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Identification and Community Management of Severe Acute Malnutrition

Empirical evidence in rural Southern Ethiopia

AMARE WORKU TADESSE



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Abstract

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The current recommended standard management for all children with severe acute malnutrition (SAM) is Community-based Management of Acute Malnutrition (CMAM). CMAM has a community-based outpatient therapeutic program (OTP) to treat uncomplicated SAM and has been scaled-up and integrated with government health services in low-resource settings. However, the context in which such large-scale programs are implemented modifies their effectiveness. This study aims at assessing factors of importance for the effectiveness of management of SAM in the community.

A population-based survey of households with children aged under five years and a longitudinal study among children admitted to the integrated OTPs of rural Southern Ethiopia was undertaken. For Study I, children aged 6-59 months (n=4,297) from randomly selected households were examined for differences between children identified as SAM by MUAC and WHZ. For Study II, subsets of 1,048 children admitted to OTPs were analyzed for program outcome and nutritional status at discharge (n=759) and 14 weeks after admission (n=991). For Study III, non-oedematous children (n=661) admitted to OTPs were analyzed for gains in anthropometric measures after 4 weeks of treatment. For Study IV, children with SAM (n=788) were studied in terms of factors of importance for their recovery. Home-visits were used to collect data and anthropometry was measured following standardized World Health Organization (WHO) techniques.

The degree of agreement between the two anthropometric indicators of severe wasting differed depending on the sex and age of the children. The indicators' response to treatment varied according to the indicator used to define SAM at admission. While 32.7% achieved the program's recovery criteria at discharge, 29.6% had SAM at discharge and 72.1% of children were acutely malnourished at the end of 14 weeks of follow-up. Despite low recovery rate, children of caregivers with the highest decision-making autonomy recovered faster from SAM than children of caregivers with lower autonomy.

The poor agreement between MUAC and WHZ in diagnosing SAM within different groups of children indicates each anthropometric indicator may select different set of children for treatment. Our study provided empirical evidence that supports the current recommendation to use MUAC and WHZ independently for the management of SAM. Linking CMAM to other complementary programmes may improve the effectiveness of integrated large-scale nutrition programmes.

Keywords: Severe acute malnutrition, children, anthropometric indicators, integrated outpatient therapeutic programme, recovery, Ethiopia

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To all my family

List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.

- I Tadesse, A.W., Tadesse, E., Berhane, Y., Ekström, E.C. (2017) Comparison of mid-upper arm circumference and weight-for-height to diagnose severe acute malnutrition: A study in Southern Ethiopia. *Nutrients*, 9(3):E267. doi: 10.3390/nu9030267
- II Tadesse, E., Tadesse, A.W., Berhane, Y., Ekström, E.C. (2017) An integrated community-based outpatient therapeutic feeding programme for severe acute malnutrition in rural Southern Ethiopia: Recovery, fatality, and nutritional status after discharge. *Maternal and Child Nutrition*, Oct 10. [Epub ahead of print]. doi: 10.1111/mcn.12519
- III Tadesse, A.W., Tadesse, E., Berhane, Y., Ekström, E.C. (2017) Choosing anthropometric indicators to monitor the response to treatment for severe acute malnutrition in rural Southern Ethiopia—empirical evidence. *Nutrients*, 9(12):1339.
- IV Tadesse, A.W., Tadesse, E., Berhane, Y., Ekström, E.C. Does caregivers' autonomy influence recovery of children with Severe Acute Malnutrition treated in an integrated community-based outpatient Therapeutic Feeding Program? (manuscript)

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Abbreviations

CMAM	Community Management of Acute Malnutrition
HEW	Health Extension Worker
MAM	Moderate Acute child Malnutrition
MUAC	Mid-Upper Arm Circumference
MUACZ	Mid-Upper Arm Circumference Z Score
OTP	Outpatient Therapeutic Programme
RUTF	Ready-to-Use Therapeutic Food
SAM	Severe Acute child Malnutrition
UNICEF	United Nations Children's Fund
WHO	World Health Organization
WHZ	Weight-for-Height Z-score

Glossary and definitions

Severe acute child malnutrition (SAM): a mid-upper arm circumference (MUAC) < 115 mm or a weight-for-height/length < -3 Z-score of the WHO growth standards (1, 2), or having bilateral oedema.

Oedematous SAM: categorized in accordance with global recommendations (2, 3).

- Mild/moderate oedema: oedema of both feet and/or involving the lower leg, hands or arms.
- Severe oedema: generalized oedema involving both feet, legs, hands, and arms, and face.

Non-oedematous SAM or severe wasting: a MUAC < 115 mm or WHZ < -3 with no oedema

Programme outcome: set of indicators defined based on national guidelines for management of SAM (2, 3)

- **Programme recovery rate:** proportion of children who recovered after treatment in outpatient therapeutic programme; where recovery is gain of 15% of admission weight for non-oedematous children, or resolution of oedema for oedematous SAM.
- **Defaulter rate:** proportion of children who missed follow-up visits for at least two weeks from the outpatient therapeutic programme.
- **Case fatality rate (CFR):** proportion of children who died while participating in the outpatient therapeutic programme.
- **Programme average weight gain** = sum of weight gains per total number of children who achieved programme recovery criteria
 - Where Weight gain = [discharge weight (g) - minimum weight (g)] / [minimum weight (kg) x number of days between minimum weight and discharge day].
- **Average length of stay:** sum of length of stay (weeks) per total number children who achieved programme recovery criteria

Introduction

Global burden of Severe Acute Malnutrition

Severe Acute Malnutrition (SAM) remains a major public health problem throughout the developing world by increasing the risk of childhood morbidity and mortality. Globally, about 17 million children under five years of age suffer from Severe Acute Malnutrition (SAM) and the majority live in Sub-Saharan Africa and Southern Asia (4, 5). SAM is responsible for nearly 540,000 (7.4%) of the global deaths in children under the age of five (5). Children with SAM suffer in a vicious cycle of recurring sickness, debilitated nutritional status, growth faltering, and diminished learning ability and potential productivity later in life (6-8). If identified before the metabolic and immunologic complications of SAM become apparent (9, 10), and if properly managed, hundreds of thousands of children's lives could be saved (11).

Use of anthropometric indicators

Severe Acute Malnutrition has been defined using various anthropometric cut-offs and clinical signs, with an intent to differentiate between those who can safely be treated as outpatients and those who need inpatient care (12-14). SAM has also been referred to by different names with partially overlapping definitions, including severe wasting, kwashiorkor, and marasmus. Marasmus refers to children who are very thin for their height (that is, they meet the weight-for-height z-score (WHZ) or mid-upper arm circumference (MUAC) cut-off, but who are without bilateral pitting oedema; while kwashiorkor refers to oedematous malnutrition (2, 14). These two terms were commonly used to differentiate between types of SAM until the most recent World Health Organization (WHO) definition of SAM replaced them with non-oedematous (severe wasting) and oedematous SAM (1). The presence or absence of medical complications, such as anorexia, fever, hypothermia, vomiting, severe dehydration, severe anaemia, altered consciousness, altered respiration or moderate to severe skin infections, further differentiates SAM into complicated or uncomplicated forms (1, 12, 15, 16). Currently, for children aged 6 to 59 months, the WHO defines SAM as a WHZ < -3 of the reference median, or MUAC of < 115 mm, or presence of bilateral pitting oedema (1, 2).

While WHZ has long been the indicator of choice to diagnose SAM in clinical settings, its complexity and cost of measuring presented a challenge in its use by community health workers in community settings. This has led programmes designed to treat SAM to use a two-stage procedure where MUAC was used for screening and case-finding in the community, and WHZ was used for admission to an Outpatient Therapeutic Programme (OTP) (17). As a consequence, the referral of many children to OTP sites based on MUAC ended up either being treatment refusals for not meeting the WHZ admission criterion, or led to crowding and long waits at treatment sites (17). Hence, this procedure created a barrier to accessing care. Thus, the need to use unified criteria for screening and referral and programme admission became inevitable. MUAC was then introduced as a criterion for both referral and admission to OTP (17, 18). Later, MUAC was endorsed as an independent and alternative admission criterion for severe acute malnutrition (SAM) to implement community management of acute malnutrition (CMAM) (2, 15). This move addressed the aforementioned problem and promoted adherence to the WHO/United Nations Children's Fund (UNICEF) joint statement of maintaining consistency between screening method and admission criteria (2, 15).

Following increasing experience with CMAM and a focus on scaling up community therapeutic feeding using Ready-to-Use Therapeutic Food (RUTF), the possibility of using MUAC as a single criterion for admission to OTP has been raised (19). Arguments in support of the shift from the use of WHZ to MUAC for the screening and admission of children with SAM to nutritional rehabilitative programmes had previously focused on the practical benefits. MUAC is a fairly simple and low-cost method that can be easily applied by one person after minimum training (17, 20), and is subject to less measurement error than WHZ (21). Furthermore, several research studies have documented that MUAC is more sensitive at high specificity levels than WHZ in predicting mortality in children (22-26).

Although this shift away from the use of WHZ to MUAC was thought to support CMAM and to scale-up therapeutic feeding to treat SAM (27), it created complications because the MUAC-based and WHZ-based definitions of severe wasting correlate poorly (2, 23, 28, 29). Previous studies in resource-limited settings, including Sub-Saharan Africa, have shown an overlap ranging from only 4.9% to 42.9% in defining SAM by MUAC and WHZ (2, 23, 30). Hence, the use of only one indicator may result in missed opportunities to treat SAM. Such incongruity between the two indicators of severe wasting can also create programmatic challenges. On the other hand, diagnosing SAM based on the use of either indicator could raise an issue of inflating programme volumes, as it is uncertain who would benefit most from the nutritional programme and subsequently reduce mortality (30). Therefore, understanding how this disagreement between the indicators is related to differences in the selection of children according to age or sex is important for improving treatment guidelines relating to malnourished children. Currently, the WHO and

UNICEF recommend the use of MUAC and WHZ as two independent anthropometric criteria for admission to programmes that treat SAM in children (1, 2).

