

Complications and Outcome of Severe Acute Malnutrition in children under Five in Africa: A Systematic Review

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Abstract

Background: This study aimed to examine the complications associated with Severe Acute Malnutrition (SAM), and the disease outcome in children under five years old in Africa.

Methods: The recommendations of PRISMA 2020 were used for the realization of this systematic review. We searched PubMed, Web of Science, Science Direct, and Google Scholar databases for articles published in English. The search covered all articles conducted in Africa and published between 2010 and 2022. The outcome of SAM was assessed in terms of weight gain, recovery rate, and fatality rate.

Results: Out of 12,553 articles identified, 62 articles met the inclusion criteria for this systematic review. The age range of 6 to 24 months was found to be the most common age group, and marasmus was identified as the most common type of malnutrition. The most frequently encountered complications were diarrhea followed by respiratory tract infections and anemia. The recovery rate was frequently less than 75%, and many studies reported a weight gain of less than 10g/kg/day.

Conclusion: Our work showed that despite the efforts made, SAM is still a major cause of mortality in African children. Such findings highlight the need for implementation of corrective measures that can address this deadly condition.

Key Words: Comorbidity, Mortality, Pediatrics, Recovery, Severe Acute Malnutrition (SAM).

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1- INTRODUCTION

Pediatric malnutrition corresponds to a pathological condition that happens when the right amount of nutrients is not provided by a child's diet (1). The United Nations Children's Fund (UNICEF) once reported that malnutrition and hunger had killed more people worldwide than AIDS, HIV, tuberculosis, and malaria combined (2). Even though pediatric malnutrition is a critical health issue all over the world, it is more debilitating in developing countries such as the African continent.

Among different types of malnutrition, Severe Acute Malnutrition (SAM) is of particular importance as it significantly contributes to child mortality (3). According to the World Health Organization, the number of children who suffer from SAM is about 20 million (4). Despite progress made in achieving the fourth millennium development goal (5), SAM is still responsible for over one million deaths that occur each year in children under five (6), and Africa alone has 5.6 million children with SAM (7).

According to WHO, SAM is referred to as non-edematous (marasmus) when weight for height length is below $-3z$ scores (WHZ) of the median WHO growth standards; or Mid-Upper Arm Circumference (MUAC) is under 115 in children aged 6-59 months. It is called edematous SAM (kwashiorkor), when there is bilateral pitting edema of nutritional origin (8).

While the management of children with SAM has been reported to decrease the Case Fatality Rate (CFR) (9, 10), normalization of metabolic and physiological changes in these children remains challenging since they are at high risk of severe illnesses (11), and most importantly because the majority of them are in resource-limited environments. Numerous research studies on SAM have been carried out in Africa. However, these

studies focus much more on the epidemiological and therapeutic aspect, without a lot of information about the disease complications and outcome. Additionally, these studies are from individual countries and the literature does not provide continental data. Such gaps make the prevalence and prevalent causes of mortality in the context of SAM in the African continent less understood. Especially, the main cause of death in malnourished children is SAM-related complications rather than SAM itself. Therefore, the purpose of this work is to examine the complications associated with SAM, their prevalence, and the disease outcome. Such work can direct the implementation of corrective measures. Moreover, it can provide updated and complete data regarding the impact of SAM on childhood mortality in the African continent.

2-MATERIALS AND METHODS

2-1. Design

This systematic review followed the PRISMA recommendations (12) (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes) throughout this review. We searched PubMed, Web of Science, Science Direct, and Google Scholar databases for articles published in English. The search covers all articles conducted in Africa and published between 2010 and December 2022. The year 2010 was chosen as the starting date due to the reported increase of undernourished people in sub-Saharan Africa between 2010 and 2016 (13). Using the references of the selected articles, manual searches were carried out to find other relevant studies. We used the following combined keywords for the search:

(Severe acute malnutrition * OR undernourished * OR marasmus * OR kwashiorkor OR SAM * AND mortality *

AND infant mortality * AND complications)

2-2. Inclusion and exclusion criteria

The inclusion criteria were: (1) studies focusing on children under five suffering from SAM as defined by the World Health Organization (8); (2) studies evaluating the complications and outcome of SAM as assessed by weight gain, recovery rate, and fatality rate. (Outpatient Therapeutic Centers (OTCs) are considered successful when recovery rate is more than 75%, CFR less than 10%, default rate less than 15%, and weight gain greater or equal to 5g/kg/day (4). Inpatient treatment of SAM is assessed by Case Fatality Rate (CFR) and weight gain during the rehabilitation phase. In terms of CFR, treatment is considered unacceptable if $CFR > 20\%$, poor if CFR is between 11-20%, moderate if CFR is between 5-10%, and good if $CFR < 5\%$). In terms of weight gain, inpatient treatment is poor if weight gain is $< 5\text{g/kg/day}$, moderate if weight gain is between 5-10g/kg/day, and good if $> 10\text{g/kg/day}$) (15) (3) Studies conducted in Africa; (4) studies published between 2010-December 2022; and (5) studies published in English.

The exclusion criteria were: (1) cross-sectional studies; (2) unpublished studies; (3) gray literature; (4) reviews; and (5) non-human studies.

2-3. Data extraction

An assessor made the initial stock selections using a screening form. The removal of duplicates was done using the EndNote library. Two separate reviewers reviewed the titles and abstracts; this is the first phase of our selection. After a complete reading, articles meeting the inclusion criteria were selected. Discrepancies were resolved by discussion with a third reviewer. We established data extraction forms, which were tested and

then used on all studies. The standardized data extraction form containing details of the results of our study is available in Supplemental digital content 1 (S1). The studies will be grouped by country into SSA sub-regions (West Africa, East Africa, Southern Africa and Central Africa) on the basis of the United Nations (UN) system classification and by year of publication. The outcome of SAM will be assessed in terms of weight gain, recovery rate, and fatality rate.

2-3 Bias assessment

The risk of bias was assessed by the Joanna Briggs Institute (JBI) checklist for cross-sectional analytical studies (16). Two reviewers independently assessed the articles selected for this review, and discrepancies were resolved by discussion or by the third reviewer if no consensus could be found. The selected studies' quality assessment is presented in Supplemental digital content 2 (S2). According to the JBI-MAStARI, these studies were of high quality.

3- RESULTS

Our database search identified 12,553 articles. 8770 articles were retained after the deletion of duplicates. The reading of the titles and abstracts made it possible to exclude 8675 articles. Reading the full text of the remaining 95 articles allowed the exclusion of another 43 articles. Finally, 52 articles meeting the inclusion criteria were selected.

The reverse search performed on the 52 selected articles enabled us to find another 10 articles that met the inclusion criteria by searching for the terms in the bibliographical references of the selected articles. Thus, a total of 62 articles are selected for the review.

The representative search design and number of eligible studies are shown in Fig. 1.

