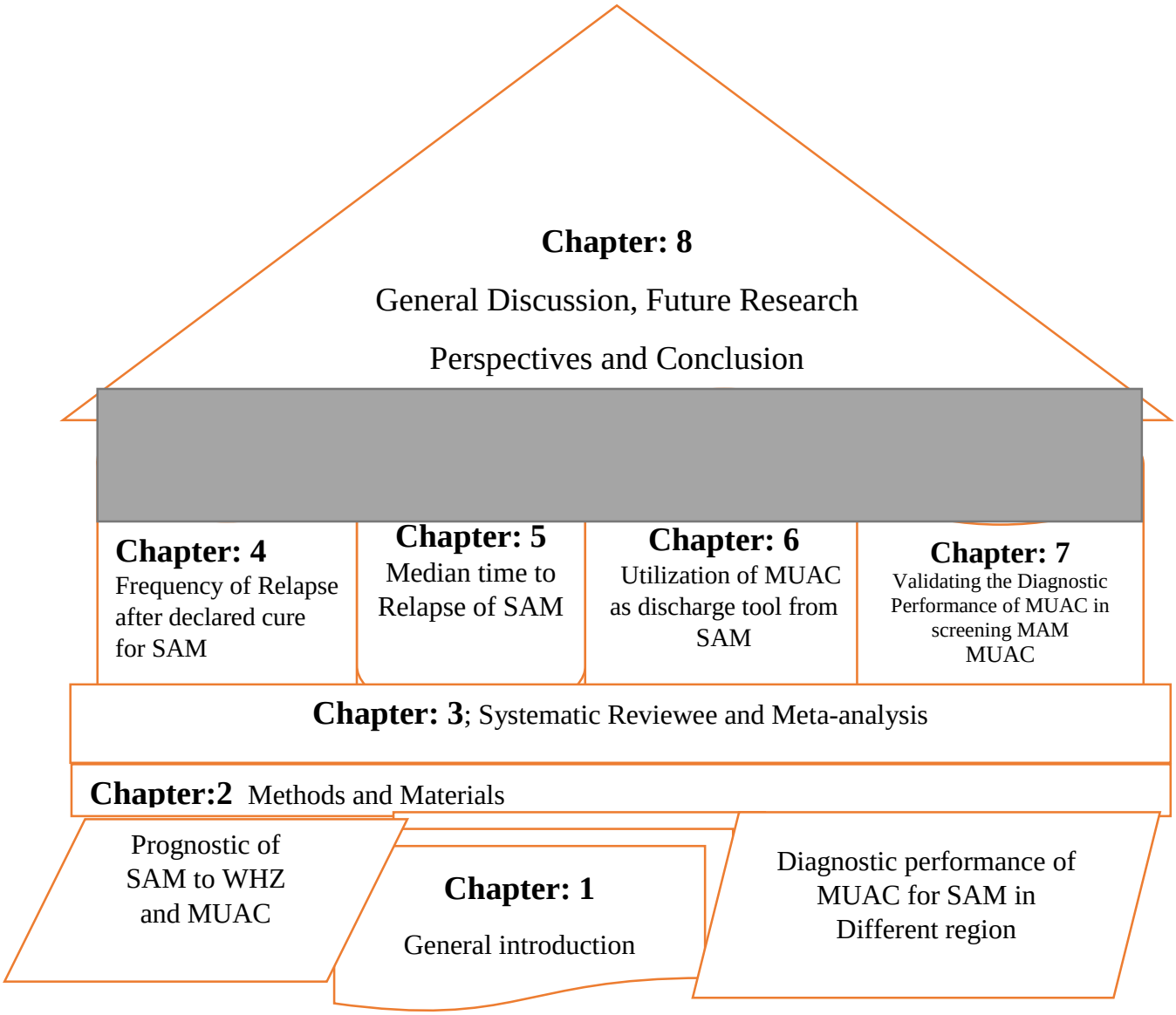

Figure 3. Schematic presentation of the dissertation

Chapter 2 :Methods and Materials

1.13. Study setting and participants

This study conducted in five regions of Ethiopia, namely, **Oromia, Somalia, Amhara, SNNPR and Gambella Regions** of Ethiopia.

Ethiopia is a country in the northeastern part of Africa, known as the Horn of Africa. It shares borders with Eritrea to the north, Djibouti to the northeast, the de facto state of Somaliland and Somalia to the east, Kenya to the south, South Sudan to the west and Sudan to the northwest.

Ethiopia's total population has grown from 38.1 million in 1983 to 109.5 million in 2018. The country is the most populous landlocked in the world and the second-most populous nation on the African continent with a total area of 1,100,000 square kilometers or 420,000 sq mi. Ethiopia is a federation subdivided into ethno-linguistically based regional states and chartered cities. This system of administrative regions replaced the provinces of Ethiopia in 1992 under the Transitional Government of Ethiopia and was formalized in 1995 when the current constitution of Ethiopia came into force (Wikipedia,2022).

The regions are each governed by a regional council whose members are directly elected to represent woredas (districts). Each council has a president, who is elected by the council. Each region also has an executive committee, whose members are selected by the president from among the councilors and approved by the council. Each region has a sector bureau, which implements the council mandate and reports to the executive committee.

There are eleven regional states and two chartered cities, the latter being the country's capital Addis Ababa, and Dire Dawa, which was chartered in 2004. Being based on ethnicity and language,

rather than physical geography or history, the regions vary enormously in area and population (Wikipedia,2022).

Ethiopia is a Federal Democratic Republic composed of 11 National Regional states: namely Tigray, Afar, **Amhara**, **Oromia**, **Somali**, Benishangul-Gumuz, Southern Nations Nationalities and People Region (**SNNPR**), Gambella and Harari, Sidama Region, South West Ethiopia Peoples' Region and two Administrative states (Addis Ababa City administration and Dire Dawa city council and its capital and largest city is Addis Ababa. The predominant climate type is a tropical wet season, with wide topographic-induced variation. Highlands cover most of the country and have a climate, which is generally considerably cooler than other regions at similar proximity to the Equator. Most of the country's major cities are located at elevations of around 2,000–2,500 m or 6,562–8,202 ft above sea level. According to the IMF, Ethiopia was one of the fastest growing economies in the world, registering over 10% economic growth from 2004 through 2009.The fastest-growing non-oil-dependent African economy in the years 2007 and 2008 in 2015. The World Bank highlighted that Ethiopia had witnessed rapid economic growth with real domestic product or GDP growth averaging 10.9% between 2004 and 2014. In spite of fast growth; in recent years, GDP per capita is one of the lowest in the world, and the economy faces a number of serious structural problems. Ethiopia's main health problems are said to be communicable or contagious diseases worsened by poor sanitation and malnutrition. There are 119 hospitals or12 in Addis Ababa alone and 412 health centers in Ethiopia.

Oromia region is consisting of 21 administrative zones. It is bordered by the Somali Region to the east; the Amhara Region, the Afar Region and the Benishangul-Gumuz Region to the north; Dire Dawa to the northeast; the South Sudanese state of Upper Nile, Gambela Region, Southern Nations, Nationalities, and Peoples Region and Sidama Region to the west; the Eastern Province

of Kenya to the south; as well as Addis Ababa as an enclave surrounded by Special Zone in its center and the Harari Region as an enclave surrounded by East Hararghe in its east(Wikipedia,2022).

West Hararge (Oromo: Hararghe Dhiha) is a zone in the Oromia Region of Ethiopia. West Hararghe takes its name from the former province of Hararghe. West Harerge is bordered on the south by the Shebelle River which separates it from Bale, on the southwest by Arsi, on the northwest by the Afar Region, on the north by the Somali Region and on the east by East Hararghe. Towns in West Hararghe include Chiro, Badessa, Gelemso, and Mieso. The study was conducted in Habro Woreda west Hararghe zone, Oromia, Ethiopia. Habro Woreda is found in West Hararghe zone of Oromia regional state. ***Detail about study area presented under chapter 6***

Gambella region; has 3 administrative Zone which is bordered by Sudan on the south, west and north, by Administrative Zone 1 on the east and Administrative Zone 2 on the southeast; the Pibor defines the border on the south and west, while the Baro defines it for the northern border. Towns in this zone included Tergol and Telut. Most of the area of this zone was added to Nuer Zone and some parts were added to Anuak Zone and the third one Mejang zone. For this study equal numbers of under-five children were allocated to the two Zones because they are different in Ethnic groups. Those are Nuer Zone and Anuak zone. **(Nailo Saharans' linguistic groups).** ***Detail is presented under chapter 7***

Somali region; The Somali Regional officially known, as the Somali West, is the largest and easternmost of the nine regions of Ethiopia. The state borders the Ethiopian states of Afar and Oromia and the chartered city Dire Dawa (Dir Dhaba) to the west, as well as Djibouti to the north; Somalia to the north, east, and south; and Kenya to the southwest**.** Like other Regions in Ethiopia, Somali Region is subdivided into eleven administrative zones and six special administrative zones:

Sitti Zone (formerly Shinile),Fafan Zone (formerly Jigjiga),Jarar zone (formerly Degehabur),Nogob Zone (formerly Fiq), Erer Zone, Dollo Zone (formerly Warder),Korahe Zone, Shabelle Zone (formerly Godey), Afder Zone, Liben Zone, Dawa Zone, Jigjiga Special Zone (special zone),Kebridehar Special Zone (Special Zone),Tog Wajale Special Zone (special zone),Gode Special Zone (special zone),KebriBeyah Special Zone (special zone),Degehabur Special Zone and (special zone,Jijiga). **(Cushitic groups).** ***Detail is presented under chapter 7***

Amhara region; is one of the nine ethnic divisions of Ethiopia. Previously known as "Region 3", its capital is Bahir Dar. Amhara is bordered by the state of Sudan to the west and northwest, and in other directions by other regions of Ethiopia: Tigray to the north, Afar to the east, Benishangul-Gumuz to the west and southwest, and Oromia to the south. Like other Regions in Ethiopia, Amhara is subdivided into administrative zones. Agew Awi, East Gojjam, North Gondar, North Shewa, North Wollo, Oromia, South Gondar, South Wollo, Wag Hemra, West Gojjam and Bahir Dar (special zone). (Sematic **Groups**). ***Detail is presented under chapter 7***

Southern Nations, Nationalities, and Peoples' Region (often abbreviated as SNNPR; is one of the nine ethnically based regional states of Ethiopia. It was formed from the merger of regions 7 to 11 its capital is Hawasa.

The SNNPR borders Kenya to the south (including a small part of Lake Turkana), the Ilemi Triangle (a region claimed by Kenya and South Sudan) to the southwest, South Sudan to the west, the Ethiopian region of Gambella to the northwest, and the Ethiopian region of Oromia to the north and east. Seventeen administrative zones and 7 special woredas which is similar to an autonomous area and is not part of a zone) is based on information from the 2007 census; Hadiya zone one of the above Zones which has 12 woradas and 2 administrates towns.

(Wikipedia,2019). ***Detail about study area presented under chapter 4***

Three study designs were employed in five regional states of Ethiopia; A cross-sectional study was conducted to assess the sensitivity and specificity of MUAC for detection of child wasting as measured by weight for height Z score or WHZ used as gold standard in the three Regions of Ethiopia; namely; Somalia, Amhara and Gamble regions.

A retrospective cohort study was conducted to assess median cure time for MUAC and count of severe acute malnutrition. For relapse cases among selected health post retrospective cohort study of under-five children who are admitted and discharged after they were declared that they were cured in Health post for Severe and moderate acute undernutrition in the last five years were assessed among 3 selected worads and 20 health posts based on their case flow in Hadiya zone, SNNPR, Ethiopia

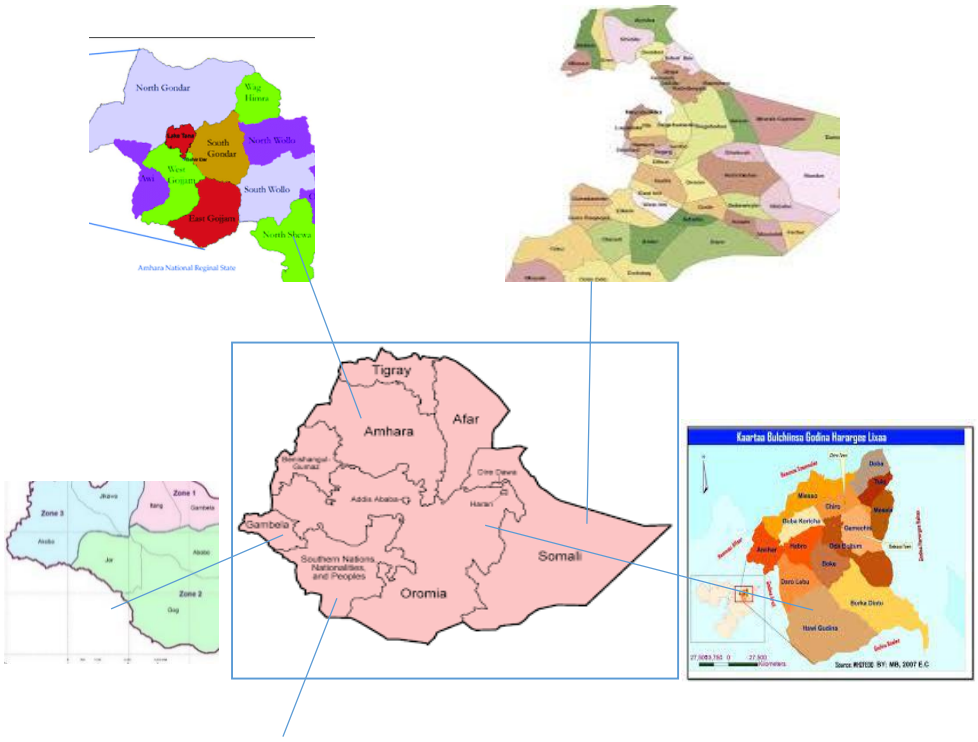

Figure 2. Google Maps of study areas (Google,20019)

1.14. Study Design

In this Dissertation four study designs were used based on different objectives.

- Systematic Review and Meta-analysis
- For the first two objectives Retrospective cohort study design was used.
- For the third objective Prospective Cohort study design applied.
- For the fourth objective is community based cross sectional study design.

1.15. Source Population

- Based on the objective of the study different source populations were considered; for systematic review of published studies different databases used, for relapse and time to relapse, cure time document review and for MUAC validation children less than five years who are from different regions were used and detail was presented under each objective.

1.16. Sample size and Sampling Technique

In this study different sample size for different objectives were used. Based on the objective of the study different sample size calculated and sampling technique for each objective is different.

Detail for each objective is presented under the different chapters for those objectives in the following chapters.

1.17. Data collection and measurement

In each data collection site training provided for all data collectors to health background professions by principal investigator and PI supervised in all sites and promoters assisted all data collection process strictly in each study site one locale guide was involved on data collection for these projects after evaluation for TEM by PI. Two data collectors, one local guide and one supervisor were involved on each data collection site. In all cases the cross-sectional and cohort studies were conducted using pretested under the supervision of the questionnaire containing variables on socio-demographic, environmental, anthropometry during admission, follow up time and discharge, discharge status, discharge and follow up, house hold food security status and wealth index.

The principal investigator determined the entire tools that were checked for its consistency and completeness of the tool immediately on the site. The information entered was checked among 5% of randomly selected respondents before data collection. ***In addition, the details were presented under each objective below.***

1.18. Anthropometry

Anthropometric survey questionnaire was based on the Nutritional Anthropometric Survey of children under five years old (Morris et al.,2005).

Middle upper arm circumference was measured in centimeter with a non-stretched measuring tape with the right arm hanging relaxed. Measurements were taken midway between the tip of the acromion and olecranon process. The tape was placed gently but firmly round the arm to avoid compression of soft tissue. Measurement was taken nearer to 0.1 cm twice; and subjects were be categorized as undernourished when MUAC was ≤115 mm both female and male.

Height was taken with barefooted in centimeter using stadiometer. A vertical tape fixed perpendicular to the ground on the wall was used and recorded to the nearest 1 cm. In order to eliminate any discrepancy caused by recumbent length versus standing height measurements for each of the references across height, all the recumbent lengths <85 cm were adjusted to standing heights by WHO Anthro software. This ±0.7 adjustment was based on the difference between length and height measurements in the NHANES II data for children aged 24-35 months who had both measurements taken. As a result, the measurement protocols used to create the reference are equivalent to standard procedures developed to measure children in clinic and field settings (WHO,1997).

Weight was measured in kilogram without shoes using a digital scale (Seca Germany) with good precision. To calibrate the weight scale before each measurement of subject's measurement the scale was calibrated to zero routinely before recording the weight of each subject. During the anthropometric measurements, the scale was repeatedly checked for its accuracy standardization was done by using a known weight. To determine Z score WHO anthro software was used.

For prospective cohort study, anthropometric measurements were done every week during SAM and MAM management at Health posts during admission, after cure for weight for height (WHZ) or mid upper arm circumference (MUAC) till children become cured for both. All admissions

were done based on admission criteria of WHO 2013 guideline and Ethiopian National Guideline (FMOH,2007, WHO,2013).

In primary health-care facilities and hospitals the mid upper arm circumference or the weight-for-height/weight-for-length status of infants and having bilateral edema were used as admission criteria. Infants and children who are 6–59 months of age and have a mid-upper arm circumference <115 mm or a weight-for-height/length <–3 Z-scores of the WHO growth standards, or have bilateral edema, were admitted to a program for the management of severe acute malnutrition (WHO,2013). However, discharges were made after children cured for MUAC but not for weight for height for this study without medical complications.

For assessing relapse of severe acute under nutrition record or document review was done to count the relapse cases. That means all case occurrence of severe acute malnutrition after discharge in between 6months' time is considered as relapse (Stobaugh et al.,2019).

1.19. Data Quality Control

To assure data quality, questionnaires were translated in to local language of data collection site by the speakers of the language or natives of the data collection site and local guides in each site were used to get planed sample size and questionnaires were tested on five percent (5%) of the sample size before data collection to check logical sequence and consistency with desired objectives outside the study setting which is believed to meet the objectives.

Intensive training was given to data collectors and supervisors before data collection time for all objectives in all site perior to data collection. Technical error of measurement TEM was calculated to minimize measurement error and maximum acceptance for this study was fixed <1.5% for data collectors for Anthropometric measurements (weight, height and MUAC) during training and

ENA SMART software used for training and evaluation of data collectors. Weight was measured by digital scale after calibration of the pointe to zero before each measurement during data collection and standardizations of each measurement was done using an object of known weight or constant scales that are available for example to check weight scale 50gm weight was measured before measuring the child. In addition, anthropometric assessment was regular at the selected time of the day to avoid diurnal effects and age of children was considered from EPI card and birth certificate if not available local calendars were considered optional. A retrospective cohort study during document review LQS was done to maintain consistence of report with existing data then completeness of the documents were checked before data review for required information.

The supervisor and principal investigator supervised the correct implementation of the data collection procedure and checked completeness and logical consistency of the study.

1.20. Data processing and analysis

Data processing was started by manual checkup for completeness and consistency on the data collection site immediately by principal investigator and supervisors. Then each checked questioner was coded manual by principal investigator by using log book and personal computer.

Exploratory analysis was conducted to find out outliers, missed value and inconsistencies. Body mass index was calculated by using WHO Anthro software and descriptive and analytic statistics was conducted using SPSS 26 version software; frequency table and numerical summary measures. Then different analytic models and analyses were done for each objective based on its outcome measure and designs accordingly. ***Detail for each analysis model described under the following chapters based on its objectives.***

1.21. Ethical Approval and Assent to participate

The study proposal was ethically approved by Jimma University Ethical Review Boards. Informed written and verbal consent and assents was obtained from each parent of children before any interview or measurement and for institution-based data collection ethical consents were obtained from the head of woradas or administrative body of the respective originations. Only those who signed written consent participated in the study and the right of withdrawal for those individuals who are not interested to participate or to stay on the study after signing the consent form at any time from the study was respected.

Confidentiality of responses was maintained throughout the research process by not using any personally identifiable information of the study participants and giving them a unique code. Privacy and cultural norms were respected during data collection. Confidentiality of the data was highly secured throughout by not using any personally identifiable information on the questionnaires and data was not shared for anyone who is not part of investigation, expect for those who have legal permission to use data. Personal identifiers and the other part of the data are separated. The project had different individuals for data entry.

Chapter 3: Sensitivity and specificity of the mid upper arm circumference for assessment of severe acute malnutrition among children aged 6-59 months. Systematic Review and Meta-analysis

Redrafted from: Abera Lambebo, Yordanos Mezemir, Dessalegn Tamiru, and Tefera Belachew. Sensitivity and specificity of the mid upper arm circumference for assessment of severe acute malnutrition among children aged 6-59 months ***(*****published on** Nutrition Journal; https://doi.org/10.1016/j.nut.2022.111918***)***

Abstract

Background;

Although MUAC is a simple and cost-effective tool for diagnosis of acute malnutrition among under five children, its diagnostic performance varies across different places and populations. In this review, the pooled estimated of the sensitivity, specify and optimal cut-off for MUAC were generated by reviewing studies that developed the cut-offs and the findings were discussed in the light of existing evidence.

Methods; Preferred reporting items for systematic reviews and meta-Analyses (PRISMA) guidelines were followed for this systematic review and meta-analysis. The databases used were; PUBMED, Google Scholar, Jane, and African Journals Online. Search terms used were; Sensitivity, specificity of MUAC

Joanna Briggs Institute Meta-Analysis and checklist for diagnostic test accuracy studies was used for critical appraisal tools were used for critical appraisal of studies. The meta-analysis was conducted using STATA 14 software. The pooled sensitivity was computed with 95% confidence interval (CI).

Results: eleven individual studies were included in the meta-analysis. The lowest sensitivity of MUAC on detection of SAM was observed at 5% in Vietnam, while the highest sensitivity was observed at 57% in Niger.

The pooled sensitivity of MUAC among under-five children was determined as 20.7 % (13.24- 28.25). Based on the pooled specificity of MUAC in the detection of the severe acute malnutrition was 97.636 % (95% CI, 96.339- 98.932, P=0.001), and the pooled optimal cut-off point for diagnosing SAM was determined as 13.228 cm (95%CI, 12.692- 13.763, P =0.001).

In conclusion; the sensitivity of MUAC was lower compared to the specificity and it also varies from area to area. The pooled estimated showed that the optimal MUAC cut-off is above the WHO cut off for diagnosing acute malnutrition, which needs consideration for optimizing the diagnostic utility of MUAC.

Keywords; Sensitivity, specificity, optimal cut of point, SAM, under-five age.

1.22. Introduction

Nutritional assessment is the interpretation of anthropometric, biochemical (laboratory), clinical and dietary data to determine whether a person or groups of people are well nourished, malnourished, over-nourished, or under-nourished (Gibson,1993).

Nutritional assessment is an integral part of the care for every pediatric patient (Mascarenhas et al.,1998). The early, rapid, and accurate diagnosis of SAM is crucial to deter deaths of SAM cases (Manoj R. and Bishan S.,2016).

Humble and reliable anthropometry is helpful for early detection and treatment of undernutrition (Hammond et al.,2016). Good nutritional care starts with good assessment and identification of nutritional status and it is a critical first step in improving and maintaining nutritional status (USAID,2015).