While MUAC has been mostly used in CMAM as a screening and admission criterion for non-oedematous SAM, protocols for discharge indicators still used weight-based criteria (2, 14). A 15–20% weight gain from admission weight has commonly been used as a discharge criterion (2). This criterion was established with the intention of removing the need for repeated height measurements during treatment and avoiding the problem of children who would already fulfill the WHZ discharge criteria on admission into the programmes (2). However, the most severely malnourished children only required smaller absolute weight gain to meet the percent weight gain discharge criteria in a shorter time than the less malnourished ones and, thus, this presented a risk of insufficient recovery among the most severely malnourished children (31–33). This led to a questioning of the validity of percent weight gain to determine nutritional recovery and programme discharge (31–33).

A good discharge indicator needs to be responsive to change in nutritional status and should reflect treatment response as proportional to the nutritional need and, thus, reliably predict sufficient or insufficient nutritional recovery (17). The current WHO guidelines on SAM management recommend the criteria for discharging children from treatment should be the same as the indicator used to diagnose SAM (1); i.e., if MUAC is used to diagnose SAM in a child, then MUAC should be used to assess and confirm nutritional recovery (1). The same procedure is recommended if WHZ is used to diagnose SAM (1). However, there is limited understanding of the relationship between these indicators as to which of these indicators ensure sufficient nutritional rehabilitation during the treatment of SAM in OTPs.

Community-based Management of Severe Acute Malnutrition

Previously, the World Health Organization (WHO) recommendations for the treatment of SAM have been restricted to facility-based approaches, which required intensive medical and nutritional protocols administered by highly trained health care professionals (14). However, this approach was not effective due to its high cost to the health system and the opportunity cost for families in areas with a high burden of SAM (16, 20). Home-based therapy of malnutrition with RUTF has been successful and supported the management of uncomplicated SAM at community level (34). Currently, the recommended standard management for children who are 6 to 59 months of age with SAM is CMAM (15).

CMAM evolved from Community-Based Therapeutic Care (CTC), which was a community-based approach for the management of acute malnutrition in emergency settings which was accompanied by high levels of external funding, high recovery rates and low case fatality rates among SAM children (16, 20, 35). The CMAM programme has a decentralized design to provide care for SAM in the community by targeting homes, minimizing geographical barriers to access, and includes intensive community sensitization and mobilization to increase understanding and participation. Thus, CMAM comprises community outreach for screening of all children aged under five years by community health workers using MUAC, a community-based Outpatient Therapeutic Program (OTP) for children diagnosed as uncomplicated SAM, and the provision of facility-based inpatient care for complicated cases. CMAM also includes treatment of moderate acute malnutrition (MAM) (15, 36, 37). The OTP approach has improved the coverage, access to, and cost-effectiveness of SAM management (15, 20, 34). Based on the experiences of those involved in delivering these programmes, OTP has been scaled-up and integrated into existing government health systems, namely, the Primary Health Care (PHC) units in sub-Saharan Africa and South Asia, to increase and sustain the high implementation coverage (38).

The introduction of RUTF, along with the development of simplified protocols for identifying and treating SAM, supported the activities of the community health workers to treat SAM at the community level and in routine health care services (3, 20, 39). The OTP provides services to uncomplicated severely malnourished children aged 6–59 months through the use of RUTF as home-based treatment and rehabilitation. Children with uncomplicated SAM are eligible for OTP admission (3). Once admitted to the OTP, children are given a weekly RUTF ration according to their body weight, and are also supplemented with routine medications during the course of the treatment. The children's nutritional status is monitored for progress on a weekly basis at each OTP site and they are subsequently discharged, as per the management protocol (3). Children suffering from complicated forms of SAM are referred to facilities for inpatient management, at least until they are clinically well.

However, there is an increasing awareness that the setting or context into which interventions are integrated modifies their effectiveness (40, 41). Hence, the implementation of the programme and its outcome could vary in an integrated and scaled-up OTP. The available literature on these programmes are commonly based on records kept by the programme itself (32, 33, 42–44) and not by independent researchers. In addition, the effectiveness of these programmes is mostly focused on the health and nutritional status of treated SAM children at discharge from nutritional rehabilitative programmes (32, 33, 42–44).

The role of care in child nutrition

The multifaceted determinants of malnutrition were highlighted in 1990 by UNICEF in their development of a conceptual model of the causes of malnutrition (45). The conceptual model shows the complex nature of the causes of malnutrition organized into three different societal levels. The conceptual model has extensively been used in systematic analysis of nutrition situations and the underlying factors of malnutrition as a basis for formulating policies and actions (45, 46).

Care is a key component in the conceptual map, stressing the role of mothers or caregivers as mediators of their children's health and nutrition (45, 47), and plays an important role in nutrition programmes (48). Care encompasses the provision of time, attention, and support in the household and the community to meet the physical, mental, and social needs of the growing child and other household members (49). A number of resources have been identified as being critical for supporting women's ability to provide care for their children. The necessary caring resources commonly considered are maternal physical and mental health status, their decision-making autonomy, knowledge, social support and time availability (47).

Caregivers' decision-making autonomy and child nutrition

Autonomy has been defined and understood in different ways depending upon contexts. The literature conceptualizes autonomy as a multi-dimensional construct that refers to both control over resources (physical, human, intellectual, and financial) and ideologies (beliefs, values, attitudes, internal strength, self-esteem, and self-confidence) (50-53). An early definition of autonomy in the literature includes the level of women's access to and control over material and social resources within the family, in the community and in society (54), women's ability to obtain and use information for making decisions (55), and their ability to execute independent decisions pertaining to themselves or their children (56). Furthermore, others suggest that autonomy consists of five interrelated components: autonomy conferred by knowledge or experiencing the world; decision-making authority; physical autonomy, including freedom of movement; emotional autonomy; and economic and social autonomy, which includes access to and control over resources (57).

Recent studies have documented that women's autonomy may be one of the important determinants that can influence child nutritional status (52, 58, 59). Children of women with larger decision-making autonomy are reported to have better nutritional status (52, 58-62). Furthermore, women's decision-

making power has a stronger effect on child nutritional status in poorer household than in richer ones, because influencing decisions over the allocation of resources is more important when those resources are scarce (59).

Conceptual framework

The theoretical basis for this thesis relied on the concepts derived from the UNICEF conceptual model for causes of child undernutrition (45) and the program theory developed by Rossi and colleagues (65). The UNICEF conceptual model was used when designing our research and in performing analysis focusing on the proximate causes of child undernutrition, in particular, household contextual factors and the care of children. The second model is called a “program theory”, whereby the rationale that links programme activities to the intended outcomes are described (63). Although there have been several ways to describe program theory, describing the interactions that take place between a programme’s operations and the population it targets have been found useful by Rossi and colleagues (63). One component of this theory is the “program process theory”, which focuses on effective implementation of the programme through proper programme organization and service delivery. The second component is the “program impact theory”, which constitutes the casual links between the programme processes and outcome (Figure 1). These concepts were used to guide the interpretation of the findings of this thesis.

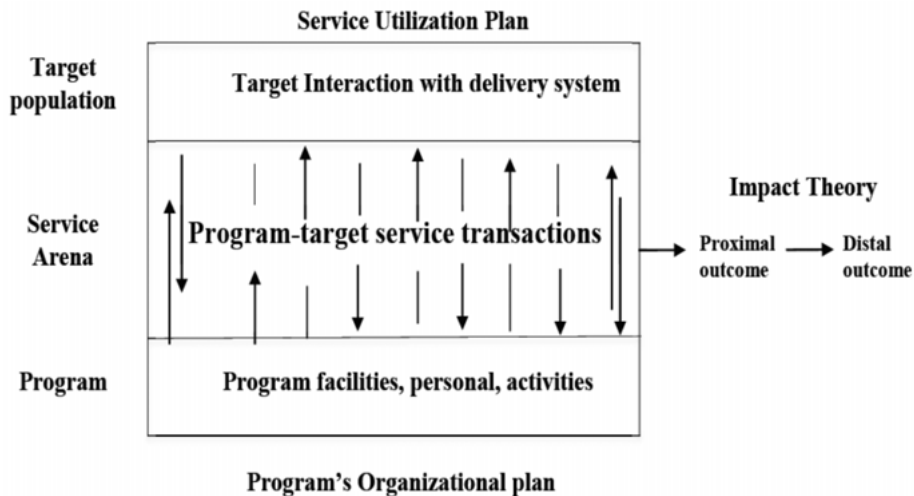


Figure 1: a conceptual framework of Rossi and colleagues’ program theory for describing the interaction between a programme’s operations and the population it serves (63)

The program theory developed by Rossi and colleagues helps us to understand the factors which are important for identification and management of SAM in an integrated community-based OTPs. It has also been previously used to summarize other key results of our research project (31, 64, 65). The OTPs aim to provide the largest possible proportion of severely malnourished children with the appropriate caring services and to prevent mortality. The structure of these programmes, such as the identification and correct classification of SAM for appropriate care and monitoring response to treatment of SAM according to recommended guidelines (1), is important so as to avoid possible negative outcomes. The organization of the OTP services involves the provision of RUTF and other resources as home-based treatment, and caregivers' ability to apply these programme resources for the correct rehabilitation and sufficient recovery of children with SAM. However, contextual factors may modify the effectiveness of such large-scale nutrition programmes (40, 41) .

