Chapter 11

Management of Severe and Moderate Acute Malnutrition in Children

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INTRODUCTION

Each year, approximately 5.9 million children around the world die before their fifth birthday (You and others 2015). The leading killers are prematurity and pneumonia, responsible for 17.8 percent and 15.5 percent of all deaths in this age group, respectively (Liu and others 2014, 2016). Degrees of malnutrition are associated with increased risk of all-cause mortality and increased risk of death due to diarrhea, pneumonia, and measles (Black and others 2013).

Defining Malnutrition

The term *malnutrition* is multifaceted. It encompasses both overnutrition, associated with overweight and obesity, and undernutrition, referring to multiple conditions including acute and chronic malnutrition and micronutrient deficiencies.

Chronic malnutrition results from insufficient intake or absorption of essential nutrients over a protracted period. Stunting (short stature for age), the most commonly used indicator of chronic malnutrition, is associated with developmental impairments and reduced economic potential later in life (Black and others 2008; Grantham-McGregor and others 2007). Micronutrient deficiencies are a form of chronic malnutrition that can have marked impacts on health, development, and productivity over the lifespan. Because visible signs are not always present, micronutrient deficiencies are often referred to as *hidden hunger* (see Das and others [2015], chapter 12 in this volume). The impacts of chronic malnutrition are particularly pronounced when they occur in the first years of life, a period of rapid growth and development.

Acute malnutrition results from sudden reductions in food intake or diet quality and is often combined with pathological causes. Acute malnutrition has been defined in various ways and has been referred to by various names with partially overlapping definitions, including protein-energy malnutrition, wasting, kwashiorkor, and marasmus. In this chapter, we use *acute malnutrition* and *wasting* interchangeably. Acute malnutrition, or wasting, is defined using anthropometric cutoffs and clinical signs. The currently accepted definitions, set out by the WHO, are as follows:

- ***Moderate acute malnutrition (MAM),*** defined as weight-for-height[1] z-score (WHZ) between −2 and −3 or mid-upper arm circumference (MUAC) between 115 millimeters and <125 millimeters (WHO 2012)
- ***Severe acute malnutrition (SAM),*** defined as WHZ < −3 or MUAC < 115 millimeters, or the presence of bilateral pitting edema, or both (WHO 2013)

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- ***Global acute malnutrition (GAM)*** refers to MAM and SAM together; it is used as a measurement of nutritional status at a population level and as an indicator of the severity of an emergency situation (GNC 2014).

Marasmus and kwashiorkor are common terms historically used to differentiate between types of SAM. Marasmus refers to children who are very thin for their height (that is, they meet the WHZ or MUAC cutoff) but do not have bilateral pitting edema; kwashiorkor refers to edematous malnutrition. The most recent WHO terminology for SAM has replaced these terms.

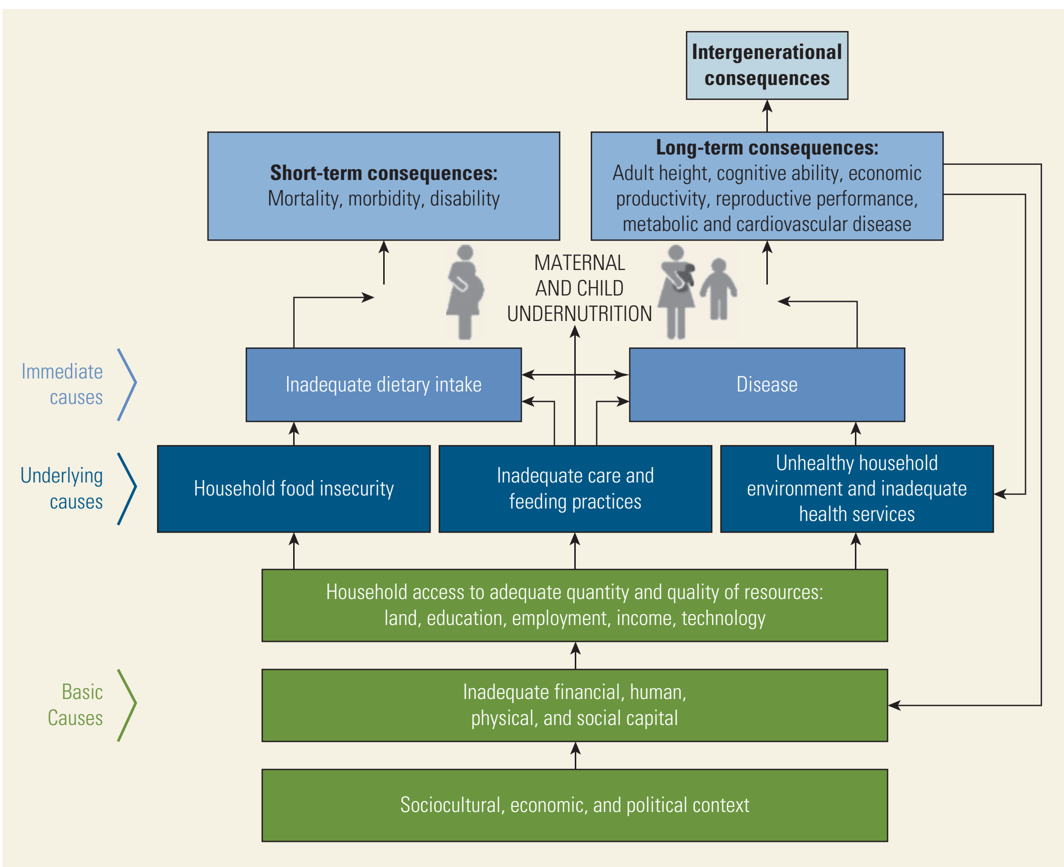
Risk Factors and Causes of Undernutrition

Undernutrition results from the complex interplay of a range of distal and proximal factors, as illustrated by the United Nations Children's Fund's (UNICEF) conceptual framework for undernutrition (figure 11.1) (UNICEF 2013). The framework defines basic, underlying, and immediate causes of undernutrition and demonstrates how these causes are interconnected. This general framework also aids in conceptualizing the reasons why children might develop acute malnutrition.

Based on scientific literature investigating the relationships among specific individual, household, and environmental factors and the development of acute malnutrition in children, the following are significant risk factors for MAM and SAM:

- Inadequate dietary intake
- Inappropriate feeding
- Fetal growth restriction
- Inadequate sanitation
- Lack of parental education
- Family size
- Incomplete vaccination
- Poverty
- Economic, political, and environmental instability and emergency situations.

Figure 11.1 Conceptual Framework of Determinants of Undernutrition



Source: UNICEF 2013.

A study in India demonstrates the impact of infant and young child feeding as well as water, sanitation, and hygiene (WASH) on wasting (Menon and others 2013). The authors found that improved dietary diversity and improved WASH were associated with better nutritional outcomes in children in India; they concluded that integrated interventions targeted to both these risk factors would have a greater impact than single interventions (Menon and others 2013).

Poverty is another risk factor for wasting (Islam and others 2013; Meshram and others 2012), as are unsafe drinking water sources and lack of latrines (Islam and others 2013). Economically disadvantaged families are less likely to have access to improved sources of drinking water, such as water from pipes or tubewells, and are less likely to have access to latrines. One study finds these to be risk factors independent of the wealth index (Islam and others 2013). Another study, which does not assess WASH indicators, finds that the family wealth index to be significantly associated with wasting (Meshram and others 2012). Both studies also find larger family sizes to be associated with an increased risk of wasting (Islam and others 2013; Meshram and others 2012), as does a study in Pakistan (Laghari and others 2013).