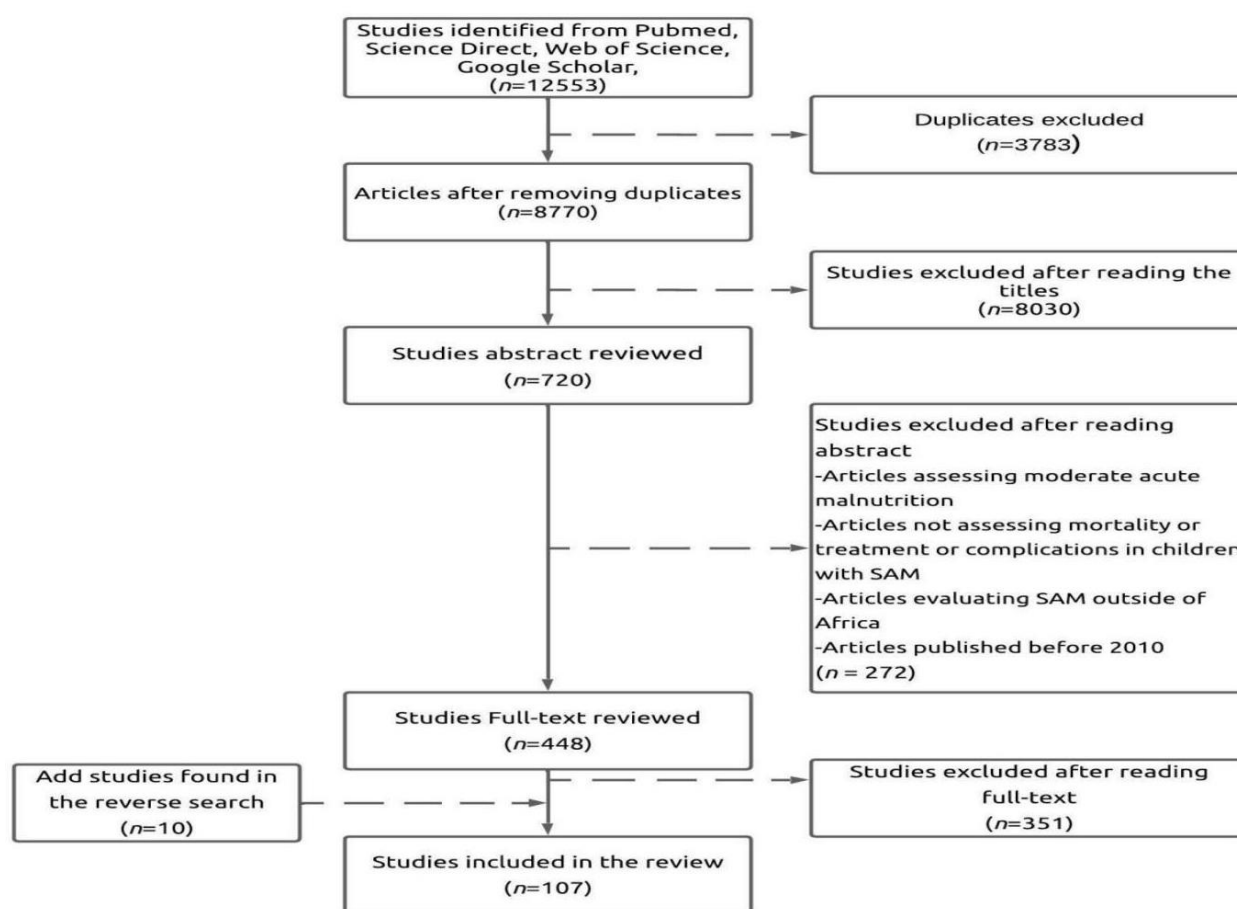


Fig. 1: Flowchart for the selection of studies based on the PRISMA 2020 guidelines

3-1. Characteristics of Included Studies

In this systematic review, one study was carried out in North Africa, two in Central Africa, nine in West Africa, eight in South Africa and forty-two in East Africa. Of these 62 studies, 11 were conducted in outpatient, while 50 were in inpatient settings. The remaining 1 study was conducted in both inpatient and outpatient facilities.

The sample size ranged from 67 to 9540 children, and children's age ranged from 0 to 5 years. Complications, recovered rate, mortality rate, and weight gain were reported by 62, 36, 62, and 21 articles, respectively. Of 62 articles that described complications, 4 evaluated subgroups of children with SAM (HIV (n=2), Infections (n=1), and Diarrhea (n=1)).

3-2. Evidence from Reviewed Studies

Table 1 shows the complications and rates (recovery, mortality, cured) of SAM. It also presents the inclusion criteria, the exclusion criteria and the objectives of the studies.

3-2.1. Distribution of SAM

The age group of 6-24 months was the most common age group for SAM. 64% of the articles found a male predominance and 70% of the included articles found marasmus to be the most frequent form of malnutrition.

3-2.2. Survival status of SAM

Among the 11 outpatient-based research studies, only 4 have found a recovery rate greater than 75%, and 7 found a recovery rate lower than 75%.

Table 1. Supplemental digital content 1 (S1): Summary of selected studies.

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
1-North Africa					
Hassan B, et al. Morocco 2013 (17)	-93 children aged 6–59 months -Inpatient	Aims to compare the effects of short-term phase of nutrition rehabilitation (21 days) in marasmus and kwashiorkor children, on catch-up growth.	Children with under 60% of expected weight are defined as marasmus in the absence of oedema, kwashiorkor if oedema is present and marasmic-kwashiorkor if oedema is present.	-Hypoglycemia -Hypothermia -Dehydration -Infections -Electrolyte Imbalance	-Recovered: 84.33 -Mortality :15.66 -Weight gain: 7.16 ±0.62
2-Central Africa					
Ndzo J.A., et al. Cameroon 2018 (4)	-254 children aged 6–59 months -Outpatient	Aims to retrospectively assess the outcomes (Rates of weight gain (RWG), rates of recovery, default rate and case fatality rate (CFR)) for a cohort of children aged 6–59 months diagnosed with uncomplicated SAM.	WHZ score < – 3 or MUAC < 115mm or bilateral pitting oedema	-Poor weight gain (44.1%) -Anorexia (26.5%) -Infections (26.5%), -Persistent oedema -Diarrhea -Malaria	-Recovered: 72.8 -Mortality: 0.8 -Weight gain:4.4
Sinanduku J.S., et al. DRC 2020 (18)	-173 children aged 6 to 59 months -Inpatient	Aims to describe the socio-demographic, clinical and outcomes characteristics of children under five years hospitalized in the Intensive Therapeutic Nutrition Unit of Sendwe Hospital in Lubumbashi.	MUAC<115mm and/or Weight for WHZ<–3 standard deviations (SD) and/or presence of bilateral oedema	-GTI (30.6%) -Severe anemia (27.75%) -lung infections (11.56%), -Malaria, -Tuberculosis and -HIV infection	-Cured: 76,3 -Mortality : 9.83
3-West Africa					
Madec Y., et al. Niger 2011 (19)	-477 Children aged 0-59 months -Inpatient	Aims to evaluate the prevalence of HIV among children hospitalized for severe malnutrition at the Niamey national hospital, and to compare	70% weight for height or oedema of both feet and clinical signs of severe malnutrition	-Malaria (24.7%) -Pneumonia (24.2%) -GTI (18.2%) -HIV	-Recovered: 76.7 -Mortality : 16.7