Anthropometric measurements are preferred methods and are a widely used because they are economical and non-invasive measure of the general nutritional status of an individual or a population group (Bruce,2003). Anthropometric measurements were better predictors of the nutritional outcome of our critically ill patients than were biochemical tests (Hejazi et al.,2016). Height- and weight-based anthropometric measurement is an excellent tool to instrument general nutritional status in a

population (WHO, 2007) and it is commonly accepted that for practical purposes anthropometry is the most useful tool for measuring the nutritional status of children (WHO,1986).

Child under-nutrition is currently assessed using body mass index for age and MUAC is considered as cornerstone of assessment in different groups (Lazarus et al.,2017) and MAUC has been considered a valid and simple tool for rapid screening wasting in children between 6 months and 5 years of age (Manoj R. and Bishan S.,2016). However, researchers are skeptical to agree on using MUAC as the only tool for detection under nutrition and this doubt is a serious barrier to decision-making for policy change to accelerate coverage of more effective, feasible and sustainable quality services at scale (Hammond et al.,2016).

Even though; the mid upper arm circumference (MUAC) is used as a proxy to assess wasting in children, its validity abounds in controversies (Dairo et al.,2012) MUAC had a lower sensitivity compared to weight-for-height z-score (WHZ), indicating it can detect only a small proportion of the total number of children aged 6–59 months who are wasted (Lamsal et al.,2021). Moreover, this affects case identification and the number of children eligible for treatment (Rana et al.,2021).

Sensitivity is the proportion of people with disease are correctly identified as diseased i.e. there are no false negatives (Crandon,2021). A test with low sensitivity can be thought of as being too cautious in finding a positive result, meaning it will create err on the side of failing to identify a disease in a sick person. When a test's sensitivity is high, it is less likely to give a false negative (Broza and Haick,2022).

Therefore, this systemic review and meta-analysis mainly focuses on evidence generation of sensitivity, specificity and diagnostic measures of the Mid Upper Arm Circumference for the assessment of wasting among children aged 6-59 months.

1.23. Methods

Study design and search strategy

A systematic review of published studies was used to determine the sensitivity and specificity of Mid Upper Arm Circumference (MUAC) to diagnosis severe acute malnutrition and optimal cut off point. Review of all published studies was done in the following major databases; PubMed, Google Scholar, Jane, and African Journals Online. The search for published studies was restricted by time, and all published articles from 2012 up to February 01/2022 were included into the review. Search of the reference list of already identified studies to retrieve additional articles was done.

The electronic search was done on several databases, which included; PUBMED, Google Scholar, Jane, and African Journals Online. With search words of ((Sensitivity) OR specificity) OR Reliability) OR Validity) OR Accuracy) OR Precision) AND Mid Upper Arm Circumference) OR Mid-Upper Arm Circumference) OR MUAC) AND Wasting) OR Undernutrition) OR Malnutrition/Protein-Energy Malnutrition) OR Severe acute malnutrition) OR Malnutrition) AND Child) OR Preschool) OR Children aged 6-59 months) OR Children <5 years) OR Children <59 months) OR Under-five children) OR Under five children).

Study selection and eligibility criteria

This review included studies that were conducted and published on sensitivity and specificity of MUAC on diagnosis of severe acute malnutrition among under five children across the world. All studies conducted at the community either community based cross sectional or community-based survey were included. Studies that include sensitivity and specificity of MUAC with an optimal cut off point among under five children and published in the English language were included. Studies conducted among under five children that contain sensitivity and specificity but who had on hospital for comorbidities, case control study and interventional programs or studies were excluded from this review. Articles were assessed for inclusion using their title, abstract and then a full review of papers was done before inclusion to the final review.

Outcome of interest

The primary outcome of this study was sensitivity and specificity of MUAC among under five children. The others variables included in this review were; optimal cut off and area under the curve or AUC,

Quality assessment and data collection

Joanna Briggs Institute Meta-Analysis and checklist for diagnostic test accuracy studies was used for critical appraisal tools (JBI Evidence Synthesis Manual,1996).

Two reviewers independently assessed the articles for overall study quality and for inclusion in the review. Any unclear information and disagreement between the reviewers were resolved through discussion and by involving a third reviewer. The researchers developed a data extraction tool. The tool included information on the name of the author/s, publication year, study period, study design, sample size, study area, age of study participants and response rate. In addition, the tool contains questions on the sensitivity and specificity of MUAC in detection of severe acute malnutrition and area under curve as well as an optimal cut off point.

Publication bias and heterogeneity

Publication bias and heterogeneity were assessed by using the Egger's and Begg's tests (Begg and Mazumdar,1994, Egger et al.,1997). A p-value less than 0.05 were used to declare statistical significance of publication bias. The heterogeneity of studies was also checked using I^2 test statistics. The I^2 test statistics of 25%, 50%, and 75% was declared as low, moderate and high heterogeneity respectively. A p-value less than 0.05 were used to declare heterogeneity. For the test result which indicates the presence of heterogeneity, the random effect model was used as a method of analysis, since it reduces the heterogeneity of studies (Higgins et al.,2003).

Statistical methods and analysis

Data were entered into Microsoft Excel and then exported to STATA 14 software for further analysis. Forest plot was used to present the combined estimate with 95% confidence interval (CI) of the meta-

analysis. Subgroup analysis was conducted by regions of the country and year of study. The findings of meta-analysis were presented using forest plot and sensitivity and specificity with 95% CI.

Study selection

This review comperes published studies on sensitivity and specificity of MUAC on diagnosis of severe acute malnutrition among under five children.

The search found a total of 1,173,586 results of published articles without year restriction and after restricting year for last five year the result become 203,584 of them 197,921 remains after selection of English language, from them 176,525 were on human subjects after fixing age of the subjects to <5 years the search result become 136,215 and final the search result become 5,755 after selection study designee to observational study and 5,698 excluded by only reading topic. The rest of 57 papers were reviewed and 46 were excluded after reading the content that contain hospital follow up, with low sample size and duplicate, the remaining 11 studies were included in this study. (Fig. 1)

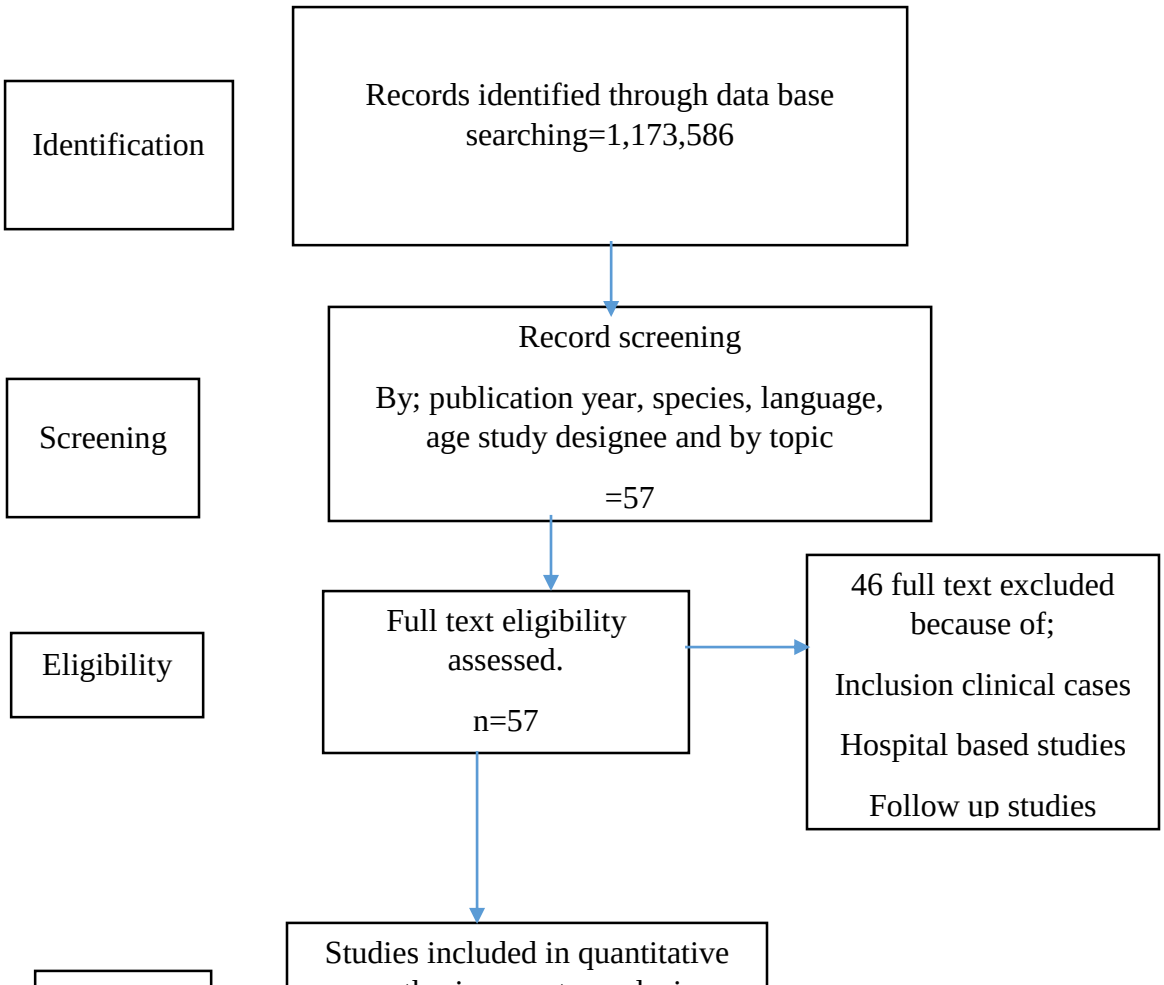

Fig. 1. Flow diagram of the studies those were included in the systematic review and meta-analysis.

Characteristics of included studies

All included studies were cross-sectional and surveys conducted among under five children to identify diagnostic performance of MUAC in terms of sensitivity and specificity in diagnosing children with severe acute malnutrition. The minimum sample size was 319 participants in a study conducted in Nigeria (Dairo et al.,2012). The highest sample size was 18, 456, study conducted in India (Kapil et al.,2018). Overall, this meta-analysis included a total of 70, 617 under five children. A total of 8 (72.73%) were community based cross sectional studies (Dairo et al.,2012, Shekhar and Shah,2012, Kapil et al.,2018, Marshall and Monárrez-Espino,2019, Sougaijam et al.,2019, Adelia and Susanto,2020, Hai et al.,2020, Lamsal et al.,2021) and 3(27.27%) study were community-based surveys (Laillou et al.,2014, Fiorentino et al.,2016, Barro et al.,2021). From the total studies reviewed three were conducted in India (Shekhar and Shah,2012, Kapil et al.,2018, Sougaijam et al.,2019) two of them Cambodia (Laillou et al.,2014, Fiorentino et al.,2016) and the rest of studies were from Indonesia, Nepal, Mauritania, Vietnam, Niger and Nigeria (Dairo et al.,2012, Marshall and Monárrez-Espino,2019, Adelia and Susanto,2020, Hai et al.,2020, Barro et al.,2021, Lamsal et al.,2021) (Table 1).

Table 1 Characteristic of studies on severe acute malnutrition (SAM) included in the meta-analysis

Authors	Year of pub	Year	Index	Country	Population	Study designe	Sample size	SP%	SN %	AU	S-Cut off
(Sougaijam et al.,2019)	2019	2012 – 2013	NIH/PubMed	India	6-59 months	CB. Cross-Sectional Study	2,650	99.7	23.5	0.88	12.8
(Laillou et al.,2014)	2014	2010-2012	NIH/ PubMed	Cambodia	<5 years	Survey	11,818	98.1	13.4	0.54	13.3
(Lamsal et al.,2021)	2021	2017	NIH/ PubMed	Nepal	6–59 months	Cross-Sectional Study	3,169	99.7	13.6	0.53	12.5
(Kapil et al.,2018)	2018	2012 – 2013	NIH/PubMed	India	<5 years	CB. Cross-Sectional Study	18, 456	99· 1	13· 4	0·933	13.5
(Marshall and Monárrez-Espino,2019)	2019	2011 – 2012	NIH/PubMed	Niger	d 6 to < 24 months	CB. Cross-Sectional Study y	1,161	97.0	57.0	0.94	12
(Fiorentino et al.,2016)	2016	2011– 2013	NIH/PubMed	Cambodia	<5 years	Surveys	14,157	99.0	8.6	0.54	13.8
(Dairo et al.,2012)	2012	2012	NIH/PubMed	Nigeria	6-59months	CB. Cross-Sectional Study y	319	96.8	27.5	0.80	15.5
(Shekhar and Shah,2012)	2021	2012	NIH/PubMed	India	6-59months	CB. Cross-Sectional Study y	346	90	43.2	0.80	12

(Adelia and Susanto,2020)	2020	2018	scholar.archive.org	Indonesia	6-59 months	CB. Cross-Sectional Study y	853	99.9	12.5	0.93	13.8
(Hai et al.,2020)	2020	2019	NIH/PubMed	Vietnam	6–59 months	CB. Cross-Sectional Study y	5,098	99	5	0.72	12.5
(Barro et al.,2021)	2021	2015	NIH/PubMed	Mauritania	6–59 months	Survey	12 590	97.49	17.98	0.8	13.8

1.1. Result

Sensetivity and spesifisity of mid upper arm circumfrance for detection of Severe acute malnutrition (SAM)

The lowest sensetivty of MUAC on detection of SAM was observed as 5% in Vietnam (Hai et al.,2020) whereas, highest sensitivity was observed as (57%) was reported from Niger (Marshall and Monárrez-Espino,2019). Heterogeneity of sensitivity of MUAC is identified as highest with I^2 = 93.29%. The highest optimal cut of point is determined in Nigeria as 15.5cm (Dairo et al.,2012) and the smallest optimal cut off point is observed as 12 cm in Niger and India (Shekhar and Shah,2012, Marshall and Monárrez-Espino,2019) (Figure 2).

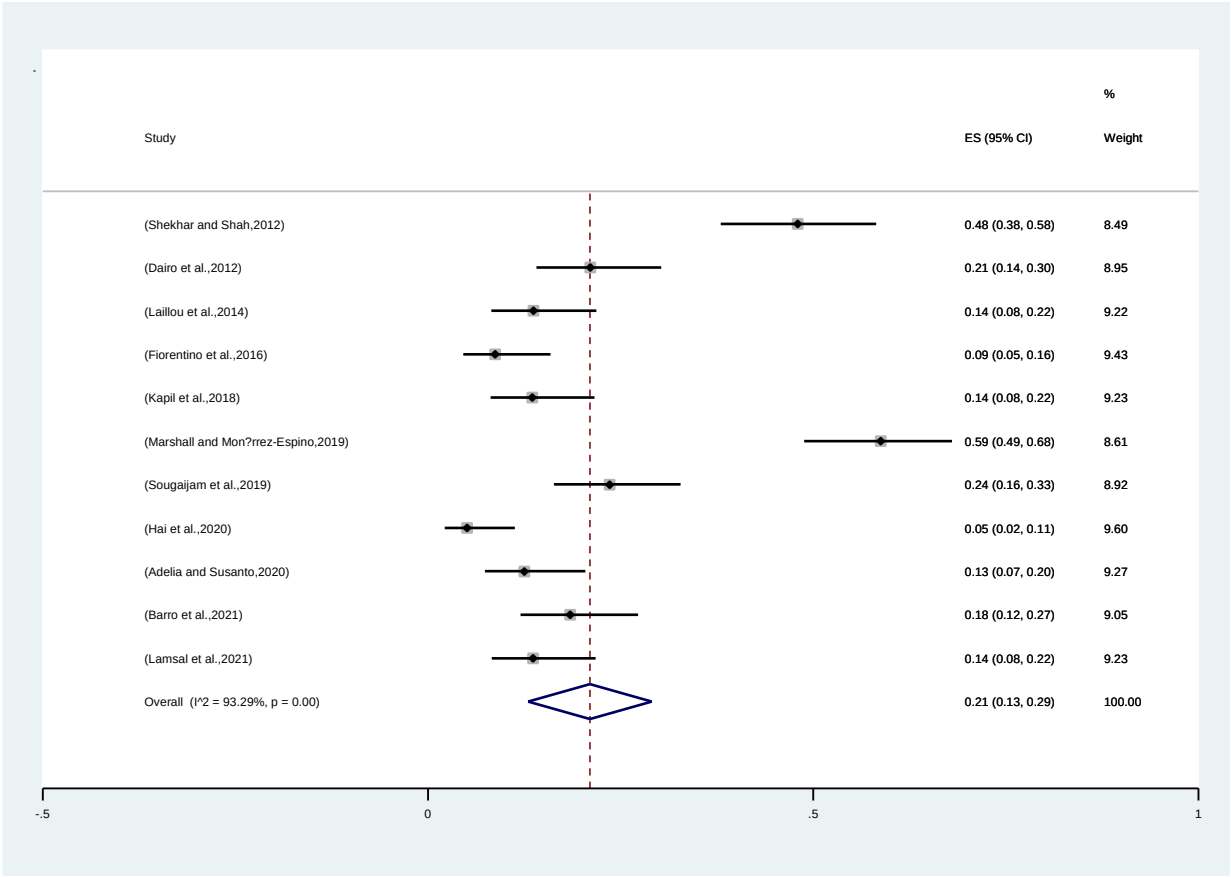

Figure 2. Forest plots that displaying the pooled sensitivity of MUAC on diagnosis SAM among under five children.

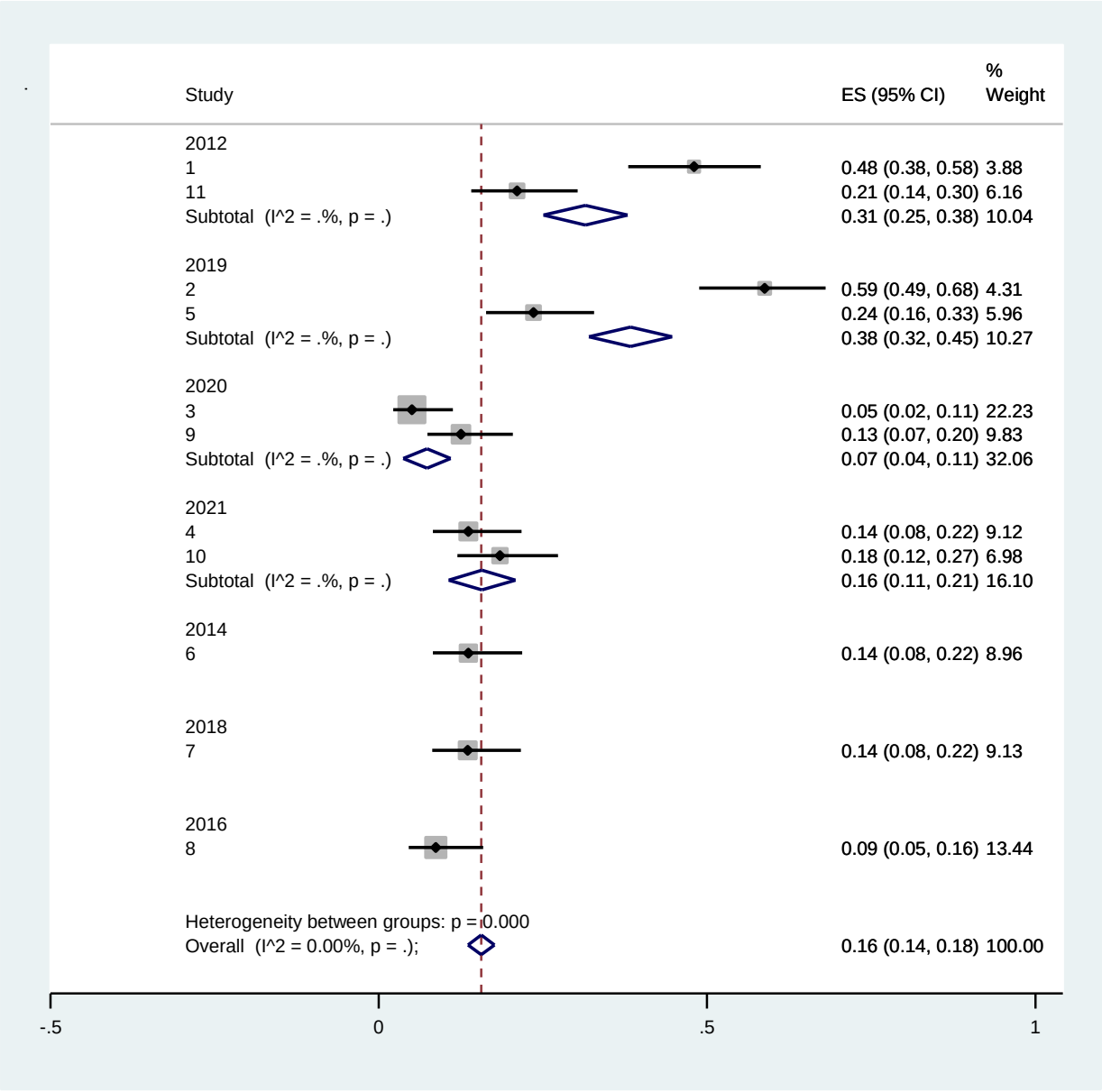

Figure 3. Forest plots that displaying the grouped pooled sensitivity of MUAC by year of publication on diagnosis SAM among under five children.

Pooled sensitivity of MUAC was 20.744 at (95%CI, 13.238- 28.249, P=0.001.) while the pooled specificity for detecting severe acute malnutrition was 97.636 at (95% CI, 96.339

, 98.932, P=0.001), and the pooled optimal cut off point for diagnosing SAM was determined as 13.228 cm at (95%CI, 12.692- 13.763, P =0.001) (Table 2).

Table 2. Pooled analysis of sensitivity, specificity and an optimal cut of point of MUAC for SAM among under five children from different studies.

Pooled variable	P	Pooled value at 95%CI	Df
Sensitivity%	0.001	20.7(13.24- 28.25)	10
Specificity %	0.001	97.7(96.34- 98.93)	10
Optimal cut off point (cm)	0.001	13.3 (12.69- 13.76)	10

1.1. Discussion

This review was conducted to determine the pooled sensitivity of MUAC on diagnosis of severe acute malnutrition among under five children globally. Sensitivity is the proportion of people with disease. A test that is 100% sensitive means all diseased individuals are correctly identified as diseased i.e. there are no false negatives (Crandon,2021). A test with low sensitivity can be thought of as being too cautious in finding a positive result, meaning it will commit error on the side of failing to identify a disease in a sick person. When a test's sensitivity is high, it is less likely to give a false negative (Broza and Haick,2022). When we come to this study the pooled sensitivity is 20.7% (13.24- 28.25) this is much lower and in other word we are going to miss 80% of children with severe acute malnutrition and this may

result in nutritional complication among under five with severe acute malnutrition in the community before diagnosis.

Specificity is the ability of a test to correctly identify people without the disease (Swift et al.,2020). In this review the specificity of MUAC is higher comparing to sensitivity and pooled specificity 97.7 % (96.34- 98.93) that means MUAC will identify true negative case.

Severe acute malnutrition is defined in these guidelines as the presence of oedema of both feet and severe wasting weight-for-height/length <-3SD or mid-upper arm circumference < 115 mm (World Health Organization,2013). As this cut off point is not sensitive enough to detect children with SAM now day's different countries suggesting their cut off points for their own country. In this study, the pooled optimal cut off point was determined as 13.3cm (12.69- 13.76).