Several studies in Bangladesh, India, and Pakistan demonstrate a correlation between low parental education and increased risk of wasting in children (Islam and others 2013; Laghari and others 2013; Long and others 2013; Menon and others 2013; Meshram and others 2012).

A study in Burkina Faso finds incomplete vaccinations and maternal literacy status to be risk factors for wasting relapse (Somasse and others 2013).

Finally, investigators studying the correlation between fetal growth restriction and child wasting find that infants born small for gestational age or those with low birth weight were at a significantly increased risk of being wasted at 24 months (Cao, Wang, and Zeng 2013). Additionally, low birth weight was found to be a risk factor for SAM in children under age five years in Pakistan (Laghari and others 2013).

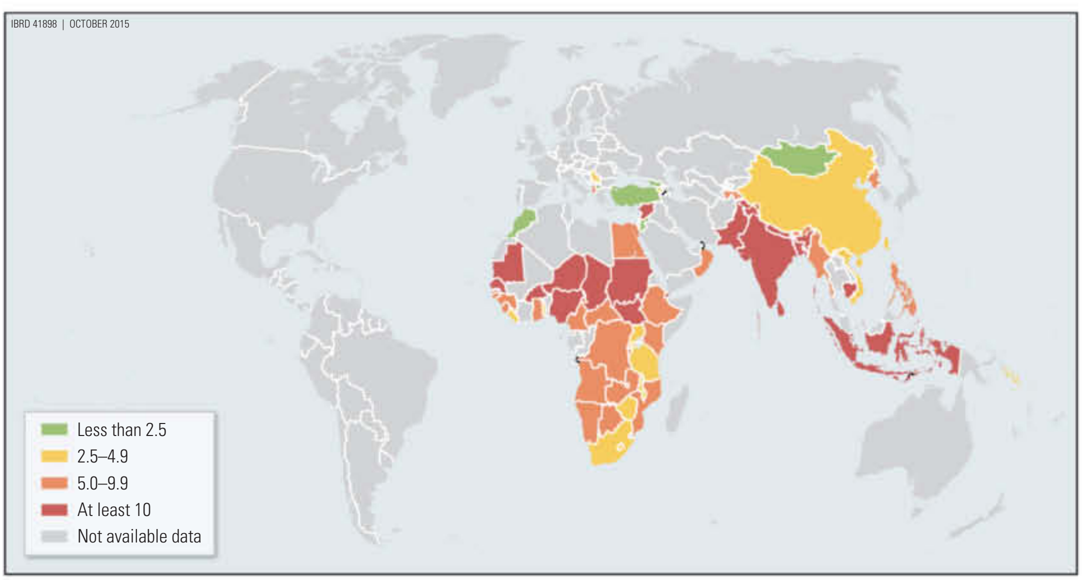
Incidence of SAM is exacerbated during emergencies, such as drought, famine, or conflict (Hall, Blankson, and Shoham 2011). Indicators such as household food consumption, harvest yield, and staple food prices are early warning signs of imminent food insecurity, followed by increases in the incidence of SAM or GAM (Hall, Blankson, and Shoham 2011).

Consequences of Acute Malnutrition

SAM and MAM are significant public health concerns and disproportionately affect populations in low- and middle-income countries (LMICs). MAM affects 32.8 million children worldwide, 31.8 million of whom reside in LMICs (Black and others 2013). SAM affects 18.7 million children worldwide; 18.5 million of those children reside in LMICs (Black and others 2013).

Map 11.1 shows the prevalence of wasting in children under age five years worldwide. The rates

Map 11.1 Percentage of Children under Age Five Years Who Are Moderately or Severely Wasted, 2007–11



Source: UNICEF 2013.
Note: Data for India are not for the same period as the other countries.

of SAM and MAM are highest in the South-East Asia region and parts of the Africa region; indeed, 70 percent of all wasted children reside in Asia (Black and others 2013).

National wasting statistics can be accessed online through the Joint Malnutrition data set published by UNICEF, the WHO, and the World Bank (UNICEF 2014b; UNICEF, WHO, and World Bank 2012). Rates of SAM and MAM vary widely at subnational levels, particularly where large disparities in income and food security exist; the availability of subnational statistics on wasting also varies widely.

The degree of wasting is positively correlated with an increase in the risk of death (Black and others 2013). Table 11.1 shows all-cause and cause-specific hazard ratios for mortality by degree of wasting. Of the deaths under age five years, 11.5 percent, or approximately 800,000, can be attributed to acute malnutrition (Black and others 2013); SAM is responsible for 540,000 of these deaths (Black and others 2013). Children with acute malnutrition have severely disturbed physiology and metabolism and need to be treated with caution. Simple refeeding can lead to high rates of mortality, and cases can be especially difficult to manage if additional medical complications are present (discussed further under "Treatment of Severe Acute Malnutrition"). Specific guidelines, supported by available evidence and expertise, have been developed for managing these cases and are discussed later in this chapter.

In addition to increasing the risk of death due to infectious illness, wasting increases a child's susceptibility to infections and the severity of illnesses (Laghari and others 2013; Long and others 2013; Meshram and others 2012; UNICEF 2013). Malnutrition has serious physiological consequences, including reductive adaptation, marked immunosuppression, and concurrent infection (Collins, Dent, and others 2006). The relationship between malnutrition and infection is often described as a vicious cycle that begins with infections, especially diarrhea, and progresses to undernourishment. The undernourishment, in turn, increases the risk of prolonged illness and the susceptibility to additional infection. Human immunodeficiency virus (HIV) infection exacerbates the risk of wasting as well as mortality due to wasting (Sadler and others 2006).

PREVENTION OF ACUTE MALNUTRITION

Providing Adequate Nutrition and Disease Prevention Strategies

Key interventions to prevent the development of acute malnutrition include appropriate breastfeeding[2] and complementary feeding practices[3] (Bhutta, Das, Rizvi, and others 2013). Disease prevention strategies are important in breaking the infection-malnutrition cycle, particularly related to diarrhea and repeated respiratory infections (Bhutta, Das, Walker and others 2013). The evidence on effective approaches to preventing malnutrition focuses on stunting and underweight as outcomes and may not be completely transferrable to prevention of wasting. However, an integrated approach to optimizing healthy growth in infants and children can have an important impact on reducing rates of wasting.

Therapeutic Foods for Preventing and Treating Acute Malnutrition

Treatment approaches are discussed in detail in subsequent sections; here we introduce some of the commonly used specially formulated therapeutic foods.

F75 and F100 are specially formulated milks used in inpatient settings to treat SAM. F75 is given in the stabilization phase of inpatient treatment; children are provided with approximately 80–100 kilocalories per kilogram per day (kcal/kg/d) spread over 8–12 meals per day for three to seven days. F75 is not designed for weight gain (personal communication, Nutriset; UNICEF 2014a). F100 is given during the rehabilitation

Table 11.1 Hazard Ratios of All-Cause and Cause-Specific Deaths, by Degree of Wasting

Weight-for-height z-score	All deaths HR (95% CI)	Pneumonia deaths HR (95% CI)	Diarrhea deaths HR (95% CI)	Measles deaths HR (95% CI)	Other infectious deaths HR (95% CI)
<–3	11.6 (9.8, 13.8)	9.7 (6.1, 15.4)	12.3 (9.2, 16.6)	9.6 (5.1, 18.0)	11.2 (5.9, 21.3)
–3 to –2	3.4 (2.9, 4.0)	4.7 (3.1, 7.1)	3.4 (2.5, 4.6)	2.6 (1.3, 5.1)	2.7 (1.4, 5.5)
–2 to <–1	1.6 (1.4, 1.9)	1.9 (1.3, 2.8)	1.6 (1.2, 2.1)	1.0 (0.6, 1.9)	1.7 (1.0, 2.8)
≥–1	1.0	1.0	1.0	1.0	1.0

Sources: Black and others 2013; Olofin and others 2013.
Note: CI = confidence interval; HR = hazard ratio.

phase of inpatient treatment of SAM, providing children with approximately 100–200 kcal/kg/d for three to four weeks (personal communication, Nutriset; UNICEF 2014a). Because F75 and F100 require preparation and have high moisture content, they cannot be stored for long at room temperature for food safety reasons, and are not given to caretakers to prepare at home (UNICEF 2014a).