Rationale of the thesis

Severe acute malnutrition (SAM) affects nearly 17 million children and contributes to 540,000 global child deaths annually (5). These figures are unacceptably high, especially when evidence-based and cost-effective nutrition interventions are known to exist, those that could avert hundreds of thousands of deaths in children (11, 20, 36, 66). Although good recovery rates among children with uncomplicated SAM treated at OTP with RUTF have been documented (34, 67-69), reports on the performance of OTP after the scale-up and integration of OTP into routine public health system are limited. Moreover, the extent to which the benefits of the programme are sustained beyond discharge are not well known.

Both MUAC and WHZ are commonly used in programmes providing care for SAM and have been shown to identify different populations of children as SAM (2, 23, 30). However, the extent of overlap or discrepancy in relation to age and sex between the different set of children is not clearly defined. This has programmatic implications in that the use of either indicator to define SAM may unreasonably increase workload and health care costs, while the use of one indicator as sole criteria for programme admissions may result in missing children in the community who would benefit most from treatment. Moreover, evaluation of the indicators' responses to treatment provides valuable information for those programmes that manage SAM. The evaluation assists in choosing the appropriate indicator to monitor response and ensures that sufficient nutritional rehabilitation is achieved during the treatment of SAM in OTP, as well as generating empirical evidence in support of the current treatment guidelines. Finally, to ensure sufficient recovery from SAM during nutritional rehabilitation, the caregivers' involvement and continuous support in providing appropriate care is crucial. While some of the resources for care, such as education (70-72), have been extensively studied, research evaluating the influence of caregivers' autonomy on recovery among children treated for SAM at OTP is scarce. Given the evidence that the context into which interventions are implemented modifies their effectiveness (40, 41), there is a need to understand the contextual factors that may affect the outcome of scaled-up and integrated OTP.

Aims and objectives

The study aims at assessing factors of importance for the effectiveness of Community-based Management of Severe Acute Malnutrition in the context of a chronic food insecure area in South Ethiopia.

The Ethiopian context provided a platform for the evaluation of a large-scale integrated OTP in a setting where under-nutrition is highly prevalent. Therefore, comparison of anthropometric indicators to diagnose severe wasting (Study I) and of analysing their responsiveness to change in nutritional status during treatment for SAM (Study III), assessing OTP outcomes (Study II), and evaluating the role of caregivers' autonomy in nutritional recovery among children treated for SAM (Study IV), will provide valuable information to improve the effectiveness of the large-scale community-based management of SAM.

Specific objectives

1. To compare MUAC and WHZ in diagnosing SAM among children in a rural community.
2. To assess programme outcomes of children with SAM at discharge and beyond participation in a large-scale government-implemented OTP.
3. To evaluate the response of MUAC and WHZ to treatment in a large-scale government-implemented OTP.
4. To evaluate the role of caregivers' autonomy in influencing nutritional recovery among children treated for SAM in a rural community.

Methods

Study area

Ethiopia is located in the northeastern part of Africa, commonly referred to as the Horn of Africa, and has a total area of around 1.1 million square kilometers (73). It is the second most populous country in Africa, with an estimated total population of 99.9 million and 14.9 million children are under five years of age (74). The country has 11 regional states and 2 city administrations subdivided into zones and woredas (districts), and is further divided into kebeles, the smallest administrative unit in the governance (73).

Although Ethiopia has experienced remarkable economic growth in the African region (75), and achieved six of the eight Millennium Development Goals (MDGs) (75-77), including reduction of child mortality, with significant progress on ensuring gender equality and empowering women and improving maternal health, the country remains one of the world's poorest countries. Rural poverty is aggravated by persistent lack of rain-fall and increased frequency of droughts, as rain-fed agriculture is the foundation of the economy, engaging 85% of the national workforce (73, 78). Thus, food availability is seasonal and rural households tend to be the most affected by seasonal food shortage (78). The majority of households are farmers, and each cultivates land with an average field size of 0.13 hectares (78). While rates of stunting and underweight have decreased over the past two decades (76), poor nutritional status of women and children has been a consistent problem in Ethiopia. Child undernutrition still remains high, with 38% of children aged under five years stunted and 24% underweight (76). A national estimate of acute malnutrition among children aged under five years is 10%, with over 400,000 (2.9%) children suffering from SAM (76). This prevalence has remained more or less static during the past two decades (76). Poor dietary diversity and micronutrient-dense food consumption, and inappropriate child feeding practices contribute to the high rates of child undernutrition (76). Furthermore, undernutrition is an underlying cause of half of the child deaths in the country, where wasting accounts for 23% of these deaths (79).

In response to the high burden of malnutrition in the country, the Government of Ethiopia established the National Nutrition Program, which aims to reduce malnutrition through a comprehensive approach that aims to both prevent and treat malnutrition. Community-based service delivery platforms have

been made available in both the health and agriculture sectors to ensure decentralized public services. Through the Health Extension Program, three out of four health posts are treating children with the establishment of over 12,000 OTPs in more than 500 districts across the country (79). The OTP service has been scaled up and integrated into the existing Ethiopian government health care system and is now typically established in most health posts. Health posts, staffed by two female community-based Health Extension Workers (HEW), provide preventive and curative health care to approximately 5000 people (80). All kebeles (the smallest administrative units in Ethiopia) have at least one health post providing OTP service. The Ethiopian national SAM management protocol uses MUAC < 110 mm and/or oedema to diagnose and admit SAM children into OTP (3).



Figure 2: Study area in Southern Ethiopia

The studies in this thesis were conducted in the Wolayita zone of the Southern Nations Nationalities and Peoples Region (SNNPR), which is composed of 12 rural districts and 3 town administrations (Figure 2). Zonal population size is estimated to reach 1,762,682, of whom 274,978 are children under five years of age. There are five hospitals, 75 health centers, and 390 health posts (81). The area is among the sites where OTP was piloted in Africa in the early 2000s, for its effectiveness in SAM management in a post-emergency context, and then scaled up and integrated into the government health system (82, 83).

With mainly mid- and low-land agro-ecologies, the population practises crop-livestock mixed farming and keeps a combination of livestock integrated with a wide range of cereals, pulses, root and tubers, and cash crops grown for household consumption and marketing. The area is also known for its recurrent nutritional emergencies and chronic food insecurity (84). As a result, SAM in children is highly prevalent in the districts, and under-five mortality is also reported to be one of the highest in this part of the country (76).

Study designs and study populations

The four papers in this thesis are based on quantitative data from a large research project; *“Effectiveness of community based management of severe acute malnutrition: Importance of maternal care and health system context”* (COMSAM), which aimed at evaluating the effectiveness of integrated OTPs in rural districts of South Ethiopia. COMSAM utilized both population-based cross-sectional and observational cohort study design. Table 1 describes the study design and other related information for the studies that are included in this thesis.

Out of twelve rural districts of the Wolayita zone, four adjacent districts, along with their respective kebeles that were reported to host majority of children with SAM in the zone, were purposively selected. Urban kebeles ($n=4$), unsafe kebeles ($n=6$) and remote kebele ($n=1$) were excluded. Thus, a total of 92 rural kebeles and their respective health posts were included in the research project.

A population survey was conducted on a weighted sample of households in the study area over a 6-month period. An observational cohort design was used to examine the effectiveness of integrated and scaled-up community-based outpatient therapeutic programmes for treating SAM among children aged 6 to 59 months. A cohort of severely malnourished children were identified through screening during the course of the Enhanced Outreach Strategy (EOS) and Community-Based Nutrition (CBN) programmes as part of the implementation of the National Nutrition Programme (NNP). The OTP services were provided by health extension workers (HEWs) at health posts (3). The nutritional status of children was assessed by the research team using anthropometric measurements.

Study I

Random sample of children under five years of age

We used data from a population-based cross-sectional study as part of COMSAM. In order to obtain a weighted sample, 4% of households ($n=3,723$) in each kebele were randomly selected from the districts' WASH (water and

sanitation and hygiene) survey registry using SPSS-generated random numbers. Selected households were assessed for eligibility. Eligibility criteria included rural kebeles and households with children aged under five years and those who were physically present during the survey. Households with no children aged under five years were replaced by new ones from the randomly selected household reserve list. A total of 3,833 household were included in the recruitment process. The survey was conducted between August 2011 and January 2012.

Studies II, III & IV

Cohort of Children admitted to OTP

We used data from longitudinal observational study as part of COMSAM. All children admitted to OTP in 94 health posts between July and December 2011 were assessed for eligibility to participate in the study. Eligibility criteria included: age 6 to 59 months, new admissions, and non-transfer out to inpatient care. Children admitted to OTP who fulfilled the inclusion criteria were enrolled in the study during the 6-month study period and were followed for 14 weeks. Data were collected at 4 household visits; the first within 1 week of admission, and then again at 4, 8 and 14 weeks after admission. A subset of children aged 6 to 59 months ($n=1,048$) who had complete information on anthropometry at admission and complete information on the 14th week of follow-up ($n=991$) were recruited. Thus, the final sample for Study II consisted of 1,048 children admitted to OTP. For Study III, 215 children with oedema and 77 children who were discharged from OTP before the fourth week of follow-up were excluded. Finally, a sub-sample of non-oedematous children ($n=661$) with a complete follow-up after 4 weeks of admission were analysed. For Study IV, after excluding children with no SAM at admission ($n=222$) and those having incomplete data on nutritional status at the end of the follow-ups ($n=38$), a final sample of 788 children with SAM was retained for analysis.

