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Abstract

Background: Severe acute malnutrition (SAM) remains a major public health concern among children under five years of age, particularly in low- and middle-income countries. Despite the availability of established treatment protocols, SAM continues to contribute substantially to childhood morbidity and mortality. Timely recovery and its determinants are important indicators of the effectiveness of inpatient nutritional rehabilitation. However, evidence regarding time to recovery and its predictors remains limited in many settings in Ethiopia. Therefore, this study aimed to determine the time to recovery from SAM and identify its predictors among children admitted to the pediatric ward of Debre Berhan Comprehensive Specialized Hospital, North shoa, Ethiopia.

Methods: A prospective cohort study was conducted among 112 children aged 6–59 months admitted with SAM to the pediatric ward of Debre Berhan Comprehensive Specialized Hospital ,North shoa from May 1 to November 1, 2024. Data were collected using a pretested, structured questionnaire developed in KoboToolbox. Data were entered, cleaned, and analyzed using Stata version 14.0. The Kaplan–Meier survival curve was used to estimate the probability of recovery over time, while the log-rank test was employed to compare recovery experiences between groups. A multivariable Cox proportional hazards regression model was fitted to identify independent predictors of time to recovery. Statistical significance was declared at a p-value of less than 0.05.

Results: A total of 112 children with SAM were followed for 1,595 child-days of observation. The overall incidence rate of recovery was 70 per 1,000 child-days (95% CI: 58–84). The median time to recovery was 12 days (95% CI: 10–15).History of Previous admission, nutritional edema, tuberculosis, rickets, anemia, oral thrush, hypothermia, vitamin A supplementation, folic acid supplementation, and immunization status were identified as independent predictors of time to recovery in the multivariable Cox regression analysis.

Conclusion: The findings indicate that recovery from SAM is influenced by the presence of comorbidities, previous admission history, and nutritional and supportive care interventions. Early identification and appropriate management of comorbid conditions, together with timely provision of essential nutritional and medical interventions, are important for improving recovery outcomes among children with SAM. Strengthening comprehensive inpatient management may contribute to improved treatment outcomes.

Keywords: Severe acute malnutrition; time to recovery; recovery incidence rate; survival analysis; predictors; children; Ethiopia.

INTRODUCTION

Background

Malnutrition is defined as a condition in which a person's nutritional status is suboptimal, resulting in impaired health and growth. It could be caused by an illness that impairs nutritional intake and metabolism, as well as inadequate macronutrient/micronutrient intakes[1, 2]. Acute malnutrition or wasting is a type of undernutrition defined by a low weight for height (WFH) or the presence of nutritional edema [1].Severe acute malnutrition (SAM) is defined as a nutritional emergency with a weight-for-height (WFH) Z score <-3, mid-upper arm circumference (MUAC) <11.5cm, and bilateral nutritional pedal edema[3].

Globally, there were 2.9 million hospitalizations, with approximately 17% of those requiring treatment[2, 4].In Africa, 14 million children under the age of five suffer from acute malnutrition, with SAM accounting for approximately 4.1 million cases[2].

In Ethiopia, studies discovered that under-five children with severe acute malnutrition (SAM) had recovery rates ranging from 25.6% to 89%, with median survival times ranging from 14 to 25 days [5-7].The Ethiopian Ministry of Health has been established therapeutic feeding centers in health facilities to reduce SAM-related deaths among under-five children. Although SAM management is available in hospitals and health centers across the country, the number of deaths remains high. Little is known about the recovery time and determinants of SAM in under-five children admitted to inpatient therapeutic feeding centers (ITFCs) [8].

In Ethiopia, the recovery rate from severe acute malnutrition among children aged 6-59 months varies between 58.4% [9]and 87%[10]. The international standard recommends that children admitted to stabilization centers recover in less than one month [11]. Research indicates that recovery time in Ethiopia can range from 11 days to 8.7 weeks [12-14]. The standard states that the proportion of recovered children from SAM should exceed 75%. Existing evidence suggests Ethiopia has not fully met this standard. For example, recovery rates for SAM in children range from 43.6% to 87%[15, 16].Various factors, including child age, Tuberculosis infection, retroviral infection, malnutrition type, and inpatient complications, can impact the recovery rate and time from SAM [6, 16-19]. Recovery from SAM remains difficult [3], insufficient [7], and little is

known about recovery time and predictors among children aged 6-59 months in Ethiopia in general, and in the study area in particular.