Conclusion: the sensitivity of MUAC is lower compared to specificity and varies from area to area. Existing WHO cutoff point 11.5cm is very low compared to the pooled optimal cut-off identifies in this analysis, which needs consideration.

Practical and policy implications; In this study the pooled sensitivity is 20.7% and it is not sensitive enough to detect children with SAM and now day's different countries suggesting their own cut off points of MUAC for their own country. In Ethiopia as we understand there is burden of SAM cases as a country we are expected to develop different cut off point of MUAC than existing and introducing pilot implementation is important to overcome this challenge.

Recommendation: The review suggests the need for more data based from local research to determine the optimal cut-off of MUAC for diagnosing acute malnutrition.

From this finding, we may say that to increase the sensitivity of MUAC at national level, each country is expected to develop its own optimal cutoff for MUAC.

2. Chapter4 :Frequency of Relapse for Severe Acute Malnutrition and Associated Factors Among Under Five Children Admitted to Health Facilities in Hadiya Zone, South Ethiopia.

Redrafted from: Abera Lambebo1, Dessalegn Tamiru1, Tefera Belachew1.

Frequency of Relapse for Severe Acute Malnutrition and Associated Factors Among Under Five Children Admitted to Health Facilities in Hadiya Zone, South Ethiopia. ***Published on PLOS ONE; https://doi.org/10.1371/journal.pone.0249232***

Abstract

Background: Severe acute malnutrition is a common cause of morbidity and mortality among under five children in Ethiopia. A child may experience more than one episode of SAM depending on the improvement of the underlying factors. However, there is no study that determined the frequency of relapse of SAM cases after discharge in Ethiopia.

Objective: To identify the frequency of relapse and associated factors among children discharged after undergoing treatment for SAM in Hadiya Zone, South, Ethiopia.

Methods: An institution based retrospective cohort study was done among under-five children discharged from SAM treatment in the health posts in the last five years (from 2014/2015-2019/2020) in Hadiya zone, SNNPR, Ethiopia. Both first admission data and relapse data were abstracted from the records of the SAM children using a data abstraction form. Data were coded and edited manually, then doubly entered into Epi-Data statistical software version 3.1 and then exported to SPSS for windows version 26. After checking all the assumptions finally Negative binomial regression fitted. All tests were two sided and P values <0.05 were used to declare statistical significance.

Results: In the last five years the proportions of relapsed cases were 9.6%, 95% CI: (7.7%, 11.7%). On multivariable negative binomial regression model, after adjusting for background variables relapse of severe acute undernutrition was significantly associated with having edema during admission with (IRR=2.21, 95% CI:1.303-3.732), being in the age group of 6-11 months (IRR=4.74,95% CI:1.79-12.53), discharge MUAC for the first admission (P=0.001, IRR=0.37, 95% CI:0.270-0.50) increase the risk of incidence rate ratio(IRR) relapse case of severe acute under nutrition.

Conclusion: Frequency of SAM relapse was positively associated with age, having edema during admission, while it was negatively associated with discharge MUAC. The results imply the need for reviewing the discharge criteria considering the recovery of MUAC as a marker for lean tissue accretion, especially in edematous children and those in the younger age,

Keywords; Relapse, Incidence rate ratio, SAM, under five children, Ethiopia.

2.1. Introduction

Malnutrition referring to deficiencies, excesses, or imbalances in a person's intake of energy and/or nutrients and it affects every country in the world by one or more forms (WHO,2020). Severe acute malnutrition (Wasting) is characterized by low weight-for length/ height and or bilateral pitting edema (Fabiansen et al.,2018). Severe acute malnutrition (Harshal T. and Samir A.) has several immediate, underlying and basic causes. Once a child develops SAM, he/she often suffers from chronic and lifelong consequences throughout life continuing the miserable legacy from generation to generation (World Bank,2012).

Nearly half of all deaths in children under 5 are attributable to undernutrition which puts them at greater risk of dying from common infections and delays recovery from them (UNICEF,2019). Large proportion of childhood malnutrition occurs mainly among under five children living in low-income and middle-income countries (Zulfiqar A. et al.,2017). In Africa there are large burden of risk factors related to childhood health and development, most of which are of an infective or social origin (Stobaugh et al.,2017).

Children with severe acute under nutrition has very low weight for their height and severe muscle wasting and they may also have nutritional edema characterized by swollen feet, face and limbs (WHO,2009, UNICEF,2014).

A study in rural Malawi among children 6 to 59 months old with MAM shows that mid-upper arm circumference and WHZ at the end of supplementary feeding were the most important factors in predicting which children remained well-nourished (Trehan et al.,2015).

In Ethiopia, children with SAM are admitted to health posts using MUAC < 11.5cm and get treated with ready to use therapeutic food and other treatments indicated in the protocol for a period of eight weeks (FMOH,2007). Children with the lowest MUAC at admission showed a significant gain in MUAC but not weight, and children with the lowest weight-for-height/length (WHZ) showed a significant gain in weight but not MUAC and response to treatment was largest for children with the lowest anthropometric status at admission in either measurement modality by WHZ or MUAC (Tadesse et al.,2017).

However, they are discharged from the program based on percent of weight gained or weight for height > 70%. During discharge recovery based on MUAC is not used (Abitew et al.,2020) however, this study was limited to factor identification and fail to identify frequency of relapse. Therefore, this study is aimed to identify the number of relapse cases and associated factors.

2.2. METHODS

An institution based retrospective cohort study was conducted among a cohort of under-five children with SAM who were admitted and discharged for SAM from 2014/2015-2019/2020 in 20

selected health posts in Hadiya zone, SNNPR, Ethiopia. The data were abstracted from their records from Aguste 1 – 30 /2020.

In Hadiya Zone, 6% of the inhabitants of have access to electricity road density was 104.1 kilometers per 1000 square kilometers compared to the national average of 30 kilometers),(World Bank,2003), the average rural household has 0.6 hectare of land compared to the national average of 1.01 hectare . Seventy four percent of all eligible children are enrolled in primary school, and 21% in secondary schools. 43% of the zone is exposed to malaria (World Bank,2006). This zone is characterized by a predominant commitment to agricultural activities, especially the *enset*-growing, which is often combined with that of grain, barley and maize, as well as the breeding of domestic animals (VALENTINA PEVERI,1997).

In Hadiya Zone there were 280 Health Posts (HPs), 60 rural Health Centers, one University teaching Hospital and 3 primary level Hospitals. The zone is divided into 11 districts for administrative purposes. The vast majority of the population is Hadiya by ethnic group and they earn their living through rain fed agriculture. The woredas were; East Bedewacho, Siraro Bedewacho, West Bedewacho and Shone town administration separated from the rest of the zone by Kembeta Tambaro (Wikipedia,2019). This study was conducted among 20 health posts in two woradas and one town administration with highest number of SAM cases East Bedawacho (Tikere kokere,Tikare Anbesa,Mahal,Jariso,Amburse Anjulo,2nd Chafa,Eddo,Lenda,Jerso Kutube and Bente Wosen).

Siraro Bedewacho (Abuka,Langano,Dongaro Bonkoya,Wera Bonkoya,sheriko Gafarso,Kumudo,Beshilo,Mahal Korga and Woldia) and Shone Town administration(Wera Gere and Shone City Adimin). Health posts were selected based on number of SAM cases.

Study population: Documents of all under five children that were admitted for severe acute undernutrition in selected health posts in the last five year.

Inclusion

All documents that full registered about the admission and discharge status were included for this study.

Exclusion criteria

Documents that were doubly registered or registration after transfer for other facilities was excluded.

Sample size calculation

Sample size for this study was all cases within selected area at fixed time that means number of relapse cases among admitted children for severe acute malnutrition in health posts of two woradas and one town administration in the last five years.

Sampling technique

For this study, all severe acute malnutrition cases those admitted in selected woradas and health posts were included and woradas and health posts were selected conveniently based on their case load.

Data Collection Methods

For collecting data from the registration book of under-five children with SAM, structured list of questioners was used during the survey for relapsed cases of SAM in the last five years. The questionnaires were adopted from previous study that was conducted in Malawi for similar topics (Stobaugh et al.,2017). To ensure data quality, a three days training was given for data collectors

and supervisors on the data collection tool, the data collection procedure and questionnaire was pretested on children with SAM in Halaba, which is not part of the study area.

Operational definition

Relapse rate/repeated relapse episodes: The proportion of children who were re-enrolled after they recovery and discharged (Akparibo et al.,2015).

Wasting is defined; as low weight-for-height. It often indicates recent and severe weight loss, although it can also persist for a long time (WHO,2020).

Severe acute malnutrition: It is diagnosed by weight for- height below -3 SD of the WHO standards, by a MUAC 11.5 cm and by clinical sign having bilateral edema (WHO,2009, UNICEF,2014, UNICEF,2019).

Kwashiorkor or edematous malnutrition: is a form of severe under nutrition, the child's muscles were wasted, but wasting may not be apparent due to generalized edema or swelling from excess fluid in the tissues (WHO,2009, UNICEF,2014).

Criteria for discharging children from treatment; weight-for-height/length is ≥–2 Z-scores and they have had no oedema for at least 2 weeks (WHO,2013).

Data Processing and Analysis

The data were doubly entered by two data clerks into Epi-Data version 3.1 to avoid clerical errors using side by side comparison. The data were then exported to SPSS for windows version 26 statistical software for cleaning and analysis. Descriptive analysis such as simple frequencies, measures of central tendency, and measures of variability was used to describe age and sex

distribution as well as discharge status of the under-five children for severe acute malnutrition treatment.

Before poison regression the assumptions were checked, as the variable is relapse case count it meets the first assumption for poison regression. Then One-Sample Kolmogorov-Smirnov Test was done to check significance test for non-significant value and as result reveals 0.978 so this data fulfills the second assumptions again when we see the distribution of the data for third assumptions; mean=0.1178 and variance=0.149 these values indicate the over dispersion of data; another assumption of poison regression is equi-dispersion of data. However, this data fails to meet the last assumption of poison regression. As the last assumption fails, we fitted **negative binomial regression** for poison. A negative binomial regression selection of variables for multiple negative binomial regression is based on P-value <0.25 and final significance for incidence Risk Ratio (IRR) was declined at a P-value of < 0.05.

Ethical Considerations:

Informed written consent was obtained from all health extension workers of selected health posts and woreda health office, confidentiality of the study documents was' information was also ensured according to the Helsinki declaration of ethical code for human subjects. ***Detail is presented in methodological part chapter 2.***

2.3. Results

In this study, the relapse case count was conducted for cases of severe acute malnutrition in two woredas and one town administrative in 20 health posts among 900 children with severe acute malnutrition in the last five years before the survey. From the total case counts from the records

465(51.7%) were females and 435(48.3%) were males. The mean (±sd) age of the children in this study was 26.1±0.496 months. Regarding the types of admissions, from 900 children with SAM, 814(90.1%) were new admissions (Table1).

Table 1. Socio demographic characteristic of under five children who are admitted for severe acute under nutrition in Hadiya Zone, SNNPR, Ethiopia in the las five years from 2014/2015-2019/2020(n=900)

Variable	Frequency	Percent
Sex of the child		
Male	435	48.3
Female	465	51.7
Age in months		
6-11	206	22.9
12-23	171	19
24-35	161	17.9
36-47	226	25.1
48-60	136	15.1
Residential worada of child		
Siraro Bedewacho	507	56.3
East Bedewacho	307	34.1
Shone City administration	86	9.6
Types of admission for SAM		
New admission	814	90.4
Re admission	86	9.6

From the total admissions for SAM, 575 (63.9%) were non-edematous diagnosed as marasmic cases, while and 325(36.1%) were edematous diagnosed as kwashiorkor and the rest were diagnosed as marasmic kwashiorkor. The mean (± SD) days of stay on treatment after admission were 46 days (±12.98) days. Regarding the treatment outcome of admitted children, 838(93.1%) were cured, 6 (0.7%) died while 20(2.2%), 16(1.8%), 14(1.6%), and 6(0.7%) were Defaulter, Unknown, Non-response, and medical transfer cases, respectively (Table 2).

Table 2. Nutritional status of the children during admission among severe acute under nourished under five children in Hadiya Zone, SNNPR, Ethiopia in the las five years from 2014/2015-2019/2020(n=900)

Nutritional status and diagnosis	Number	Percent
Presence of edema		
Yes	325	36.1
No	575	63.9
Diagnosis during admission		
Marasmus	575	63.9
Kwashiorkor	319	35.4
Marasmic kwashiorkor	6	-
Treatment out comes		
Cured	838	93.1
Dead	6	-
Defaulter	20	2.2
Unknown	14	1.6
Transfer out	16	1.8
Non-response	6	
MUAC of the children when termination treatment(cm)		
<11.5	270	30
11.5 <-12.5	396	44
>12.5	175	19.4
Not recorded	59	6.6

Of the total cases treated in the 20 health posts, 86 (9.6%), 95% CI: (7.7%, 11.7%) of SAM cases were readmitted with similar cases in the last five year out of which 66 children were readmitted once and the rest 20 cases were readmitted twice (Figure 1).

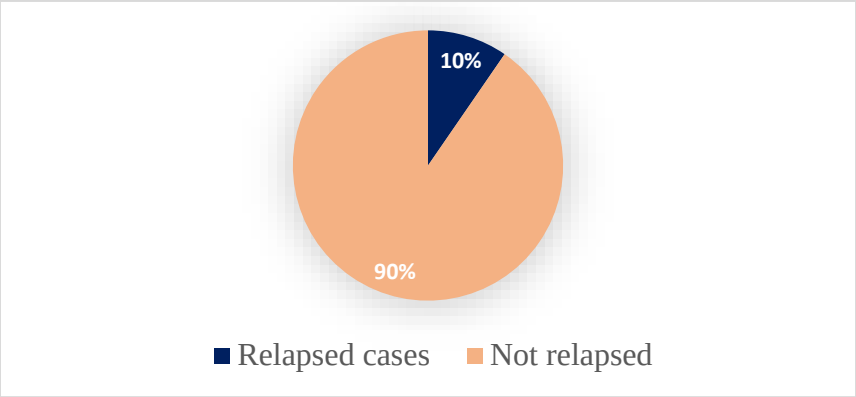

Figure:1 the number of relapsed cases of severe acute under nourished under five children in Hadiya Zone, SNNPR, Ethiopia from 2014/2015-2019/2020(n=900)

From the total of 86 (9.6 %,) 95% CI: (7.7%, 11.7%) relapsed cases 44 (4.9%) were males and the rest 42(4.7%) were females. The outcome for the first admission showed that 48(5.3%) were cured and discharged for the first admission 20(2.2%) were defaulters for the first admission 10(1.1%) was with unknown status and the rest 8 were transferred out for a medical reason. Regarding the age of relapsed cases 34(39.5%) was at the age of 6-11 months followed by those in the age group of 36-47 months (23.3%) and 12-23 months (15.1%). (Table 3)

Table 3. Relapsed cases with other variables severe acute under nourished under five children in Hadiya Zone, SNNPR, Ethiopia from2014/2015-2019/2020(n=900)

Variable	Relapse of SAM cases	
	Yes	No
	n (%	n (%
Sex		
Male	44 (4.9)	391(43.4)
Female	42(4.7)	423(47)
Admission edema		
Yes	32(3.6)	293(32.6)
No	54(6)	521(57.9)
Outcome for the first admission		
Cured	48(5.3)	790(87.8)
Defaulter	20(2.2)	0
Non-responses	0	6
Transfer out	8	8
Unknown status	10(1.1)	4
Age, months		
6-11	34(3.8)	172 -19%
12-23	13(1.4)	158(17.6)
24-35	14(1.6)	147(16.3)
36-47	20(2.2)	206(22.9)
48-60	5	131(14.6)

Discharge MUAC (cm)		
<11.5	53(5.9)	217(24.1)
11.5-12.5	23(2.6)	373(41.4)
>12.5	6	169(18.8)
Not recorded	4	55(6.1)

On multivariable negative binomial regression, after adjusting for background variables including sex of the child, admission edema, child age, discharge weight for age ratio Z score (8), discharge of mid-upper arm circumference (MAUC) and a number of days in treatment having edema at admission, age of the child, MUAC at discharge, and having edema on the first admission were independent predictors of relapse.

Having nutritional edema during the first admission increased incidence rate ratio of relapse for SAM by 2.205 times (IRR=2.21, 95% CI: 1.303-3.732). Similarly, being in the age groups of 6-11 months increased the incidence rate ratio of relapse for SAM by 4.7 times compared to the age group of 48-60 months (IRR=4.74,95% CI:1.79-12.53). Likewise, having edema during the first admission increased the incidence rate ratio of relapse by 2.2 times ((P=0.003, IRR=2.2, 95% CI: 1.30-3.73).

Conversely, there was a negative association between discharge MUAC for the first admission and relapse of SAM. For 1cm increase in the discharge MUAC of the first admission, the incidence rate ration of relapse of SAM decreased by 63% (P=0.001, IRR=0.37, 95% CI:0.270-0.50) (Table 4).

Table 4. Negative binomial regression model for factors associated with incidence rate ratio (IRR) of relapse of SAM case in Hadiya Zone, SNNPR, Ethiopia. 2014/2015-2019/2020(n=900)

Variable	B	P	IRR (95% CI)
Sex			
Male	148	0.52	1.16 (0.74-1.82)
Female		.	1.00
Edema during admission			
Yes	0.79	0.003*	2.20(1.30-3.73)
No		.	1.00
Age, months			
6-11	1.56	0.002*	4.74(1.79-12.53)
12-23 24-35	0.93	0.093	2.53(0.86-7.50)
36-47	0.71	0.160	2.04 (0.76 -5.51)
	0.68	0.148	1.984 (0.78 -5.02)
		-	1.00
Discharge MUAC for the first admission	-1.001	0.001*	.368 (.27-.50)
Number of days in treatment for the first admission	0.006	0.48	1.006 (.990-1.02)

IRR: Incidence rate ratio.

P<0.01.

CI: Confidence interval.

2.4. Discussion

We found out that the proportion of relapse was 9.6% ,95% CI: (7.7%, 11.7%) which is in line with study conducted in rural Malawi reveals that children treated for SAM and discharged in 8 weeks 7% relapse after treatment (Trehan et al.,2015). Similarly, another prospective cohort studies in Bangladesh, among severely malnourished children reveal that from those who were treated for severe malnutrition and discharged by weight for height but not for MUAC; 7% required readmission to the nutrition program because of (Ali et al.,2013). From this, we may conclude that the problem of relapse among children with severe acute nutrition is common. However, there is no tracer system after discharge from the programs in health system and this may lead to repeated admission of children for similar problem.

On other hand, it was observed that MUAC at discharge of the first admission was associated with incidence rate ratio of relapse. For 1cm increase in the MUAC at the discharge of the first admission the incidence rate ratio of relapse by decreases 63%. This finding is in line with the study done in rural Jharkhand and Odisha, eastern India, and in Burkina Faso which showed that as anthropometric indicators was hazardous for MAM and for SAM as MUAC at 11.5 cm (9, 10). As MUAC is a measure fat free mass, which is mostly lean tissue, it is an indicator of recovery in terms of fat free masa accretion (Briend et al.,2019). The findings imply that early discharge of children with SAM before return of MUAC will result in a relapse of severe acute malnutrition, as there is still a need for more time before discharge for restoration of the wasted lean tissue. This implies the need for revising the existing cutoff point of MUAC for discharge as anthropometric cure may not guarantee the risk of relapse in SAM cases.

Similarly, having edema during admission increased the incidence rate ratio of relapse by 2.2 times compared to non-edematous children during admission. This may be related to the fact that edematous children lose significant amount of lean body mass and have marginal protein status that precipitated the edema, requiring more time for recovery (Di Giovanni V et al.,2016). Experimental studies on the edema showed that dietary treatment improved edema even before the albumin concentration rose. Among edematous children, there was low plasma zinc concentration and which was strongly associated with nutritional edema and there were significant relationships between plasma zinc concentrations and stunting, skin ulceration, and wasting (Tadesse et al.,2017).

However, as earlier weight losses among children with severe acute malnutrition and edema after treatment may lead to early discharge before cure for some micronutrients like Zink and this may result in recurrence of SAM cases among under five children. Regarding the discharge criteria of children with severe edematous acute malnutrition with weight gain; however, no specific cut-off points for discharge weight for children with edema.

Another variable that is linked to incidence rat ratio of relapse was age. Being in the age group between 6 -11 months increased the incidence of relapse for SAM by 4.74 times compared to those in the age of 48-60 months. This may be related to the fact that the target group for screening for the nutritional problem mainly focuses on under five-year. This could be related to the fact that age group 6-11 months is the time when complementary feeding is initiated, exposing children to different nutritional and health problems increasing the risk of relapse compared to older ages where children can have different options including family meal.

Practical implication; In this study as we have seen above children with severe acute malnutrition who had edema and discharge early before MUAC reaches normal stage results in increasing risk

of incidence of relapse. Based on this result we may suggest that existing MUAC for SAM discharge needs rehearsal. It is better to develop additional criteria for discharge from SAM among children with edema rather than using weight loss as sole criteria.

Strength; In this study as much as, possible we have tried to cover a number of health posts with highest number of cases for the last five year with limited number of resources and used negative binomial poison regression for this study, to overcome some of the problems over dispersion. This makes it ideal for a distribution in which the mean or the most typical value is close to 0.

Limitation; as this study is retrospective cohort and study design itself brings some limitation and it is better to support this study with prospective cohort to know the sequential order of factors and to identify which factors proceeds as cause of relapse. In this study, some important factors were not included due to lack of appropriate or complete registration (e.g., antibiotics, vitamin A, vaccination status, access to health services, standard of living, food security, and access to clean water that may affect relapse to SAM.

Conclusion: Based on these findings, we may conclude that the relapse cases for severe acute undernutrition among under-five children were higher in Ethiopia compared to the other countries. There were also some factors that increase the incidence of relapse cases; early discharge of MUAC, edema during admission, and age of the child were associated witrh Incidence Risk Ratio (IRR) with relapse of SAM cases**.**

Recommendation: As there is the highest relapse rate for severe acute malnutrition it is better to have a tracer system for SAM children after discharge from the outpatient treatment program (OTP). to the findings imply the need to differ the discharge cut-off point for the weight for age for edematous SAM children and non-edematous SAM children.

In addition to that as the existing discharge point of MUAC is another contributing factor for the incidence of relapse it is an indication for looking a new cutoff point for the discharge of MUAC for SAM under-five children may result in better outcomes after discharge for

CHAPTER5:

Time to relapse of severe acute malnutrition and risk factors among under-five children treated in the health posts of Hadiya Zone, Southern Ethiopia

Redrafted from: Abera Lambebo, Dessalegn Temiru, Tefera Belachew.

Time to relapse of severe acute malnutrition and risk factors among under-five children treated in the health posts of Hadiya Zone, Southern Ethiopia. (**Published on journals.cambridge.org/jns Journal of Nutritional Science (2021), vol. 10, e105, page 1 of 6 doi:10.1017/jns.2021.99)**.

Abstract

Malnutrition has many unpleasant results on child health during illness and after discharge. However, in Ethiopia there is luck of study that address either time to relapse or post discharge status.