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
		nutrition and mortality by HIV-status.		-Anemia	
Page A.L., et al. Niger 2013 (20)	-311 aged 6 to 59 months with complicated SAM -Inpatient	to assess the case fraction, etiology and clinical characteristics of invasive bacterial infection, malaria, respiratory and urinary tract infection and infectious diarrhea among children admitted with complicated SAM	WfH less than 3z-score of the median WHO growth standards and/or MUAC < 110mm and/or bipedal edema	-RTI (17.7%) -GTI (13.2%) -Malaria (8.4%) -Anemia -HIV	-Mortality: 9
Akparibo R., et al. Ghana 2016 (21)	488 children aged 6–59 months -Outpatient	An aim was to assess the performance of the CMAM approach to treat SAM within routine community health care services in a non-emergency context.	Children aged 6–59 months old who had MUAC ≤ 11.5cm.	-Malaria (17.6%) -Diarrhea (8.2%) -Anemia (0.6)	-Recovered: 71.0 -Mortality: 2.0 -Weight gain: 4.7
Alvarez Morán J.L., et al Mali 2018 (22)	235 children aged 6–59 months (control group) 699 children aged 6–59 months (intervention group) -Outpatient	Aims to investigate the potential of integrating SAM identification and treatment delivered by CHWs, in order to improve the coverage of SAM treatment services.	MUAC < 115mm; Bilateral oedema or Weight for Height (WHZ) < -3Z-score	-Malaria	-Cured: control group (94.2), intervention group (88.6) -Mortality: control group (0.8), intervention group (0.9)
Obani K.O., et al Nigeria 2019 (23)	171 children aged 6–59 months -Inpatient	Aims to determine the prevalence of severe acute malnutrition and outcomes of severely malnourished children 6 – 59 months old admitted to Magumeri General Hospital	All children with age between 6 and 59 months admitted with severe acute malnutrition (with co-morbidities like malaria, gastroenteritis, anaemia and measles).	-Diarrhea disease (55.6%) -URTI (33.9%) -Malaria (23.4%) -UTI -Dermatitis	-Recovered: 82 -Mortality: 3
Chamla D., et al. Nigeria 2019	396 children aged 6 – 59 months -Outpatient	To present evidence on the burden and outcomes of co-morbidities among severely malnourished	A child with measurement of less than 115mm, which corresponded to red color in the MUAC tape,	-Pneumonia -Diarrhea -Malaria	-Recovered: 57.8 -Mortality: 5.1

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
(24)		children in the conflict setting of Borno.	with or without medical complications	-Dehydration -HIV	
Aliyu I., et al. Nigeria 2020 (25)	123 Children aged 0-59 months -Inpatient	Aims to determine the clinical profile of children admitted with MAM and SAM. Determine the outcome of children admitted with MAM and SAM.	MUAC <11.5 cm or a weight-for-height/length <-3 Z scores aged 6-59 months – or nutritional edema	-Infection (73.17%) -Electrolyte derangement (64.22%) -Diarrhea (61.80%) -Hypoglycemia, -Hypothermia -HIV infection	-Recovered: 62 -Mortality : 8.9
Compaoré E.W.R., et al Burkina Faso 2021 (26)	377 Children aged 0-59 months -Outpatient/ Inpatient	Aims to assess main causes of the abandonment of care and the most predictive factors associated with the mortality of severe acute malnourished children under five years old in the sanitary district of Gorome Gorom.	CRNE: P/T<-3Z-score or a PB<115mm with complications who were declared cured or abandoned at the exit. CHSP: P/T<-3Zscore or; a PB<115mm but without complications and declared cured or abandoned at the exit.	-Diarrhea (44.4%) -Malaria (24.3%) -Anorexia -Lethargy (9%) -Septic shock -Oral candidiasis -Dehydration -Strict anemia	-Cured : CHSP 74.2, CRNE 79.9 -Mortality : CRNE 9.72, CHSP 1.2
Seck N., et al Senegal 2021 (27)	-67 children aged 6 – 59 months -Inpatient	The overall objective was to describe the management of severe acute malnutrition (SAM) in children six months to five years of age	A weight-for-height ratio of less than -3 standard deviations according to the WHO growth charts; and/or MUAC less than 115 mm; and/or the presence of nutritional-type edema in the lower and/or upper limbs.	-Infections (85%) -Anaemia (74.6%) -Severe acute Dehydration (40.3%) -HIV -Hypoglycemia	-Cured: 73.1 -Mortality : 3 -Weight gain: 8.9
4-Southern Africa					
Irena A.H.,et al. Zambia 2011 (28)	-430 children aged 6-59 months -Inpatient	To analyze data of children admitted to the Zambia University Teaching Hospital's in patient unit to identify the prevalence of diarrhea and HIV infection and assess their effect on	The presence of bilateral pitting edema and/or weight for height Z-score<-3 standard deviations	-Diarrhea (67.3%) -HIV (38.9%) -TB -Dehydration	-Recovered: 53.7 -Mortality : 40.5

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
		treatment outcome.			
Benyera O., et al. Swaziland 2013 (29)	-227 children aged 6-59 months -Inpatient	To determine the case fatality rate for childhood malnutrition after implementation of the WHO treatment guidelines.	WHZ <-3 and/or MUAC<11.5 cms and/or nutritional oedema	-Pneumonia -Gastroenteritis -HIV -TB -Herbal intoxication	-Mortality : 40.1
Munthali T., et al. Zambia 2015 (30)	-9540 children aged 0- 60 months -Inpatient	Aims to determine morbidity and mortality patterns and to investigate factors that could be associated with severe acute malnutrition among under five children attending UTH from 2009 to 2013.	Presence of bilateral pitting edema and/or weight for height Z- scores (WHZ)<-3 standard deviations	-Diarrhea (29.8%) -Pneumonia (25.3%) -Anemia (11.6%) -HIV -TB	-Mortality : 46
Muzigaba M., et al. South Africa 2017 (31)	454 children aged 6 - 60 months -Inpatient	To determine baseline clinical characteristics among children with SAM and assess whether HIV infection, disease stage, critical illness at baseline and other comorbidities independently and interactively contributed to excess mortality in this sample.	WHZ <-3 and/or mid-upper arm circumference (MUAC) <11.5 cms and/or nutritional oedema	-HIV (43.2%) -Dermatosis (12.1%) -LRTIs (Lower respiratory tract infection) (28.9%)	-Recovered: 75.6 -Mortality : 24.4
Tripoli F.M., et al. Angola 2021 (32)	163 children aged 6 - 59 months -Inpatient	Aims to investigate potential prognostic factors in the clinical evolution of acute malnutrition	MUAC<115mm and/or WHZ<-3 SD and/or presence of bilateral pitting oedema	-Tuberculosis -sickle cell disease -Encephalopathy -HIV -Tuberculosis+HIV	-Mortality : 11.7
Wen B., et al. Kenya and Malawi 2021 (33)	843 aged 6-156 months -Inpatient	Aims to determine the prognostic value of monitoring clinical signs on a daily basis for assessing mortality risk during hospitalization in children with SAM.	MUAC<11.5cm (forage<60 months) or WHZ <-3 (forage <60 months) or BMI for-age Z score <-3 (for age ≥60 months) or bilateral pitting edema with either	-Anorexia (58.2%), -Diarrhea (42.1%), -Hypothermia (5.5%), -Hypoglycemia, -Severe pneumonia,	-Recovered: 83.7 -Mortality : 16.3