According to a study done at the Chattogram Medical College hospital in Chattogram, Bangladesh, patients with edema had a mean hospital stay (in days) of 15.64±SD 7.133 days, which was longer than the mean hospital stay (in days) for patients without edema (9.47±SD 5.881 days)[20].

Research revealed that the recovery times in Malawi were reported to be longer (49.0 days), but in Bangladesh and India they were shorter—less than three weeks compared to 15.5 days, respectively[21, 22].

A prospective studies done in 2020 in Jimma University Hospital on treatment outcome and associated factors among under-five children showed that recovery was 25.6% from the enrolled children and the nutritional recovery rate is (26.1% versus 25.4; p=0.4) and median time to recovery between children who had diarrhea at admission (26 days; 95% CI:; 24.0-28.7) and those who had not (26.0 days; 95% CI: 21.90-30.10). Children diagnosed with tuberculosis (AHR=0.19, CI: 0.06-0.62), anemia (AHR=0.32, CI: 0.14-0.74) and treatment failures (AHR=0.17, CI: 0.16-0.03) were factors to determine the recovery rate of severe acute malnutrition children in Jimma University Hospital, Ethiopia[7].

In 2019, survival study conducted on under-five children with severe acute malnutrition (SAM) in South Wollo Amhara, Ethiopia, which showed that 75.4% of children recovered and discharged and the mean (±standard deviation) time to recovery was 12(±5.26) days, whereas the median time to recovery was 11(interquartile range of 8-15) days[23].

Therefore, this study aimed to estimate survival rates, median survival times, recovery times and determinants among under-five children with severe acute malnutrition admitted to inpatient therapeutic feeding centers (ITFCs) in North Shoa Zone, Debre Berhan Comprehensive Specialized Hospital, Ethiopia. The findings will be crucial for decision-makers, health facilities, and care providers to prioritize children at high risk of slow recovery.

Methods

Study Design, Study Area, and Study Period

A prospective cohort study was conducted among children admitted with severe acute malnutrition (SAM) to the pediatric ward of Debre Berhan Comprehensive Specialized Hospital (DBCSH), located in Debre Berhan, North Shoa Zone, Ethiopia. The study was conducted from May 1 to November 1, 2024. Eligible children were enrolled upon admission and prospectively followed throughout their hospital stay until they experienced the predefined study outcome or another outcome that resulted in the termination of follow-up.

Source and Study Population

The source population comprised all children aged 6–59 months diagnosed with SAM and admitted to the pediatric ward of Debre Berhan Comprehensive Specialized Hospital during the study period.

The study population consisted of children aged 6–59 months who fulfilled the eligibility criteria and were selected from the source population during the study period.

Eligibility Criteria

Inclusion Criteria

All children aged 6–59 months who were admitted to the pediatric ward of Debre Berhan Comprehensive Specialized Hospital with a confirmed diagnosis of SAM during the study period were eligible for inclusion.

Exclusion Criteria

Children with incomplete medical records containing insufficient information to determine their eligibility, exposure status, or recovery outcome were excluded. Children with major congenital abnormalities that could substantially interfere with nutritional rehabilitation or recovery assessment were also excluded.

Study Variables

Outcome Variable

The primary outcome variable was **time to recovery from severe acute malnutrition**, defined as the time elapsed, in days, from admission to the pediatric ward until the child met the predefined clinical and anthropometric criteria for recovery according to the applicable national SAM management protocol.

Children who did not achieve recovery during the follow-up period were considered censored at the time of discharge without recovery, death, default, referral, or completion of the observation period, as applicable to the study protocol. The specific classification of each outcome was determined according to the study's operational definitions.