Table 1: Summary of the methodology in the papers

Paper	Study design	Population and sample size	Study outcome	Main Data analysis
I	Cross-sectional	4,297 non-oedematous children aged 6–59 months in the study area	Severe wasting based on WHZ and MUAC	Descriptive
II	Prospective observational cohort	1,048 children admitted in OTP	Nutritional status at discharge and 14 weeks of follow-up, OTP outcome including recovery (based on programme criteria, i.e., 15% weight gain), death, defaulter	Descriptive
III	Prospective observational cohort	661 non-oedematous children admitted to OTP	Response to treatment based on gains in MUAC and weight	Linear regression (GLM)
IV	Prospective observational cohort	788 children with SAM admitted to OTP	Recovery based on MUAC ≥ 125 mm &/or resolution of oedema	Kaplan-Meier and Cox-regression

Data collection

In all four studies, data were collected by trained female nurses. Home-visits were used to collect children's anthropometric data, socio-demographic and other relevant information on households, caregivers and children's characteristics. All data collection instruments were translated from English to the local language and were pre-tested in a similar context for modification before the actual survey was conducted. For the cohort study, a weekly visit to all the health posts in the selected districts was made to identify children participating in OTP. Accordingly, enumerators conducted the interview with the caregivers of children admitted to OTP within 7 days of admission. Similarly, for the population survey, a weekly schedule was set to collect data from selected households. All enumerators were trained in interviewing techniques and in the standardized use of anthropometric measurements.

Variables

Child anthropometry

The weight of the children was measured to the nearest 0.1 kg using the UNICEF electronic scale. MUAC was taken using the WHO-recommended MUAC tape and procedure, and recumbent length and height were measured to the nearest 0.1 cm using UNICEF's recommended model wooden board as per WHO protocol (85, 86). The presence of bilateral oedema was verified and graded as per global recommendations (85, 86). A child with bilateral oedema is always classified as SAM (85). The WHO Anthro software was used to convert weight, height and age data into Z-scores using the 2006 WHO Growth Standards (87).

In Studies I, II and III, non-oedematous children were categorized into three groups based on their MUAC at admission, i.e., most severe degree of wasting (MUAC < 110 mm), less severe degree of wasting (MUAC 110–114 mm), and not severely wasted (MUAC \geq 115 mm). In Studies II and IV, children with oedema on admission were categorized into two groups based on severity, i.e., mild/moderate oedema and severe oedema. For Studies I and III, children with oedema were excluded, as WHZ is heavily influenced by the weight of fluid retained in the body and can obscure low WHZ (17). For Study IV, children with no SAM (MUAC \geq 115mm and no oedema) were excluded.

Caregivers' decision-making autonomy

Caregivers' level of decision-making autonomy was measured by a constructed 10-item questionnaire. The Demographic and Health Survey women's questionnaire (88) and questions included in similar studies measuring women's autonomy in relation to child health and nutrition were used as input when developing the questions. The questionnaire measured different dimensions of autonomy, including financial independence, decisions on household, child and reproductive health, and freedom of movement (50, 51, 57). A Likert scale of 1 to 3, similar to one previously used in another instrument (89), was used to construct a continuous score upon adding up caregivers' responses to each items.

Outcomes

In Study I, the nutritional status of non-oedematous children in the population was defined in accordance with the global recommendations (1, 85). Hence, wasting was defined as WHZ < -2 SD or MUAC < 125 mm, and severe wasting was defined as WHZ < -3 SD or MUAC < 115 mm.

In Study II, programme outcomes, such as recovery from SAM, were defined using the national guidelines (2, 3), i.e., a gain of 15% of admission

weight for non-oedematous children and the resolution of oedema for oedematous children. The nutritional status of children after discharge from OTP and 14 weeks after admission was defined using MUAC as per the WHO recommendation (1).

In Study III, gains in MUAC and weight were the anthropometric indicators used to define response to treatment (90). The gain in MUAC was calculated by taking the difference in the MUAC measurements between the admission and the second visit conducted after 4 weeks of follow-up in the programme and dividing this value by the total number of days between each measurement. The gain in weight was calculated by dividing the rate of weight gain between admission and the 4th week of follow-up by the child's average weight, in accordance with the recommendations (90).

In Study IV, the recovery from SAM was defined as $MUAC \geq 125$ mm and the resolution of oedema after the end of treatment or the end of follow-up, in line with the WHO guidelines on SAM management (1).

Statistical analysis

All statistical analyses were performed with SPSS 20 (International Business Machines Corporation, New York, NY, USA) statistical software package for Windows and OpenEpi (a web-based Statistical Calculator). Descriptive characteristics of the study participants were presented as frequency and percentage for categorical variables and mean and standard deviation (SD) for continuous variables. The median values were reported for data that were not normally distributed. Statistical differences were considered significant at P -value < 0.05 .

Study I

Proportions of children with severe wasting, as diagnosed by MUAC and WHZ, along with the 95% confidence intervals were computed. The degree of agreement between MUAC and WHZ was assessed with the kappa coefficient (k). All analyses were further disaggregated by age and sex.

Study II

Proportions with 95% confidence intervals (CI) were used to allow comparisons between groups as well as describe programme status, outcome and nutritional status on discharge and at 14 weeks after admission.

Study III

Mean values and 95% confidence intervals (CI) were used to describe the change in nutritional status as defined by the gains in each anthropometric measures (MUAC and weight). A general linear model (GLM) was used to evaluate the gain in MUAC and weight after 4 weeks of therapy in OTP. Final models were adjusted for child age, sex, and length and height, housing quality, caregiver characteristics (occupation, age in years, education), and duration of the follow-up until the 2nd visit.

Study IV

As all children do not continue treatment in the OTP for the same period of time, modeling recovery rate is more helpful than modeling the recovery status without a time determinant. A Kaplan Meier (KM) survival analysis and log rank test was employed to estimate and compare the recovery rates of the children treated for SAM for grouped factors. To determine the independent effect of caregivers' autonomy in decision making on the recovery rate from SAM, multivariate cox-regression was employed over child, caregivers' and household characteristics by controlling for possible confounders. Additional models were created where the other two resources of care (caregivers' education and social support) were added to the previously mentioned confounders.

Ethics

The institutional ethical review board of Addis Continental Institute of Public Health (ACIPH) in Ethiopia and the regional ethical review board in Uppsala, Sweden approved the research protocol. Permission to conduct the study was obtained from regional and district health offices. The Helsinki Declaration was followed when conducting the study. Caregivers of children were informed about the survey procedures, confidentiality and voluntary participation, and verbal consent was sought prior to interview. All interviews and anthropometric measurements were conducted in privacy during home visits.

Results

Children aged under five years in the population of the study area

A population-based survey between August 2011 and January 2012 was conducted in 92 rural kebeles. Seven rural kebeles were excluded for reasons of safety ($n=6$) and remoteness ($n=1$). Randomly selected households were assessed for further eligibility i.e., households with children aged under five years who were physically present during the survey. Ineligible households were replaced with new ones. A total of 3,833 households were recruited. Children aged under 6 months ($n=410$), those who were oedematous ($n=33$), or had implausible anthropometric values ($n=55$) and missing data ($n=13$), were excluded from analyses and a total of 4,297 non-oedematous children with valid anthropometric measures were included in the analysis (Figure 3).

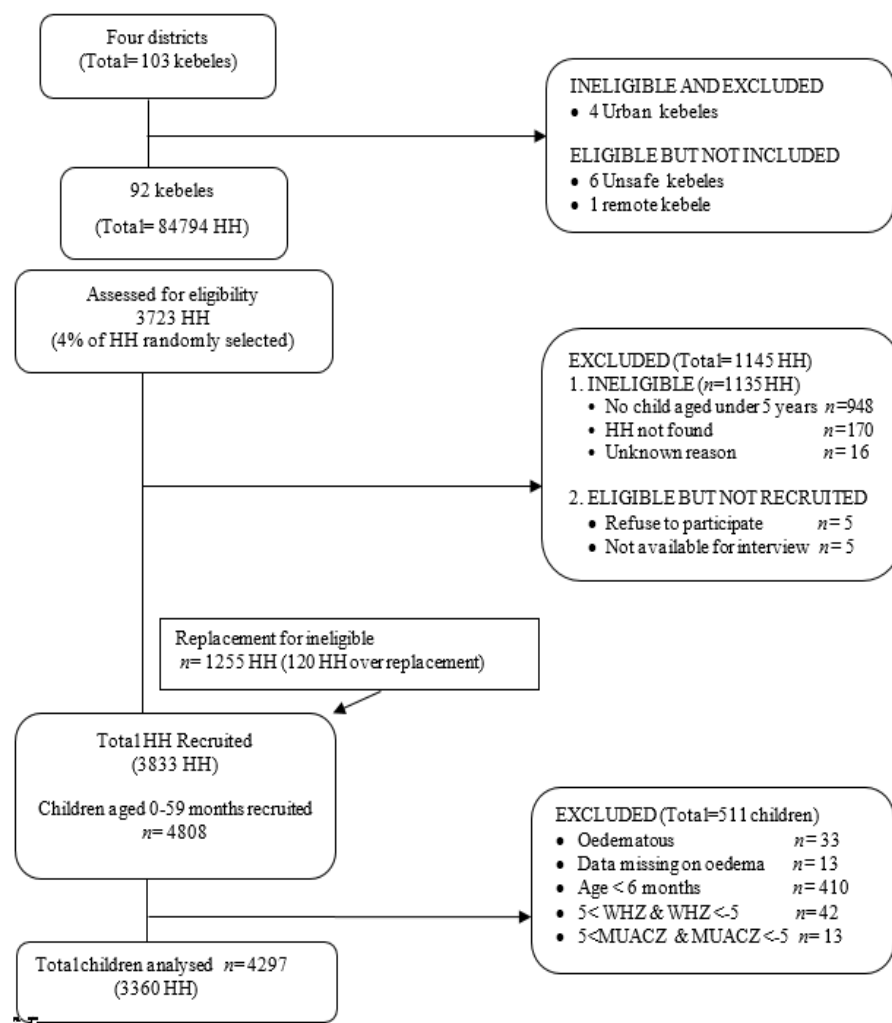


Figure 3. Flow chart of study participants in the population survey (HH: Household)

Identification of SAM

General characteristics of study participants (Study I)

The majority of the children lived in smallholder farming households who own an average field size of less than 0.2 hectares. They lived in huts with wood and mud walls and earth floor. While four out of five households have access to improved drinking water, access to improved sanitation (6.5%) and

electricity (1.0%) was rare. All caregivers who were interviewed were women, where 78.2% were aged between 25 to 44 years, and 36.6% had some level of education. Thirty-two percent of the children included in the study were under 24 months with a male-to-female sex ratio of 1.03.