Ready-to-use-foods (RUFs) are specially formulated bars, pastes, or biscuits that provide varying ranges of high-quality protein, energy, and micronutrients. These products are more nutrient dense than available home foods and do not require preparation; they typically have very low moisture content and are resistant to microbes. With use of each of these products, continued breastfeeding is recommended.

- Ready-to-use therapeutic foods (RUTFs), such as Plumpy'Nut are designed for the treatment of uncomplicated SAM.
- Ready-to-use supplementary foods (RUSFs), such as Plumpy'Sup, are designed as a supplement to treat MAM.
- Medium-quantity lipid-based nutrient supplements (LNSs), such as Plumpy'Doz, are designed as a supplement to prevent MAM.[4]

Fortified blended flours (FBFs) are an additional class of specially formulated foods. The most commonly used product is Supercereal Plus, formerly called Corn Soy Blend Plus (CSB++). FBFs require some preparation before consumption and are typically distributed in larger quantities as family rations for treating or preventing MAM.

The nutrient composition of some common formulated foods for treatment and prevention of acute malnutrition are shown in table 11.2. Annan, Webb, and Brown (2014) provide a more comprehensive product list of specially formulated foods for MAM management.

Locally Produced Therapeutic Foods

The bulk of RUFs are commercially prepared by a select number of companies and are then distributed to program sites. Decentralizing production could be beneficial for several reasons. Therapeutic foods are often a significant program cost and could be less expensive to produce in-country. Decentralized production could create valuable local economic opportunities.

RUFs can be safely and easily produced in most settings; however, feasibility of production is limited because of the unavailability of necessary ingredients in some settings (Manary 2005). Lenters and others (2013)

Table 11.2 Nutritional Composition of Commonly Used, Specially Formulated Foods for the Prevention and Treatment of Acute Malnutrition

	F75 (100 g milk powder)	F100 (100 g milk powder)	Plumpy'Sup (100 g)	Plumpy'Doz (100 g)	Plumpy'Nut (100 g)	Supercereal Plus (100 g dry matter)
Used for	SAM	SAM	MAM	MAM	MAM or SAM	Prevention of MAM
Recommended serving size (kcal/kg/d)	80–100	200	75	46.3 g/day	SAM: 200 MAM: 75	200 g/day
Macronutrients						
Energy (kcal)	446	520	520–550	534–587	520–550	410
Protein (g)	5.9	>13	12.6–15.4	13.4–17.7	13–16	>16.4
Lipid (g)	15.6	>26	31.5–38.6	26.7–39.1	26–36	>4.1
Minerals						
Potassium (mg)	775	1,100	980–1,210	660–870	1,100–1,400	140
Calcium (mg)	560	300	300–350	800–980	300–500	452
Phosphorus (mg)	330	300	300–350	530–660	300–600	232
Magnesium (mg)	50	80	80–100	115–140	80–100	—
Zinc (mg)	12.2	11	12–15	8.7	11–14	5

Sources: Nutriset catalogs; Supercereal Plus from USAID specifications.
Note: — = not available; d = day; g = gram; kcal = kilocalorie; kg = kilogram; MAM = moderate acute malnutrition; mg = milligram; SAM = severe acute malnutrition.

find no difference in the effectiveness for promoting weight gain from a pooled analysis of data from two studies (Diop and others 2004; Sandige and others 2004) comparing locally produced and imported RUTF that met the same product specifications.

There is interest among academic, donor, and nonprofit communities in developing new formulations of RUFs that make use of locally available ingredients while targeting taste preferences of different populations. For example, RUFs could substitute other legumes for the standard peanut base, or reduce or substitute the milk powder component in areas in which dairy is not commonly consumed (Matilsky and others 2009; Oakley and others 2010; Sandige and others 2004). Research is ongoing with respect to the treatment effectiveness and cost-effectiveness of alternate formulations.

MANAGEMENT OF MODERATE ACUTE MALNUTRITION

Although the typology of interventions for MAM and their indicated uses in different contexts have been topics of considerable discussion, substantial ambiguity remains in practice in the classification of interventions, and evidence gaps persist regarding the effectiveness of interventions. One example of guidelines recently developed is the Global Nutrition Cluster decision-making tool that guides the selection of appropriate programming approaches in emergency situations (GNC 2014).

The management of MAM can be broadly categorized into *prevention* and *treatment* strategies. In general, because wasting results in a loss of body mass relative to height, the standard practice has been to provide the child with additional energy and nutrient-dense foods to promote weight gain. The selection of the particular management approach is context specific; different approaches are warranted for populations that are more stable and food secure than for populations experiencing significant food insecurity or humanitarian emergencies.

Strategies for Prevention

Strategies for the prevention of MAM dovetail with public health interventions promoting optimal child growth and development. These strategies include the promotion of appropriate breastfeeding and complementary feeding practices, access to appropriate health care for the prevention and treatment of disease, and improved sanitation and hygiene practices. Additionally, although micronutrient deficiencies are most commonly linked to stunted linear growth, these deficiencies can also contribute to wasting, for example, through the malnutrition-infection cycle. Undernourished children tend to be more susceptible to infection, which can contribute to weight loss through increased metabolism, as well as reduced nutrient intake and absorption (Guerrant and others 2008; Petri and others 2008). Multiple-micronutrient powders, small-quantity LNSs, and single-nutrient supplements are used to augment the nutritional content of the home diet.

Strategies for Treatment

Research is ongoing with respect to optimal treatment approaches. In 2008, the WHO established a working group on dietary management of MAM; since then, the emphasis on exploring optimal food-based treatments for MAM has increased (GNC 2014). The 2012 WHO technical note on supplementary foods for managing MAM in children ages 6–59 months calls for providing locally available, nutrient-dense foods to improve nutritional status and prevent SAM (WHO 2012). In situations of food shortage, supplementary foods have been supplied with suboptimal effectiveness. WHO (2012) suggests that an energy intake of 25 kcal/kg/d in addition to the standard nutrient requirements of a nonmalnourished child would support a reasonable rate of weight gain without promoting obesity. However, there is no evidence-informed recommendation for the composition of specially formulated foods for treatment (WHO 2012).

The Community-Based Management of Acute Malnutrition (CMAM) Forum published a technical brief in 2014 that echoed the WHO guidelines and discussed recommendations for diets suitable for children with MAM, approaches to counseling caregivers, and a decision-making framework for selecting appropriate supplementary feeding program (SFP) approaches (Annan, Webb, and Brown 2014).

Food-Secure Populations

In food-secure populations, caregivers can be counseled and supported in using high-quality, home-available foods to promote recovery in acutely malnourished children (Bhutta, Das, Rizvi, and others 2013). This intervention can be coupled with general health-promotion approaches to mitigate the underlying factors contributing to acute malnutrition, for example, WASH and health-seeking behaviors.

Two systematic reviews (Lazzerini, Rupert, and Pani 2013; Lenters and others 2013) find no significant differences in mortality between the provision of any type of specially formulated food and standard care, which consists of medical care and counseling without food provision. Children provided with food were significantly more likely to recover, based on two studies in the meta-analysis

(Lazzerini, Rupert, and Pani 2013). This systematic review could not identify any trials investigating the effect of improving the adequacy of local diets.