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
			medical complications	-Cerebral palsy,	
Mandla N., et al. South Africa 2021 (34)	1 296 children aged 6 – 59 months -Inpatient	Aims to assess the prevalence of SAM at Dora Nginza Hospital, assess outcomes of children with SAM at the institution, determine factors associated with SAM and determine the role of SAM-associated co-morbidities	WHZ less than -3 Z score, and/or MUAC of less than 115mm, in children aged 6–59 months and/or with nutritional oedema	-Anaemia (78%) -LRTIs (77%) -Diarrhoea (51%) -HIV -Tuberculosis -Sepsis	-Mortality : 6.5
Bwakura-Dangarembizi M., et al. Zambia and Zimbabwe 2021 (35)	755 children aged 0–59 months -Inpatient	Aims to ascertain patterns and factors associated with hospital readmission, nutritional recovery and morbidity, in children discharged from hospital following management of complicated SAM	WHZ <-3, MUAC<115 mm and/or the presence of nutritional oedema in children above 6 months of age (and WHZ<-3 or nutritional oedema in those below 6 months)	-HIV -Diarrhea -TB -Anemia -Cerebral palsy	Mortality: 9.4
5-East Africa					
Gebremichael D.Y., et al. Ethiopia 2015 (36)	420 children aged 6-59 months -Inpatient	Aims to estimate nutritional recovery time determine the contextual factors of nutritional recovery rate and assess effectiveness of TFCs compared to minimum international standard set for management of SAM.	W/H was <70% of the median WHO growth standard, or if the MUAC was found to be less than 11cm, or children with bilateral pedal edema	-Diarrhea (53.1%) -Malaria (28.8%) -Pneumonia(20.5%) -Hypoglycemia -Hypothermia -Severe anemia	-Cured: 82.4 -Mortality: 9.3
Jarso H., et al Ethiopia 2015 (37)	947 children aged 0-59 months -Inpatient	Aims to assess survival status and predictors of mortality in severely malnourished children admitted to Jimma University Specialized Hospital	Infants less than 6 months or less than 3kg being breast-fed were admitted if too weak or feeble to suckle effectively or if they had W/L less than 70% or bilateral oedema. Children 6 months to 18 years were admitted if they had W/H or W/L<70% or	-Pneumonia (49%) -Acute gastroenteritis (16.3%) -UTI (16.3%) -TB -HIV -Hypothermia -Anemia	-Cured: 77.8 -Mortality: 9.3 -Weight gain:10.4

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
			MUAC<110mm with a length>65cm or bilateral pitting oedema	-Dehydration -Diarrhea -Skin lesions	
Shanka N.A., et al. Ethiopia 2015 (38)	711 children aged 1–5 years -Outpatient	Aims to assess the success rate of OTP in treatment of children with SAM and identify its determinants at Kamba district, South West Ethiopia.	A weight-for-height measurement of 70% or more below the median, or three SD or more below the mean National Centre for Health Statistics reference values, which is called “wasted”; the presence of bilateral pitting oedema of nutritional origin, which is called “oedematous malnutrition”; or a MUAC of less than 110 mm in children age 1–5 years	-Diarrhea (18%) -Anemia (0.5%) -Skin infections (0.3%)	-Recovered: 67.7 -Mortality: 1.7 -Weight gain: 5.76
Massa D., et al. Ethiopia 2016 (39)	332 children aged 6 to 59 months -Outpatient	Aims to describe the treatment outcomes of out-patient therapeutic feeding program and to identify their determinants prospectively	Kwashiorkor: the presence of any bilateral pitting edema. Marasmus: weight for height ≤ -3 z scores or ≤ 70% of the median NCHS reference W/H. Marasmus kwashiorkor: weight for height ≤ -3 z scores or ≤ 70% of the median NCHS reference weight-for-height and bilateral pitting edema.	-Diarrhea -Dehydration	-Recovered: 76.8 -Mortality: 0.6 - Weight gain:8.3+-3.7
Kanan S.O.H., et al. Sudan 2016 (40)	593 children aged 6 to 59 months -Inpatient	Aims to determine the prevalence of acute severe malnutrition, and outcomes of severely malnourished children less than five years old admitted to Omdurman pediatrics	All children with age less than 5- year-old admitted to Omdurman Pediatric hospital with severe malnutrition	-Gastroenteritis -Malaria -Anemia -UTI -Giardiasis	-Recovered: 75.7 -Mortality: 9.3

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
		Hospital			
Nyeko R., et al. Uganda 2016 (41)	251 children aged 6-59 months -Inpatient	Aims to determine the treatment outcomes among severely malnourished children admitted at St. Mary's hospital Lacor	Weight-for-height/length < -3 z- score and/or mid upper arm circumference (MUAC) <11.5 cm, or presence of bilateral pitting pedal oedema	-HIV -Hypothermia -Diarrhea -Oral thrush -Dehydration	-Cured: 66.9 -Mortality: 11.9
Kabeta A., et al. Ethiopia 2017 (42)	196 children aged 0-59 months -Inpatient	Aims to assess treatment outcome and associated factors among under- five children with severe acute malnutrition admitted to therapeutic feeding unit of Yirgalem Hospital	MUAC<115mm and/or WHZ<-3 SD and/or presence of bilateral pitting oedema	-Diarrhea (64.4%) -Pneumonia (43%) -TB Co-infection (14.1%) -Anemia -Dermatosis	-Cured: 78 -Mortality : 16.2 -Weight gain:9.5
Yohannes T., et al. Ethiopia 2017 (43)	500 children aged 0-59 months -Inpatient	Aims to investigate morbidity and mortality trends and factors associated with mortality of under- five children admitted and managed for severe acute malnutrition	Infant less than 6 months or less than 3kg: the infant is too weak or feeble to suckle effectively or W/L less than 70% or Presence of bilateral oedema. Infant 6 months to 59 months: W/H or W/L<70% or MUAC<110mm with a Length>65cm or Presence of bilateral pitting oedema	-Pneumonia (33.1%) -AGE (21.9%) -Diarrhoea (11%) -Acute febrile illness -TB -Anaemia -Conjunctivitis -Malaria -Intestinal parasite	-Mortality: 7
Kabalo M.Y., et al. Ethiopia 2017 (44)	794 children aged 0-59 months -Outpatient	Aims to assess treatment outcomes of SAM and identify factors associated among children treated at OTP in Wolaita Zone.	MUAC<11.5cm, nutritional edema is +/+++, they passed the appetite test, and no medical complications identified	-Dehydration (12.6%) -Diarrhea (4.8%)	-Recovered: 64.9 -Mortality: 1.2 -Weight gain:4.2
Mekuria G., et al. Ethiopia 2017 (45)	253 children aged 6-59 months -Inpatient	Aims to assess treatment outcome and associated factors of SAM recovery among 6-59 months old children in Debre Markos and Finote	WFH<70% or WFH less than -3 Z-score or WFL<70% or WFL less than -3 Z-score or MUAC<110 mm with	-Diarrhea (28.2%) -Pneumonia (23.3%) -Anemia (18.4%,) -TB	-Recovered: 77.9 -Mortality: 5.5