Severe wasting in a population of children aged 6 to 59 months as defined by the two anthropometric indicators of SAM (Study I)

Households living in the same geographical area as the children admitted to OTP were visited. The two indicators of SAM classified children as severely wasted in a significantly different way. MUAC categorized more children as severely wasted (1.6% vs. 1.0%) compared with WHZ. MUAC categorized a larger proportion of girls as severely wasted compared with WHZ. Of all children defined as severely wasted using any of the two indicators, only 16.7% of the children were categorized as severely wasted by both MUAC and WHZ (Figure 4). Furthermore, the degree of agreement, as measured by kappa coefficient, between MUAC and WHZ definitions of severe wasting revealed a fair agreement in boys ($k = 0.37$) and children younger than 24 months ($k = 0.32$) but poor agreement in girls ($k = 0.15$) and children aged 24 months and above ($k = 0.13$). Thus, the degree of agreement between anthropometric indicators of severe wasting differed depending on the sex and age of the children.

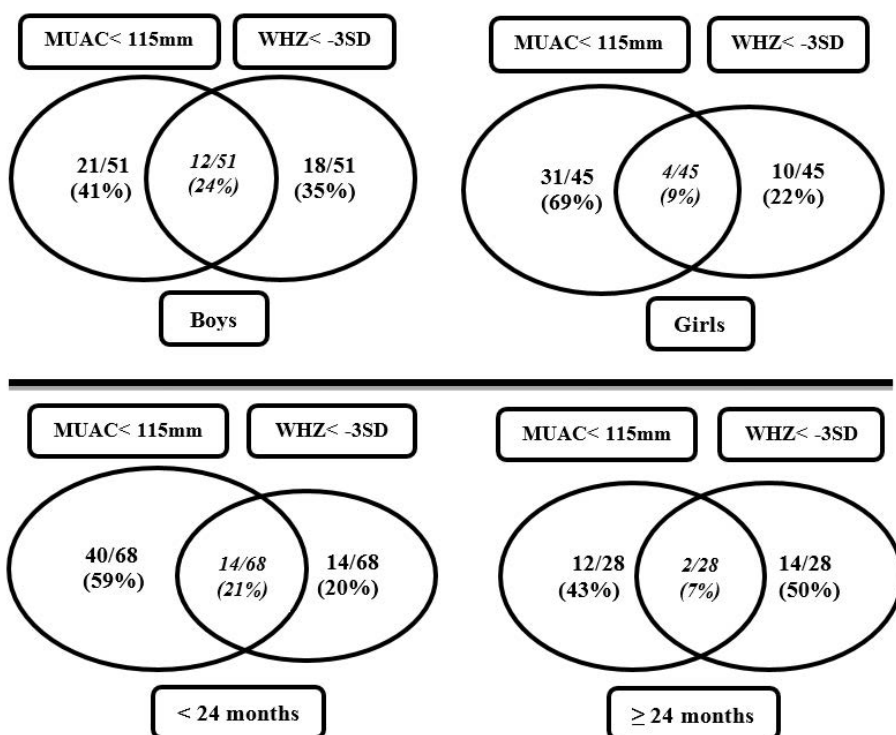


Figure 4. The relationship between MUAC <115 mm and WHZ < -3 SD by age and sex among children age 6-59 months in rural South Ethiopia

Children admitted to OTP

Between July 2011 and December 2011, a total of 1,659 children were admitted to the OTPs in the 94 health posts located in the study area, of which 179 were ineligible. Children who were not assessed within 7 days of admission ($n=355$) and lacked data on key child variables ($n=77$), such as age, sex and anthropometry, were excluded. Finally, a cohort of 1,048 children and their subsets were included in the analysis (Figure 5).

General characteristics of children admitted to OTP

A cohort of 1,048 children admitted to OTP were followed for 14 weeks. Using MUAC criteria, larger proportion of non-oedematous children admitted to OTP were girls (40.9%, 95% CI: 37.0%, 44.9% vs boys: 59.1%, 95% CI: 55.1%, 63.0%) and young children (78.2%, 95% CI: 74.7%, 81.4% vs older children: 21.8%, 95% CI: 18.6%, 25.3%).

All caregivers of the children admitted to OTP were women, 89% of whom were biological mothers of the children and between the ages of 20 to 39 years, and 69% had some level of primary schooling. The majority (75%) of the children lived in thatched roof huts with wood and mud/grass walls. Three-quarters of the households where the children resided had open pit latrine, improved source of drinking water (77%) and more than one under-five child (42.4%).

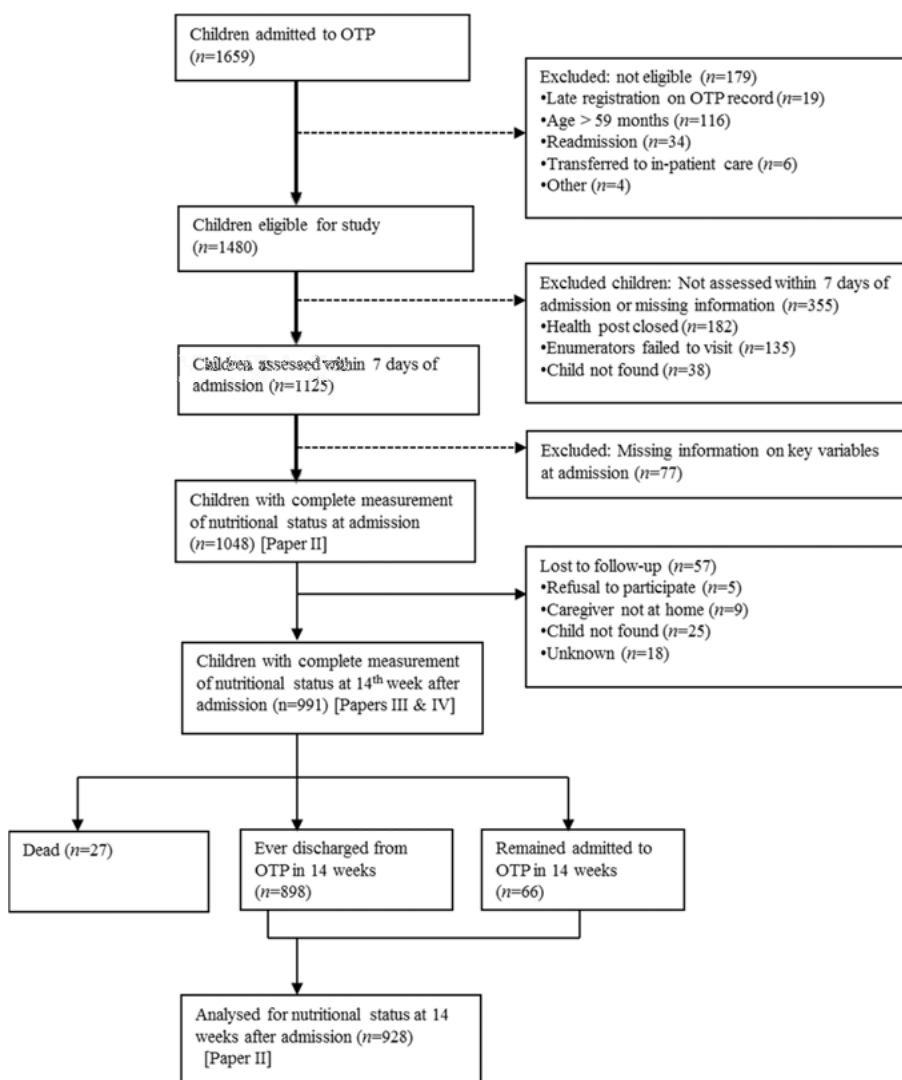


Figure 5. Flowchart of children admitted to the outpatient therapeutic programme (OTP)

Treatment of children with severe acute malnutrition at integrated and scaled-up outpatient therapeutic programme

Nutritional status of children admitted to OTP (Study II)

MUAC and presence of bilateral pitting oedema were criteria used to diagnose SAM in children by the programme for treatment at the OTPs. The nutritional status of the 1,048 children admitted were assessed by the research team and 71.5% (749/1,048) were found to have uncomplicated SAM, of whom 449 had MUAC < 110 mm, 162 had MUAC 110–114 mm, and 38 had mild/moderate oedema. On the other hand, 7.3% (77/1,048) of the children had severe oedema and nearly one-fifth (222/1,048) had MUAC \geq 115 mm (Figure 6). Thus, some children with complicated SAM who required inpatient care or children with no SAM were also admitted to the programme.