The literature search conducted by Lenters and others (2013) identifies very few rigorous trials that compare the provision of RUTFs or RUSFs with other types of interventions to modify household- and community-level factors that contribute to the development of wasting. In one study, the mean weight gain was significantly higher in the group provided with RUTFs than in the standard care group in which mothers were taught to prepare a high-calorie cereal milk (Singh and others 2010). However, because this study assessed nutritional status using weight-for-age, children who were not wasted may have been included in the study.

Ashworth and Ferguson (2009) review dietary counseling for treatment of MAM and use programmatic data from United Nations agencies, nongovernmental organizations, and national programs to assess whether the counseling and recommendations given were likely to meet children's dietary needs. The authors conclude that messages tended to be vague and were unlikely to be effective. Their review also aims to assess the effectiveness of dietary counseling in the management of MAM; based on an analysis of 10 studies, they suggest that counseling families on the consumption of family foods can have a positive effect on weight gain. However, this review does not contain a meta-analysis; the studies included are a mix of quasi-experimental and observational data and employ a variety of indices to measure malnutrition.

Food-Insecure Populations

In food-insecure populations, including humanitarian emergency contexts, SFPs are used to reduce mortality and prevent further deterioration of children's nutritional status. These SFPs are classified as targeted SFPs or blanket SFPs, depending on the recipients. A blanket approach provides supplemental food to everyone within a defined population, regardless of whether children are acutely malnourished; a targeted approach provides supplemental rations only for malnourished children meeting program cut-off criteria.

The standard practice for SFPs is to provide a ration of staple food, such as FBF, commonly Supercereal Plus (GNC 2014). However, a growing range of RUFs have been developed specifically for treating MAM. A Cochrane review (Lazzerini, Rupert, and Pani 2013) compares the effectiveness of LNSs with FBFs for the treatment of MAM. This review concludes that both products appear to be effective; there is insufficient evidence to recommend the use of LNS over corn-soy blend (CSB), despite the growing interest from the policy and programming community in these new specially formulated foods. No reduction in mortality, differences in numbers of children progressing to SAM, or dropping out of the study were found when comparing LNS with CSB for the five studies included in the meta-analysis. Yet, treatment with LNS led to a 10 percent increase in recovery compared with CSB, and slightly improved nutritional status among those recovered. No significant differences were seen when Supercereal Plus was compared with LNS. These findings are echoed in the systematic review conducted by Lenters and others (2013) as part of *The Lancet* series on maternal and child nutrition, as well as in a review conducted by the Food Aid Quality Review group (Webb and others 2011).

In situations that warrant the provision of supplemental foods, there is growing recognition of the need to use integrated approaches to address the immediate need for an improved diet to treat MAM and prevent the progression to SAM, while simultaneously addressing the underlying factors. Livelihood diversification, social protection schemes, and conditional cash transfers are some of the approaches being explored in these contexts (Bhutta, Das, Rizvi, and others 2013).

Seasonal Supplementation

Seasonal blanket feeding programs are an emerging approach aimed at suppressing predictable increases in the rates of SAM and MAM. In chronically food-insecure settings, a spike in the incidence of MAM and SAM is seen in the period before the harvest, known as the "lean season." Seasonal SFPs, which may be targeted by geographic region or age group, tend to include all children who either have, or are at risk for, MAM. The evidence remains limited on the effectiveness or cost-effectiveness of such approaches for prevention; however, several studies investigate the use of RUF supplementation for nonwasted children to reduce seasonal increases in population-wide prevalence rates of wasting (Defourny and others 2009; Grellety and others 2012; Hall and others 2011; Huybregts and others 2012; Isanaka and others 2009; Karakochuk, Stephens, and Zlotkin 2012).

A blanket SFP in Niger provided children ages 6–26 months (MUAC < 110 millimeters millimeters) with roughly 50 grams per day of RUSFs (Defourny and others 2009). Fewer children in the target locality presented in need of therapeutic care than in previous years; however, it was not possible to rule out overall improvements in food security in the absence of a comparison group in the study.

Another study in Niger randomized villages to receive the intervention (one packet of RUTF per day for children) versus no intervention. The intervention led to an estimated 36 percent difference in the incidence of wasting and a 58 percent difference in the incidence of severe wasting (Isanaka and others 2009). Although the authors claim that the difference represented a reduction in wasting, some reviewers argue that the statistically significant difference could be ascribed to increased incidence of wasting in the control villages coupled with no change in the intervention sites (Hall and others 2011).

Where markets are viable, interventions that aim to stimulate the local economy through cash transfers, voucher schemes, or the provision of locally available food rations may be more sustainable and acceptable than the provision of imported RUFs.

TREATMENT OF SEVERE ACUTE MALNUTRITION

Approaches to identifying, referring, and treating SAM cases have been evolving, and a mix of programmatic approaches can be found globally. The WHO endorses community-based management of uncomplicated SAM and recommends that children with poor appetite, severe edema (Grade III), and any of the Integrated Management of Childhood Illness danger signs or medical complications (table 11.3) be treated in inpatient facilities in accordance with their 10-step model (figure 11.2) (WHO 2013).

This section focuses on the WHO-endorsed treatment approaches. Although these approaches are evidence informed, many of the recommendations are rooted in imperfect evidence and supplemented by best practices and expert opinion.

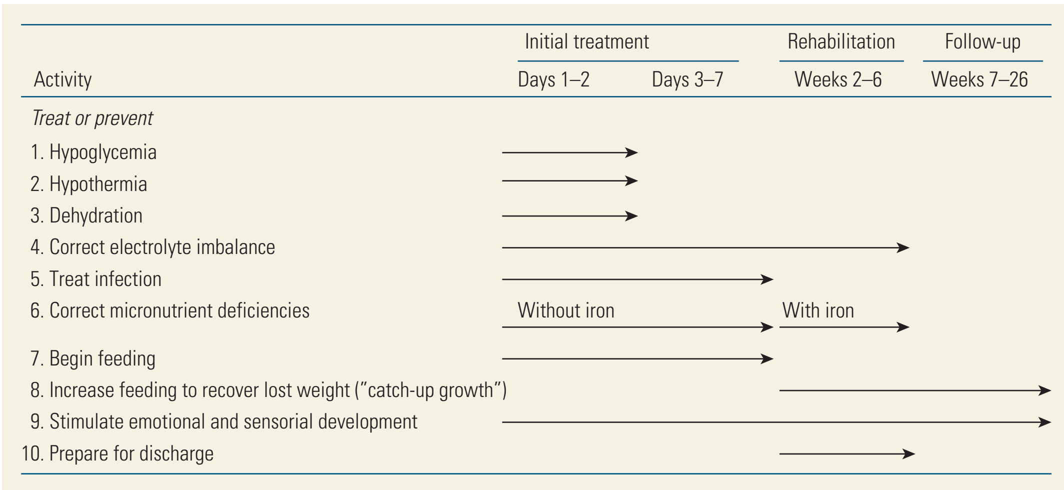
From the 1950s through the 1990s, case fatality rates (CFRs) for the treatment of SAM in health facilities remained static and were typically 20 percent to 30 percent (Ashworth and others 2003; Collins, Dent, and others 2006); specialized treatment centers were able to achieve CFRs of less than 5 percent (Collins, Dent, and others 2006). As a response to the high CFRs and high opportunity costs of inpatient treatment, a community-based approach to treating acute malnutrition has received growing attention from the academic and humanitarian sectors. Community-based treatment of malnutrition was initially referred to as the community therapeutic care model, but it may also be called community management of acute malnutrition (CMAM) and integrated management of acute malnutrition. For clarity, this chapter refers to community-based management as CMAM.