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
		Selam Hospitals.	length>65cm or presence of bilateral pitting edema/complication treated	-HIV -Dehydration	
Girum T., et al. Ethiopia 2017 (46)	545 children aged 0-59 months -Inpatient	Aims to assess survival status and identify predictors of mortality among children <5 years of age with SAM in SCs of Gedeo Zone	A very low WFH (below -3z scores of the median WHO growth standards, or <70% of the median National Center for Health Statistics standard) and by the presence of nutritional edema or MUAC<11.5 cm for age 6- 59 months	-Diarrhea (57.6%) -Pneumonia (27%) -Hypothermia (16.9%) -Dehydration -Shock -Anemia -Malaria -TB	-Cured: 59.7 -Mortality: 9.3 -Weight gain: 8.7
Tirore M.G., et al. Ethiopia 2017 (47)	195 children aged 6-59 months -Inpatient	Aims to assess the survival status and treatment outcome of patients with severe acute malnutrition and to identify contributing factors for poor treatment outcome.	A very low WFH less than - 3 standard deviations below the median reference population or WFH ratio of below 70%, visible severe wasting or presence of nutritional edema (pitting edema) or a MUAC less than 11cm	-Diarrhoea (67.2%) -Dehydration (44.6%) -Anemia (43.1%) -TB -AFI (Acute Febrile Illness) -RVI	-Cured: 22.1 -Mortality: 3.6
Rytter M.J.H., et al. Uganda 2017 (48)	120 children aged 6-59 months -Inpatient	Aims to assess risk factors for death in children who were treated formal nutrition in a hospital	A weight-for-height z score<-3 with the use of the WHO Growth Standard, a MUAC<11.5cm, or bilateral pitting edema	-Diarrhea -HIV -Oral thrush -Dehydration	-Mortality: 14
Asres D.T., et al. Ethiopia 2018 (49)	401 children 6-59 months of age -Inpatient	Aims to determine recovery time from severe acute malnutrition and identify predictors among children of 6-59 months of age	Weight for height ratio of less than-3 standard deviations or weight for height ratio of below 70% or MUAC<110mm or presence of nutritional edema	-Anemia (64.8%) -Diarrhea (52.6%) -Pneumonia (28.9%) -TB -HIV	-Recovered: 51.9 -Mortality: 4.2 -Weight gain: 8
Derseh B., et al. Ethiopia 2018	413 children aged 1-59 months -Inpatient	Aims to assess the comorbidity, treatment outcome and factors affecting the recovery rate of children	(Age>6 months to 59 months) were Weight/Height value<70% or MUAC<110 mm or children	-Pneumonia(54.8%) -Diarrhea (41.8%)	-Recovered: 55.9 -Mortality: 5.8 -Weight gain: 15.61

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
(50)		aged 1-59 months with SAM	having bilateral pitting edema. (Participants less than 6 months) too weak to suckle breast milk or weight/length<70% or presence of bilateral edema.	-Rickets (21.4%) -Anemia -Hypothermia -HIV -TB	
Guesh G., et al. Ethiopia 2018 (51)	569 children aged 6-59 months -Inpatient	Aims to assess survival status and predictors of mortality among children with severe acute malnutrition admitted to stabilization centers of general hospitals in Tigray region	A very low WFL/WFH below -3 z scores of the median WHO growth standards, or less than 70% of the median National Center for Health Statistics standard or the presence of nutritional edema	-Diarrhoea (44.1%) -Pneumonia (25.2%) -Dehydration (23.7%) -Skin lesions -shock -Anemia	-Cured: 82 -Mortality: 3.8
Wagne F., et al. Ethiopia 2018 (52)	527 children aged 6-59 months -Inpatient	Aims to assess the potential predictors of mortality among under- five children with SAM admitted to a stabilization center.	weight for height below -3 z scores of the median WHO growth standards or presence of bilateral edema or MUAC<115mm for a child ≥6 months age	-Diarrhea (38.71%), -Pneumonia (18.04%) -TB (9.68%) -Anemia, -Shock	-Recovered: 67.7 -Mortality: 12.52 -Weight gain:29.1
Nabukeera-Barungi N., et al. Uganda 2018 (53)	400 children aged 6-59 months -Inpatient	Aims to determine the predictors of mortality among children admitted with severe acute malnutrition (SAM)	MUAC< 11.5 cm or weight-for- height z-scores <-3 SD or bipedal pitting oedema	-Diarrhea (61%) -Septicaemia (24%) -Severe pneumonia(17%) -HIV -TB -Malaria	-Recovered: 81.8 -Mortality: 9.8
Abate H.K., et al. Ethiopia 2019 (54)	826 children aged 6-59 months -Inpatient	Aims to identify the prevalent cause of mortality in Severe Acute Malnutrition, among children aged 6- 59 months, admitted to Hiwot Fana Specialized University Hospital,	MUAC<115mm and/or a weight- for-height z score (WHZ) less than 3 of the median WHZ in WHO Child Growth Standards. All children 6-59 month with	-AGE -Pneumonia -Severe Anemia -Hypoglycemia -Hypothermia	-Recovered: 36 -Mortality: 2.1

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
		Pediatric ward, Nutrition Rehabilitation Unit from 2013 to 2015.	bilateral pitting edema, and/or MUAC<115mm will be admitted to the NRU.	-Diarrhea -Sepsis	
Hassen S.L., et al. Ethiopia 2019 (55)	414 children 0–59 months of age -Inpatient	Aims to estimate the survival status and its determinants among under- five children with severe acute malnutrition admitted to inpatient therapeutic feeding centers	W/H<70% of the median WHO growth reference, or if the MUAC less than 11cm, or children with bilateral pedal edema	-Pneumonia (44.1%) -Diarrhea (40.4%) -Skin or ear infection (10.3%) -Dehydration -Malaria	-Recovered: 75.4 -Mortality: 3.4
Atnafe B., et al. Ethiopia 2019 (56)	713 children aged 6–59 months -Outpatient	Aims to fill gaps by assessing the magnitude of recovery rate, the median time of recovery from SAM and factors affecting time recovery	Weight-for-height z-scores of<-3 or MUAC<110mm. Childrens may also present with nutritional edema characterized by a swollen face, feet and limbs.	-Diarrhea (31.1%) -Anemia (25.4%) -Superficial skin infection or skin peeling (0.7%) -HIV -TB	Recovered: 79.8 -Mortality: 0.6 -Weight gain: 6
Wagnew F., et al. Ethiopia 2019 (57)	416 children aged 6–59 months -Inpatient	Aims to determine treatment cure rate and its predictors among children aged 6–59 months with SAM admitted to a stabilization center.	weight for height below -3 z scores of the median WHO growth standards or presence of bilateral edema or MUAC<115mm for a child≥6 months age	-Dehydration (33.2%), -Pneumonia (20.6%) -TB (15.9%) -Kwash-dermatosis -Anemia	-Cured: 69.2 -Mortality: 10.8
Desyibelew H.D., et al. Ethiopia 2019 (58)	401 children aged 6–59 months -Inpatient	Aims to determine mortality rate, time to death and factors affecting the time to death among children with SAM admitted to therapeutic feeding unit of Felege Hiwot Referral Hospital, Bahirdar.	A nutritional bilateral pitting edema and/or weight for height Z- scores (WHZ) < - 3 standard deviations	-Pneumonia (39.2%) -Diarrhea (36.2%) -TB -HIV -URTI	-Mortality: 8.47
Fikrie A., et al. Ethiopia	420 children aged 6–59 months	Aims to assess treatment outcome and factors affecting recovery time	Children 6–59 months with<-3 z- scores, and/or MUAC<11.5 cm,	-Diarrhea (46.7%) -Pneumonia (41.5%)	-Recovered: 69.3 -Mortality: 10.8