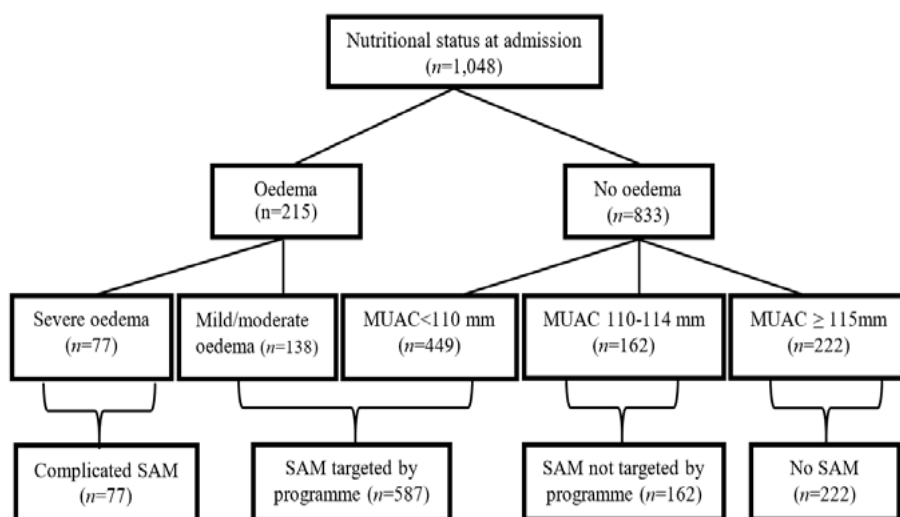


Figure 6. Nutritional status of children admitted to integrated OTP

Anthropometric indicators to monitor response to treatment for SAM (Study III)

The MUAC and weight gains of 661 non-oedematous children admitted to OTP and who received 4 weeks of therapy were analysed. While both measures detected a good response to treatment, the average MUAC and weight gains varied between children with different degrees of severity of malnutrition as well as in the anthropometric indicator used to diagnose SAM. On average, the MUAC and weight gains were 0.17 mm/day (± 0.2 SD) and 1.8 g/kg/day (± 4.0 SD), respectively. MUAC gain was significantly larger among severely malnourished children (MUAC < 110 mm) compared with children with no SAM (MUAC \geq 115 mm). Similarly, weight gain was significantly larger among severely malnourished children (WHZ < -3) compared with children with no SAM (WHZ \geq -2). However, there was no significant change in the response to treatment when using a measure different from the one used to define SAM at admission.

Caregivers' status as a determinant for recovery from SAM (Study IV)

A total of 788 children with SAM admitted to OTP were analysed for recovery rate at the end of follow-up. In this study, 20.6% (162/788) of children had a MUAC \geq 125 mm and no oedema at the end of follow-up. Fifty percent of the recovered children achieved sufficient recovery in less than 8 weeks of stay in the OTP. The median recovery time for children whose caregivers are in the lowest tertile was longer, with a statistically significant difference in recovery rates of children among the three caregivers' autonomy groups. Children with SAM whose caregivers' autonomy in decision making in the highest tertile have a 65% increased probability of recovery (AHR=1.65; 95% CI: 1.12–2.42). In both unadjusted and adjusted models, no significant association was observed between caregivers' educational status and social support, and recovery rate.

Programme outcome of integrated and scaled-up outpatient therapeutic programme (OTP)

Nutritional status and fatality on discharge (Study II)

The program status of children admitted to OTP who were followed for 14 weeks revealed 898 discharges, 66 on treatment, 57 lost to follow-up, 17

deaths before discharge, and 10 deaths after discharge. Of the 881 live children at discharge, 35.8% were still severely malnourished. Children with the most severe degree of wasting (MUAC < 110 mm) on admission had the highest proportion of SAM (MUAC < 115 or oedema) on discharge.

Programme outcome was measured for children with SAM at admission and discharged ($n=759$). Only 32.7% achieved recovery, as defined by the programme's recovery criteria of 15% weight gain or resolution of oedema. The median length of admission was 6.6 weeks and 4% defaulted from the programme. Programme average weight gain for all non-oedematous children with SAM was 2.5 gm/kg/day. However, among the children who reached the 15% weight gain programme recovery criteria at discharge, 76.5% were still acutely malnourished (29.6% had SAM - MUAC < 115 or oedema; 46.9% had MAM - MUAC 115 – 124 mm).

Nutritional status and fatality 14 weeks after admission (Study II)

During the 14 weeks of follow-up, 79.8% of the children were discharged, 6.7% were never discharged, 10.8% were re-admitted after discharge, and 2.7% died. A larger proportion of re-admissions were for children with the most severe degree of wasting (MUAC < 110 mm) compared with children with a lesser degree of severe wasting (MUAC 110 – 115 mm) at admission. The fatality rate was higher among oedematous children with SAM (6.2%) compared with other children admitted to OTP (1.8%).

More than two-thirds (72.1%) of children were acutely malnourished (34.6% had SAM and 37.5% had MAM) at the end of 14 weeks of follow-up. More than half (51.3%) of the children with the most severe degree of wasting (MUAC < 110 mm) on admission remained severely malnourished, the proportion being higher compared with their counterparts.

Discussion

MUAC categorized a larger proportion of girls and young children as severely wasted compared with WHZ. There was fair agreement between the two anthropometric indicators of severe wasting in boys and young children, but poor agreement in girls and older children. In the integrated OTPs, which used MUAC and/ or oedema-criteria to define SAM for programme admission, the proportion of girls and young children admitted was significantly higher compared to their counterparts.

Following treatment, children with SAM showed significant changes in both MUAC and weight measurements. Our results indicate MUAC gain should be used to monitor the response to treatment when it was used to define SAM at admission. Likewise, weight gain was the indicator that should be used to monitor the response to treatment, when WHZ was used to define SAM at admission. Only 32.7% achieved the programme recovery criteria at discharge, despite adequate duration of stay in OTP. Further, children with oedematous SAM at admission had a high fatality rate. While more than two-thirds of the children were discharged from the programme without sufficient recovery, children of caregivers with highest decision-making autonomy recovered faster from SAM.

Identification of SAM

We analysed the anthropometric data of randomly selected children aged 6 to 59 months of age and compared MUAC and WHZ to determine which anthropometric indicator could be more effective in identifying children with SAM in the field. The overall proportion identified as SAM differed between MUAC and WHZ. We found MUAC categorized a larger proportion of girls and young children as severely wasted compared with WHZ. When using MUAC, employing a common cut-off to define severe wasting may result in overestimating the proportion of SAM in girls or under-estimating the proportion of SAM in boys because girls are physically smaller than boys (91). In the same manner, as MUAC increases with increasing age, MUAC-based definition of SAM is likely to categorize more young children as severely wasted compared with older children. Consistent to our expectation, the age and sex compositions of children admitted to the OTPs were similar to the severely wasted (MUAC-based definition) children in the population. Other studies in

sub-Saharan Africa also reported that MUAC-based programmes tend to identify significantly more girls and younger children than those identified by WHZ (19, 23). Thus, the decision regarding the use of MUAC or WHZ for admission to therapeutic feeding programme is complicated by the fact that each indicator may select different set of children for treatment.

A recent review of large anthropometric data also documented that the relationship between MUAC and WHZ is more complex than previously thought as the two anthropometric criteria identify different children in a different way in different countries (92). The magnitude and proportion of the discrepancy varied considerably between countries with some having most children diagnosed as malnourished by MUAC and others where nearly all the children were diagnosed by WHZ alone (92). The age-distribution of children, age-specific malnutrition rates, body shape and composition (19, 30, 92-94) have been put forward as an explanation for the discrepancy between the two anthropometric indicators of SAM. However, none of these factors provided adequate explanation for why larger proportion of children are diagnosed by one indicator and not by the other in different countries (92).

Our findings show that the strength of agreement between the anthropometric indicators of severe wasting was fair for young children and poor for older children. This is important for programmes managing SAM, as both indicators identified more young children as severely wasted than older children. Taking accurate weight and height measurements is reported to be more difficult when compared to using MUAC (21, 95). Thus, considering MUAC's simplicity (17, 20), MUAC appears to have an advantage in the early identification of malnourished children at a younger age. Further, as younger children are known to be affected earlier in the wasting process before the onset of medical complications, they have an increased risk of death (23, 33, 96). Research on prediction of mortality shows that MUAC identifies children at risk of dying better than WHZ (22, 23). Moreover, MUAC has been shown to predict mortality independent of age (22, 23), while the predictions using WHZ vary with age (97). Thus, before making a decision regarding the use of WHZ and/or MUAC for admission to nutritional rehabilitative programmes, it is important to further understand how each of the aforementioned factors predict the risk of death.

Provision of treatment for SAM at OTP

Children with SAM experience rapid catch-up growth in response to a treatment with therapeutic diet, such as RUTF (32, 33). We determined MUAC and weight gain for all non-oedematous children over the first 4 weeks of therapy, the time interval during which maximum growth velocity is expected (69, 98). The national programme uses only average weight gain of the children recovered, i.e., those who have reached the programme's recovery criteria, to

monitor response to treatment (3) and compare against the international recommended standard (99). We found the average rate of weight gain among programme-recovered non-oedematous SAM children to be considerably less than the Sphere recommendation. Our findings on the gains in each measure also compared unfavorably with other reports from nutritional programmes with external donor support for children who received 4 weeks of therapy at OTP (98, 100). The OTPs that we studied were part of the routine health system and programmes that depend on resources from routine health systems could face a shortage of supplies (101). Our results also showed that more than half of the children admitted to the OTPs did not receive the recommended amount of RUTF during their stay in the programme. Our findings of lower gains might be because our data were from OTPs integrated with resource-constrained government health facilities, while the aforementioned studies were from programmes with technical and resource support from NGOs.