Objective: To identify time of relapse and associated factors among children discharged after undergoing treatment for SAM in South, Ethiopia. Retrospective cohort study was done among children admitted to health posts for SAM from 2014/2015-2019/2020. After checking all the assumptions finally multivariable Cox regression was fitted. All tests were two sided and P values <0.05 were used to declare statistical significance.

Results: The mean time for relapse of severe acute malnutrition among under five children was determined to be 22 (95% CI: 20.69-24.82) week to relapse.

On multivariable Cox regression model, after adjusting for background variables, time for relapse of SAM was significantly associated with edema during admission (AHR,2.02 ,95%, CI: 1.17-3.50), age group of 6-11 months (AHR 5.2,95%, CI:1.95-13.87), outcome for the first treatment or not cured for first admission increase hazard of relapse to time by 12 with (95%, CI: 7.90-19.52) compared to cured one.

In conclusion mean time to relapse was 22 weeks and edema, age and MUAC was associated time to relapse.

Keywords; Time to relapse, Hazard of relapse, SAM, under five children, Ethiopia.

2.5. Introduction

Malnutrition is a significant global public health burden with greater concern among children under five years in Sub-Saharan Africa (Obasohan et al.,2020).

In Ethiopia, every month over 25,000 children with severe acute malnutrition are admitted to hospitals across Ethiopia and the survivors are more likely to perform poorly in school and, once grown up, girls are more likely to suffer from complications during childbirth (Lanyero et al.,2019). Severe acute malnutrition is a life-threatening condition among the children with SAM and children with SAM were 11 times more likely to die comparing to a non-malnourished child (AAH,2019).

Malnutrition has many unpleasant results on child health during illness and after discharge. Many children younger than 5 years in developing countries are exposed to multiple risks, including poverty, malnutrition, poor health, and unstimulating home environments, which detrimentally affect their cognitive, motor, and social emotional development (Grantham et al.,2007). Nearly half of all deaths in children under 5 are attributable to undernutrition; undernutrition puts children at greater risk of dying from common infections, increases the frequency and severity of such infections, and delays recovery (UNICEF,2020).

On another hand relapse after treatment is another challenge for SAM cases in some study suggests that after cure relapse rates at 4 months or 16 weeks post-discharge (Lelijveld et al.,2021). A close follow-up of SAM following discharge is crucial for successful management, since complications, i.e., relapse, development of complications and mortalities, can happen during this period. Weekly follow-up for at least two months is recommended, as these patients tend to relapse. A quarter of

these children fail to follow up in six months due to migration, social, political and logistic reasons (UNICEF,2020).

However, in Ethiopia there is luck of study that address either time to relapse or post discharge status. As we have seen above, after treatment of SAM and discharge under five children may face multiple health challenge so, this study is paramount important for government focus on post discharge status of SAM children.

2.6. Methods

Study area and design

An institution retrospective cohort study was conducted. ***More detail presented in chapter 4***

Population

All records of under-five children who were admitted to the health posts of Southern people, Hadiya Zone among three woradas from November 2014/2015-August 30/2020 were the source population of this study

Sample size determination and sampling procedure

To assess time to relapse of severe acute malnutrition and risk factors among under-five children treated in the health posts of Hadiya Zone, Southern Ethiopia.

Sample size was determined from the study conducted in North Gondar zone, Northwest Ethiopia (Mamo et al.,2019). Then it was calculated by medcalc©version 119.1.1.3 survival analysis (logranktest) at http://www.medcal.org (MedCalc Statistical Software version 19.1.3,2019). And diarrhea on admission as the main exposure cured=51, censored=17, outcome 75%, AHR=0.81

and Log rank=19 total event needed 484 as we have moving from zones to woradas and from worada to Kebeles multiplying factor for design effect is considered as 1.5. And final sample size is 484*1.5=726 were chosen,

Sampling procedure

Health posts were selected based on number of SAM cases and all severe acute malnutrition cases those admitted in selected woradas and health posts in last five years were included. All records of under-five children who were admitted to the health posts of Southern people, Hadiya Zone among three woradas from November 2014/2015-August 30/2020 were the source population of this study. ***Detail about sampling frame is presented in chapter 4***

Data collection procedure

A data extraction tool was prepared from the national treatment protocol for the management of SAM (Lanyero et al.,2019). The data extraction format used consisted of socio-demographic data (age, sex), anthropometric measurements (height, weight, MUAC, edema), four data collectors (Andrew J. et al.) and one supervisor were recruited based on their experience in data collection. Data collectors received a one-day training on the data collection tool and were deployed to collect data once the principal investigator was convinced of their competency.

Operational definition

Relapse rate/repeated relapse episodes: The proportion of children who re-enrolled after they recovered and discharged (Akparibo et al.,2015).

Wasting: is defined as low weight-for-height. It often indicates recent and severe weight loss, although it can also persist for a long time (WHO,2020).

Severe acute malnutrition: It is diagnosed by weight for- height below -3 SD of the WHO standards, by a MUAC 11.5 cm and by Clinical sign like bilateral edema (WHO,2009, UNICEF,2014, UNICEF,2019).

Criteria for discharging children from treatment; weight-for-height/length is ≥–2 Z-scores and they have no oedema for at least 2 weeks, or mid-upper-arm circumference is ≥125 mm and they have had no oedema for at least 2 weeks (WHO,2013).

Data processing and analysis

Data were coded, entered, Ep-data software version 4.2 and exported to SPSS version 25 software for analysis. The presence of missing values, possible outliers, and multicollinearity were checked through exploratory analysis.

Both bi-variable and multivariable Cox regression analyses were performed. Kaplan Meier survival curve with the log-rank test was fitted to identify the presence of a difference in recovery rate among the categorical variables. And Mantel-Cox and Generalized Wilcoxon test of equality of survival distributions was significant and one minus survival function line is also parallel for those candidate variables of multivariable Cox regression (Figure 1).

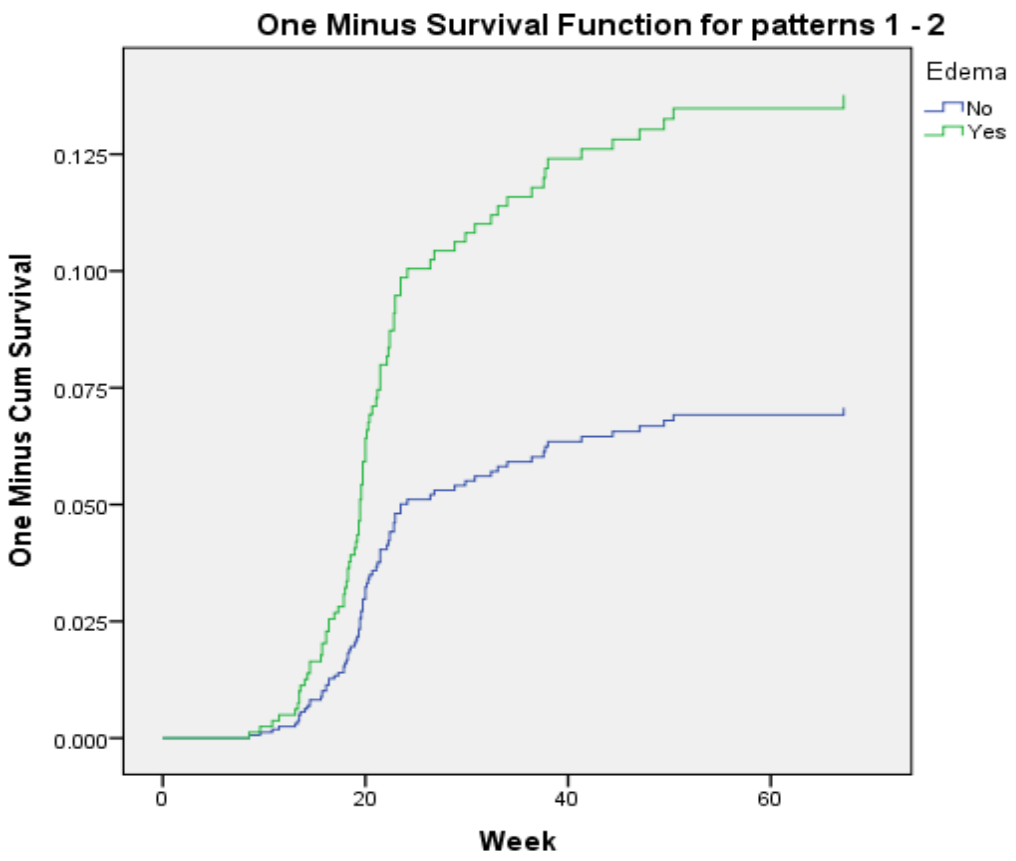

Figure. 1. Log minus log plot hazard function test for edematous children.

In this study, person-time was reported in child-week. Child-week are total follow up times of each child from admission to the occurrence of the events (relapse or censored).

Those variables with p≤0.25 in the bi-variable with parallel line in Kaplan Meier survival curve analysis were selected for entry into multivariable Cox-regression analyses. All statistical tests were considered significant at 95% confidence interval and the final significant value was determined at p-values of 0.05.

Ethical Considerations:

Informed written consent was obtained from all health extension workers of selected health posts and woreda health office, confidentiality of the study documents was' information was also ensured according to the Helsinki declaration of ethical code for human subjects. ***Detail is presented in chapter 4***

2.7. Results

Sociodemographic Characteristics and Anthropometric

In this study, 726 SAM cases were seen from registration book for severe acute malnutrition among 20 health posts. From the total admission 640 (88.2%) were new admission and 86(11.8%) were relapsed or readmitted with severe acute malnutrition in the last five years and of the total 374(51%) were female and 352 (48.5%) were male children. When we see age distribution, 176(24.2%) of SAM cases were at the age of 6-11 months followed by 147(20.2%) comprising children 12-23 months.

When we see admission condition of the under five children for the first admission of SAM 242(33.3%) of children has edema during first admission and the rest 484(66.7%) has no edema and the mean weight of children during admission is determined as 7.94 at (95%, CI: 7.769-8.11) in similar way the mean MUAC of children during admission was 10.60 at (95%, CI: 10.50-10.60)

Treatment outcomes

The outcome of SAM treatment for the first admission was majority of children cured for SAM during first admission or 667(91.9%) cured and the rest 6(0.8%) died, 20(2.8%),11(1.5%),6(0.8%) and 16(2.2%) defaulter, unknown status or not recorded, non-response during treatment and transfer out from the program and mean time for recovery from severe acute malnutrition is 10

weeks with 95%, CI (10.4-10.9) week for the first admission. The mean discharge weight was 11.13 Kg (95%, CI: 10.98-11.29) and mean discharge MUAC was 11.57 cm at (95%, CI: 11.51-11.64), when we see the admission condition there were 640(88.2%) at (95%, CI: 85.8-90.2) new admission and 86(11.8%) at (95%, CI: 9.8-14.2) relapsed cases for severe acute malnutrition.

Time to relapse of children with SAM

From the total cases seen 86(11.8%) were relapsed or readmitted with severe acute malnutrition in las five years. The mean time for relapse of severe acute malnutrition among under five children was 22 (95% CI:20.69-24.82) week from discharge and minimum relapse time was determined as 9 weeks and the maximum time of relapse was 67 weeks after discharge.

The mean time of relapse with different variables when we see sex of children and relapse time among male children was 21 (95%, CI: 19.02-23.94) weeks and 23 (95%, CI: 21.04-27.40) week among female children. Among edematous children, the mean relapse time was 22 (95%, CI:18.79-26.29) weeks, the mean time of relapse for the age of 6-11 months was 21 (95%, CI: 18.71-24.47) weeks25 (95%, CI: 20.27-30.10) week for 12-23 months, 26 (95%, CI: 19.84-35.29) week for the age group of 24-35 months and 21 (95%, CI:18.47-25.32) weeks for the age 36-47 months Tabel 1.

Table1. Mean time of relapse among children with severe acute malnutrition in Sothern Region Hadiya zone Ethiopia**.**

Variable	Mean time of relapse in week	95%, CI
Sex		
Male	21	19.02-23.94
Female	23	21.04-27.40
Age in months		
6-11	21	18.71-24.47
12-23	25	20.27-30.10
24-35	26	19.84-35.29
36-47	21	18.47-25.32
48-60	15	12.61-17.76
Edema during first admission		
Yes	22	18.79-26.29
No	22	20.55-25.19
Outcome of treatment		
Cured	23	20.26-26.81
Not cured	21	19.75-23.93

Factors affecting time to relapse

In Cox Regression the following variables were associated with hazard to time to event. In this study, early age of 6-11 months increase the hazard of relapse to time by 5.2 with (95%, CI:1.95-13.87) higher than that age of 48–60-month, edema for the first admission increase the risk of hazard to time relapse by 2.02 with (95%, CI: 1.17-3.50) compared to non-edematous children and outcome for the first treatment or not cured for first admission increase hazard of relapse to time by 12 with (95%, CI: 7.90-19.52) compared to cured one. Table 2

Table 2. Predictors of time to relapse among children with severe acute malnutrition in Sothern Region Hadiya zone Ethiopia**.**

	B	P	AHR	95.0% CI for AHR
Sex				
Male	-	-	-	-
Female	-0.32	0.16	0.72	0.46-1.14
Admission edema				
Yes	0.70	0.01	2.02	1.17-3.50
No	-	-	-	-
Admission MAC	-0.10	0.53	0.90	0.65-1.25
Age of the child in month				
6-11	1.65	0.001	5.200	1.95-13.87
12-23	0.79	0.151	2.194	0.75-6.41
24-35	0.80	0.131	2.230	0.79-6.31
36-47	0.86	0.090	2.369	0.87-6.42
48-60	-	-	-	-

Outcome during discharge				
Cured	-	-		-
Not cured	2.519	0.001	12.42	7.90-19.52

2.8. Discussion

In this study mean time for relapse of severe acute malnutrition among under five children was 22 weeks and there is sex difference in time of relapse among male relapse will occur earlier than female 21 weeks for male and 23 weeks for female and when we see type of admission condition there were 640(88.2%) new admission and 86(11.8%) at relapsed cases for severe acute malnutrition.

Variables that was associated with hazard of relapse among severe acute malnourished children. Being in the age of 6-11 months increase the hazard of relapse to time by 5.2 with compared with the age of 48–60-month. Likewise, edema during the first admission increase hazard of relapse by 2.02 times compared to the non-edematous children. Children who were not cured for first admission had 12 times higher hazard of relapse as compared to cured ones.

In this study, the frequency of relapse was 86(11.8%) for severe acute which is similar with the report of a study in Burkina Faso (Somasse et al.,2016). The mean time of relapse in this study was 22 weeks which is a long relapse time compared to the report of a study conducted in Nigeria (Adegoke et al.,2021). This may be because of differences in study design as study conducted in Nigeria is prospective cohort for only six months, however this study is for five years and retrospective cohort and sample size by itself may result these differences.

This study identified that age of the child increases the hazard of time relapse higher among the age of 6-24 month and finding from this study in line with other cross-sectional study conducted in Ethiopia Afar region(Gebre et al.,2019).This may be at this age children were mostly dependent on maternal source of energy and physiological it includes the age for highest demand in energy kg/day and it also may be the chance of readmission for SAM at this age is high because as we know that screening and admission .

As nutritional oedema resulted with endothelial glycocalyx that is key to control of fluid movement from and into the capillaries calls for complete revision, the factors so far known to affect the function of the glycocalyx are depend upon sulphated proteoglycans and other glycosaminoglycan's and fundamentally related to a defect in Sulphur metabolism which can explain all the clinical features of the condition, including the formation of oedema (Golden,2015).

The fact that this study is retrospective cohort and study design may limit the exact measurement of time of relapse which needs to be addressed using a prospective cohort study.

Conclusion: The finding showed that children discharged from severe acute malnutrition are likely to have relapse in three weeks' time given the prevailing situation of the home environment.

Practical and policy implications; Based on the finding of this study it is better to have tracer mechanism or preparing guide line that include follow up appliance among under five children with SAM after discharge from the program until their 22 weeks last at home level. Moreover, this will be expected to reduce frequency of readmission and burden among children's and health care providers as well as economical sound.

Recommendations; The findings imply the need for rigorous monitoring and follow up of children with severe acute malnutrition especially those who have edema and are younger during the first three weeks after discharge to prevent the hazard of relapse

Chapter 6;Utilization of Mid Upper Arm Circumference as Discharge Tool for Children in Outpatient Therapeutic Program, Ethiopia.

Redrafted from: Abera Lambebo[1], Dessalegn Tamiru[2], Tefera Belachew : Utilization of Mid Upper Arm Circumference as Discharge Tool for Children in Outpatient Therapeutic Program among under five children of West Harage Zone, Oromia, Ethiopia **(published on Journal of Nutritional Science (2022), vol. 11, e0, page 1 of 7 doi:10.1017/jns.2022.98)**

Abstract

And management of severe acute malnutrition is critical for child survival and is a key cost-effective component of the scaling up nutrition framework for addressing undernutrition and mid upper arm circumference (MUAC) is easy to use and cheap in Ethiopia both MUAC and target weight used but time to cure for MUAC is not stated.

Objective; Cure time of Mid Upper Arm Circumference for Children in Outpatient Therapeutic Program in West Harage Zone, Oromia, Ethiopia and its associated factors.

Methods; Prospective cohort study conducted among 414 severe acute malnourished under five children admitted to selected health 22 posts from February 1 to Juley 30,2021 in Habro Worada west Hararghe zone, Oromia, Ethiopia.

Data were coded, entered into Ep-data version 4.2 software and exported to SPSS for windows version 25 software for analysis. After checking all the assumptions, multivariable Cox Proportional Hazards model was fitted to isolate independent determinants of time to cure by MUAC. All tests were two sided and statistical significance at P values <0.05

Result; In this study the minimum week for cure was 4 weeks, the maximum was16 week and overall mean time to cure from severe acute malnutrition by mid upper arm circumference (MUAC) is determined as 10 weeks with, 95% CI (9.65-10.35).

In this study family size 6 and above member were 2.16 times at higher risk for long duration in treatment with (AHR=2.16, 95% CI: 1.53-3.06) compared to lower family size. In similar way children from low wealth index category family members have 1.4 times hazard to long term treatment for severe acute malnutrition to cure for MUAC. In addition, SAM children from food

insecure households were 2.61-time higher risk to stay at treatment for MUAC comparing to food secured households.

Conclusion and Recommendation: In this study the median time to cure from severe acute malnutrition by mid upper arm circumference (MUAC) is determined as 10 weeks. Moreover, family size 6 and above member, low wealth index category and Household food insecure were identified as risk to stay at treatment for MUAC.

From this study, we recommend that better to use MUAC as diagnosing and discharge criteria for severe acute malnutrition and increase treatment week to 10 and above or until MUAC becomes to 12.5 cm for all under five children irrespective admission criteria.

Key words; SAM, Mean time, under five children, Oromia, Ethiopia.

2.9. Introduction

Children with SAM are nine times more likely to die compared to well-nourished children. Moreover, management of severe acute malnutrition is critical for child survival and is a key cost-effective component of the scaling up nutrition framework for addressing undernutrition (UNICEF,2015).

In the resource, limited settings where malnutrition is common, accurate measurement of weight and height may be a challenge. Mid-upper arm circumference is easier to measure and interpret and it is similar in boys and girls and is relatively constant from 6 months to 5 years that leads to avoid the requirement to calculate exact age (Kramer and Allen,2015). In countries with a high prevalence of undernutrition, timely, accurate screening at the community level is essential to identify children with wasting (Lamsal et al.,2021). In addition, the mid upper arm circumference (MUAC) is used as a proxy to assess wasting in children. However, its validity abounds in controversies (Dairo et al.,2012).

There is uncertainty amongst practitioners, and difference of opinion amongst practitioners and academic specialists, concerning the strength of the evidence to support this recommendation and the consequences for children identified with SAM using weight-for-height z score or WHZ only (Save The Children,2012).

The MUAC and weight-for-height Z score or WHZ or weight-for-length Z score or WLZ have different associations with body composition, and length influences these associations differently and MUAC acts more as a composite index of poor growth indexing (Eternod et al., 2015).

Weight gain is routinely monitored to assess hydration and growth during treatment of children with complicated severe acute malnutrition. However, changes in weight and mid-upper arm circumference (MUAC) gain velocities over time are scarcely described (Kamugisha et al.,2021).

Another challenge for Mid-upper-arm circumference or MUAC based on a single cut-off value for all the children less than 5 years of age has been used for many years as an alternative nutritional status index for children during famines or refugee crises, and as an additional screening tool in non-emergencies. However, it has recently been questioned whether MUAC is age- and sex-independent(WHO, 2006).Study in Senegal suggests that MUAC is better than WHZ to identify high-risk children in the community and using both WHZ less than -3 and MUAC less than 115 mm increases specificity but decreases sensitivity to identify high-risk children. There is no advantage for programs in combining WHZ and MUAC to identify high-risk children (Briend et al.,2012).

A problem that encountered is severe acute malnutrition management during treatment follow-up. for instance, admission criteria for severe acute undernutrition are based on children with a; weight-for-height below -3 SD, MUAC less than 110 mm, and with medical complications like loss of appetite and edema but this is more specific more than 99% over the age range 6–60 months and discharge only 15-20% of weight gain (WHO,2009).

And another study suggests that cut-off of <11.5 cm is not enough to detect SAM children's so it needs to increase to ensure early diagnosis of SAM children's and to avoid miss of children from referral for management of malnutrition. So, to reduce the risky and death of under nutrition more sensitive cutoff point MUAC is needed (Stobaugh et al.,2019).

Evidence from papers shows that among the aged of 6 to 23 months with a MUAC between 115 and 125 mm. Moreover, a weight-for-height Z score ≥−2 suggests that short children with low MUAC do not gain excessive fat during supplementation and the use of length as a criterion for measuring MUAC to determine treatment eligibility should be discontinued in policy and practice (Fabiansen et al.,2018).

The anthropometric indicator that is used to confirm severe acute malnutrition should also be used to assess whether a child has reached nutritional recovery, i.e. if mid-upper arm circumference is used to identify that a child has severe acute malnutrition, then mid-upper arm circumference should be used to assess and confirm nutritional recovery. Similarly, if weight-for-height is used to identify that a child has severe acute malnutrition, and then weight-for-height should be used to assess and confirm nutritional recovery (WHO,2008).

However, World health organizations on its 2013 severe acute management Guide line suggests that there is no difference for weight for height and mid upper arm circumference; for program using mid-upper arm circumference weight gain is15–20% after edema disappears and for program using weight-for-height: weight-for-height >–1standard deviation or weight gain is 15–20% after edema disappears (WHO,2013).

Mid upper arm circumference is easy to use for diagnosing and follow up of severe acute malnutrition among under five children. However, cure time for MUAC not known and this study aimed to identify median cure time of MUAC and factors affecting the survival of under five children from severe acute malnutrition for MUAC in Ethiopia.

2.10. METHODS

Study area and period

The Prospective cohort study was conducted in HabroWoreda west Hararghe zone, Oromia, Ethiopia from February 1 –July 30, 2021 among under five children admitted for management of severe acute malnutrition in health posts.

Habro woreda is found in West Hararghe zone of Oromia regional state. The capital city of HabroWoreda is called Gelemso which is located about 326 Km Eastof Addis Ababa and 76 km away from Chiro zonal town of West Hararghe. According to the 2019 population forecast the woreda has 269,279 population, of which male to female ratio is approximately 1:1. The total under five of population of the woreda was 44, 243, 6-59 month was 40392 and households of the woreda was 56099. The Woreda has 32 rural kebeles and 5 urban Kebeles. It also has 32 health posts and 7 health centers and 1 general hospital, all of the health facilities, except the hospital are providing OTP services. The main income of the population depends on Agriculture (Wikipedia,2022).