Predictor Variables

The explanatory variables investigated in this study were categorized as follows:

1. Sociodemographic characteristics

- Age of the child
- Sex
- Place of residence (urban or rural)
- Number of children in the household

2. Anthropometric and nutritional characteristics

- Body weight
- Height or length
- Mid-upper arm circumference (MUAC)
- Presence or absence of nutritional edema
- Clinical classification of SAM (marasmus, kwashiorkor, or marasmic-kwashiorkor)

3. Comorbidities and clinical conditions

- Tuberculosis
- Anemia
- Congestive heart failure
- Pneumonia
- Diarrheal disease
- Malaria
- Other documented comorbidities, where applicable

4. Therapeutic and medication-related factors

- Vitamin A supplementation
- Folic acid supplementation
- Deworming treatment
- Antimalarial treatment
- Rehydration solution for malnutrition (ReSoMal)
- Intravenous antibiotic administration
- Intravenous fluid administration
- Blood transfusion
- Other supportive medical interventions, where applicable.

Operational definitions

Exposed children- all children aged 6-59 months with severe acute malnutrition and those who have nutritional edema admitted to pediatric stabilization center in Debre Berhan Comprehensive Specialized Hospital from May1st to November 1st,2024.

Unexposed children- all children aged 6-59 months with severe acute malnutrition and haven't nutritional edema and admitted to pediatric stabilization center in Debre Berhan Comprehensive Specialized Hospital from May1st to November 1st,2024.

Edematous (nutritional): -edema, which appears as bilateral pitting edema, is an indication of extreme acute malnourishment. Every time there is nutritional edema, it always begins in the feet and moves up to other body parts

Non –edematous (nutritional): - Malnutrition without edema is called marasmus; malnutrition with edema is called kwashiorkor. Accordingly, a clinician should not be persuaded to treat protein-energy malnutrition based on the existence or absence of edema.

Time to recovery- the average time that the patient will take to recover from an illness or disease.

The incidence density rate- will determined by dividing the number of events by the total follow-up time in person-days.

Survival time-The number of days it takes from admission to the recovery of a child from SAM (measured by incidence density rate and median recovery time).

Censored- children aged 6-59 months who have referral sheets, death summary sheets, incomplete medical records, medical against (caregivers sign on behalf of the child) will be censored.

Event- children aged 6-59 months who recovered from severe acute malnutrition.

Co-morbidities- children aged 6-59 months with severe acute malnutrition and other medical problems.

Defaulter: A severe acute malnutrition patient admitted to an inpatient program who fails to meet discharge criteria after 40 days.

Died- those children aged 6-59 months who passed away and whose death report is recorded on the charts during follow up time.

Data collection tool and procedure

The structured format of the data collection was encompassed anthropometric measurements, medical conditions at admission and throughout the study period, nutritional status, laboratory tests, and socio-demographic variables. We were reviewed and improved the data collection tool with one pediatrician and one nurse. Data collection were carried out by two pediatric nurses who have been trained in the protocol. Daily visits to the pediatric ward allowed the data collectors to determine whether each newly admitted child met the predetermined inclusion criteria and could be included in the study. Key variables for this study were include vital signs, anthropometry measurements, laboratory results, nutritional and other medical diagnoses, treatments, and baseline and follow-up clinical information combined with sociodemographic data. At admission, all children were undergoing a complete blood count (CBC) to identify anemia and/or other medical problems, as well as a plasma glucose level, a Gene-Xpert/RIF test for Mycobacterium tuberculosis, and HIV testing. Stool examination and urine analysis was performed to determine the presence of parasites and urinary tract infections, respectively. Additionally, weight and edema caused by malnutrition was documented daily when presented. To ensure the data quality and consistency of the data collection tool, professional translators prepare the questionnaire in English first, then translate it into Amharic and back to English. Supervisors and data collectors are trained for two days. A pre-test is administered to 8(5%) of the sample one week before data collection to assess the acceptability and applicability of the procedures and tools. The data collectors are closely supervised by the supervisors throughout the data collection process to ensure that the questionnaire is complete and consistent. Double data entry reduces data entry errors by ensuring that the two data sets are consistent.