In our study, children with the lowest MUAC at admission had the largest rate of gain in MUAC. Likewise, children with the lowest WHZ at admission had higher proportional weight gain than children with higher WHZ at admission. The rapid gains, besides the normal physiologic growth, could reveal changes in the lean tissue during recovery (36, 102) and catch-up growth in response to RUTF (32, 33). However, our findings also suggested that using a measure different to the one used to define SAM at admission did not allow us to detect a significant change in the response to treatment. Therefore, these gains are likely to reflect only the normal physiologic growth during rehabilitation to achieve sufficient recovery from SAM (17). Thus, when monitoring the response to treatment, it is important to use the same indicator as the one used for defining SAM on admission. We found no influence on the rate of MUAC and weight gains by child characteristics, which supports the independent use of these indicators to monitor the response to treatment.

Research has documented that the gains in MUAC and weight follow a similar recovery trajectory (33, 103), and that decreasing growth velocity measures based on MUAC and weight are useful in identifying children at risk of death (21, 22, 104). While application of velocity measures in the field by community health workers is a challenge, decreased gains in weight and MUAC could reflect a recent drop in the growth curve and could possibly identify children at an increased risk of death (22). It may be possible to develop simpler monitoring tools and protocols for the appropriate management of SAM based on changes in MUAC and weight with field testing and refinement (104).

The WHO treatment protocol for the management of SAM includes essential medical treatments (3). In addition to RUTF, children who receive broad spectrum antibiotics at the OTPs have improved response to treatment for SAM (67, 105). Although the Ethiopian guideline recommends the use of oral antibiotics (amoxicillin) for children with uncomplicated SAM admitted to OTP, other studies from COMSAM reveal that only 19.3% of the children

were given antibiotics during treatment for SAM at OTP (64). According to this study, children who received antibiotics had higher probability of achieving programme recovery criteria than those treated with RUTFs alone.

Ready-to-Use Therapeutic Food (RUTF) remains the key commodity for the treatment of SAM (106). The OTPs we studied suffered from severe shortage of RUTF and other programme supplies (64, 65). Although the Ethiopian Ministry of Health has taken the leadership and coordination roles and have established partnership with UN agencies, donors and NGOs, not all elements of OTP service delivery are fully integrated into the national health systems. UNICEF procures RUTFs through the regional health bureaus and the bulk of RUTF is imported, while local production has a smaller share of the market to cover the annual RUTF demands. During the study period, the research team observed that lack of transport has been an impediment to deliver RUTFs and other programme supplies to health posts, despite having stock at district level. Such shortage of essential resources have been identified as barriers to access and equitable service delivery in other similar settings (101), which could potentially limit the effectiveness of community-based programmes.

Treatment outcome and nutritional rehabilitation

Our study revealed that the recovery rate of children treated for SAM at integrated OTPs was below the acceptable international sphere standard (99). Among the children who were discharged as “recovered” using the programme criteria, the majority were still acutely malnourished, as assessed by research team, despite an adequate length of stay in the programme. Our results showed that, on average, the children stayed in the programme nearly 3 weeks longer than the acceptable minimum standard; yet this was within the national programme standard, which allows children to stay under treatment to a maximum of 8 weeks. A longer stay in the programmes is expected to increase the chance of recovery from SAM, which promotes sufficient nutritional rehabilitation (32, 33). Such understanding has been based on the successful management of SAM in a community by programmes operating with external resource and technical assistance (32, 33).

The national SAM management protocol follows a percentage weight gain as a single discharge criterion from the programme for children with non-oedematous SAM (3). The use of 15% weight gain discharge criteria has been shown to disfavour the most severely wasted children as they had a shorter stay in the programme, but allows longer stay for the less severely wasted children (33). In contrast, when MUAC was used as the discharge criterion, the average duration of treatment for the most severely malnourished children was longer than for the less severely malnourished children (107). However, in our study area, the discharge criteria were not strictly applied and there was

no significant difference in length of stay among children with different degree of severity of malnutrition. In support of this finding, during data collection, the research team noticed that health extension workers appeared to discharge children based on length of stay in the programme rather than percentage weight gain. This could possibly be based on the maximum length of stay in OTP indicated in the national protocol (3).

The majority of children with SAM on admission were discharged from the programme neither achieving programme recovery criteria nor being transferred to an inpatient treatment facility. A possible explanation for non-referral might be that health extension workers were unable to identify these children as having complicated SAM (44). Another potential explanation might be that caregivers may have refused the referral due to perceived difficulties in performing household chores and providing care for other children, while having their child admitted to inpatient care (36, 100).

Current guidelines for the management of SAM recommend the use of MUAC ≥ 125 as a discharge criterion for non-oedematous SAM (1), which is based on evidence that suggested mortality risk to be minimal at this cut-off (1, 17). This adjustment of the discharge criterion has also been shown to be associated with low levels of relapse to SAM, low mortality, and longer duration of treatment seen only in the most severe SAM children (103, 108). In our study, the combination of low rates of MUAC and weight gain and low mortality rates suggest that there might be other contextual factors that may lead to low recovery rates.

The sharing of RUTF has been justified by prevailing social norms that favour food sharing in the study area. Shortage of food in the household, the good taste of RUTF, and its high-energy properties also either necessitated or facilitated the sharing (64, 65). RUTFs were also being sold to generate income for purchasing food for the whole family and the weekly RUTF ration provided for one child with SAM was perceived by caregivers as excessive amount of food (65). In addition, the OTPs included in our studies function in an area that has suffered from repeated drought and crop failure which resulted in chronic food insecurity (84), but with no other nutrition interventions during the study period. In situations where there are high levels of food insecurity, emergency relief programmes operate a targeted supplementary feeding programme that provides dry take-home rations. The ration is provided for the other children in the family, but not for the severely malnourished child. Previous studies have reported about similar unintended use of RUTF in a food-insecure household (109) and nutrition interventions have been instigated to minimize the sharing of the RUTF (20). The aforementioned factors might explain the modest rate of change in anthropometric measures observed in this study which ultimately led to incomplete nutritional rehabilitation. It also suggests that nutritional rehabilitation programs operating in a chronically food insecure areas need to see the family as a unit to ensure children treated for SAM are given the opportunity to full recovery.

Contextual factors of importance in community-based management of SAM

Caregiver perspective

The results from our study showed children of caregivers with higher decision-making autonomy recovered faster from SAM after treatment in OTP. The literature supports the notion that an association exists between increases in maternal autonomy and better measures of child nutritional status (51, 59, 62). Caregivers with greater autonomy over household decision-making would more likely provide more appropriate care for their children (52). Maternal autonomy has been important in situations of resource scarcity, especially in poor economic conditions and high rates of child wasting (58, 59). No significant association between recovery and caregivers' education and social support was observed in our study. This might be because there were no sufficiently large variations by education and social support among the caregivers. Thus, as women have the central role in providing appropriate care for children, our findings suggest that linking OTP with other programmes that promote women's autonomy may improve the effectiveness of such large-scale nutrition programmes.

Other studies from COMSAM documented that there were differences in perspective in how RUTFs should be used (65). While the programme's intention was to treat SAM with the use of RUTF, caregivers perceived RUTF as a treatment, food aid and a resource that can be used for common benefits within their household (65). This was mainly because the community has been a beneficiary of food aid programmes for decades. Therefore, a longer period of RUTF supply was a common perception in the community as caregivers expect their children to be readmitted to the programme at certain intervals to replenish their depleted stock of RUTF (65). Procedures to ensure the proper use of RUTF have led to a conflict between HEWs and caregivers (65), which might have contributed to unintended limitations on the effectiveness of the programme.

Provider perspective

Not all children identified as SAM were targeted by the integrated OTPs on admission. According to the WHO guidelines on SAM management (1, 2), the target population for community-based OTPs are children who are 6–59 months of age with uncomplicated SAM (MUAC < 115 mm and/or grade I or II bilateral oedema). The Ethiopian guideline for the management of SAM (3), however, uses a MUAC < 110 mm to define SAM in children. This lower cut-off excludes some children, despite them being severely wasted, from ad-

mission and treatment in OTPs. However, in the OTPs that we studied, children with MUAC ≥ 115 mm ($n=222$), children with MUAC 110 – 114 mm ($n=162$), and grade III oedema ($n=77$), were admitted. The latter two included children with SAM but not the target population of the national programme. The reason for not conforming to the current WHO-recommended MUAC standard was due to resource implications that would result in a marked increase in the number of admissions (110). In our study setting, the majority of the children with MUAC 110–114 mm could have recovered, if properly managed, as illustrated by a simulation of 15% weight gain of admission weight (31). The OTP scenario in the field appears to be guided by the intuition of the providers rather than the national or WHO guidelines.