Study population; under five children admitted for severe acute malnutrition in selected health posts during study period.

Sample Size and Sampling Procedures

Sample size was determined based on the assumptions with recovery rate of 93.3%, hazard ratio of 0.38 (Gebremichael,2015), 5% margin of error, 95% CI, and power of 80%. Then it is calculated by medcalc©version 119.1.1.3 survival analysis (logranktest) at http://www.medcal.org (MedCalc Statistical Software version 19.1.3,2019). Finaly, by considering after 10% adding for loss to follow-up, the total number of study sample size was 414.

Sampling procedure

In West Hararghe zone of Oromia regional state, Habro woreda there are 32 rural kebeles and 5 urban Kebeles and 32 health posts Providing OTP service. From them 22 Health post were randomly selected namely; Chefe 12 HP, Bareedaa HP, Wenne kallo HP, Medda Jaalalaa HP, Booraa HP, Maqrac HP, Ifaa Gemechu HP, Busoytu HP, Melkaa balloo HP, Odaa Mudaa HP, Daraaraa HP, Kallachaa HP, Gerbi Teka HP, Ibsaa HP, Kufa kaas HP, Dikkichaa HP, Bedada HP, Haro Carcar HP, Lallisaa HP, Lagabeeraa HP, odaa Ananii HP and Gadisa HP.

Measurement

A data was collected from the children's admitted for SAM management in health post; prospective cohort study conducted for six months from February to July in randomly selected health posts. Data collection tools include about socio-economic data (age, sex, Food security and house hold wealth index), time (time for first admission, time for discharge and anthropometric measurements (height, weight, MUAC, edema). One supervisor and 22 data collectors trained involved in data collection. Data collectors received a one-day training on data collection tool and interpersonal reliability on Anthropometric measurement were checked by technical error of measurement TEM after that deployed to collect data once the principal investigator was

convinced about their competency. The primary investigator of the study and the supervisors critically followed the data collection process to minimize missing information and inconsistencies.

Operational definition

Wasting: weight-for-height Z-score < -2. It often indicates recent and severe weight loss, although it can also persist for a long time (UNICEF,2013).

Criteria for admission; if the child have severe acute malnutrition (Harshal T. and Samir A.): It is diagnosed by weight for- height below -3 SD of the WHO standards, by a MUAC <11.5 cm and by Clinical sign like bilateral edema (WHO,2020).

Kwashiorkor or edematous malnutrition; is also form of severe under nutrition, the child's muscles were wasted, but wasting may not be apparent due to generalized edema or swelling from excess fluid in the tissues (WHO,2020).

Criteria for discharging children from treatment; weight-for-height/length is ≥–2 Z-scores and having no oedema for at least two weeks, or mid-upper-arm circumference is ≥125 mm and no oedema for at least 2 weeks (WHO,2020). In this study only MUAC ≥125 mm uesd as sole criteria of discharge.

HFIAS/HHS; HFIAS gave the highest prevalence estimates of food insecurity, as might be expected given its inclusion of less severe manifestations of insecurity, including psychological anxiety and food consumption preferences (FANTA,2018).

Data Processing and Analysis

Data were coded, entered into Ep-data version 4.2 software and exported to SPSS for windows version 25 software for analysis. The presence of missing values, possible outliers, and multicollinearity were checked through exploratory analysis. The wealth index was calculated using Principal Component Analysis (PCA), based on PCA assumptions. Accordingly, the households were categorized into three wealth terciles for further analysis.

Both bi-variate and multivariable Cox regression analyses were performed. Kaplan Meier hazard curve with the log-rank test was fitted to identify the presence of a difference in recovery rate among the categorical variables. Mantel-Cox and Generalized Wilcoxon test of equality of survival distributions is significant and one minus survival function line is parallel for those candidate variables of multivariable Cox regression (Fig; 1, Fig; 2 and fig; 3).

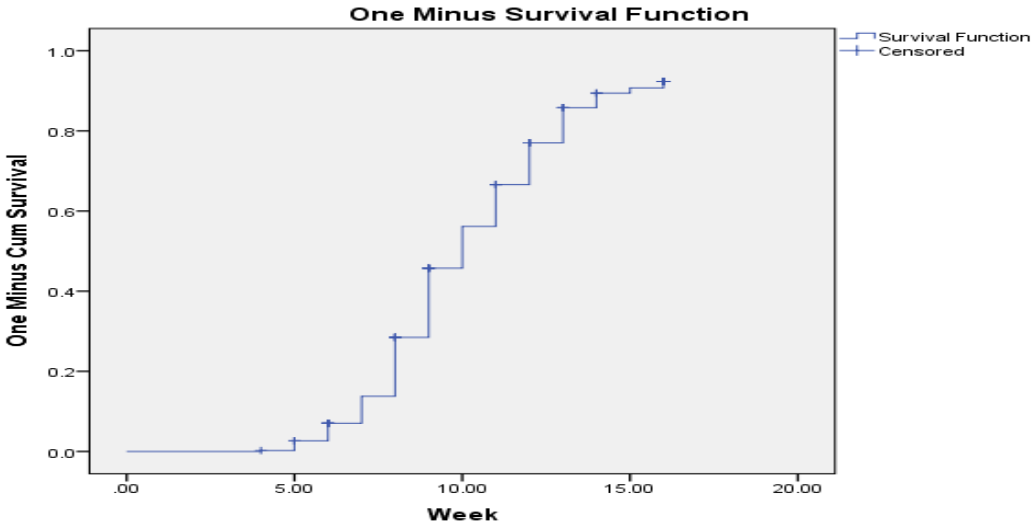

Figure 1; one minus survival function test for severe acute malnourished children cured for MUAC for overall children's in west Hararghe zone Oromia, Ethiopia.

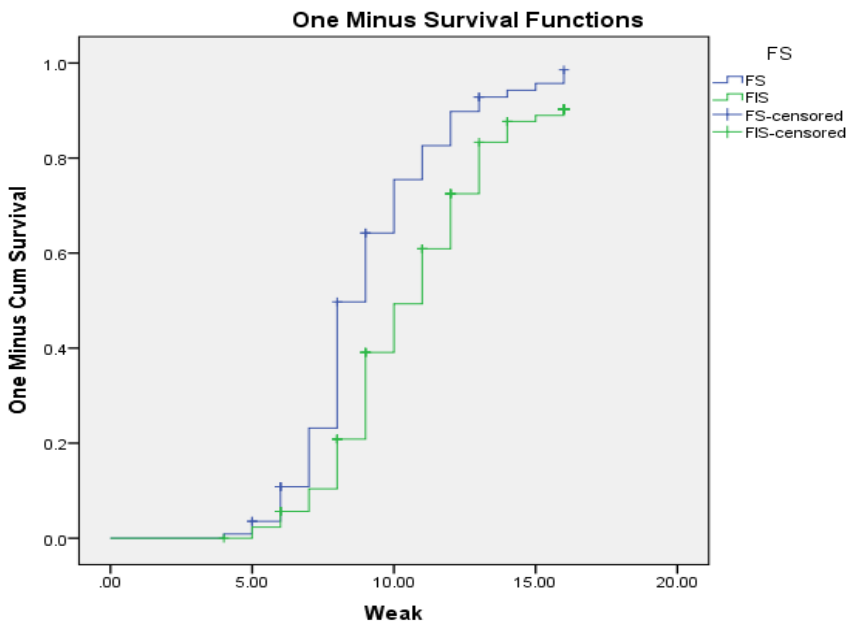

Figure 2; one minus survival function test for severe acute malnourished for SAM children cured For MUAC from food in-secure households in west Hararghe zone Oromia, Ethiopia.

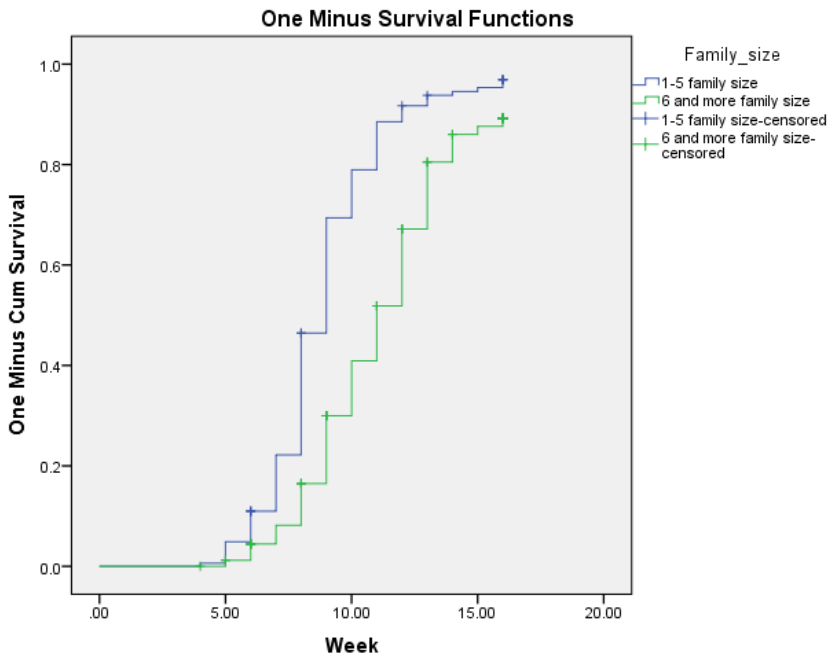

Figure 3; one minus survival function test for severe acute malnourished children cured for MUAC from house hold members 6 and more family households in west Hararghe zone Oromia, Ethiopia.

At different levels, under-five children with SAM cases followed in weeks from admission to the occurrence of the event (cured). Person-time was calculated and the incidence was determined. In this study, person-time reported in child-week. Child-week is total follow up times of each child from admission to the occurrence of the events (cured or censored)

Those variables with $p \leq 0.25$ in the bi-variate Cox-regression were selected for the multivariable Cox-regression analysis. All statistical tests were considered significant at p-values of < 0.05.

Ethical Considerations:

Informed written consent was obtained from all health extension workers of selected health posts and worada health office, confidentiality of the study documents and the abstracted information was ensured according to the principle of Helsinki declaration ethical code for human subjects. ***More detail presented in chapter 2***

2.11. Result

Socio-economic characteristics

In this study 414 under five children were participated of them 257(62.07%) were females. When we come to the age of under-five children's majority of the children participated in this study were at the age of below 24 months 311(75.1%) and more than half of the children were from the household with family members of six and above 250(60.4%) the rest were below six family members. When we come to the household wealth index from the participants 166(40.1%) households were under the lowest tercil of the rank in similar way majority of households or family members of under five children admitted with severe acute malnutrition were food insecure with 302(72.9%). Table 1

Table 1; socio demographic characteristics of under five children and their family in Habro Worada west Hararghe zone Oromia region, Ethiopia

.

Variable	Frequency%
Sex	

Male	157(37.9)
Female	257(62.1)
Age in months	
6-11	137(33.1)
12-23	174(42.0)
24-35	56(13.5)
36-47	37(8.9)
48-60	10(2.4)
Family size in Household	
<6 members	164(39.6)
6 and above member	250(60.4)
House hold wealth index	
Low	166(40.1)
Medium	172(41.5)
High	76(18.4)
House hold food security status	
Food secure	112(27.1)
Food insecure	302(72.9)

Treatment outcome

In this study, children were followed for 16 weeks after admission for severe acute malnutrition in health posts. Most of children 354 (85.5%) cured during follow up the remaining were not

cured, transferred to stabilization center and defaulter of the treatment were 30(7.2 %), 22(5.3%) and 8(1.9%) respectively. Figure 4

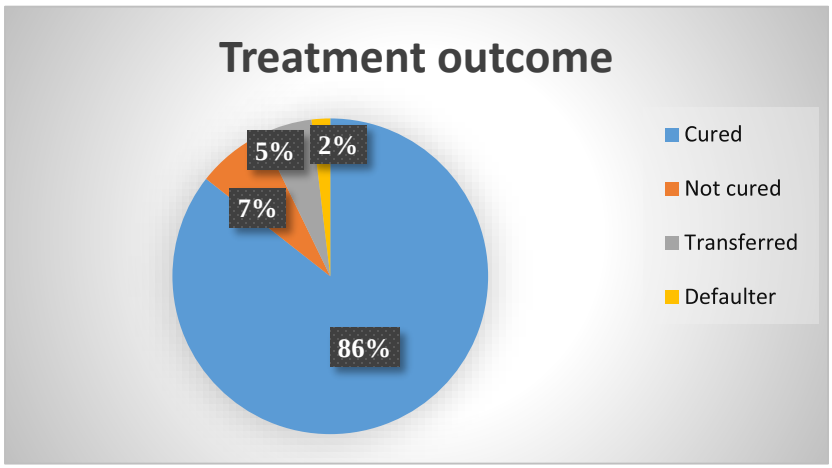

Figure 4; Treatment outcome of severe acute malnourished children's for MUAC in health post in Habro Woreda, west Hararghe zone, Oromia region, Ethiopia.

Mean time in week for Survival from severe acute malnutrition by MUAC

In this study the minimum week for cure was 4 weeks, the maximum was16 week and overall mean time survival from severe acute malnutrition by mid upper arm circumference (MUAC) is determined as 10 weeks with 10 weeks, 95% CI (9.65-10.35). However, cure time varies with different variables for example at the age of 6-11 months cure time was determined as 11 weeks with 95%CI (10.47-11.53) at the age of 12-23 months cure falls to 9 weeks with 95%CI (8.66-9.34). In addition, family members with six and more members have median time to cure for MUAC is 11 weeks with 95%CI (10.51-11.49). In the same way cure, time for MUAC among food insecure household was 11 weeks with 95 % (10.48-11.52), among lowest wealth index 11 weeks with 95 % (10.41-11.59) and with highest wealth index the cure time will fall to 9 weeks with 95% CI (8.23-9.77). Tabele2

Tables 2; Mean week for Survival from severe acute malnutrition by MUAC in Habro Woreda west Hararghe zone Oromia region, Ethiopia

Variable	Mean estimate week	95% Confidence Interval
Over all children's	10	9.65,10.35
Sex		
Male	10	9.31,10.69
Female	10	9.56,10.44
Age of children in months		
6-11	11	10.47,11.53,
12-23	9	8.66,9.34
24-35	10	9.38,10.62
36-47	10	7.76,12.24
48-60	10	9.65,10.35
Family size		
1-5 family size	9.000	8.70, 9.30
6 and more family size	11.000	10.51,11.49
House hold food security		
Food Secured	9.000	8.55, 9.45
Food in Secured	11.000	10.48,11.52

Wealth index category		
Lowest	11	10.41,11.59
Medium	10	9.44,10.56
High	9	8.23,9.77

Factors associated with survival status of children for MUAC

Factors associated with cure time to MUAC in Cox Proportional Hazards Model, after adjusting for related variables to control confounders and testing for Kaplan-Meier test done to identify parallel line assumptions. Under five children with severe acute malnutrition from family size 6 and above member were 2.16 times at higher risky for long duration in treatment with (AHR=2.16, 95% CI: 1.53-3.06) compared to lower family size. In similar way children from low wealth index category family members have 1.4 times hazard to long term treatment for severe acute malnutrition to cure for MUAC with (AHR=1.40, 95% CI: 1.095-1.770). And SAM children from food insecure households were 2.61-time higher risk to stay at treatment for MUAC comparing to food secured households with (AHR=2.61, 95% CI1.53, 3.06). Table 3

Table 3; Multivariable Cox proportional hazards model identifying the determinants of time to cure among children with severe acute malnutrition for MUAC in Habro Worada west Hararghe zone Oromia region, Ethiopia.

Variable	B	P -value	AHR	95.0% CI
Sex				
Male	-	-	1	-
Female	-0.009	0.935	0.99	0.79,1.24
Age in months				
6-11	0.42	.480	1.52	0.48, 4.83
12-23	0.83	.156	2.30	0.73, 7.26
24-35	0.85	.156	2.35	0.72, 7.64
36-47	0.42	.490	1.53	0.46, 5.06
48-60	-	-	1	-
Family size in Household				
<6 members	-	-	1	-
6 and above member	0.75	0.001	2.16	1.53, 3.06*
Wealth index				
Low	0.33	0.007	1.40	1.095 1.770*
Medium	-0.15	0.497	0.86	.559 1.325
High	-	-		-
Household Food security				
Food secure	-	-	-	-

Food insecure	0.77	0.001	2.16	1.53,3.06*
Admission MUAC	0.23	0.68	1.259	0.98, 1.60

2.12. Discussion

In this study, the minimum and maximum time to cure is determined as 4 and 16 weeks respectively and mean time to cure from severe acute malnutrition by mid upper arm circumference (MUAC) is determined as 10 weeks. The following factors were associated with time to cure were family size, wealth index and household food insecurity were associated with cure time by MUAC from severe acute malnutrition.

When we compare the median time to cure to MUAC in this study with other studies, study conducted in Dire Dawa among different health institutions suggests the median recovery time was 8.7 weeks (Atnafe and Roba,2019) and another study from North Gondar Zone, reveals that the median time to recovery was 38.5days or 5 weeks (Mamo et al.,2019). However, in this study, the median week for survival was determined as 10 weeks for MUAC and this is greater or long duration or stay in studies. This may be because of the above study durations were based on target weight gain from admission but the discharge criteria in this study based on target MUAC or 12.5 cm. This may suggest us children who are declared cured and discharged from severe acute malnutrition management program by weight gain were may not cured for MUAC.

When we come to the factors associated with median time to cure, in this study number of family size associated with median time to cure. This study is similar with the retrospective study

conducted among under-five children admitted to therapeutic feeding unit at Dubti referral hospital, Afar region, Ethiopia (Tegegne and Belay,2021). This may be because children in large family may face several problems that may include lack care, competition on supplementary treatment food, Plumpy'nut, or "Nefis Aden," among severely malnourished children and other family members.

Another factor associated with medians time is wealth index in similar way study conducted at Dubti referral hospital, Afar region, Ethiopia reveals that household income in ETB is associated with m edian cure time (Tegegne and Belay,2021). Even though, there are different way that means study conducted in Afar is followed by target weight as discharge criteria but in this study, we have followed MUAC <12.5cm as discharge criteria for severe acute malnourished children. The similarity of the cure time among poor or low wealth index households in two studies may low income or being poor directly affect cure time.

On other hand in this study household food insecurity one of associated factors with median time to cure this may be because of food insecure households maybe children from the food insecure household may suffer with severe acute malnutrition more and it may result in long cure time from the SAM (Doocy et al.,2019).

Practical implication; in this the maximum cure time from malnutrition is 16 weeks by MUAC and the median time is 10weeks. This indicates that cure time of MUAC <12.5 cm is longer than target weights. As MUAC is easy to utilizations and there is no need of knowing age of child as target, weight is based on the age of child. And cure by MUAC is longer than that of weight and in another study, we have suggested that discharge MUAC less than 12.5cm were result in relapse or repeated admission (Lambebo et al.,2021).

Conclusion: In this study the median time to cure from severe acute malnutrition by mid upper arm circumference (MUAC) is determined as 10 weeks. Moreover, family size 6 and above member, low wealth index category and Household food insecure were identified as risk to stay at treatment for MUAC.

Recommendation; from this study we recommend that better to use MUAC as diagnosing and discharge criteria for severe acute malnutrition among under five children and better to increase treatment week to 10 and above or until MUAC becomes to 12.5 cm for all under five children irrespective admission criteria.

CHAPTER7 :Validating the Diagnostic Performance of MUAC for Screening Moderate Acute Malnutrition and Developing an Optimal Cut-Off for Under Five Children Of Different Regions in Ethiopia

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'Validating the Diagnostic Performance of MUAC in screening moderate Acute Malnutrition and developing an optimal cut-off for Under Five Children of Different Regions in Ethiopia

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Abstract

Background: Valid and reliable anthropometric indicator is useful for early detection and treatment of under nutrition. Although, mid upper arm circumference (MUAC) is used for screening of children with moderate acute malnutrition in Ethiopia hwoevere, its performance for the different ethnic groups has not been evaluated.

Objective: To determine the diagnostic performance of MUAC for determination of moderate wasting among children of different ethnic background and develop optimal cut-off.

Methods: a community based cross-sectional study was conducted among under five children of the three regions namely: Somalia, Amhara and Gambella Regions. The diagnostic performance of MUAC was validated using weight for height Z-score< -2 as a gold standard binary classifier. Test variables is mid upper arm circumference (MUAC< 12.5cm). ROC analysis performed based on the assumptions of MUAC value lower the cut-off point indicates the undernutrition. Area under the curve and validity measures (sensitivity and specificity) was generated as parameter estimated. The results were presented using tables and ROC curves.

Results: Except in the Gambella region, there was fair agreement between MUC<12.5cm and Weight for Height Z score<-2 in diagnosing wasting in Somali (Sensitivity = 29.3%, Kappa = 0.325, P<0.001) and in Gambella regions (Sensitivity =16.7%, Kappa=0.19, P<0.001). In Amhara region there was fair agreement between the two measures in diagnosing MAM (Sensitivity=16%, Kappa=0.216). For the Overall sample, the sensitivity of MUAC<12.5cm was 20.6% (Kappa=0.245, P<0.001. Based on ROC analysis, the optimal cutoff value of MUAC for diagnosing moderate acute malnutrition for the two regions namely for Gambella and Amhara was

13.85cm with sensitivity of 0.99 and 1.00, respectively. However, for Somali Region the optimal cut was 13.75cm (Sensitivity= 0.98 cm and specificity = 0.71.

Conclusion: Findings revealed that the inter reliability of measurement for MUAC< 12.5cm and WHZ<-2 for diagnosing MAM was low among different ethnic groups with the cut-off varying in each region. The existing cutoff point is less sensitive for diagnosis of MAM. As Ethiopia is home of diverse ethnic groups with different body frame and environmental conditions, the new cut off points developed for each region recommended to be used for screening moderate acute malnutrition to prevent relapse of MAM and reduce chronic malnutrition.

Keywords; Sensitivity, Specificity, MUAC, WHZ, under five, Ethiopia.

2.1. Introduction

Background

Nutritional assessment can be done using anthropometric, clinical and biochemical methods and, dietary practices (FANTA,2016). Anthropometry is the measurement of the human body in terms of the dimensions of bone, muscle, and adipose tissue Anthropometric measurements are preferred methods widely used because they are economical and non-invasive measure of the general nutritional status of an individual or a population group (Bruce,2003). In children, measurements reflect general health status, dietary adequacy and growth and development over time, while they are used to evaluate health and dietary status, disease risk, and body composition in adults (Fryar et al.,2016). Although height and weight-based anthropometric measurement is an excellent tool assess general nutritional status in a population (WHO, 2007), it is not used for practice at the community level due to issues related to cost, ease of measuring and transporting the instruments in geographically scattered and mountainous terrains. As a result, there is uncertainty among practitioners and academic specialists, concerning the consequences of screening children with severe acute malnutrition (Harshal T. and Samir A.) solely using weight-for-height Z score in developing country's contexts (Save The Children,2012).