Table 11.3 Common Medical Complications in Severe Acute Malnutrition

Medical complication	Case definition
Anorexia, poor appetite[a]	Child is unable to drink or breastfeed; failed RUTF appetite test.
Intractable vomiting[a]	Child vomits after every oral intake.
High fever	Child has high body temperature, or axillary temperature > 38.5°C, rectal temperature > 39°C.
Hypothermia	Child has low body temperature, or axillary temperature < 35.0°C, rectal temperature < 35.5°C.
Lower respiratory tract infection	Child has a cough with difficult breathing, fast breathing (if child is age 2–12 months: 50 breaths per minute or more; if child is age 12 months to 5 years: 40 breaths per minute or more), or chest indrawing.
Severe anemia	Child has palmar pallor or unusual paleness of the skin (compare the color of the child's palm with your own palm and with the palms of other children).
Skin lesion	Child has broken skin, fissures, flaking of skin.
Unconsciousness[a]	Child does not respond to painful stimuli (for example, injection).
Lethargy, not alert[a]	Child is difficult to wake. Ask the mother if the child is drowsy, shows no interest in what is happening around him or her, does not look at the mother or watch your face when talking, is unusually sleepy.
Hypoglycemia	There are often no clinical signs of hypoglycemia. One sign that does occur in a child with SAM is eyelid retraction: child sleeps with eyes slightly open.
Convulsions[a]	During a convulsion, child's arms and legs stiffen because the muscles are contracting. Ask the mother if the child had convulsions during this current illness.
Severe dehydration	Child with SAM has a recent history of diarrhea, vomiting, high fever or sweating, and recent appearance of clinical signs of dehydration as reported by the caregiver.

Source: Saboya, Khara, and Irena 2011.
Note: °C = degrees centigrade; RUTF = ready-to-use therapeutic food; SAM = severe acute malnutrition.
a. Integrated Management of Childhood Illness danger signs.

Figure 11.2 World Health Organization's 10-Step Plan for the Management of Severe Acute Malnutrition



Sources: Picot and others 2012; WHO 2003.

Community-Based Treatment

The first CMAM programs, developed under the community therapeutic care model and implemented in the early 2000s, achieved recovery rates of almost 80 percent and CFRs of less than 5 percent (Collins, Sadler, and others 2006). More than 75 percent of children treated for malnutrition in these programs were treated on an outpatient basis, reducing opportunity costs to caregivers (less time away from income-generating activities and responsibilities as caregiver to additional children).

The community therapeutic care model of treatment rests on the four following principles:

- Maximum coverage and access
- Timeliness
- Appropriate care
- Care for as long as it is needed (Collins, Sadler, and others 2006).

This model strives to reach all severely malnourished children before the development of medical complications and to provide appropriate care until recovery. The model uses community health workers or volunteers (CHWs or CHVs) to actively find cases of wasting within the community. Children are screened to assess their nutritional status, typically using MUAC cutoffs and simple algorithms to assess the presence of medical complications, which would necessitate referral to a facility-based treatment program.

The most commonly seen medical complications in SAM are outlined in table 11.3. Only about 15 percent of children with SAM have medical complications that require inpatient treatment (Collins, Sadler, and others 2006). Substantial programmatic evidence has demonstrated that the community-based model can achieve low mortality rates and decrease opportunity costs to caregivers, resulting in lower default rates (Collins, Sadler, and others 2006; Guerrero and Rogers 2013). *Defaulters* are children who are lost to follow-up (Sphere Project 2011).

In the CMAM model, mothers administer the RUTFs to their children. The rapid changes in the children's condition provide positive feedback to those associated with the recovery process and strengthens community motivation for case-finding, foreseeably increasing coverage (Collins, Sadler, and others 2006).

The 2013 WHO guidelines (WHO 2013) recommend that children should be enrolled and discharged from treatment using the same mode of classification. Children who were admitted based on MUAC should be discharged once their MUAC is ≥ 125 millimeters for at least two weeks or their WHZ is ≥ −2 for at least two weeks. Children who were admitted based on their edema should be discharged based on the measurement routinely used in the program. Once discharged, the children should be followed up periodically to avoid relapse.

The 2013 WHO guidelines (WHO 2013) include several additional updates:

- Children who are not treated with fortified therapeutic foods should receive a high dose of vitamin A on admission; children who receive therapeutic food do not need the high dose of vitamin A.
- RUTFs should be given to children regardless of whether they have diarrhea (WHO 2013).

The CMAM model is endorsed in the Sphere Project guidelines, an evidence-based, sector-wide consensus on minimum standards for humanitarian relief. The guidelines state that treatment programs for SAM should achieve a CFR of less than 10 percent, a recovery rate greater than 75 percent, and a defaulter rate of less than 15 percent (Sphere Project 2011).

The WHO's 10-Step Program for Inpatient Treatment

The WHO published a 10-step guide for inpatient management of complicated SAM to combat the poor CFRs in some health facilities (WHO 2003) and subsequently undertook a series of systematic reviews to update the guidelines on the management of severe malnutrition (WHO 2013).

These systematic reviews collated evidence related to treatment of SAM, including criteria for identifying SAM, discharge, follow-up, treatment of HIV-positive children with SAM, appropriate hydration, and treatment of infants younger than age six months. Overall, the reviews found low or very low quality evidence to support their recommendations as a result of limited availability of randomized controlled trials (RCTs) investigating the treatment options.

The 10-step plan for inpatient management of SAM is shown in figure 11.2. The 10 steps are divided into three phases; children's emotional and sensorial development should be stimulated throughout all phases:

- ***Initial treatment***: Hypoglycemia, hypothermia, dehydration, infections, and electrolyte imbalances are corrected, as are micronutrient deficiencies with the exception of iron deficiency.
- ***Rehabilitation***: Electrolyte imbalances and micronutrient deficiencies continue to be corrected, and iron is added. Feeding is increased to stimulate catch-up growth, and children are prepared for discharge.
- ***Follow-up***: Increased feeding is continued to recover lost weight (Picot and others 2012; WHO 2003).

Initial Treatment Phase

During the initial treatment phase, frequent feeding is important to prevent both hypoglycemia and hypothermia. Feeding during the initial treatment phase should be approached cautiously because of the fragility of the child's physiological state. F75 should be given every 30 minutes for two hours, followed by F75 every two hours, day and night. Breastfed children should be encouraged to continue breastfeeding. Children with hypothermia should be rewarmed by being clothed, covered with a warmed blanket, placed near a heater or lamp, or placed on the mother's chest (skin-to-skin) and covered. Specific protocols for assessing and treating hypothermia and hypoglycemia can be found in the WHO guidelines (WHO 2003, 2013).

Dehydration should be treated following the WHO's 2013 guidelines; several key updates have been included. For example, dehydrated children who are not in shock should be rehydrated orally or by nasogastric tube using ReSoMal or half-strength WHO low-osmolarity oral rehydration solution with added potassium and glucose. If the child has profuse watery diarrhea or suspected cholera he or she should be rehydrated with full-strength WHO low-osmolarity oral rehydration solution. Children who are severely dehydrated or with signs of shock should be rehydrated intravenously, using half-strength Darrow's solution with 5 percent dextrose, Ringer's lactate solution with 5 percent dextrose, or, if neither is available, 0.45 percent saline with 5 percent dextrose (WHO 2013).

Infections should be treated routinely upon admission by provision of a broad-spectrum antibiotic, and measles vaccination should be given for unimmunized children older than age six months.