The presence of severe oedema is one factor for differentiating between children who need inpatient care and those who can be cared for in the community (1, 2). Children with severe bilateral oedema have an increased risk of mortality compared to children with lesser degrees of oedema (1). The higher death rates in children with severe oedema have been attributed to inappropriate RUTF use (111, 112), as RUTF contains higher protein and energy than the recommended F-75 milk-based diet (109). Our findings of a higher mortality rate in children with severe oedema, when compared to the recommended sphere standard (99), suggest that OTPs were not the appropriate place to treat those children. Instead, they should have been referred to inpatient care for appropriate management (1, 2). While the possible reasons for non-referral were mentioned earlier, evidence on treatment outcomes of severe oedema and other complicated SAM at inpatient care in the study area is not available. Therefore, it is not known whether these children with complicated SAM achieve better outcomes at inpatient treatment facilities.

Providers' non-adherence to the guidelines on SAM management could lead to the exclusion of children with SAM from OTP or the inclusion of children not targeted by the programme. Such misclassification of children could result in missing an opportunity to treat a condition that has high case-fatality rate. On the other hand, it could also unduly increase the caseload on OTPs and result in dispensing the limited OTP supplies to children not targeted by the programme in addition to those targeted by the programme. This would likely result in inadequate supply of RUTF to children with SAM and, thus, limit the overall effectiveness of the programme.

The OTP services are delivered by the HEWs. Their responsibility is diverse, and, over the course of a week, they divide their time between activities relating to family health, disease prevention and control, hygiene and sanitation, and other activities (113). Findings from COMSAM indicated majority of HEWs feel overwhelmed due to the numerous tasks they have to fulfil and do not have sufficient time to complete all activities they are expected to deliver (64).

Methodological considerations

This thesis is based on quantitative methods that applied cross-sectional and cohort study designs. There are two key features of COMSAM, unlike routine programme data. First, the research team collected all data independently as opposed to most other studies that evaluated SAM management in OTP, where data were extracted from programme records and the analysis was performed by organizations involved in the programme implementation. Our research team was not part of the service delivery team or any other health and nutrition-related intervention programmes in the study area. Second, data were collected on short-term outcomes, up to 14 weeks after the programme admission date. Many programmes focus on outcomes at discharge and would miss short-term negative outcomes, including incidence and recurrence of SAM and mortality after discharge from programme, and this may result in an over-estimating of the programmes' positive outcomes.

External validity

The findings from the four papers included in this thesis might be relevant in other areas of the country and in low-income settings with a similar context. The consequence of SAM is evident and documentation of experiences from a large-scale government-operated nutrition programme is relevant to policy makers as challenges in implementation could be common across similarly operated programmes.

The first study was derived from a cross-sectional population-based survey which ensured a representative sample of children aged under five years in the study area. The study area revealed typical features of rural southern Ethiopia. The research aimed to include all 99 rural kebeles (smallest administrative units) of the four study districts. We excluded seven rural kebeles from the research that were not accessible due to remoteness and security concerns, which could reflect a lower socio-economic environment. However, it would be unlikely that this omission would affect our findings on the evaluation of the agreement between the indicators, as the age and sex distribution of the children who participated in the study from all four districts were comparable.

The other three studies used data from a cohort of children admitted to the OTPs of the same 92 rural kebeles included in the population-based survey. From the children who were assessed for eligibility to participate in the study,

a relatively large number of children were excluded from our analyses. However, comparison of background household and caregivers' characteristics between these children and those included in the analyses revealed no significant differences. Thus, the study samples were likely to be representative of the populations studied.

Internal validity and reliability

All enumerators underwent careful training in different aspects of interviewing, anthropometric measurement techniques and data collection to ensure the validity and reliability of the data collected. All enumerators had training in the standardization of anthropometric measurements to minimize measurement errors and ensure the validity and precision of measurements in the field-work. To assure the quality of anthropometric data, the WHO-recommended MUAC tapes and the UNICEF-recommended weight and height boards were used. Existing validated survey instruments were used except minor modifications to adapt few questions to the local cultural context. In addition, all questionnaires were pre-tested in a pilot study in the study area and regular supervision of data collectors was carried out throughout the data collection period.

There are some limitations of the papers included in this thesis. In the cohort studies, we included all children whose anthropometric measurements were taken within 7 days of programme admission to analyse their nutritional status. We followed a similar procedure to analyse nutritional status at discharge and 14 weeks after admission. This one-week delay for anthropometric measurements may have contributed to an over-estimation or under-estimation of their actual nutritional status at time of admission and/or discharge, depending on their use of RUTF and household characteristics. However, for our analyses, categories based on number of days between date of anthropometric measurement and discharge were first established to compare the proportion of SAM in each category. We found no significant difference between the proportions. Thus, it is likely that we had a valid estimate of recovery (Studies II and IV).

Another potential limitation was that we may have missed a number of SAM children, defined by WHZ criteria, in the cohort. This was because the screening criteria used by the programme was MUAC. However, in our population survey, we had access to the background characteristics of children with low WHZ. There was no significant difference in terms of background characteristics in the proportion of children with low WHZ between the population and the study sample. Thus, an evaluation of the performance of WHZ in relation to MUAC was possible and the gains in anthropometric measures are likely to reflect valid estimates of the response to treatment.

A third limitation was our exclusion of children who were lost to follow-up (57/1048) and missing anthropometric measures (36/991) during analysis for programme outcomes. However, the excluded children are small in number, and the children's and their caregivers' background characteristic captured at admission revealed no significant difference compared to those who completed the study. Thus, this limitation is unlikely to affect the validity of the study in any significant way.

Selection bias

In order to provide a weighted sample representative for all of the children aged under five years in the population, 4% of households were randomly selected using SPSS-generated random numbers from survey registry conducted 3 months prior to the research. Households with no children aged under five years were replaced by new households using the randomly selected household list. Furthermore, for children admitted to OTP, an effort was made to visit all children at home during the study period.

Refusal rate was very low (<1.0%) in all four study samples. Inability to find child at home during home-visit was the main reason for loss to follow-up. However, the proportion of lost on follow-up in all three papers on children admitted to OTP (<6 %) and missing information on anthropometry (< 5%) was rather small and it appears unlikely that this potential selection bias would have influenced the outcomes. Child deaths were few (< 3%) during the follow-up studies and therefore could not bias the results.

Information bias

In-person interviews using the local language were conducted with women respondents and efforts were made to ensure privacy during interviews. In the absence of vaccination certificates or a family health card, age was estimated by using local calendars that report dates of important events, common to most participants, which occurred in the previous five years.

Our assessment of whether children received adequate supply of RUTF at admission and follow-up was based on caregivers' response, and not on a count of RUTF sachets. The adequate supply could have been verified by counting the sachets and comparing with the weekly ration based on the recommended amount. However, this was not possible because the home-visits were made at an average of 4-week intervals.

Many studies define autonomy operationally in different ways due to lack of standard definition of autonomy. Therefore, limitations in the measurement of autonomy is inevitable. We assumed that caregivers are ideal self-reporters and we relied on true self reporting of the concept of autonomy, which may

not necessarily be the case. There is a potential that, in some cases, a caregiver's control over certain aspect of household decision-making may not represent the autonomy of the caregiver, but rather, a responsibility that she is obligated to fulfil. However, most of the current work measuring autonomy also uses self-reported scores of autonomy, and the Cronbach's α for the questionnaire we used was 0.87, exhibiting good internal consistency.

Confounding bias

During the design of the study questionnaire, confounding variables that were known, based on the literature and previous knowledge, were included; but we may have not addressed all confounders. During analyses, known confounders were included in the multivariate models. However, even after adjusting for confounders in the regression models, residual confounding may remain due to unknown confounders. This may occur when the confounder is not included in the models or where it was not properly measured.

Conclusion and recommendations

The results presented in this thesis addressed important factors for improving effectiveness of large-scale community-based management of SAM. The study provided empirical evidence in support of current treatment guidelines and contextual factors that modify the effectiveness of an integrated and scaled-up OTPs from low-income rural setting.

MUAC and WHZ are two anthropometric indicators that have poor agreement in diagnosing SAM in girls and older children. This has important programmatic implications for community management of SAM that it questions the indicators' performance to predict risk of mortality. The most useful indicator to define SAM is the one which can identify children who are at high risk of dying if they remain untreated, who otherwise would possibly survive if treated in an appropriate nutritional rehabilitation programme. More research on the prediction of mortality using different anthropometric measurements could improve current treatment guidelines.

MUAC and weight should be used independently to monitor response to treatment and assure sufficient recovery in children treated for SAM. This finding provides empirical evidence to support the current WHO treatment guideline.

The majority of the children treated at the integrated and scaled-up OTPs of the study setting failed to achieve sufficient recovery from SAM. The OTPs lacked sufficient supplies, which contributed to the programme's inability to provide services according to the programme's intention. Despite an adequate length of stay in the programme, many children were discharged without reaching the programme's recommended weight gain and continued to suffer from SAM after treatment. Children who did not recover, and those with severe oedema, who had a consequent high fatality rate after treatment in OTPs, were not referred to inpatient care. Moreover, children who did not have SAM at admission, as assessed by the research team, had become severely or moderately malnourished 14 weeks after admission. Given the global evidence that prevention and treatment of MAM reduces the incidence and severity of SAM, our findings support the need for scaled-up and integrated OTPs to consider combining MAM management and prevention strategies.

In rural southern Ethiopia, higher levels of caregivers' decision-making autonomy had a positive effect on the recovery rate of children with SAM treated at OTPs. This result indicates that the effectiveness of scaled-up nutrition programmes for management of SAM may depend on maternal status. Further

research is warranted to understand the role of other resources for care on the recovery of children treated for SAM in integrated and scaled-up OTPs.

In general, linking CMAM to other complementary programmes could improve the effectiveness of such large-scale nutrition programmes. Moreover, the stakeholders' commitment to building the capacity of integrated OTPs service provision is vital for the appropriate and effective management of SAM.

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