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
2019 (59)	-Inpatient	from SAM among 6–59 month's old children in HUSCH.	and/or bilateral pitting nutritional oedema	-TB -Anemia -HIV	-Weight gain: 12.7
Bilal J.A., et al. Sudan 2020 (60)	404 children aged 6-59 months -Inpatient	Aims to determine the outcomes of children with SAM ages 6–59 months admitted for inpatient management to Singa Hospital in central Sudan	All children whose MUAC was <115 mm	-Diarrhea (52.6%) -Infections (45.7%) -Malaria (34.8%) -Pyuria -Dermatoses	-Recovered: 89.1 -Mortality: 3.7
Gebremedhin K., et al. Ethiopia 2020 (61)	402 children aged 6–59 months -Outpatient	Aims to identify predictors of time-to-recovery from SAM among children treated at an OTP in health posts of Arba Minch Zuria woreda, Gamo Zone, Southern Ethiopia.	MUAC<115mm and/or WHZ<-3 SD and/or presence of bilateral pitting oedema	-Diarrhea (33.83%) -Pneumonia (17.66%) -Anemia (11.19%) -Malaria -Dermatosis	-Recovered: 70.40 -Mortality: 1.49
Tesfay W., et al. Ethiopia 2020 (62)	564 children aged 0–59 months -Inpatient	Aims to assess length of stay to recover from severe acute malnutrition and associated factors among under five children hospitalized to the public hospitals in Aksum Tow	Infants <6 months of age or <3 kilogram with median WLH of<70% and/or presence of bilateral pitting edema, or visible severe wasting. Children aged 6–59 months with median WLH<70%, and/or bilateral pitting edema, or MUAC<11Cm	-HIV (60.9%), -Diarrhea (42.7%) -Anemia -Pneumonia -TB -Malaria -Skin lesion	-Cured: 56 -Mortality: 6 -Weight gain:10.1
Abate B.B., et al. Ethiopia 2020 (63)	600 children aged 0–59 months -Outpatient	Aims to assess the treatment outcome of SAM and associated factors among under-five children in the outpatient therapeutics unit.	Records of children under-five years at outpatient therapeutic feeding units.	-Diarrhea (12.8%) -HIV (2%) -TB (2%)	-Recovered: 65.0 -Mortality: 2.0

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
Adem F., et al. Ethiopia 2020 (64)	133 children aged 6–59 months -Inpatient	Aims to evaluate the nutritional recovery rate and its associated factors in children under five years of age with SAM	Children/infants with WFH<-3 Z score or MUAC<11.5cm with length>65cm at admission, and children who had bilateral nutritional pitting edema with any complication	-Diarrhea -Malaria -Tuberculosis -Anemia -Hypoglycemia -HIV	-Recovered: 25.6 -Mortality : 3.8 -Weight gain>5
Negussie A.S., et al. Ethiopia 2020 (65)	259 children aged 6–59 months -Inpatient	Aims to examine predictors of undesirable treatment outcomes of severely malnourished children hospitalized	Weight-for-height/length ratio<70% of median or less than- 3Z-score, MUAC<110mm with Length >65 cm, Presence of bilateral pitting edema with medical complications or a fail in the appetite test	-Diarrhea (55.5%) -Pneumonia (39.6%) -Anemia (29.5%) -HIV -TB -Sepsis -Gastroenteritis	-Cured: 70.4 -Mortality: 12.2 -Weight gain: 8.13
Hussen Kabthyer R., et al. Ethiopia 2020 (66)	375 children aged 6–59 months -Inpatient	Aims to estimate time to recovery and to determine predictors of time to recovery among children aged 6–59 months with severe acute malnutrition.	Weight for height < 70% NCHS median or a low MUAC <110 mm or if there is bilateral pitting edema	-Diarrhea (71.5%) -Anemia (42.4%) -Pneumonia (29.6%) -Dehydration -TB	-Recovered: 73.1 -Mortality: 12.3
Wondim A., et al. Ehiopia 2020 (67)	398 children aged 6-59 months -Inpatient	Aims to assess time to recovery from SAM and its predictors among admitted children aged 6-59 months at the therapeutic feeding center of Pawi General Hospital	W/H was <70% of the median WHO growth standard, if the MUAC was found to be less than 11cm, or if the children had bilateral pedal edema	-Dehydration (52.3%) -Diarrhea (52%) -Pneumonia (49%) -Anemia -Malaria	-Recovered: 65.8 -Cured: 27.1 -Mortality: 9.6
Tefera T.K., et al. Ethiopia 2020 (68)	341 children aged 6-59 months -Inpatient	Aims to assess the time to recovery and its predictors among children 6– 59 months with severe acute malnutrition admitted to public hospitals in East Amhara -inpatient	Weight for height (below-3 z scores of the median WHO growth standards, or below 70% of the median of the National Centre for Health Statistics standard) and by the presence of nutritional edema. In children 6–	-Pneumonia (34.3%) -Diarrhea (31.9%) -Anemia (18.8%) -HIV -TB -Dermatosis -CHF.	-Recovered: 74.49 -Mortality: 5.28 -Weight gain:>5

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
			59 months of age, a MUAC less than 11.5cm		
Budul A.B., et al. Ethiopia 2020 (69)	350 children aged 6 to 59 months -Outpatient	Aims to assess treatment outcomes of severe acute malnutrition and associated factors among children treated at outpatient program in Gursum woreda	MUAC <11.5, nutritional edema is +/+++, passed the appetite test, and no medical complications	-Diarrhoea (12.9%) -Anemia (4.6%)	-Recovered: 81.7 -Mortality: 0 -Weight gain: 3.8
Nduhukire T., et al. Uganda 2020 (70)	122 children aged 0-59 months -Inpatient	Aims to determine the in hospital mortality and its associated factors among U5s admitted with SAM	A weight for length z score < -3SD, MUAC of <11.5 cm or bilateral edema	-Diarrheal illness(41.2%) -Pneumonia (26.8) -Malaria (26.8%) -Severe dehydration -Shock -Hypothermia -Severe Anemia	-Mortality: 10.7
Banga D., et al. Uganda 2020 (71)	338 children aged 6-59 months -Inpatient	Aims to determine the proportion of mortality, the comorbidities, and factors associated with in-hospital mortality among children under five years of age admitted with SAM at Jinja Regional Referral Hospital	All children under five years of age admitted with SAM in the nutritional unit of Jinja Regional Referral Hospital	-Dehydration (37.9) -Pneumonia (37.6) -Malaria (25.7%) -Diarrhea -HIV	-Recovered:85.5 -Mortality: 14.5
Bitew Z.W., et al. Ethiopia 2021 (72)	610 children aged 0-59 months -Inpatient	Aims to identify the incidence density rate of mortality and determinants among under-five children with severe acute malnutrition in St. Paul's Hospital Millennium Medical College, 2012 to 2019.	weight for height < 70% or weight for height Z-score < -3, MUAC<115mm, bilateral pitting edema or presence of visible severe wasting among children under 6 months of age	-Diarrheal disease (56.6%) -Pneumonia (51.8) -Anemia (47%) -Dehydration -HIV/AIDS	-Recovered: 74.6 -Mortality : 10
Oumer A., et al. Ethiopia	665 children aged 0-59 months	Aims to assess the predictors of death from complicated severe acute	MUAC <11.5 cm and/or a WFH Z-score less than -3	-Diarrhea (60.3%) -Dehydration (46.6%)	-Recovered: 67.5 -Cured: 11.1