Micronutrient deficiencies should be treated by giving vitamin A (200,000 international units [IU] for children older than age 12 months, 100,000 IU for children ages 6–12 months, and 50,000 IU for children ages 0–5 months), coupled with daily multivitamin, folic acid, zinc, and copper supplementation for at least two weeks. Iron supplementation should only be given once children have begun gaining weight.

Rehabilitation Phase

During the rehabilitation phase, F75 should be replaced with F100 in the same amounts for 48 hours before increasing successive feeds by 10 milliliters until some remains unconsumed. If available, children could be transitioned from F75 to RUTF according to the updated WHO guidelines (WHO 2013). Children's respiratory and pulse rates should be monitored closely. After transition to F100, children should receive feedings consisting of 100–200 kcal/kg/d and 4–6 g protein/kg/d at least every four hours. Breastfeeding should continue to be encouraged.

Follow-Up Phase

After recovery, parents should be taught to feed children frequently with energy- and nutrient-dense foods and to continue to stimulate their children's sensorial and emotional development. Parents should be requested to bring children back for regular follow-up checks. Vitamin A supplementation and booster immunizations should be provided.

Managing Infections in Children with SAM

In addition to increased susceptibility to infections, children with SAM are more likely to have more severe illnesses and higher mortality rates than nonwasted children (Jones and Berkley 2014; Laghari and others 2013; Long and others 2013; Meshram and others 2012; UNICEF 2013). Common infections include diarrhea, acute respiratory infection, HIV, tuberculosis, meningitis, anemia, bacteremia, and sepsis (Chisti and others 2014; Irena, Mwambazi, and Mulenga 2011; Jones and Berkley 2014; Kumar and others 2013; Nhampossa and others 2013; Page and others 2013; Schlaudecker, Steinhoff, and Moore 2011). The proportion of children with SAM who have comorbidities varies. For example, 31 percent and 33.6 percent, respectively, of children with SAM in two studies in Mozambique and India had acute diarrhea, compared with 67.1 percent of children with SAM in a study in Zambia (Irena, Mwambazi, and Mulenga 2011; Kumar and others 2013; Nhampossa and others 2013).

Determining the etiology of infections can be difficult because of limited resources and because clinical signs of infection may not be apparent (Jones and Berkley 2014; Page and others 2013). Diagnosis of malaria can be challenging because its symptoms can be indistinguishable from other febrile illnesses; rapid diagnostic tests or microscopic blood examination are recommended for malaria diagnosis. Children with SAM who have radiologic-confirmed pneumonia may not exhibit any typical signs or symptoms (Jones and Berkley 2014). The diagnosis of tuberculosis can be especially challenging (Chisti and others 2014; Jones and Berkley 2014). Laboratory-confirmed tuberculosis through *Mycobacterium tuberculosis* culture is the gold standard, but children with SAM often do not produce suitable sputum samples, and culturing the bacteria is a lengthy procedure. Skin tests have high false negative rates, and scoring systems have been developed. Jones and Berkley (2014) recommend the consideration of clinical response to nutritional rehabilitation, such as weight gain and fever, in the diagnosis of tuberculosis.

Treatment for malnourished children with concurrent infections should follow the WHO guidelines. Severely malnourished children diagnosed with tuberculosis should be treated with a single dose of 5–10 milligrams per day of vitamin B6 along with isoniazid. Antiretroviral therapy (ART) should be initiated in the rehabilitation phase of treatment in HIV-positive children with SAM, and they should be given co-trimoxazole daily. HIV-positive mothers should receive ART or infants should receive prophylaxis, and mothers should be encouraged to breastfeed exclusively for six months and continue for up to two years (Jones and Berkley 2014; WHO 2010). Severely malnourished children infected with malaria should be treated with artesunate; those with diarrhea who are dehydrated or in shock should be managed as described in the WHO 10-step plan for inpatient management of SAM.

The provision of broad-spectrum antibiotics to all outpatient children with SAM would mirror WHO recommendations for treatment of nonmalnourished children with pneumonia (Jones and Berkley 2014), although blanket provision of antibiotics is controversial. Because of the differences in the presentation of infection in malnourished versus well-nourished children, Jones and Berkley (2014) recommend that children who do show abnormal radiology be carefully evaluated for tuberculosis.

Considering Antibiotic Treatment

New evidence is emerging on the importance of managing SAM, including uncomplicated SAM, using a package of care that includes antibiotic treatment. The use of broad-spectrum antibiotics has been conditionally recommended for treatment of uncomplicated SAM in community-based treatment programs (WHO 2007). Local governments and policy makers are asked to make this determination in light of local contexts. Although routine antibiotic treatment at the enrollment stage in CMAM programs is part of the protocols of many organizations, this practice remains controversial.

One systematic review of antibiotics as part of SAM management concludes that the evidence for the addition of antibiotics to therapeutic regimens for uncomplicated SAM is weak and urges further efficacy trials (Alcoba and others 2013). Another review concludes that the evidence was insufficient to recommend antibiotic use (Picot and others 2012). An RCT in Malawi looked at children with uncomplicated SAM treated in a community setting, comparing RUTFs to RUTFs plus antibiotics (either amoxicillin or cefdinir). The trial found a significantly higher mortality rate in children receiving placebo than in either antibiotic arm (amoxicillin: relative risk = 1.55, 95 percent confidence interval 1.07–2.24; cefdinir: relative risk = 1.80, 95 percent confidence interval 1.22–2.64) (Trehan and others 2013). Criticisms have been raised, however, because HIV-infection rates are high in this region and could be a major cause of immunodeficiency; 68 percent of the children enrolled were not tested for HIV (Koumans, Routh, and Davis 2013). Additional questions have been raised about the approach to the analysis (Okeke, Cruz, and Keusch 2013).

Because of the small number of studies with limited generalizability, as well as the costs and resistance risks associated with broad use of antibiotics, this topic requires immediate further investigation.

Treatment of Edematous Acute Malnutrition

Edematous acute malnutrition, referred to as kwashiorkor, is a form of acute malnutrition characterized by stunted growth, generalized edema, dermatologic manifestations, and hepatic steatosis (Garrett 2013). Its etiology is not well understood; it has been attributed to a range of factors, including insufficient dietary protein, excessive oxidative stress, a compromised intestinal wall, and intestinal inflammation (Garrett 2013; Smith and others 2013). The prevailing theory implicates the intestinal microbiota. Certain microflora appear to play a role in the development of kwashiorkor, as indicated by a longitudinal comparative study of Malawian twins by Smith and others (2013), as well as a mouse study (Garrett 2013; Smith and others 2013).

Given that children with severe edema[5] have a higher risk of mortality even in the absence of other medical complications, the recommendation is to treat these children in an inpatient setting (WHO 2013). The treatment protocol for children with edematous malnutrition is largely the same but with several important caveats outlined in the WHO guidelines (WHO 2013). For example, initial refeeding should occur at a rate of 100 milliliters per kilogram per day (ml/kg/d) as opposed to the general recommendation of 130 ml/kg/d, with a tailored schedule for progression after initial refeeding (Ashworth and others 2003).

The optimal setting for managing children with SAM who have mild to moderate edema remains unclear; these children may be treated in outpatient settings or referred to inpatient facilities, depending on the protocol of particular programs. No RCTs have compared inpatient treatment to community-based treatment for this group. An evidence review found eight reports describing outcomes for single cohorts of children with edema treated in the community for SAM (WHO 2013). These reports found an average recovery rate of 88 percent and CFR of less than 4 percent. However, the authors graded the quality of this evidence as very low, stating that it is difficult to make any firm recommendations about the effectiveness and safety of outpatient treatment for children with mild to moderate edema (WHO 2013).