Mid Upper arm Circumference (MUAC) is considered as a simple tool for the assessment of undernutrition in different groups (Lazarus et al.,2017). MUAC is a decades-old anthropometric measurement of the amount of muscle in the arm, which theoretically reflects the total amount of muscle or protein in the body (Steven McGee,2018). In programs managing moderated acute malnutrition, MUAC bids the advantages of easy-to carry, even to geographically hard to reach

areas because it needs slightest preparation and it is effective in the assessment of nutrition status when measured with care and precision (WHO,2006, Jeyakumar et al.,2013). This makes MUAC one of anthropometric tools as effective as the body mass index-for-age Z score for assessing mortality risks associated with under-nutrition among African children (Lazarus et al.,2017). According to the WHO 2009 children 6–60 months with a MUAC less than 125 mm are considered as under nourished (Mosby's Medical dictionary,2009).

Mid-upper arm circumference is easier to measure and interpret and it is similar in boys and girls and is relatively constant from 6 months to 5 years that and avoids the requirement to calculate exact age (Kramer and Allen,2015). Study in Senegal suggests that MUAC is better than WHZ to identify high-risk children in the community and using both WHZ less than -2 and MUAC less than 125 mm increases specificity but decreases sensitivity to identify high-risk children. It was reported that there is no advantage of combining WHZ and MUAC to identify high-risk children (Briend et al.,2012).

However, there are doubts about sensitivity and specificity of MUAC<125 mm on identification of undernutrition among children implying an urgent need for revising the cutoff value of MUAC to improve its sensitivity and specificity based on locally and ethnically relevant data (Grellety .E et al.,2015, Manoj R. and Bishan S., 2016). Another challenge related to MUAC is that it is based on a single cut-off value for all the children less than 5 years. However, it has recently been questioned whether MUAC is age- and sex-independent. In addition to that the currently existing cut-off point for anthropometric measurements have lower survival rate, increasing number of relapse and overburdening health system by relapse cases (Lambebo. A et al.,2021).

It may also be sensed inadequate nutritional status (growth) is not necessarily due to inadequate diet but also due to slightly genetic or ethnic and geographical variation that may make a difference

in nutritional status and in the sensitivity and specificity of MUAC in detecting malnutrition. Therefore, this study aimed to determine new cut-off point for different ethnicity for utility of MUAC in diagnosing acute malnutrition among children under five children's different region of Ethiopia (Gambella, Amhara and Somalia) as compared to weight for height Z-Score.

2.2. Methods

Study area and design

Community based cross-sectional study was conducted among under five children of the three regions namely: Somali, Amhara and Gambella Regions of Ethiopia.

The study population comprised of under five children from the three regions namely Gambella, Amhara and Somalia, Ethiopia.

All seemingly healthy under five children who were from selected regions were include in the study. Under five children who are from another ethnic background, those with deformity that interferes with anthropometric measurements were excluded and those who were severely ill during data collection were excluded from the study and represented by another participant during data collection.

The study population included under five children, 305 randomly selected from each region to represent ethnicity of each region using list of children from health extension workers of the selected areas as a sampling frame. ***Detail about study area presented under chapter 2***

To determine the diagnostic accuracy of MUAC in detecting undernutrition by taking weight for height (WHZ) as gold standard among under five children of different ethnic backgrounds in

Ethiopia, the required sample size was determined for sensitivity and specificity of MUAC based on the following assumptions and formula for sensitivity and specificity sample size calculation (Hajian-Tilaki,2014).

$$n = (1.96)^2 x \frac{0.95(1-0.95)}{0.05^2 * 0.24} = 305$$

$n=1.96^2$x (0.95x0.05)/0.05^2x0.24=3.8416x0.0475/0.0025x0.24=0.182476/0.0006=305

Where;

n= expected sample size for sensitivity test, d = margin of error of=0.05, SN=anticipated sensitivity=0.95, SP= anticipated specificity=0.95, P =expected national proportion underweight 24% from EDHS report of Ethiopia (CSA and ORC Macro,2017). A = size of critical region=5% 1-α=confidence level=95% Z_1-α/2=standard normal deviate corresponding to the specified size of critical region α =1.96, $n = (\frac{Z\alpha}{2})^2 x \frac{SN(1-SN)}{d^2 * p}$

Sampling technique: For selection of **915** under five children from study population, 305 from each region simple random sampling method was employed that means 305 from Gambella region, 305 from Amhara region and 305 from Somalia region. The list of children was obtained from health extension workers of the selected areas were used as sampling frames.

Measurements

A data abstraction tool was prepared for anthropometric measurement weight, height and mid upper arm circumference (MUAC) as well as socio-demographic information like age of the child estimated from EPI card and birth certificate while ethnicity of the child was collected by

interviewing the parents. The WHO standard measurement protocol was used for conducting anthropometric measurements (WHO,2006). Height was measured using standard wooden sliding portable stadiometer by keeping the head of the child in the Frankfurt plane with knees straight and the heels, buttocks and the shoulders blades touching the vertical stand of the stadiometer (anthropometry). For measuring weight seca Germany was used based on standard procedure, before each measurement the scale was calibrated to zero position and heavy clothes and shoes were removed. For measuring MUAC a non-stretchable insertion tape is typically used and it's graduated in millimeters. The steps used during measurement; the non-dominant arm selected. Then arm of the child was bent at the elbow to a 90-degree angle to get mid-point, upper arm was held parallel to the side of the body, the arm length between the shoulder tip (acromion) and the point of the elbow (olecranon process) is measured and the midway identified and marked between these anatomical landmarks. The upper arm circumference is taken at this point, while the participant's arm hanged loosely by the side. The tape measure is comfortable around the upper arm but not too tight and the measurement is recorded to the nearest millimeter (Andrew J. et al.). Four data collectors and one supervisor were recruited based on their experience in data collection. Data collectors received a one-day training on anthropometric measurement and deployed to collect data once the principal investigator was convinced about their competency. The principal investigator of the study and the supervisors critically followed the data collection process to minimize missing information and inconsistencies.

Operational definitions

Cohens Kappa results were interpreted as follows: values ≤ 0 as indicating no agreement ,0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial and 0.81–1.00 as almost perfect agreement (McHugh,2012).

Wasting: weight-for-height Z-score < -2. It often indicates recent and severe weight loss, although it can also persist for a long time (WHO,2009).

Moderate under nutrition (Harshal T. and Samir A.): It is diagnosed by weight for- height below -2SD of the WHO standards, by a MUAC <12.5 cm and it includes stunting or low length/height-for-age, wasting or low weight-for length/ height or
bilateral pitting edema and underweight or low weight-for-age(Reynaldo and Amanda,2012).

Data Processing and Analysis

Data were coded, entered into Ep-data version 4.2 software and exported to SPSS for windows version 25 software for analysis. The presence of missing values, possible outliers, and multicollinearity were checked through exploratory analysis. Before main analysis inter-rater reliability of WHZ and MUACZ was checked with Cohen's Kappa analysis for agreement between test variable MUAC and state variable WHZ<-2 and sensitivity and specificity as well as Kappa value were determined. A MUAC value <12.5 was used to define moderate acute malnutrition, while in similar direction of definition for moderate acute malnutrition was used by the gold standard WHZ<-2 (WHO, 2006).

Finally, cut off point for MUAC was developed using Receiver Operating Characteristic (ROC curve) based on area covered under the curve using WHZ<-2 score as gold standard binary classifier.

Ethical Considerations: An official letter was written from Jimma University to each regional health office; namely Gambella, Amhara and Somalia Health Office. Informed written assents was obtained from all parents of selected under five children and confidentiality of the study

documents and the abstracted information was ensured according to the ethical principles preserved in the Helsinki declaration. **Detail about Ethical is presented at chapter 2**

2.3. Results

In this study, 914 under five children were involved from three regions namely from Gambella, Amhara, Somalia regions representing different ethnic groups. In the three regions, children from four ethnic groups were involved in the study constituting Anuak (16.3%), Nuer (17.1%), Amhara (33.4%) and Somalia (33.3%) Half of (50.8%) them were males and 49.2% were females (Table 1).

Table 1; Socio demographic characteristics of study participants from three regional states of Ethiopia. N=914

Variable	Frequency (Bauer and Capra)
Sex	
Male	464(50.8)
Female	450(49.2)
Age in months	
6-11	66(7.2)
12-23	106(11.6)
24-35	119(13.)
36-47	262 (28.7)
48-60	361(39.5)
Region	
Gambella	305(33.4)
Amhara	305(33.4)
Somalia	304(33.3)
Ethnic combination	
Anuak	149(16.3)
Nuer	156(17.1)
Amhara	305(33.4)
Somalia	304(33.3)

Nutritional status of under-five Children

In this study 9.7% under five children were malnourished for WHZ<-2 and 6% were malnourished for MUAC<12.5cm, regarding regional or ethnic differences in in the agreement of malnutrition by WHAZ and MUAC, a prevalence of malnutrition 23.6% and 5.9% were observed by WHZ < - 2 Z score and MUAC < 12.5 cm, respectively. Likewise, for Amhara region, a prevalence of 16.4% and 3.6% were observed WHZ < - 2 Z and MUAC < 12.5 cm, respectively and in Gambella region 23.6% were malnourished for WHZ<-2 and only 5.9% of under five children malnourished for MUAC<12.5cm. Similarly, for Somali region, prevalence of 19.1% and 8.6% were documented by WHZ < - 2 Z and MUAC < 12.5 cm, respectively. Regarding gender differences in the diagnostic agreement between WHZ and MUAC, a moderate wasting prevalence of 22.0% and 5.8% using WHZ < - 2 Z and MUAC < 12.5 cm, respectively among males. Likewise, a prevalence of 17.3% and 6.2% had moderate wasting using WHAZ<-2 and MUAC<12.5cm, among females under five children's respectively (Table 2).

Table 2; Nutritional status of under-five children's by using WHZ and MUACZ from different regions of Ethiopia (n=914)

Variables	Measurement by WHZ <-2		Measurement by MUAC< 12.5cm		Percent misclassified by MUAC<12.5
	Normal N (Bauer and Capra)	Malnourished N (Bauer and Capra)	Normal N (Bauer and Capra)	Malnourished N (Bauer and Capra)	
Region					
Gambella	233(76.4)	72(23.6)	287(94.1)	18(5.9)	17.7
Amhara	255(83.6)	50(16.4)	294(96.4)	11(3.6)	12.8
Somalia	246(80.9)	58(6.4)	278(91.4)	26(8.6)	10.5
Total	734(80.3)	180(19.7)	859(94.0)	55(6.0)	13.7
Age in month					
6-11	56(84.8)	10(15.2)	61(92.4)	5(7.6)	7.6
12-23	94(88.7)	12(11.3)	98(91.6)	9(8.4)	1.9
24-35	93(78.2)	26(21.8)	108(90.0)	12(10.0)	11.8
36-47	215(82.1)	47(17.9)	251(95.8)	11(4.2)	13.7
48-60	276(76.5)	85(23.5)	341(95.0)	18(5.0)	18.5
Sex					
Male	362(78.0)	102(22.0)	437(94.2)	27(5.8)	16.2
Female	372(82.7)	78(17.3)	422(93.8)	28(6.2)	11.1

Estimating Inter-Rater Reliability of WHZ and MUACZ with Cohen's Kappa.

Inter rater reliability for diagnosis of under five children for Moderate acute malnutrition by using Cohen's Kappa for the overall sample from the three regions (Gambella, Amhara and Somalia). Sensitivity of MUAC<12.5cm in screening of undernutrition was 20.6% while its specificity was 97.5% showing a fair agreement with (Kappa=0.0.245, P=0.001).

For Gambella region (among Nuer and Anuak ethnic groups) the sensitivity and specificity of MUAC<12.5cm were 16.7% and 97.4%, respectively showing a slight agreement of (Kappa=0.19, p =0.001). In similar way, for Somalia region (among Somali ethnic groups) sensitivity and specificity of MUAC were 29.3% and 96.3% with fair agreement (Kappa=0.325, p =0.001). Correspondingly, for Amhara region sensitivity and specificity of MUAC<12.5cm were 16.0% and 98.8%, respectively showing a fair agreement (Kappa =0.216, P =0.001) (Tabel 3).

Table 3. Validity of MUAC in detecting moderate acute malnutrition among different ethnic groups of Ethiopia as compared to as compared to weight for Height Z score as gold standard

Region	Test tool (MUAC<12.5	Standard tool (Weight for height Z score or WHZ < -2)											
		TP(a)	FP(b)	FN(c)	TN (d)	Total	Sensitivity	Specificity	PPV	NPV	Kappa	Agreement	P
Gambella	MUAC <12.5 cm	12	6	60	227	305	16.7	97.4	66.7	79.1	0.19	Slight	<0.001
Somali	MUAC <12.5 cm	17	9	41	237	304	29.3	96.3	65.4	85.3	0.325	Fair	<0.001
Amhara	MUAC <12.5 cm	8	3	42	252	305	16.0	98.8	72.7	85.7	0.216	Fair	<0.001
Overall	MUAC <12.5 cm	37	18	143	716	914	20.6	97.5	67.3	16.6	0.245	Fair	<0.001

Sensitivity = a/a + c, specificity = d/b + d, positive predictive value (PPV) = a/a + b, negative predictive value (NPV) = d/c + d.

Kappa agreement (0 = no/poor), (0.01–0.20 = slight), (0.21–0.40 = fair), (0.4–0.60 = moderate), (0.61–0.80 = substantial), and (0.81–1.00 = almost perfect

Optimal cut off point of MUAC for detection of Moderate acute malnutrition

Cut-off point for MUAC that was equivalent with WHZ<-2 score as gold standard was determined using Receiver Operating Characteristic (ROC curve). Based on ROC analysis, the cutoff point of MUAC for the overall sample involving children from the three regions (Gambella, Amhara and Somali) 13.85cm with sensitivity and specificity of 98,9% and 80.7, respectively (P =0.001). Table4

There was a regional difference in the new MUAC cut-off, sensitivity and specificity in diagnosing moderate acute malnutrition. For Gambella Region, the optimal MUAC cut-off was determined as 13.85 cm with sensitivity and specificity of 98.6 and 81.7, respectively. This value corresponds to the positive likelihood ratio of 5.4 and the area under roc curve of 0.92. For Amhara Region, the optimal MUAC cut-off for diagnosing MAM was 13.85 cm with sensitivity and specificity of 100% and 87.5%, respectively giving the corresponding positive likelihood ratio of 8 and an area under roc curve of 0.97. For Somali Region, the optimal MUAC cut-off for diagnosing MAM was 13.75 cm with a sensitivity and specificity of 98.3% and 72.9%, respectively giving the corresponding positive likelihood ratio of 3.6 and area under roc curve of 0.90 (Table 4, Figures 1-4).

Table 4. Optimal MAUC Cut off for moderate acute malnutrition among under five children using weight for height Z<-2 as a gold standard

Region	Optimal MUAC Cut-off	Sensitivity	Specificity	Youden index	Positive Likelihood Ratio	Area under curve	P	CI at 95%
Over all	13.85	0.99	0.80	0.79	4.99	0.93	0.001	0.91-0.94
Gambella	13.85	0.99	0.81	0.80	5.20	0.92	0.001	0.89-0.95
Amhara	13.85	1.00	0.87	0.87	7.70	0.96	0.001	0.94-0.98
Somalia	13.75	0.98	0.73	0.71	3.60	0.90	0.001	0.88-0.94

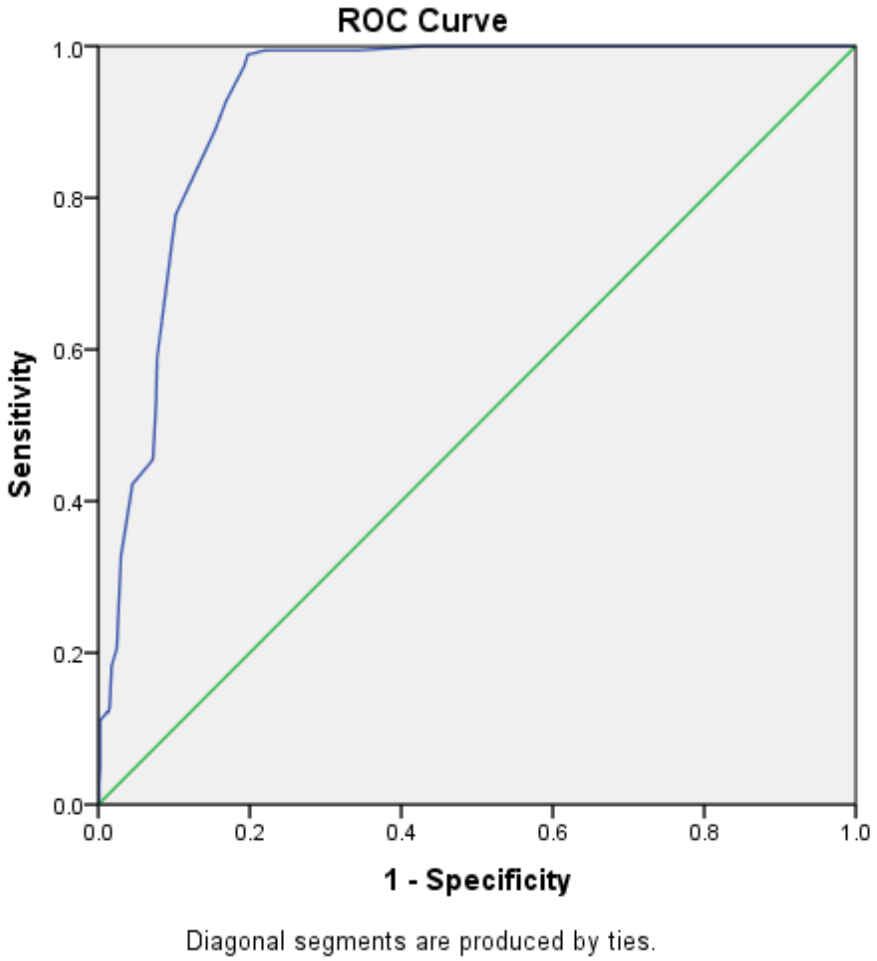

Figure 1; ROC curve for sensitivity and specificity of MUAC as compared to WHZ<-2 among under five children in Ethiopia.

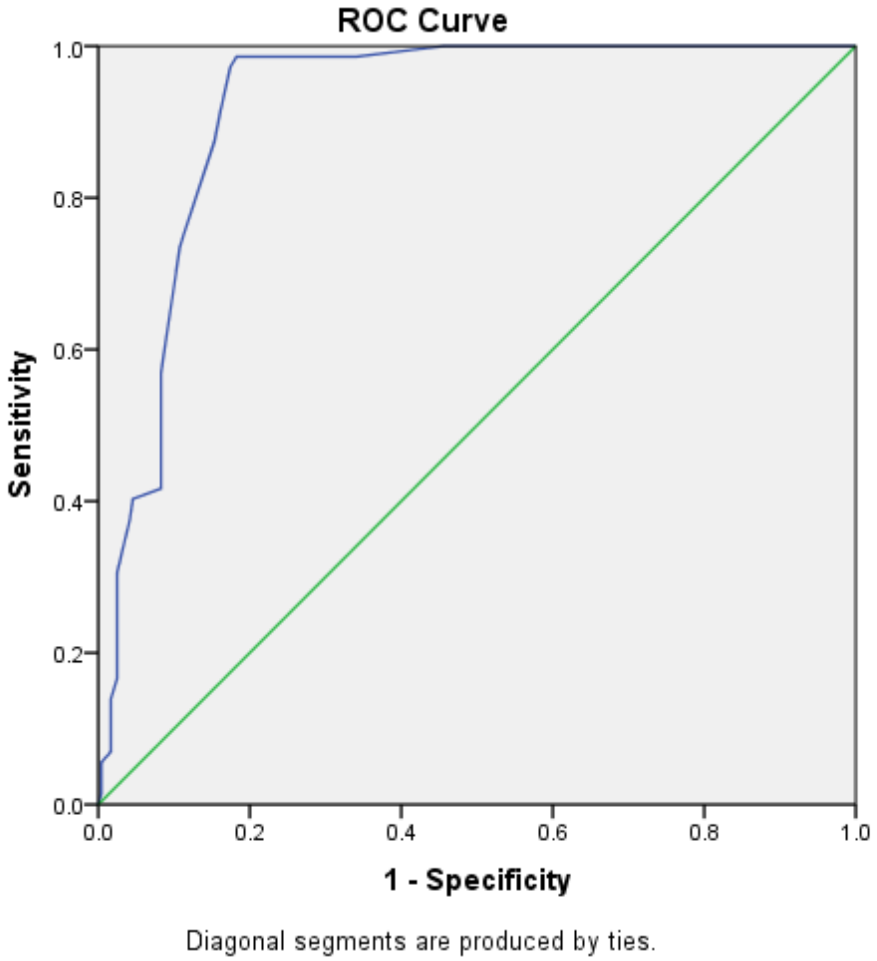

Figure 2; ROC curve for sensitivity and specificity of MUAC as compared to WHZ<-2 among under five children of Gambella, Ethiopia.

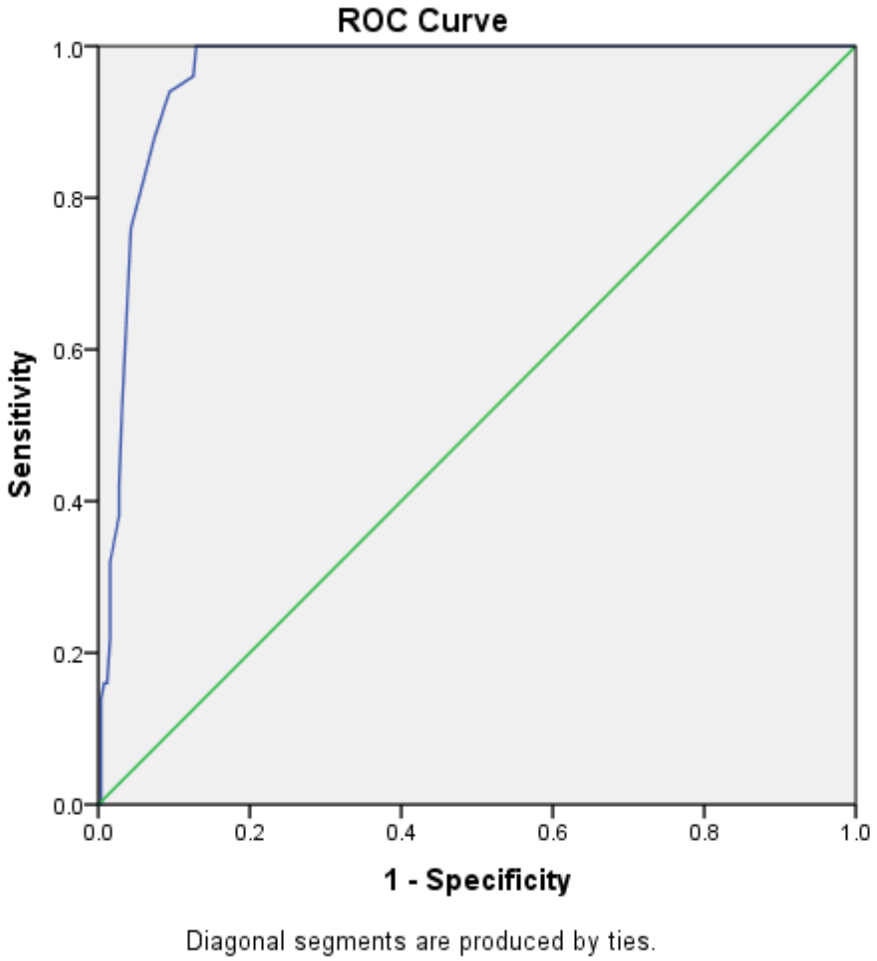

Figure 3; ROC curve for sensitivity and specificity of MUAC as compared to WHZ<-2 among under five children of Amhara, Ethiopia.