Author Country Year (Ref.)	Age of children Sampling and treatment setup	Objective of study	Admission Criteria: Inclusion criteria	Complications and comorbidities	-Recovered (%) -Cured (%) -Mortality (%) -Weight gain(g/kg/day)
2021 (73)	-Inpatient	malnutrition among admitted children treated in East Ethiopia		-Anemia (45.7%) -Pneumonia -Malaria	-Mortality: 9
Kassaw A., et al. Ethiopia 2021 (74)	488 children aged 6-59 months -Inpatient	Aims to estimate time to death and its predictors can provide an input for program planners and decision- makers.	A very low WFL/WFH below – 3 z scores of the median WHO growth standards, or less than 70% of the median National Center for Health Statistics standard or the presence of nutritional edema	-Anemia (43.8%) -Diarrhea (40.9%) -Pneumonia (40.7%) -TB -HIV	-Recovered: 68.1 -Mortality: 11.3
Tegegne A.S., et al. Ethiopia 2021 (75)	650 children aged 6-59 months -Inpatient	Aims to assess the recovery time and its predictors of children under five from SAM admitted to Therapeutic Feeding Unit at Dubti Referral Hospital, Afar region	MUAC value of B110 mm or bilateral pitting nutritional edema, children who tested their appetite and passed the test and children without treatment difficulties in the hospital were included in current investigation.	-HIV -TB -Diarrhea -Anemia, -Malaria -Pneumonia	-Recovered: 62.89 -Mortality: 5.7
Odikro M.A., et al. Uganda 2021 (76)	322 children aged 6-59 months -Inpatient	Aims to assess the incidence and predictors of time to recovery among SAM children admitted as inpatients in MRRH nutrition unit	A very low weight for height (below -3 z scores of the median WHO growth standards) or MUAC<11.5 cm or presence of bilateral pitting edema	-RTI (61.5%) -Dehydration (53.4%)	-Recovered: 77.1 -Mortality: 1.2 -Weight gain >5
Muwanguzi E., et al. Uganda 2021 (77)	LH : 390 Children aged 1–5 years GRRH : 320 Children aged 1–5 years -Inpatient	Aims to determine treatment outcome and associated factors among children 1–5 years hospitalised with SAM in Lacor Hospital and Gulu Regional Referral Hospital	Weight-for-height less than–3 Z- score, nutritional oedema and MUAC<11.5cm	-Dehydration (80%) -Hypothermia (46%) -Hypoglycemia (35%) -Severe anemia -HIV	-Cured: LH (70.6) GRRH (71) -Mortality: LH (9.5) GRRH (12.6)

RUTF: ready to use therapeutic food, SAM: severe acute malnutrition, SMS-RUTF: soya-maize-sorghum ready to use therapeutic food, ITT: intention to treat, PP: per protocol, P-RUTF: peanut paste-based ready-to-use therapeutic food, CMAM: community-based management of acute malnutrition, RWG: rates of weight gain, CFR: case fatality rate, WHZ: weight for height length, WFH: weight for height, WLZ: weight-for-length z-score , MUAC: mid-upper

arm circumference, SD: standard deviations, CM/MASO: Cow milk/Maize-soya beans, TM: Therapeutic milk, GTI: Gastroenteritis, UTI: urinary tract infection, TB: Tuberculosis, HIV: human immunodeficiency virus, ART: antiretroviral drugs, RTI: respiratory tract infection, AIDS: acquired immunodeficiency syndrome, ACT: Artemisinin-based combination therapy, CHWs: community health workers, HFs: health facilities, ReSoMal: oral rehydration salt solution, CRNE: center for recovery and nutritional education, TFC: Therapeutic feeding center, SC: stabilization center, WHO: world health organization, NCHS/WHO: national center for health statistics/WHO, DSM: dried skimmed milk, WPCs: whey protein concentrates, UTH: University Teaching Hospital, PM/RUTF: peanut and milk/RUTF, FSMS: milk-free soya-maize and sorghum, LRTI: Lower respiratory tract infection, AGE: Acute gastro enteritis, HAC: hospital acquired complication, AFI: Acute Febrile Illness, RVI:, CHF: Congestive heart failure, HF: Heart failure.

Table 2. Supplemental digital content 2 (S2): Risk of Bias of the Selected Studies by JBI-MAStARI

Author, Year, Ref	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Yes Score (_/8) Methodological quality
Supplementary Annex S2: Risk of Bias of the Selected Studies by JBI-MAStARI									
North Africa									
Hassan B, et al. 2013 (17)	Y	Y	Y	N	N	N	Y	Y	5/8
Central Africa									
Ndzo J.A., et al. 2018 (4)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Sinanduku J.S., et al. 2020 (18)	Y	Y	Y	Y	N	N	Y	Y	6/8
West Africa									
Madec Y., et al. 2011 (19)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Page A.L., et al. 2013 (20)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Akparibo R., et al. 2016 (21)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Alvarez Morán J.L., et al. 2018 (22)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Obani K.O., et al. 2019 (23)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Chamla D., et al. 2019 (24)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Aliyu I., et al. 2020 (25)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Compaoré E.W.R., et al. 2021 (26)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Seck N., et al. 2021 (27)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Southern Africa									
Irena A.H., et al. 2011 (28)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Benyera O., et al. 2013 (29)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Munthali T., et al. 2015 (30)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Muzigaba M., et al. 2017 (31)	Y	Y	Y	Y	Y	Y	Y	Y	8/8

Complications and Outcome of Severe Acute Malnutrition in ...

Author, Year, Ref	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Yes Score (_/8) Methodological quality
Tripoli F.M., et al. 2021 (32)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Wen B., et al. 2021 (33)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Mandla N., et al.2021 (34)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Bwakura-Dangarembizi M., et al. 2021 (35)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
East Africa									
Gebremichael D.Y., et al. 2015 (36)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Jarso H., et al. 2015 (37)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Shanka N.A., et al. 2015 (38)	N	N	Y	Y	Y	Y	Y	Y	6/8
Massa D., et al. 2016 (39)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Kanan S.O.H., et al. 2016 (40)	N	N	Y	Y	Y	Y	Y	Y	6/8
Nyeko R., et al. 2016 (41)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Kabeta A., et al. 2017 (42)	N	Y	Y	Y	Y	Y	Y	Y	7/8
Yohannes T., et al. 2017 (43)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Kabalo M.Y., et al. 2017 (44)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Mekuria G., et al. 2017 (45)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Girum T., et al. 2017 (46)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Tirore M.G., et al. 2017 (47)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Rytter M.J.H., et al. 2017 (48)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Asres D.T., et al. 2018 (49)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Derseh B., et al. 2018 (50)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Guesh G., et al. 2018 (51)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Wagnew F., et al. 2018 (52)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Nabukeera-Barungi N., et al. 2018 (53)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Abate H.K., et al. 2019 (54)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Hassen S.L., et al. 2019 (55)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Atnafe B., et al. 2019 (56)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Wagnew F., et al. 2019 (57)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Desyibelew H.D., et al. 2019 (58)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Fikrie A., et al. 2019 (59)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Bilal J.A., et al. 2020 (60)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Gebremedhin K., et al. 2020 (61)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Tesfay W., et al. 2020 (62)	Y	Y	Y	Y	Y	Y	Y	Y	8/8