Data processing and analysis

Data were coded, amended, and cleaned before being imported into Google Spreadsheet and exported to STATA version 14.0 for further analysis. The data will be presented using descriptive and inferential statistics. Schoenfeld's residual test will confirm the Cox-proportion hazard regression model assumptions. The Kaplan-Meier survival curve is used to measure survival time, whereas the Log rank test is used to evaluate survival curves between categorical variables. A bivariate Cox-proportional hazards regression model would be applied to each explanatory variable. To find independent predictors of asphyxiated neonate survival, factors with p-values less than 0.25 were fitted to a multivariable Cox regression model. The hazard ratio at a 95% confidence level was used to evaluate predictor associations. Significant predictors of asphyxiating neonate survival were identified in multivariable Cox regression analysis with p-values less than 0.05. The findings were summarized in text, tables, and graphs.

Results

Sociodemographic Characteristics of the Study Participants

A total of 112 children diagnosed with severe acute malnutrition were enrolled in the study, yielding a 100% response rate. The participants were aged 6–59 months. Regarding sex distribution, 64 (57.14%) of the children were female. Most participants, 70 (62.50%), were from rural areas.

Clinical, Nutritional, and Treatment-Related Characteristics

Regarding clinical conditions at admission, pneumonia was the most frequently reported comorbidity, affecting 84 (75.00%) children, followed by diarrhea in 52 (46.43%) and anemia in 32 (28.57%). Other documented comorbidities included dehydration in 33 (29.46%), oral thrush in 17 (15.18%), sepsis in 17 (15.18%), tuberculosis in 11 (9.82%), and nutritional edema in 10 (8.93%) children. Additionally, 52 (46.43%) children presented with fever, while 46 (41.07%) experienced vomiting.

Regarding the clinical classification of SAM, marasmus was reported in 102 children. Rickets was documented in 65 (58.04%) participants.

Concerning immunization status, only 22 (19.64%) children were fully immunized. Regarding nutritional and therapeutic interventions, 85 (75.89%) children did not receive folic acid supplementation, while 80 (71.43%) did not receive vitamin A supplementation. Furthermore, 74 (66.04%) children received the reported routine medication.

Table 1: Socio-demographic and clinical characteristics of child with SAM admitted in DBCSH, Debre Berhan, Ethiopia,2024.

Variables		**Censored (%)**	**Recovered (%)**	**Total (%)**
Pneumonia	No	1(0.89)	27(24.11)	28(25%)
	Yes	24(21.43)	60(53.57)	84(75%)
Nutritional edema	No	22(19.64)	80(71.4)	102(91.04%)
	Yes	3(2.68)	7(6.25)	10(8.93%)

Sepsis	No	18(16.07)	77(68.75)	95(84.82%)
	Yes	7(6.25)	10(8.93)	17(15.18%)
Tuberculosis	No	19(17.12)	81(72.97)	100(90.09%)
	Yes	6(5.41)	5(4.5)	11(9.91%)
Anemia	No	10(8.90)	70(62.50)	80(71.40%)
	Yes	15(13.39)	17(15.18)	32(28.57%)
Oral thrush	No	20(17.86)	75(66.96)	95(84.82%)
	Yes	5(4.96)	12(10.71)	17(15.67%)
Rickets	No	7(6.25)	40(35.71)	47(41.96%)
	Yes	18(16.07)	47(41.96)	65(58.03%)
Diarrhea	No	2(1.79)	58(51.79)	60(53.58%)
	Yes	23(20.54)	29(25.89)	52(46.43%)
Dehydration	No	9(8.04)	70(62.50)	79(70.54%)
	Yes	16(14.29)	17(15.18)	33(29.47%)
Marasmus	No	2(1.82)	6(5.45)	8(7.27%)
	Yes	23(20.91)	79(71.82)	102(92.73%)
Fever	No	10(8.93)	50(44.64)	60(53.57%)
	Yes	15(3.39)	37(33.04)	52(36.43%)
Vomiting	No	11(10.00)	53(48.18)	64(58.18%)
	Yes	14(12.73)	32(29.09)	46(41.82%)
HIV positve	No	3(2.68)	20(17.86)	23(20.54%)
	Yes	22(19.64)	67(59.82)	89(79.46%)