At country and sub-country levels, the prevalence and incidence rates of edematous SAM are not well characterized; experts have called for more data on prevalence to establish the burden as an initial step to shed light on its public health importance (personal communication, CMAM Forum). The proportion of edematous SAM ranges from 0 percent in Albania and Indonesia to greater than 70 percent in the former Yugoslav Republic of Macedonia and Nicaragua (personal communication, CMAM Forum).

COSTS AND COST-EFFECTIVENESS OF TREATMENT OF SEVERE ACUTE MALNUTRITION

The published literature on the cost-effectiveness of SAM is limited; the authors of this chapter were unable to find published cost-effectiveness studies for MAM. Accordingly, the following cost-effectiveness section focuses on SAM.

The maternal and child nutrition series in *The Lancet* (Bhutta, Das, Rizvi, and others 2013) estimated the cost of increasing coverage of SAM treatment to 90 percent in 34 high-burden countries. The overall cost of scaling up SAM treatment to 90 percent in these target countries was US$2.6 billion. Of this amount, approximately 35 percent of the costs were for consumables, which is in line with the costs of other estimates for RUTFs in the treatment of SAM (Bhutta, Das, Rizvi, and others 2013).

Inpatient Treatment Programs

Inpatient treatment programs have several disadvantages for treating children who may not require it. Resource constraints can limit the number of children who can be treated. The centralized nature of the facilities means that the difficulties patients face in transport can result in delayed presentation of cases and lower coverage rates. An evaluation of 21 community-based treatment programs in Ethiopia, Malawi, and Sudan found an average coverage rate of 72.5 percent, compared with less than 10 percent coverage in inpatient programs; coverage is defined as the proportion of children needing treatment who receive it for inpatient programs (Collins, Dent, and others 2006). Moreover, because mothers often need to stay with children for longer than three weeks, inpatient treatment can cost families lost labor and economic productivity, as well as pose challenges for families with other children at home. Finally, hospitalization puts children at risk of cross infection (Bachmann 2010; Collins, Dent, and others 2006; Tekeste and others 2012).

Facility-based treatment, however, is required for complicated cases; approximately 15 percent to 20 percent of SAM cases require such treatment (Bachmann 2010; Collins, Dent, and others 2006). We were unable to find any recent studies reporting the costs of inpatient treatment of SAM other than the assumptions of costs made in the 2013 *Lancet* series on maternal and child nutrition. Costs for inpatient treatment of SAM would be highly context-dependent.

Community-Based Programs

Approximately 75 percent to 80 percent of all SAM cases can be effectively treated in the community (Bachmann 2010). A review of cost of treatment found that community-based treatment of SAM was consistently less expensive and had similar or better outcomes, compared to inpatient treatment; however, because many studies were nonrandomized, this finding could have occurred because more severely ill children were admitted to inpatient care (Bachmann 2010).

According to Horton and colleagues (see Ashok and others [2015], chapter 18 in this volume), CMAM is an attractive strategy from a cost-effectiveness perspective. The high risk of death, coupled with reductions in programming costs, lead to a cost-effective strategy. Of the three studies identified and reviewed by Horton, the cost-effectiveness ranged between US$26 and US$39 per disability-adjusted life year (DALY) averted.

Several studies have examined the costs and cost-effectiveness of CMAM programs. Puett and others (2012) compare the cost-effectiveness of a CMAM program delivered by CHWs in Bangladesh with standard inpatient treatment. The authors find that the CMAM program cost US$26 per DALY averted and US$869 per life saved. The costs of SAM treatment in the control group were US$1,344 per DALY averted and US$45,688 per life saved, respectively.

A study in Ethiopia that retrospectively examined the costs of CMAM versus treatment in a therapeutic feeding center (TFC) finds that costs were substantially lower in the CMAM program, with a cost per recovered child for the CMAM and TFC of US$145.50 and US$320.00, respectively (Tekeste and others 2012). Studies in Malawi (Wilford, Golden, and Walker 2012) and Zambia (Bachmann 2009) examining the costs of CMAM compared with hypothetical simulations of no care both find CMAM to be cost-effective and on par with other child health interventions, including universal salt iodization, iron fortification, immunization, and micronutrient fortification. The study in Zambia also finds CMAM to be cost-effective according to the WHO standards, given that the cost per DALY averted was less than the national per capita gross domestic product (GDP). The study in Malawi finds CMAM to cost US$42 per DALY averted; the study in Zambia finds CMAM to cost US$53 per DALY averted. The authors estimated the cost per child to be US$203 and per life saved to be US$1,760 (Wilford, Golden, and Walker 2012).

Overall, CMAM programs are both less expensive and as effective as inpatient care or TFCs, and accordingly are highly cost-effective for treating children with uncomplicated SAM. Community-based programs have higher coverage rates and the potential to catch cases earlier because CHWs and CHVs actively find cases; these programs present lower opportunity costs for families and caregivers of children with SAM. In many CMAM programs, RUTFs are a major contributor to the cost of treatment, constituting 24 percent to 43 percent of the total cost of treatment per child (Puett and others 2012; Tekeste and others 2012). Exploring the use of local rather than imported constituents could lower their relatively high cost.

LOOKING FORWARD

Addressing Evidence Gaps for Effective Management

Approaches to managing SAM have shifted dramatically since the early 2000s, leading to improvements in coverage rates and treatment outcomes (Collins, Dent, and others 2006; Hall, Blankson, and Shoham 2011; Lenters and others 2013). Greater attention is turning to the need for effective strategies to manage MAM. A remarkable range of specially formulated foods for the management of acute malnutrition has been developed and the need for integrated packages of care that include SAM and MAM management has been increasingly appreciated.

Despite these advances, questions remain with respect to etiology, effective treatment approaches, long-term outcomes, and the most effective modes for implementing and sustaining high-quality programs. Furthermore, interpretations of the existing body of literature are limited by study design issues, as well as by a lack of standardization in measurement and reporting. Box 11.1 highlights key research priorities for the effective management of SAM and MAM.

Enhancing Study Design and Standardizing Reporting

It is also imperative to discuss study design issues in the existing body of literature, as well as issues related to reporting of results. A more coordinated, standardized approach to study design and reporting will enhance the interpretability of individual studies and increase the feasibility of conducting pooled analyses, resulting in a stronger evidence base.

The majority of SAM and MAM trials follow children for a short period and only report on changes during the intervention, providing little insight into what happens after treatment. Studies with a short

Box 11.1

Key Priorities for Enhancing Effectiveness of Severe Acute Malnutrition (SAM) and Moderate Acute Malnutrition (MAM) Management

Research Priorities for Effective Management of SAM

- Develop mid-upper arm circumference cut-offs specific to age: 6–11 months, 12–23 months, and 24–59 months (WHO 2013).
- Understand specialized needs of subgroups (Picot and others 2012; WHO 2013):
  - Identification and management of infants younger than age six months with SAM
  - Treatment and long-term support for children with SAM and human immunodeficiency virus, tuberculosis, or other comorbidities.
- Characterize relapse rates and morbidity later in life through follow-up studies (Hall, Blankson, and Shoham 2011; Lenters and others 2013).
- Understand the etiology of nutritional edema and effective strategies for the management of SAM plus edema (WHO 2013).
- Investigate the role of the microbiome and environmental enteropathy in the development of, and recovery from, acute malnutrition (Petri, Naylor, and Haque 2014).
- Clarify the appropriateness of antibiotics for treatment of uncomplicated SAM (Picot and others 2012; WHO 2013).
- Investigate the efficacy of daily low-dose versus single high-dose vitamin A supplementation in children with SAM who have edema or diarrhea (WHO 2013).
- Establish efficacy and effectiveness of local formulations of therapeutic foods that meet WHO specifications (WHO 2013).
- Determine effective fluid management strategies for children with SAM and dehydration or diarrhea (WHO 2013), as well as effective approaches for managing shock in children with SAM (Picot and others 2012).