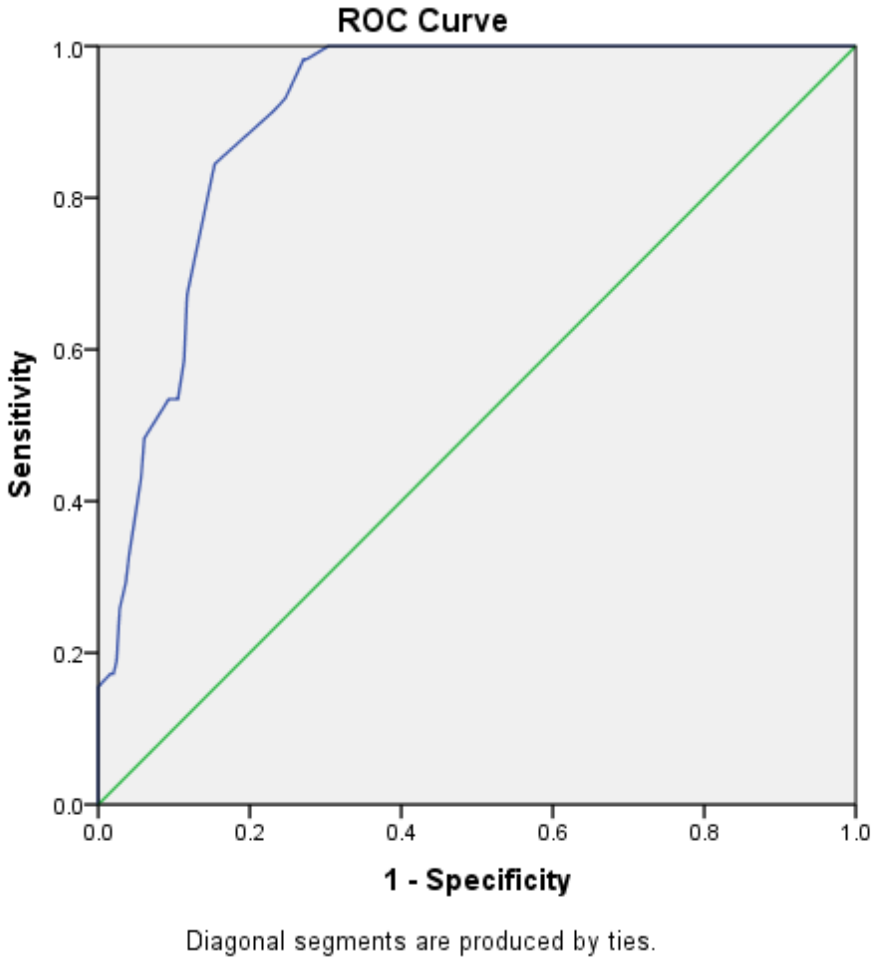

Figure 4; ROC curve for sensitivity and specificity of MUAC as compared to WHZ<-2 among under five children of Somalia, Ethiopia.

2.4. DISCUSSION

In this study we identified significant variation in diagnosis of moderate acute malnutrition by MUAC<12.5cm and WHZ<-2-score among under five children in the overall sample as well as in each of the three regions. In the overall sample, the prevalence of moderate acute malnutrition was estimated to be 19.7% by WHZ<-2, whereas it was 6.0% by MUAC<12.5 cm indicating a misclassification of 13.7%.

This difference also varies among different ethnic groups across region. In Gambella Region among Nuer and Anuak ethnicity the prevalence of moderate acute malnutrition was 23.6% by WHZ<-2 score and 5.9% by MUAC<12.5 cm showing difference of 17.7%. For Amhara region, the prevalence of MAM was 16.4% by WHZ<-2 while it was 3.6% by MUAC<-12.5 showing a Difference of 12. 8%. Likewise, for Somalia Region the prevalence of MAM was 19.1% by WHZ<-2 and 8.6% by MUAC<12.5cm resulting in a difference of 6.6%.

The findings show that the current MUAC cut-off (<12.5cm) used in real service setup for screening children significantly underestimates the prevalence of MAM leading to a significant misclassification as compared to WHZ<-2 for the whole country although there were some regional variations. The highest misclassification (17.7%) was observed in Gambella Region while the lowest misclassification (6.6%) was observed in Somali Region.

The sensitivity and specificity of the current MUAC cut-off <12.5cm as compared to WHZ <-2, for the whole sample were 20.6% and 97.5%, respectively with fair agreement (Cohen's Kappa = 0.245) with WHZ<-2 score, which is consistent with a study in India that showed a low sensitivity and specificity of this MUAC Cut-off (Manoj R. and Bishan S., 2016). This finding implies an urgent need for revising the cutoff value of MUAC to higher value to improve its

sensitivity in detecting children with MAM. The Cohen's Kappa result also suggests the need for developing a new cut off for health intervention programs better to have maximum Cohen's Kappa (McHugh,2012).

There was a regional difference the diagnostic validity of the currently MUAC cut-off <12.5cm as compared to WHZ<-2. For Gambella region among Nuer and Anuak ethnic groups it showed a lower sensitivity (16.7%) and higher specificity (97.4%) with slight agreement (Kappa=0.19), suggesting that the existing cut off point of MUA<12.5 cm for detection of under nutrition may not capture all under nourished children. Therefore, we need to have new cut off point to maximize success of the treatment and to minimize the relapse of malnourished cases.

Similarly, for Amhara region, the existing MUAC cut off point for diagnosing MAM (<12.5cm) had lower in sensitivity (16.0%) and high specificity (98.8%) giving a fair agreement (Kappa-value=0.216) with WHZ<-2 score. This also needs revision of the cut-off to higher values to maximize detection of MAM cases and improve inter reliability agreement with gold standard.

In similar way, of the diagnostic performance of the currently used MUAC cut-off (<12.5cm) showed low sensitivity (29.3%) and high specificity (96.3%) for detection of MAM among the children from the Somalia region or Somali ethnic group showing a faire agreement (Kappa-=0.325) compared to gold standard WHZ<-2 score. This result also shows the currently used MUAC cut-off fails to detect significant proportion of MAM cases Somali Region implying the need for revision of the MUAC cut-off for a better diagnostic performance.

Based on the findings of low performance of the existing MUAC in diagnosing MAM cases, new cut off points of MUAC were developed using ROC curve for the overall sample as well as for the three regions. Finding showed that the revised MUAC cut-off for the overall sample (three regions

namely for Gambella, Amhara and Somalia) 13.85cm with better sensitivity (98.9%) and specificity (80.7%) with the positive likelihood ratio of 5.1 and area under ROC curve of 0.93 showing an excellent performance.

For Gambella and Amhara regions the optimal cut-off was similar to the total sample (MUAC<13.85) giving good sensitivity (96.6%) and specificity (81.7%). This result shows that this MUAC cutoff point enhances the diagnostic performance for identifying MAM cases and prevent relapse. However, the optimal cutoff point of MUAC for diagnosis of MAM was MUAC<13.75cm for Somali Region giving highest sensitivity (98.3%) and specificity (72.9). The suggestions of WHO growth standards confirm prior explanations that the effect of ethnic variations on the growth of infants and young children in populations is small compared with the effects of the environment but there are genetic differences among individuals (WHO and UNICEF,2009). The difference in the optimal cut-off value for Somali region may be explained due to differences in environmental conditions (Reynaldo and Amanda,2012) and may be by differences in body frames. The findings of this study have wider practical implications. The fact that the currently used MUAC cut-off demonstrated low performance in diagnosing MAM cases and that the higher optimal cut-off (MUAC <13.85) developed in this study suggests the need for revision of the cut to 13.85 to enhance the diagnostic capacity of the MUAC as screening tool. As wasting (Moderate acute malnutrition) is associated with stunting if it happens for prolonged duration, failure to diagnose and treat MAM cases timely due to the use of the current MUAC cut-off(<12.5cm) would enhance relapse cases and becomes a stumbling block of the efforts to reduce stunting to zero level.

This study involved different regions with different ethnic backgrounds and geographical locations. It gives a new insight for cutoff point of MUAC among different regions and ethnic

variation. However, it did not take sample from other ethnic groups, although much of as variability is not expected from the study regions represented due to similarities of the majority of the ethnic groups in body frames to either of the ethnic groups represented in sample from the three regions.

Conclusion; Findings from this study suggests that current MUAC cut-off of <12.5cm cutoff point is less sensitive for diagnosis of MAM and significantly underestimates the caseload, relapse and consequent chronic malnutrition. The optimal cut-off that gives high sensitivity and specificity for diagnosing MAM cases is MUAC<13.85 cm.

Policy implications; Based on the findings, it is recommended that federal ministry of health expected to revise the MUAC cut-off point to <13.85cm to enhance its diagnostic performance.

Recommendation; Ethiopia is home of diverse ethnic groups with different body compositions, geographical and climate conditions there was need to validate and develop new cut off points for each region among different ethnic groups. Accordingly, better to conduct further investigation among different ethnic groups.

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CHAPTER8 : General Discussion, Conclusion and Future Research Perspectives

2.5. Introduction

Nearly half of all preventable deaths in children under the age of five are related to malnutrition and the burden of disease is heaviest in Sub-Saharan Africa (Russell et al.,2020). Acute malnutrition is common among children in developing countries due to inadequate food supply caused by social, economic, and environmental factors (Dipasquale et al.,2020). Unfortunately, contributors to the burden of acute malnutrition are increasing every year because of natural and man-made disasters, including floods, droughts, earthquakes, and armed conflicts creating nutrition crises (Bahwere,2014).

Improving nutrition requires managing the political and economic challenges that persist in the nutrition field at global, national and sub-national levels (Balarajan and Reich,2016). Children with primary acute malnutrition can be managed at home with nutrition-specific interventions whereas those with severe acute malnutrition and complications; require inpatient treatment (Dipasquale et al.,2020). Nutritional rehabilitation centers are effective in management of severe malnutrition with complications (Maurya et al.,2014) with therapeutic feeding programs achieving higher impact if WAZ and MUAC admission criteria are used (Myatt et al.,2019). MUAC<11·5 cm is a better predictor of mortality in hospitalized under-5 children as compared with WHZ<−3(Sachdeva et al.,2016). However, for screening and case detection in the community, the current WHO definition of MUAC for severe acute malnutrition may not be rational in all area (Kapil et al.,2018). Again, other studies reveal that the validity of using a single MUAC cut-off such as 125 mm as a suitable discharge criterion for all age groups is questioned (Guesdon et al.,2021). AS practicalities of implementation must be considered, the higher MUAC cut-off for

cases of SAM would maximize early case-finding of high-risk acutely malnourished (Marshall et al.,2019). Based on the above literature this study aimed to improve sensitivity and specificity of MUAC among children with different ethnic background in Ethiopia.

Another problem in management of malnutrition for either severe acute malnutrition or moderate acute malnutrition is relapse. Some studies revealed that lower dosage of RUTF for most SAM children in the combined protocol resulted in a similar relapse rates at 4 months post-discharge with the standard care (Lelijveld et al.,2021). Identification of the different diagnostic and treatment methods and consistent to outcomes of SAM treatment(Carboo et al.,2020).Further follow-up studies with complete assessment of nutritional status at discharge and not based on a restricted MUAC-only definition of relapse as SAM would be urgently needed to set evidence-based discharge criteria(Guesdon et al.,2021).So the main aim of this studies to determine diagnostic and prognostic utility of MUAC during SAM management and screening for malnutrition.

2.6. Summary of the main findings

The main findings of this research emerge from five studies: chapter_ 3 Systematic Review and Meta-analysis, Retrospective Cohorts designs **(Chapter _4and_ 5),** prospective cohort **(Chapter _6)** and cross-sectional study designee **(chapter _7).**

Based on the above studies **(Chapter-3)** in this chapter global evidence on sensitivity and specificity of MUAC on detection of severe acute malnutrition were generated by systematic review and meta-analysis (**(published on Nutrition Journal; https://doi.org/10.1016/j.nut.2022.111918)).**

Chapter 4 generated finding on frequency of relapse for SAM cases that were discharged after cure. This will help to develop new insight and follow up strategies for severe acutely malnourished children after discharge from the treatment program (**Published on**; **PLoS ONE: March 25, 2021https://doi.org/10.1371/journal.pone.0249232)**.

Chapter 5; aimed at determining the time after discharge when relapse of severe acute malnutrition occurs. This will help to know what is critical time to follow up of children after discharge at house hold level to minimize next repeated admission for SAM (**published on journals.cambridge.org/jns Journal of Nutritional Science (2021), vol. 10, e105, page 1 of 6 doi:10.1017/jns.2021.99)**.

Chapter-6; Utilization of mid upper arm circumference as discharge tool for children with moderate acute malnutrition in outpatient therapeutic program, Ethiopia. This study responds about how long children will stay in treatment for moderate acute malnutrition until MUAC become in a normal range or 12.5cm **(published on Journal of Nutritional Science (2022), vol. 11, e0, page 1 of 7 doi:10.1017/jns.2022.98).**

Finally, the dissertation showed that the validity of MUAC for diagnosis of SAM cases among different ethnic back ground children and suggesting optimal cut-off point for MUAC to diagnosis malnutrition for different ethnic background children. Validating the Diagnostic Performance of MUAC in screening moderate Acute Malnutrition and developing an optimal cut-off for Under Five Children of Different Regions in Ethiopia, 2021**;(Chapter-7).** This study addresses the ethnicity and diagnostic performance of MUAC as well suggested the optimal cut-off point for MUAC across different regions and ethnic backgrounds (**published in PLoS ONE journal** https://doi.org/10.1371/journal.pone.0273634**).**

2.7. Implications of the Findings

There is need of determining sensitivity and specificity of MUAC for detection of severe acute malnutrition and developing optimal cut-off points for detection of malnutrition among children with different ethnic backgrounds in Ethiopia. The new WHO growth standards confirm prior explanations that the effect of ethnic variations on the growth of infants and young children in populations is small compared with the effects of the environment although there are genetic differences among individuals (WHO,2009).

Another problem in the management of children with SAM is the fact that there is no follow up after discharge, which may lead to relapse. SAM management among children 6 to 59 months old shows that mid-upper arm circumference and WHZ at the end of supplementary feeding were the most important factors predicting which children remained well-nourished (Trehan *et al.*,2015). This study was designed to identify frequency of relapse and time to relapse, as there is no study conducted in Ethiopia that assessed this. Because a systematic review and secondary data analyses suggests that relapse after treatment of severe acute malnutrition or SAM is poorly defined and scarcely measured across programs and of children following SAM treatment, with the highest proportions occurring within 6 months post discharge (Stobaugh *et al.*,2019).

2.7.1. Implication of the findings for management of malnutrition

There is a need for development and validation admission and discharge criteria to the enhance diagnosis and management of malnutrition. Although malnutrition is a common health and social care problem, there is no universal agreement about its definition, prevalence, or method of identification and report (Elia,2017). Malnutrition is easily preventable disorder if there is early

diagnosis and management with appropriate tools and facility. Nutrition policy analysis and solving existing problems in children can reduce the effects of malnutrition (Mohseni *et al.*,2019).

Growing dynamic–Ethiopia is 'on course' to meet targets for maternal, infant and young child nutrition and some progress towards achieving the target for stunting. Nevertheless, 36.8% of children under 5 years of age are still stunted. There is also some progress towards achieving the target for wasting although 7.2% of children under 5 years of age are still affected (Global Nutrition Report,2021). Recently, especially in the northern Ethiopia, the security situation security becomes difficult, hindering effective delivery of lifesaving assistance to the most affected populations (UNHCR .Ethiopia,2022). Meta-analysis in Ethiopia showed that overall estimate of wasting prevalence was 10.6% with highest differences among regions and between residents and refugees (Altare *et al.*,2016). Inequality in malnutrition is caused by inequality in socioeconomic status in which it disfavors the poor in both cases (Yayo Negasi,2021). Therefore, this study considered ethnic variation of anthropometric tool in Ethiopia.

A study suggested that cut-off of <11.5 cm is not enough to detect SAM children. It needs to be increased to safeguard early diagnosis of SAM children and to avoid misdiagnosis of children and their referral for management of malnutrition. To reduce the risk and death related to under nutrition, more sensitive cutoff point of MUAC is needed (Stobaugh *et al.*,2019). Evidence shows that among children aged 6 to 23 months with a MUAC between 115 and 125 mm and a weight-for-height z score ≥−2 suggests that short children with low MUAC do not gain excessive fat during supplementation and the use of length as a criterion for measuring MUAC to determine treatment eligibility should be discontinued in policy and practice (Fabiansen *et al.*,2018). However, World Health Organization on its 2013 severe acute management Guide line suggests that there is no difference between weight for height and mid upper arm circumference; for

program using mid-upper arm circumference weight gain is 15–20% after edema disappears and for program using weight-for-height: weight gain is 15–20% after edema disappears (WHO,2013).

As MUAC is easy to measure, cheap, feasible and portable nutritional assessment method, it is recommended for emergency nutritional assessment during displacement time **chapter -7** of this dissertation focuses on, optimal cut-off for mid upper arm circumference (MUAC) development and validation for undernutrion screening among under five children from different ethnic backgrounds in Ethiopia.

Nation Policies and strategies indicating Ethiopian government's commitment to improving nutrition is outlined in the following documents: National Food and Nutrition Policy (NFNP) 2019–2029 ,National food and nutrition strategy, Growth and Transformation Plan II (GTP II) 2015/16–2019/20, Second National Nutrition Programme (NNP II) 2016–2020, Seqota Declaration 2015, Health Sector Transformation Plan (HSTP) 2016–2020,Agriculture Sector Policy and Investment Framework 2010–2020, National Nutrition Strategy 2008, Rural Development Policy and Strategies (RDPS) 2003, Agricultural Development Led Industrialization Strategy 1995(USAID,2021). Furthermore, Ethiopia has declared that 'Seqota' declaration as a special commitment which involves different implementing sectors including Ministry of Agriculture and Natural Resources (MOANR), Ministry of Livestock and Fishery Resource Development (MOLF), Ministry of Health (MOH), Ministry of Water, Irrigation and Electricity (MOWIE), Ministry of Education, and Ministry of Labor and Social Affairs (MOLSA) to achieve Zero stunting in children less than 2 years (FMOH,2016).

To answer national plan and objectives validated more sensitive tools are needed for early diagnosis and management or prognoses follow up of severe acute and moderate acute malnutrition in both community and clinical areas

In Ethiopia there is no any policy document that addresses about relapse or post discharge status of under five children after treatment of SAM. In this dissertation there were suggestions for national health policy developers on relapse and time to relapse of severe acute under nutrition**(Chapter 4-5)**

Economic Reasons

Malnutrition, in all its forms, imposes unacceptably high direct and indirect costs on individuals, families and nations. The estimated impact on the global economy could be as high as US$3.5 trillion per year or US$500 per individual and these are enormous costs lost investments and human capital (Global Panel,2019). The Cost of Hunger in Africa demonstrates that child nutrition can be a determinant factor in achieving Africa's transformation agenda (UNECA,2014). It's believed that, economic growth reduces child undernutrition in Ethiopia and this verifies the fact that the economic growth of the country accompanied should accompany socio-economic development and improvement of the livelihood of the poor (Biadgilign *et al.*,2016). So, knowledge of the frequency of relapse **(Chapter _four),** time to relapse of acute malnutrition (**Chapter _five**) and the time to cure of MUAC (**Chapter_ six**) enables to determine the optimal duration of treatment and follow so that repeated admission that incur the above-mentioned costs are averted.

2.7.2. Implication of the findings for diagnosis of malnutrition

Malnutrition is common in hospital and it is important to implement an appropriate nutrition screening tool to identify the risk of malnutrition (Bauer and Capra,2003). Effective nutritional screening, nutritional care planning and nutritional support are essential in all settings, and there is no doubt that a health service seeking to increase safety and clinical effectiveness must take

nutritional care seriously. Screening and early detection of malnutrition is crucial in identifying patients at nutritional risk (Håkonsen *et al.*,2015). Quick-and-easy malnutrition screening tools are suitable for use in a hospital inpatient setting and outpatient setting (Neelemaat *et al.*,2011). However, the current WHO guidelines for community screening for malnutrition recommend a Mid Upper Arm Circumference of <115 mm to identify severe acute malnutrition or SAM. However, it is unclear that how MUAC relates to the other indicator used to define acute malnutrition like with weight-for-height Z-score.

This dissertation addressed both prognostic and diagnostic performance of mid upper arm circumference (MUAC) against weight for height in clinical and community setups in different regions of Ethiopia.

Mainly in the first two chapters prognostic performance of MUAC was determined using WHZ as a confirmatory indicator. Frequency of relapse of severe acute malnutrition in **chapter 4**, time to relapse for acute malnutrition was assessed in **chapter 5** and utilization of MUAC as discharge tools among SAM children in **chapter 6,** the findings in these s chapters have paramount important in tracing post discharge status of under five children admitted for severe acute malnutrition management program in Ethiopia. The other focus of this dissertation is diagnostic performance of MUAC in detection of severe acute malnutrition among under five children from different ethnic background children from several regions in Ethiopia. Mainly in **chapter 7** the validity of MUAC in detection of under nutrition with ethnic deference was checked and new optimal cut-off point for diagnosis of under nutrition with ethnic variation is suggested to enhance sensitivity and specificity of MUAC. Furthermore, this chapter helps to detect undernourished children community level with different ethnic backgrounds that will help national health system in early diagnosis and management.

2.7.3. Methodological Considerations

In this study, different study designs were used to answer different questions of the study; meta-analysis and systematic review, retrospective cohort, prospective cohort and community based cross-sectional study designs.

To generate global evidence on sensitivity and specificity of MUAC for diagnosis of severe acute malnutrition among under five children's and suggested optimal cut off points of MUAC for diagnosis of severe acute malnutrition were determined by meta-analysis and systematic review in **chapter_3**

Ethnicity and regional variation were used during selection of study participants to identify the sensitivity and specificity of MUAC in diagnoses of severe acute malnutrition. To validate and suggest new optimal cut-off point of MUAC to diagnoses moderate acute malnutrition in children from **three philological groups**; Nahilosaharns (Agnuwak and Nuer), Semitic (Amhara) and Cushitic (Somalian) were included in the sample for cross sectional study. During anthropometric measurement equal sample was considered from the three ethnic backgrounds and age of the children was extracted from EPI card and for those who were registered for peer school from school documentation or birth certificate (**Chapter -7)**. However, some linguistic groups like Omotic groups were not included in this study due to resource shortage.

For prospective cohort study in **Chapter-6**; health posts were used to follow up under five children admitted for severe acute malnutrition in Oromia region West haraghe zone for 16 weeks. During the follow up weeks' children were allowed to stay in treatment program until the MUAC become 12.5 cm irrespective of weight gain to identify cure time of MUAC. Anthropometric measurements

of children were collected every week by program health workers until declared cured and discharged by MUAC=12.5cm.