Folic acid	No	19(16.96)	80(71.43)	99(88.39%)
	Yes	6(5.36)	7(6.25)	13(11.61%)
Vit-A supplementation	No	21(18.75)	72(64.29)	93(83.04%)
	Yes	4(3.57)	15(13.39)	19(16.96%)

Nutritional Assessment and Therapeutic Intervention-Related Characteristics

Regarding nutritional assessment, 80 (71.43%) children failed the appetite test, while 83 (74.11%) had a weight-for-height Z-score below −3 SD at admission. Concerning therapeutic feeding, 102 (91.07%) and 104 (92.86%) children did not receive diluted F100 and F75 therapeutic feeds, respectively, during the observation period.

Time to Recovery from Severe Acute Malnutrition

Kaplan–Meier survival analysis was used to estimate the probability of remaining unrecovered over the follow-up period. The estimated cumulative probabilities of remaining unrecovered at the 3rd, 7th, 12th, and 28th days were 96%, 80%, 49%, and 5%, respectively. The median time to recovery was 12 days (95% CI: 10–15 days) (Figure 1).

Incidence Rate of Recovery from Severe Acute Malnutrition

A total of 112 children aged 6–59 months with SAM were enrolled and followed prospectively. The total accumulated observation time was reported as 1,595 child-days. The incidence density of recovery was 70 per 1,000 child-days of observation (95% CI: 58–84). Overall, 77.68% of the children achieved recovery during the follow-up period (Figure 2).

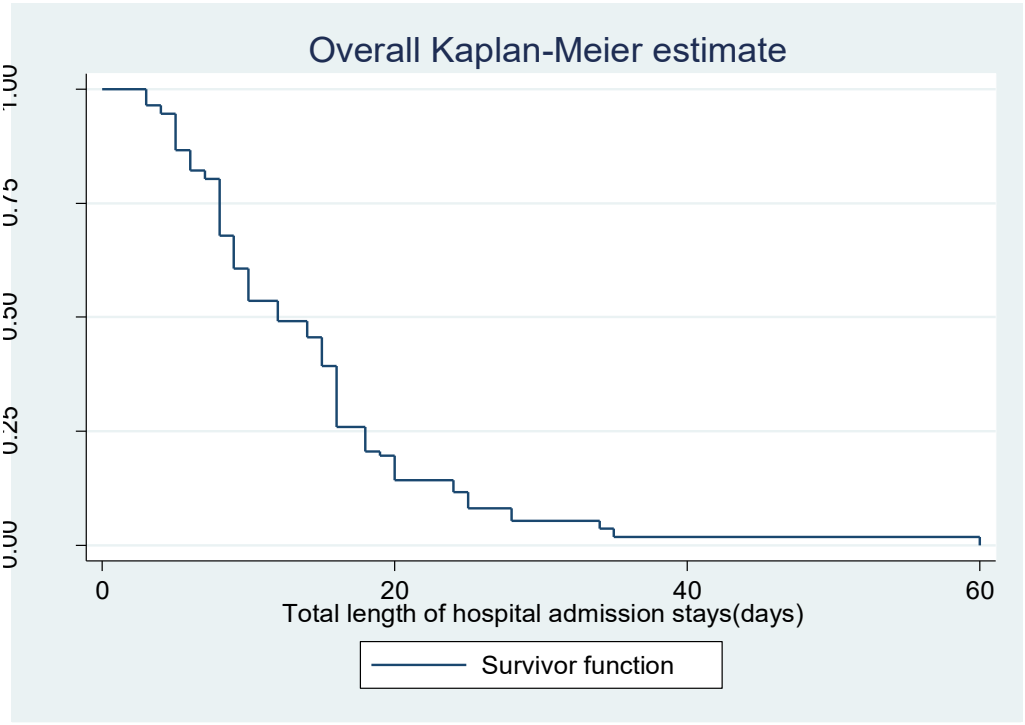


Figure 1: Overall Kaplan -Meier survival estimate of SAM children admitted in DBCSH,2024

Predictors of Time to Recovery from Severe Acute Malnutrition

Bivariable Cox proportional hazards regression analysis was initially performed to identify candidate variables associated with time to recovery. Variables with a p-value below 0.25 were considered for inclusion in the multivariable Cox proportional hazards regression model. The candidate variables included maternal education level, religion, admission status, mid-upper arm circumference (MUAC), hemoglobin level, blood film findings, hypoglycemia, nutritional edema, tuberculosis, anemia, oral thrush, hypothermia, vitamin A supplementation, folic acid supplementation, deworming, immunization status, and history of blood transfusion.