Author, Year, Ref	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Yes Score (_/8) Methodological quality
Abate B.B., et al. 2020 (63)	N	Y	Y	Y	Y	Y	Y	Y	7/8
Adem F., et al. 2020 (64)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Negussie A.S., et al. 2020 (65)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Hussen Kabthymmer R., et al. 2020 (66)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Wondim A., et al. 2020 (67)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Tefera T.K., et al. 2020 (68)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Budul A.B., et al. 2020 (69)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Nduhukire T., et al. 2020 (70)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Banga D., et al.2020 (71)	N	Y	Y	Y	Y	Y	Y	Y	7/8
Bitew Z.W., et al. 2021 (72)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Oumer A., et al. 2021 (73)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Kassaw A., et al. 2021 (74)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Tegegne A.S., et al. 2021 (75)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Odikro M.A., et al. 2021 (76)	Y	Y	Y	Y	Y	Y	Y	Y	8/8
Muwanguzi E., et al. 2021 (77)	Y	Y	Y	Y	Y	Y	Y	Y	8/8

The items were collapsed into 8 quality-appraisal criteria (Q1-Were the criteria for inclusion in the sample clearly defined? Q2-Were the study subjects and the setting described in detail? Q3-Was the exposure measured in a valid and reliable way? Q4-Were objective standard criteria used for measurement of the condition? Q5-Were confounding factors identified? Q6-Were strategies to deal with confounding factors stated? Q7-Were the outcomes measured in a valid and reliable way? Q8-Was appropriate statistical analysis used?).

JBI-MAStARI was used to assess risk of bias. Articles that scored between 1 and 2 were classified as low methodological quality, articles with scores between 3 and 4 were classified as moderate quality, and those with scores ≥ 5 were classified as high quality.

N: no, NA: not applicable, U: unclear, Y: yes.

The recovery rate varied between 57.6% and 88.8% in the reviewed articles. 9 articles described a mortality rate of less than 10%, the mortality rate varied between 0.6% and 5.1%. Weight gain was mentioned in 7 articles, and all of them reported weight gains of less than 10g/kg/day.

Among the 50 inpatient-based studies, 26 had found a recovery rate of less than 75%. These 50 studies had mentioned mortality rates ranging from 1.2% to 46%. Of these studies, 4, 14, 22, and 10 reported an unacceptable (>20%), poor (11-20%), fair (5-10%), and good (<5%) mortality rates, respectively. On the other hand, the weight gain was reported by 14 articles. Of them, 10 had reported a weight gain less than 10g/kg/day (fair), and 4 had described a weight gain >10g/kg/day (good).

3-2.3 Complications of SAM

In this systematic review, 95% of the studies revealed that the most frequent complications encountered were diarrhea, followed by respiratory tract infections (69%), anemia (69%), HIV (55%), and malaria (37%).

3-3. Sub-studies

Here, the term Sub-studies refers to publications that only focus on an exclusive aspect of SAM, such as the impact of a specific complication on SAM. In total, we identified 4 studies falling into this category. Among them, 2 articles (20, 32) evaluated the impact of HIV on children with SAM and the reported recovery and mortality rates were higher than 75% and 15%, respectively. Diarrhea and pneumonia were found to be the most common co-infections.

Other infections were evaluated by 1 study (21) and RTI was the most reported comorbidity. This comorbidity was frequently associated with GTI and malaria.

One additional study (29) has exclusively explored the impact of diarrhea on SAM, and it revealed a high mortality rate (up to 40%).

4- DISCUSSION

4-1. Distribution of SAM

In this systematic review, children with SAM mainly were between 6-24 months and a male gender predominance was largely reported. Similar studies conducted in India, Pakistan, Yemen, and Nepal (6, 78-82) also found that the 6-24-month age group was the one most exposed to SAM.

Regarding the male predominance, similar results have been reported by other Indian and Pakistani researchers (79, 80, 83, 84).

This systematic review found that the most common type of malnutrition in Africa was marasmus, followed by kwashiorkor. This finding is similar to other studies conducted by Panda P.C. (20), Das (85), and Ahmed A.U (86), but different from a Colombian study that found kwashiorkor to be the most prevalent form of malnutrition (87).

4-2. Complications of SAM

The frequently reported complication was diarrhea, followed by lung infections and anemia. The same conclusion was made by a study from India (80, 88). However, other researchers from the same country found anemia (83, 85) and pulmonary infections (89) to be the most frequent complications. These comorbidities often challenge the management of SAM due to the presence of physiological disorders and impaired immune system. Interventions such as adequate immunization, sanitation, clean water, and universal health coverage will likely help to achieve better results (90).

4-3. Survival status of SAM

According to international guidelines, Outpatient Therapeutic Centers (OTCs)

are considered successful when recovery rate is more than 75%, CFR less than 10%, default rate less than 15%, and weight gain greater or equal to 5g/kg/day (4). In our review, more than half of the outpatient-based studies (64%) reported a cure rate of less than 75%. Likewise, a mortality rate greater than 10% was described by 82% of the included studies. Therefore, it can be concluded that in terms of recovery rate, OTCs are not able to meet the recommended criteria. Unlike our findings, several Indian studies have reported recovery rates of over 75% with mortality rates of less than 10% (78, 91, 92). As for the weight gain, weight gains less than 10g/kg/day were mentioned by all of the 7 OTC based studies. This value was seen in India as well (78, 92).

The evaluation items concerning the inpatient-based studies were mortality rate and weight gain. The WHO guidelines for the inpatient treatment of SAM state that failure to respond to therapy is indicated by a high mortality rate (unacceptable for $CFR > 20\%$, poor for 11-20%, moderate for 5-10%, and good for $< 5\%$) and a low weight gain during rehabilitation phase (poor for $< 5g/kg/day$, moderate for 5-10g/kg/day, and good for $> 10g/kg/day$) (15). In our review, 8%, 28%, 44%, and 20% of the selected studies reported unacceptable, poor, fair and good weight gains. Thus, the majority of the selected studies (40/50, 80%) had found a mortality rate greater than 5%. As for the weight gain, three quarters of such studies (10/14, 71%) had found a weight gain of less than 10g/kg/day, suggesting a poor response to treatment. In India (79, 85), mortality rates below 5% have been found. In Bangladesh, however, the reported mortality rate was in line with our findings (86).

5- STRENGTHS AND LIMITATIONS

A thorough search of the literature on SAM had been performed, and all included studies were of high quality. All

enrolled studies were conducted in Africa and published between 2010 and 2021. Gray literature sources, books and theses were excluded from this systematic review. We evaluated several factors, but some studies had limitations, such as the lack or omission of certain factors. Indeed, a few articles did not reveal the weight gain, mortality rate, or comorbidities, which made their interpretations challenging.

The lack of data from certain countries is also another weakness. Since the literature provides no information regarding the status of malnutrition in some African countries, it is quite impossible to generalize our findings. This is because the African continent is heterogeneous. Even within regions, there can be differences between countries.

6- CONCLUSION

To the best of our knowledge this is the first article that assesses the complications and outcome of malnutrition in African children under five years of age, at the continental level. Our work has indicated that up to now pediatric malnutrition is still a major issue in the African continent. Diarrhea, lung infection and anemia were found to be the most common complications which are mainly responsible for SAM-related pediatric mortality. This mortality could be improved by strengthening the adherence to the WHO/National guidelines for the management of SAM. Besides proper compliance with these guidelines, management of SAM at the community level requires further driving the costs down, since the parents of malnourished children still find it challenging to bear the treatment costs.

7- AUTHOR CONTRIBUTIONS

GG and MMA conceived the project; GG, MMA, MX, and J.C. performed the search, extracted data and drafted the manuscript. All authors contributed to the

article and approved the submitted version.

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10- CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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