Research Priorities for Effective Management of MAM

- Expand understanding of specialized nutrient needs for children with MAM (GNC 2014).
- Investigate effective strategies for improving the home diet using locally available ingredients, where feasible (Lazzerini, Rubert, and Pani 2013), and effective nutrition counseling for the prevention and management of MAM (GNC 2014).
- Investigate effective approaches for management of MAM with diarrhea (Annan, Webb, and Brown 2014).
- Understand specialized needs of subgroups, including identification and management of MAM in infants younger than age six months (Annan, Webb, and Brown 2014).
- Clarify the appropriateness of different specially formulated foods and management strategies for different contexts (GNC 2014).

General Priorities for SAM and MAM Research and Programming

- Define *healthy recovery* and investigate body composition and long-term risk of morbidity in children treated with lipid-based specially formulated foods (Annan, Webb, and Brown 2014).
- Improve national and subnational capacity for accurately and consistently measuring coverage rates of SAM and MAM programs (GNC 2014).
- Enhance active case finding in communities and screening at health centers (WHO 2013).
- Explore whether children experience issues when they make the transition to standard family foods from a therapeutic diet (Hall, Blankson, and Shoham 2011).
- Investigate relative effectiveness and costs of different packages of care that include SAM and MAM management (Lenters and others 2013).
- Investigate effectiveness of seasonal blanket supplementation and other strategies (voucher schemes, cash transfers) for the prevention of SAM and MAM.
- Explore patterns of sharing of specially formulated foods (GNC 2014).
- Conduct research in more locations and contexts to be able to assess regional differences in effectiveness and acceptability of treatment and management approaches (Annan, Webb, and Brown 2014).
- Understand how products are used within community interventions, including rates and patterns of sharing (Annan, Webb, and Brown 2014; GNC 2014).

follow-up time are not able to adequately measure time to recovery, and children who have not recovered by the end of the intervention are simply labeled "nonresponders." This practice fails to give an accurate picture of how long it would have taken for the children to recover—a key element in assessing cost-effectiveness or whether another underlying issue, such as HIV infection, is hindering recovery. Furthermore, most SAM and MAM trials rely on passive recruitment: caregivers bring affected children to a health facility, where they may be recruited into a trial. Thus, study results may not be generalizable and can result in selection bias if the characteristics of caregivers who seek help differ systematically from those who do not bring their children for treatment.

Given the wide range of specially formulated foods for managing SAM and MAM, greater care is needed in trial design to ensure that accurate conclusions are drawn. Intervention arms should be comparable in caloric content and nutrient density, with similar packaging, programming, and promotion associated with the interventions (GNC 2014).

In addition to addressing study design challenges, reporting metrics need to be standardized. The pooling of data in meta-analyses is hindered by variability in the definition of acute malnutrition used across studies as well as the lack of consistent outcome definitions (for example, relapse, nonresponse, and default rates are measured differently across studies). If studies choose to include a mix of children with wasting, stunting, and underweight, disaggregated data should be presented according to type of undernutrition.

The need for standardized metrics extends beyond research and into the programming sphere. There is also a need for programs to standardize enrollment and discharge criteria, and to measure and report program outcomes consistently so that program impacts can be tracked over time and compared between sites (GNC 2014; Hall, Blankson, and Shoham 2011; Lenters and others 2013).

Considering Implementation Research and Integrated Programming

Research has trended toward studying the effectiveness of one specially formulated food versus another through RCTs. Although the relative effectiveness of products is an appropriate field of study, it is important to remember that the products are delivered within the context of a program and that the effectiveness of the treatment depends significantly on the quality of care (Puoane and others 2008). Further implementation research is needed to understand how to effectively deliver high-quality programs to consistently achieve optimal outcomes over a sustained time frame.

Experimental designs are not always feasible given constraints within the context as well as the complexity of the intervention. In such cases, high-quality quasi-experimental studies are an important approach for generating evidence. Additionally, RCTs are not always best suited to answering implementation questions. High-quality studies using quality-improvement methods and observational designs, as well as qualitative research and program reports, are all important investigative approaches.

Additionally, with respect to MAM, it is essential not to lose sight of the need for upstream, integrated approaches in the face of growing interest in specially formulated foods for the treatment of MAM. Lenters and colleagues (2013) conducted a rapid Delphi exercise in tandem with a systematic review and meta-analysis of approaches to managing MAM and found a striking discordance. Intervention trials identified through the systematic literature review all focused on comparing specially formulated food, but a thematic analysis of what experts believe to be the optimal management of MAM demonstrated that a more comprehensive approach is needed. The effectiveness of disease prevention and treatment, WASH interventions, community empowerment, livelihood diversification, and other upstream interventions need to be studied to prevent the development of MAM and its progression to SAM.

The current scientific evidence base and programmatic expertise provide a foundation for making substantial strides toward reducing the prevalence of SAM. However, crucial gaps remain in our understanding of the causes of acute malnutrition; the cost-effectiveness of various treatment approaches, particularly for MAM; and the requirements of particular subpopulations, such as young infants and children with HIV or other serious infections. These gaps and challenges can readily be explored through trials and programmatic research using standardized definitions and metrics. While building the best practices and evidence base for SAM and MAM, it is imperative that effective treatment approaches be considered within context: thus, implementation research on how to deliver and sustain high-quality programs must be given high priority. In addition, research, programs, and policies aimed at addressing the social determinants of health and distal factors that ultimately lead to SAM and MAM must be prioritized.

The global burden of acute malnutrition remains unacceptably high; progress toward reducing the prevalence of SAM and MAM has lagged behind reductions in stunting (Black and others 2013). Programs to reduce SAM are a cost-effective investment that should be given high priority by national governments. Finding the balance of preventive and therapeutic strategies for MAM and SAM in varying contexts is a major global priority and a clear focus of attention on the post-2015 agenda.

NOTES

World Bank Income Classifications as of July 2014 are as follows, based on estimates of gross national income (GNI) per capita for 2013:

- Low-income countries (LICs) = US$1,045 or less
- Middle-income countries (MICs) are subdivided:
  - a) lower-middle-income = US$1,046 to US$4,125
  - b) upper-middle-income (UMICs) = US$4,126 to US$12,745
- High-income countries (HICs) = US$12,746 or more.

This chapter uses the six World Health Organization (WHO) regions: Africa, the Americas, South-East Asia, Europe, Eastern Mediterranean, and Western Pacific.

1. This chapter refers to weight-for-height for simplicity; however note that weight-for-height is used in children 2 to 5 years of age and weight-for-length used in children under age two years.
2. The WHO defines appropriate breastfeeding as early initiation (within the first hour of life) and exclusive breastfeeding on demand for the first six months of life. http://www.who.int/nutrition/topics/exclusive_breastfeeding/en.
3. Appropriate complementary feeding practices, or infant and young child feeding are outlined by the WHO. http://www.who.int/mediacentre/factsheets/fs342/en.
4. LNS may also be formulated as “small-quantity LNS”—these products deliver micronutrients and essential fatty acids in a lipid matrix. The primary intention is to prevent stunting and micronutrient deficiencies.
5. The severity of edema is graded as + (mild: both feet), ++ (moderate: both feet, plus lower legs, hands, or lower arms), or +++ (severe/generalized: both feet, legs, hands, arms, and face) (WHO 2013).

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