Subsequently, multivariable Cox proportional hazards regression analysis was conducted to identify factors independently associated with time to recovery while controlling for potential confounding variables. The reported factors associated with recovery included immunization status, hypothermia, rickets, tuberculosis, anemia, blood transfusion, admission status, deworming, maternal education level, oral thrush, and nutritional edema.

The adjusted hazard ratios indicated substantial differences in the rate of recovery across clinical and sociodemographic characteristics. Children without hypothermia had a higher instantaneous recovery rate than those with hypothermia (AHR = 53.88, 95% CI: 9.40–308.80). Similarly, children without anemia had a higher recovery rate than those with anemia (AHR = 14.63, 95% CI: 3.47–61.73). Children without oral thrush had a higher recovery rate than their counterparts (AHR = 8.21, 95% CI: 2.49–27.04).

Children without nutritional edema at admission also demonstrated a higher recovery rate than those presenting with edema (AHR = 4.25, 95% CI: 1.18–15.28). Maternal educational attainment at diploma level was associated with a higher recovery rate compared with the reference educational category (AHR = 18.84, 95% CI: 1.67–211.60).

Admission status was also associated with recovery. Children with a new admission had a higher recovery rate than those with a history of readmission (AHR = 158.38, 95% CI: 12.76–1,964.57).

The associations involving immunization status and tuberculosis require verification of the reference categories and variable coding before their direction can be interpreted. The reported association between rickets and recovery also requires statistical verification because its confidence interval includes the null value (AHR = 3.61, 95% CI: 0.76–4.67).