For retrospective cohort study in **Chapter-4-5** for SAM registration books in the last five years form health posts of two woradas and one administrative town in Hadiya Zone, Southern Ethiopia were used to extract data about frequency and time to relapse of severe acute malnutrition among under five children.

In all type of study designs during data collection ethical producers were tracked from beginning to accomplishment of the study.

2.7.4. Future Research Perspectives

In this dissertation in **Chapter 4** and **Chapter 5** frequency of relapse and time to relapse of severe acute malnutrition after treatment in health institutions was determined. We assessed the frequency of relapse from five-year documents or recordings in the intuitions in two woradas and one town administration. To address variables related to relapse and time to relapse; household food security, family economic status and progress of overall nutritional status after discharge, a prospective study was conducted at national level or different regions including the mentioned and other variables to trace the relapse cases and time to relapse may improve national policy.

To determine time to cure by MUAC for SAM in **Chapter 6** among under five child prospective cohort study was done and this study is expected to maximize curing of children, as change in MUAC is not acute. It is recommended that another similar study is conducted in different areas to assist national management information system for severe acute undernutrition.

In **Chapter 7** of this dissertation, MUAC performance was validated to diagnose moderate acute malnutrition among different ethnic backgrounds under five children namely in Gambella, Amhara and Somalia regions and new optimal cut-off point for screening moderate acute malnutrition was validated. However, only three philological groups were involved in this study as recommendations better to include other linguistic groups like omotic and other regions to validate and develop optimal cut-off point of MUAC for screening all forms of malnutrition to help National policy on tool validation.

2.8. Conclusions

In Ethiopia existing cut-off point of WHO is less sensitive in detecting under nutrition among under five children which drops many children with under nutrition from getting treatment and eventually this will result in admission of children with complicated severe acute under nutrition that can lead to inpatient admission and increase health care cost both on government and patient's family.

Newly developed cut-off points of MUAC for under five children for three ethnic backgrounds in three regions has better performance with high sensitivity, specificity, predictive values and agreements; therefore, it can be used as a simple, cost-effective, and valid indicator in community setups for moderate acute under nutrition.

Both in the WHO recommendation and in Ethiopian national guidelines, there is no any mechanism to follow-up SAM cases after treatment or discharge. The findings of this dissertation indicated that there was frequent relapse of severe acute under nutrition after discharge. The frequent admission to the program may lead to extra expenditures in health care sectors and frequent infection that may incur further health care cost and deteriorate the growth and wellbeing

of the children. The findings suggest need to devise post discharge tracing system for children cured from SAM to ensure the continuum of care at household, community and facility levels to prevent relapse.

Finally, based on this dissertation cure time to MUAC is not more than cure time for weight that means according to the in new national guidelines children with SAM can staying in the treatment program up to 16 weeks. This study assures that children for MUAC can be cured in a given time as minimum cure time is 4 week and maximum cure time is 16 weeks, the median time of 10 weeks.

Recommendations

- The existing WHO cut-off point to detect severe acute malnutrition has poor in sensitivity and it needs rehearsal and, in this dissertation, overall cut-off point for MUAC to detect moderate acute under nutrition become <13.85 cm for Amhara and Gambela region and <13.75 cm for Somalia region. The findings suggest the need for further nationwide study and strong evidence to change existing WHO cut-off <12.5cm and to accept as screening tools.
- Follow up during treatment of severe acute malnutrition and discharge by MUAC is possible. Finding from this study suggests that time to cure by MUAC is not different from weight as MUAC is easy to measure and cheap and portable. Especially, in hard to reach areas, we can replace MUAC and use it as discharge criteria if the treatment period for SAM is modified to 10 weeks to a maximum of 16 weeks.

- A total of 9.6% of SAM children discharged using Anthropometric criteria are likely to be readmitted(relapse) after 22 weeks implying the need for a continuum of care a both at household and community level to prevent the relapse. This will prevent repeated admissions for SAM treatment.

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ANNEXES

Jimma University

2.9. ANNEXES 2; PARTICIPANT INFORMATION SHEET

Participant code. ----------

PARTICIPANT INFORMATION SHEET AND INFORMED VOLUNTARY CONSENT FORM FOR (parents of child)

My name is M/r/s …….. I am working as a data collector for the study being conducted in this region specially in this locality by ABERA LAMBEBO who is studying for his philosophical doctorate in Human nutrition (PhD) at Jimma University, the College of Health and Medical Sciences. I kindly request you to lend me your attention to explain you about the study and being selected as your child is the study participant.

The study/project title:

Performance of mid upper arm circumference for Diagnostic and prognostic assessment of Sever acute and moderate acute malnutrition among different Ethnic groups of under-five children's in EHIOPIA.

Purpose/aim of the study: The findings of this study can be of a paramount importance for the national health policy to plan intervention programs to prevent child undernutrition in your community and others;

Thereby improve community health. Moreover, the aim of this study is to write a dissertation as a partial requirement for the fulfillment of a PhD Program in human nutrition for the principal investigator.

Procedure and duration: I will be interviewing you using a questionnaire to provide me with pertinent data that is helpful for the study. There are 14 questions to answer where I will fill the questionnaire by interviewing you and there is also measurement of height, mid upper arm circumference (MUAC) and weight of your child. The interview will take about 10 minutes and

measurement my take 5 minutes, so I kindly request you to spare me this time for the interview and measurement.

Risks and benefits: The risk of being participating in this study is very minimal, that only taking few minutes from your time. There would not be any direct payment for participating in this study. But the findings from this research may reveal important information for the national health planners.

Confidentiality: The information you will provide us will be confidential. There will be no information that will identify you in particular. The findings of the study will be general for the study community and will not reflect anything particular of individual persons or housing. The questionnaire will be coded to exclude showing names. No reference will be made in oral or written reports that could link participants to the research.

Rights: Participation for this study is fully voluntary. You have the right to declare to participate or not in this study. If you decide to participate, you have the right to withdraw from the study at any time and this will not label you for any loss of benefits which you otherwise are entitled. You do not have to answer any question that you do not want to answer.

Contact address: If there are any questions or enquires any time about the study or the procedures, please contact: ABERA LAMBEBO 0910153058 / (lambebo70@gmail.com) and Health Research Ethics Review Committee (IHRERC) at office phone …….. or P.O.Box378, Jimma].

Declaration of informed voluntary consent:

I have read/ was read to me the participant information sheet. I have clearly understood the purpose of the research, the procedures, the risks and benefits, issues of confidentiality, the rights

of participating and the contact address for any queries. I have been given the opportunity to ask questions for things that may have been unclear. I was informed that I have the right to withdraw from the study at any time or not to answer any question that I do not want. Therefore, I declare my voluntary consent to participate in this study with my initials (signature).

Name and signature of participant: _____ _____

Name and Signature of Data Collector: _____ _____

N.B

This is signed face to face in the presence of the data collector. Please provide a copy of this signed consent to the participant.

2.10. Ethical clearance letter

Jimma University Institute of Health

Institutional Review Board

Ref.No IRB 00021/2012

Date: 12/9/2012

To: Mr. Abera Lambebo

Subject: Ethical Approval of Research Protocol

The IRB of Institute of Health has reviewed your research project **"Diagnostic and Prognostic Performance of Mid Upper Arm Circumference for Severe and Moderate Acute Malnutrition among under Five Children in Ethiopia"**

Thus, this is to notify that this research protocol as presented to the IRB meets the ethical and scientific standards outlined in national and international guidelines. Hence, we are pleased to inform you that your research protocol is ethically cleared.

We strongly recommend that any significant deviation from the methodological details indicated in the approved protocol must be communicated to the IRB before it has been implemented.

With Regards!

Netsanet Workneh (MD, DTM&H)
IRB chairperson
Tel: +251 917762109
E-mail: konetsanet@gmail.com

ጅማ ዩኒቨርሲቲ የጤና ኢንስቲትዩት የአካዳሚክ እና ምርምር ዋና ዳይሬክተር Chief Academic and Research Director Health Institute Jimma University

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2.11. ANNEXES 2; PARTICIPANT INFORMATION SHEET

Information sheet and informed voluntary consent form for head of the health institutions Informed (for Head Health office)

My name is----------. I am working as a data collector for the study being conducted in your worada. By the principal investigator ABERA LAMBEBO who is studying for his philosophical Doctor of philosophy human nutrition (PhD) at Jimma University the College of Health and Medical Sciences, department of Nutrition and dietetics. I kindly request you to lend me your attention to explain you about the study as the head health office.

The study /project title: Median cure time based on mid upper circumference for children with severe and moderate acute undernutrition at treatments in stabilization center, hemoglobin level during admission and discharge, frequency of illness and relapse during treatment in selected Health post.

Aim of the study: To determine the mean cure time of mid upper circumference for severe acute undernutrition treatments in stabilization center, hemoglobin level during admission and discharge, frequency of illness and relapse during treatment. The study finding helps you to plan evidence-based screening and treatments of under nutrition treatment to limit case relapse and comorbidity among under five children.

Procedure and duration: The information will be collected using follow-up chart that is developed by principal investigator, hemoglobin or hematocrit level will be done during

admission and discharge also some time there may be documents reviewee. children will stay in your in program until they get cured for MUAC. There is also the Weight, mid upper arm circumference and height of children will be measured. The study may take months. I kindly request you to allow me your patients?

Risk and benefits: The risk of participating in this study is minimal, but only their time of stay in the program be lengthen. There is payment for your staffs for extra spending work based on negotiation with principal investigator for the time they are working for extra time. The finding from this study may support at different levels to plan prevention activities of under nutrition.

Confidentiality: The information that will provide from patients as well as from your institution will be confidential. There will be no information that will identify you and patients particular. The findings of the study will be general for community and will not reflect anything particular of individual persons or housing. The questionnaire will be coded to exclude showing names. No reference will be made in oral or written reports that could link participants to the research.

Rights: Participation in this study is fully voluntary. The participants have the right to declare to participate or not in this study. If they decide to not participate, they have the right to withdraw from the study at any time and this will not label them for any loss of benefits which they otherwise are entitled. They do not have to answer any question that they do not want to answer. And the administrative has the right to stop this study from being conducted in the institution if any misdeeds and unethical procedures are observed.

Contact address: If there are any questions or inquires any time about the study or the procedures, please contact: **ABERA LAMBEBO**(lambebo70@gmail.com) or Mobile -

0910153058; as well as contact address of the responsible Institutional Health Research Ethics Review Committee (IHRERC) at office phone …… or P.O.Box378, Jimma).

Declaration of informed voluntary consent: I have read the participant information sheet. I have clearly understood the purpose of the research, the procedure, the risks and benefits, issues of confidentiality, the rights of participating and contact address for any queries. I have been given the opportunity to ask questions for things that may have been unclear. I was informed that participants have the right to withdraw from the study at any time or not to answer any question that they do not want. I am also informed that the administrative has the right to stop this study from being conducted in the institution if any misdeeds and unethical procedures are observed during the data collection process in the institution premises. Therefore, I declare my voluntary consent to on behalf of Health posts for this study to be conducted with my initials (signature).

Name and signature of Head of Health office: _____

Name and signature of Data collector: _____

N.B

This is signed face to face in the presence of the data collector. Please provide a copy of this signed consent to the participant.

Data collection tool

2.12. ANNEXES 3; Questionnaire for Cross Sectional Study

ANTHROPOMETRIC SURVEY QUESTIONNAIRE

Survey Date…./…../….

Survey time……..am/……..pm

Altitude of the area----------

Surveyor Name…….

Region ……Zone……kebele ……village……

Question N	Variable	Response code	Remark
	Family profile		
Starter	Is there under five children in your family members		If Yes continue If No stop here
01	Number of family members	---------	Total number of house hold

02	Number of under five children	----------	Living with family
03	Relations of care taker to child	1. Parent, 2. Siblings, 3. Other relative 4. non-relative	
04	Sex of care taker	1. male 2. female	
05	Ethnic group of the father	1. Anuak, 2. Nuer, 3. mejang, 4. Somali, 5. Amhara, 6. others specify-----	
06	Ethnic groups of mothers	1. Anuak, 2. Nuer, 3. mejang, 4. Somali, 5. Amhara, 6. others specify-----	
07	Other ethnic in blood relation to child	Specify-------	

	Child profile		
08	Age in month	-----	From family members
09	Date of birth	-------/--------/------EC	From EPI card or local calendar estimate
10	Sex	1. male 2. Female	
11	Birth order	1. 1st 2. 2nd 3. 3rd 4. 4th and above	
12	Birth type	1. Single birth 2. Twine birth	
13	Breast feeding History	1. Yes 2. No	
14	Complimentary feeding	1. Yes 2. No	
Age start complimentary feeding in month		----------	

15	Weight	----------kg	
16	Height	----------cm	
17	Mid upper arm circumference (MUAC)	--------cm	
18	EPI card	1. yes 2. No	By observation
19	Measles	1. yes 2. No	
20	History of any illness?	1. Yes 2. No	
21	If yes at weak?	----------	
	Environmental conditions		
22	Living condition	1. Resident 2. Displaced 3. Family temporarily resident in village (cattle camp, water point, visiting family…) 4. Returnee	

23	Resident area	1. Urban 2. Rural 3. other specify-------	
24	Altitude from GPS	----------	Use you SMART mobile GPS

Survey start date……/…../…….

Name of the Health post……

Altitude…….

2.13. OTP follow up Questionnaire

SN	Question															
1	Full name of the child											Target weight				
2	Address	Family Phone number										Target MUAC				
3	Mothers Name											Health post Name				
4	Region							Zone				Worada				Kabale
5	OTP site name of the health post															
6	Age in month	----------month										Sex	male	Female		Date of ad
7	Admission type	New						Readmission after default				Readmission after six months of cure				From TFU
8	Weak	1		2		3		4	5		6	7			8	
9	Date															
		Anthropometry														
10	Weight kg															

11	MUAC cm								
12	Edema +++								
13	Height in Cm								
		General health condition							
14	Seizure Y/N								
15	Anemia Y/N								
16	Lethargy Y/N								
17	Vomiting Y/N								
18	Unable to feed Y/N								
		History							
19	Diarrhea in (days)								
20	Blood in the stool Y/N								
21	Vomiting in (Days)								
22	Fever in days								
23	Cough in days								
24		Physical examination							

25	Apatite test pass/fail **P/F**								
26	Temperature C^0								
27	Respirator rate beat/min								
28	Dermatitis0+++								
29	Action needed Y/N								
30		Routine medication							
31	Amoxicillin mg								
32	Malaria treatment								
35	Vitamin A in IU								
36	Deworming								
27	Measles								
28	Folic acid								
30	Other medications								
31	RUTF # sachets for each week								

32	Number of sachets consumed								
33	Is there any other child shared his/her RUTF?								
34	Additional family food in home given Describe each food item								
35	Name of examiner								
36	Out come								
37		If there is any action taken during follow-ups or other diagnosis other than SAM o --- --- --- ---							

2.14. Child profile assessment for follow-up in cohort

Sn	Question	Answer	code
1	Full name of the child		
2	Sex	1. Male 2. female	
3	Type of birth?	1. Single 2. Twin	
4	Age in month	--------month	
5	Is this child breast feeding now?	1. Yes 2. No	
6	If no age of weaning in month	-------	
7	How many family members are there?	-------	
8	Birth order of the child?	1. 1st 2. 2nd 3. 3rd 4. 4th and above	
9	How many under five children are there in your house hold?	---------	

10	How many family members are there?	------	
11	Is your child living with both father?	1. Yes 2. No	
12	If no child living with whom?	1. With mother 2. With father 3. With other	

2.15. ANNEXES 4; Questionnaire for Retrospective cohort study

Survey date……/…../…….

Name of the Health post……

Altitude…….

……

The following questions will be answered from documents in Health post.

SN	Question's	Reponses	Code
	Health facility and child profile		
1	Name of the health post	1. ----------	

2	Is there SAM and MAM program	1. Yes 2. No	
3	If yes year of start to full functioning?	----------	
4	How many health extensions are there?	----------	
5	Have you got training for SAM and MAM management?	1. Yes 2. No	
7	If yes year of training?	----------	
8	Number of total admissions in the last 5 years in your facilities for SAM and MAM? total number	_____	
	Total report from registration book	----------	
	Total report from Patient card	----------	
	Total reports from HMIS	----------	
Part 2	**Child profile**		
9	Is this child readmitted?	1. Yes 2. No	If no stop further questions

			And if yes go to question 10
10	Age of the child during re admission in month?	----------	
11	Sex of the child	1. Male 2. Female	
12	History of breast feeding	1. Yes 2. No	
13	Complimentary feeding	1. Yes 2. No	
14	Age start complimentary feeding in month	----------	
Part 3	**Admission history and health condition at heath facility admission to discharge time for first admission**		
15	Date of admission in Ethiopian calendar date (date/month/year	----------/----------/--------	
16	Diagnosis during admission?	1. Marasmus 2. Kwashiorkor 3. Marasmickwash 4. Other---------	

17	Is there diagnosis of anemia?	1. Yes 2. No	
18	If yes what is hemoglobin or hematocrit level during admission?	--------	
19	Is anemia cured? What is hemoglobin level during discharge?	---------	
20	Is there any medical complication during admission?	1. Yes 2. No	
21	If yes what is that complications?	----------	
22	Is there vomiting during admission?	1. Yes 2. No	
23	Is that complications managed?	1. Yes 2. No	
24	Does nasogastric tube used?	1. Yes 2. No	
25	What is admission weight in?	----------KG-	
26	What is admission height in?	----------cm-	
27	What is admission MUAC?	----------cm----	
28	Admission weight for height WHZ?	----------%-----	

29	Types of food given during admission? List	_____ _____ _____	
30	What are the medications during admission? list	_____ _____ _____	
31	How many days this child get in treatment?	----------	
32	What is the child's outcome during treatment?	1. Improved and referred to TSFP 2. Worsened and referred to SC 3. Cured and discharged 4. Other----------	
33	Date of discharge? Date/month/year	---------/----------/---------	
34	What is discharge weight?	--------KG-	
35	What discharge height?	--------cm-	

36	What is discharge MUAC? If there	----------	
	Readmission history		
37	Readmission date day/month/year	----------/----------/----------	
38	Readmission age? in month	----------	
39	Diagnosis during readmission	1. Marasmus 2. Kwashiorkor 3. Marasmickwash 4. Other	
40	Is there anemia during readmission?	1. Yes 2. No	
41	If yes what is hemoglobin level?	----------	
42	Is there other disease diagnosed?	----------	
43	What is readmission weight?	---------Kg-	
44	Readmission height?	----------cm------	
45	Readmission MUAC?	----------cm---	
47	Readmission weight for height?	-------%--	
46	Discharge status?	1. Improved and referred to TSFP	

		2. Worsened and referred to SC 3. Cured and discharged 4. Other----------	

2.16. CV and signature of principal investigator

Curriculum Vitae (CV)

1. **Personal information**
   - Name ABERA LAMBEBO TEMAMO
   - Sex Male
   - Age 35
   - Date of Birth August 21, 1988
   - Place of birth ; LENDA
   - Marital Status ; Single
   - Nationality ; Ethiopian
   - Address Debre Berhan University Ethiopia.
     Mob. 0910153058/0919224396
     Email; lambebo70@gmail.com
2. **Educational Back ground**
   - Higher education
     - PhD candidate for Human nutrition at Jimma University
     - MPH in Public Health Nutrition from Haramaya University on 5, July, 2017.
     - B.Sc. in Public Health Officer from Haramaya University on 6, July, 2013.
3. **Language**
   - English (Fluent in speaking, reading, writing and listening).
   - Amharic (Fluent in speaking, reading, writing and listening).
   - Oromiffa (Fluent in speaking, reading, writing and listening).
   - Kambetegna (Fluent in speaking, reading, writing and listening).
   - Halabigna (Fluent in speaking, reading, writing and listening).
   - Hadiyisa Native.
4. **Computer skill**
   - Microsoft Office packages (Word, Power Point and Excel)
   - Research software (EPI data, Epi info, SPSS, ENA,WHO Antrhos and WHO Antrhos+)

5. **Professional experience**

- ❖ Shone primary Hospital SNNPR September 26, 2013
- ❖ Lecturer at Debre Berhan University from September 19/2017 till now.
- ❖ Research advisory and counselling (RAC) member at Federal minister of Health
- ❖ Scientific Advisory for program member (SAP) member in Oromia region.

Duties and Responsibilities

- Community services at community problem
- Conducting problem solving research
- Teaching or lecturing students

- **Additional Trainings**

- ➢ Adult education and training on reproductive health
- ➢ Effective Teaching Methodology
- ➢ Instructional designing

Publications at National and international journals;

Lambebo, A., Temiru, D. and Belachew, T., 2021. Frequency of relapse for severe acute malnutrition and associated factors among under five children admitted to health facilities in Hadiya Zone, South Ethiopia. *PloS one*, *16*(3), p.e0249232.

Lambebo, A., Tamiru, D. and Belachew, T., 2021. Time to relapse of severe acute malnutrition and risk factors among under-five children treated in the health posts of Hadiya Zone, Southern Ethiopia. *Journal of Nutritional Science*, *10*.

Lambebo, A., Mezemir, Y., Tamiru, D. and Belachew, T., 2022. Validating the diagnostic performance of MUAC in screening moderate acute malnutrition and developing an optimal cut-off for under five children of different regions in Ethiopia. *PloS one*, *17*(9), p.e0273634.

Lambebo, A., Tamiru, D. and Belachew, T., 2022. Utilization of mid-upper arm circumference as discharge tool for children in outpatient therapeutic program, Ethiopia. *Journal of Nutritional Science*, *11*, p.e101.

Lambebo, A., Mezemir, Y., Tamiru, D. and Belachew, T., 2022. Sensitivity and specificity of mid-upper arm circumference for assessment of severe acute malnutrition among children aged 6-59 months. Systematic review and meta-analysis. *Nutrition*, p.111918.

Lambebo, A., Egata, G., Mangistie, B. and Irenso, A.A., 2018. Overweight and Obesity among Type 2 Diabetic Patients at Nigist Elleni Memorial Hospital, Hosanna Town, Southern Ethiopia. *East African Journal of Health and Biomedical Sciences*, *2*(1), pp.18-25.

Mezemir, Y., Egata, G., Geset, D. and **Lambebo, A.,** 2020. Nutritional Status and Associated Factors Among the Community-Dwelling Elderly Population in Debre Berhan Town, North Shewa Zone, Ethiopia. *Nutrition and Dietary Supplements*, *12*, pp.289-299.

Other academic activities

Seven research papers were reviewed on the following scientific journals

PloS one journal 1 paper

Journal of Public health nutrition Cambridge University Press 1 paper

Journal of Nutritional Science in Cambridge University Press 5 paper

6. Interest and Hobbies

- ❖ Reading books

7. Reference

- ✓ Professor Tefera Belachew (MD, MSc PhD) *SGS coordinator of Jimma University ;* email *teferabelachew@gmail.com; phone+251-917-80-40-72*
- ✓ D/r Gudina Egata (MPH, PhD, Associate professor *Haramaya Universit SGS coordinator email; gudina_egata@yahoo.com phone +2519-11-64-13-62*
- ✓ D/r Bizatu Mengistie (MSC, PhD, Associate professor) *Educational development center coordinator of Haramaya University CHM SC; email bizatum@gmail.com phone +2519-11-06-88-32*

I undersigned the above information is true and explains about me.