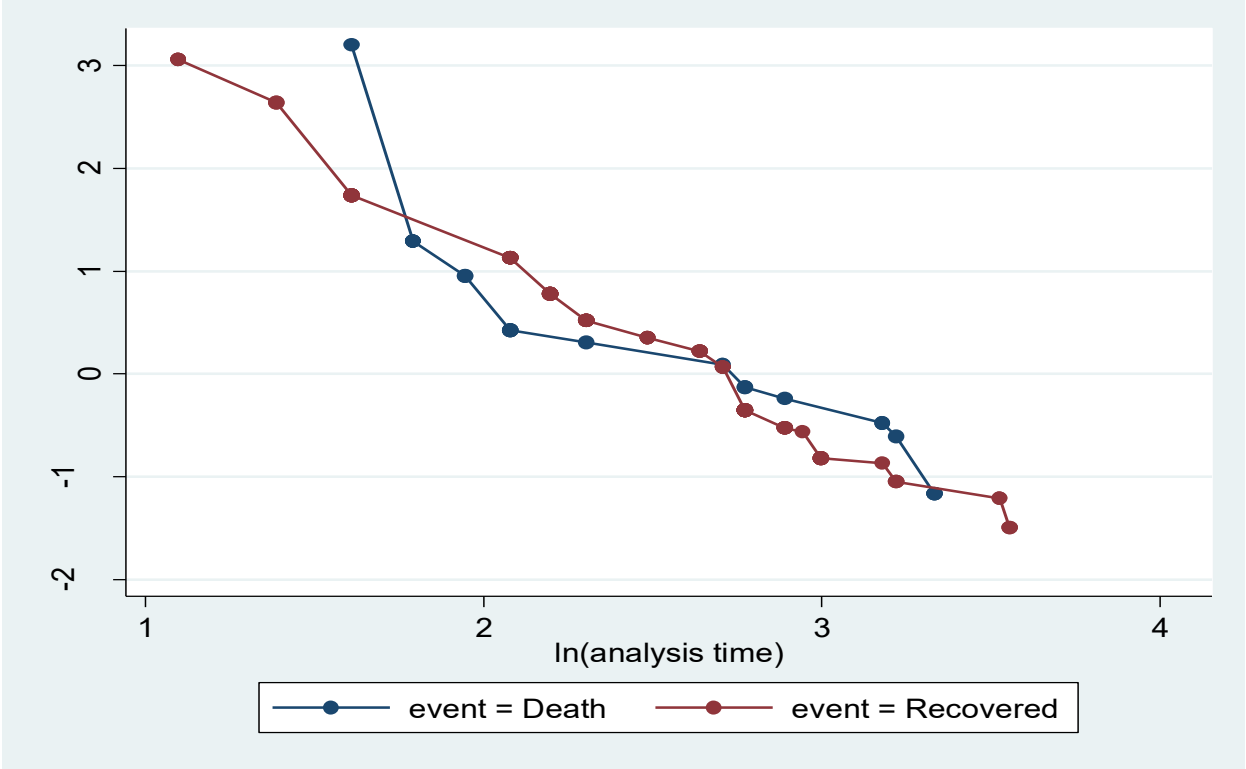


Figure 2: Overall survival recovery status

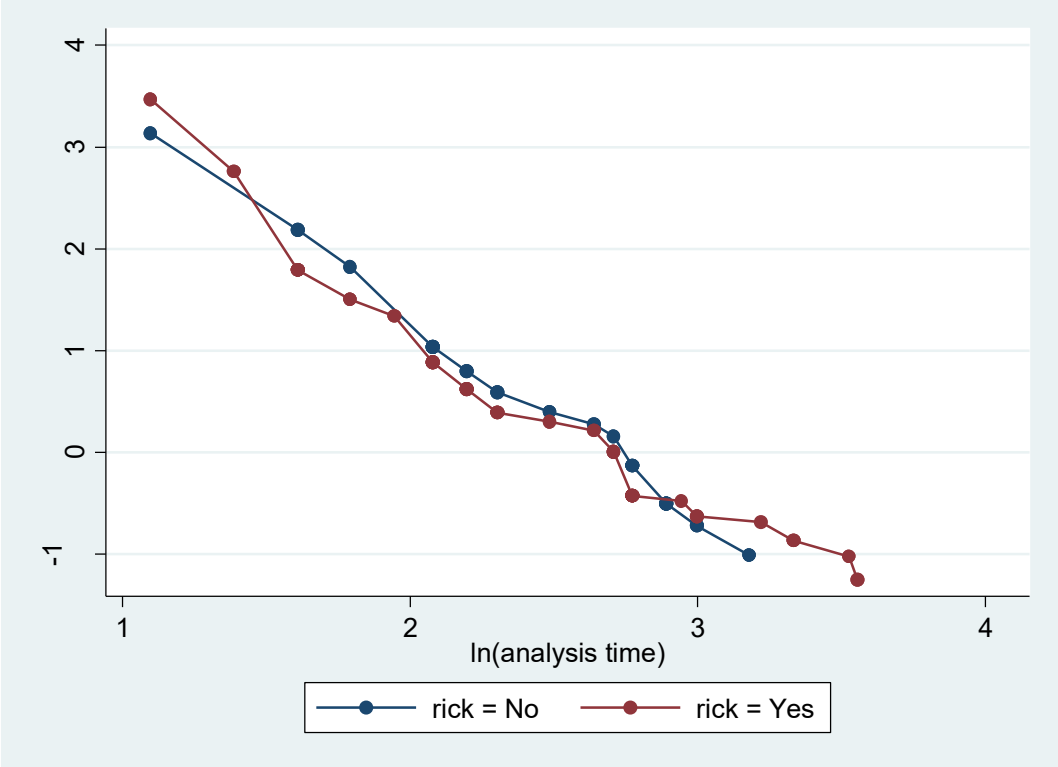


Figure 3: Log-rank survival estimate for time to recovery from severe acute malnutrition by rickets admitted to DBCSH pediatric ward, Debre Berhan, Ethiopia,2024

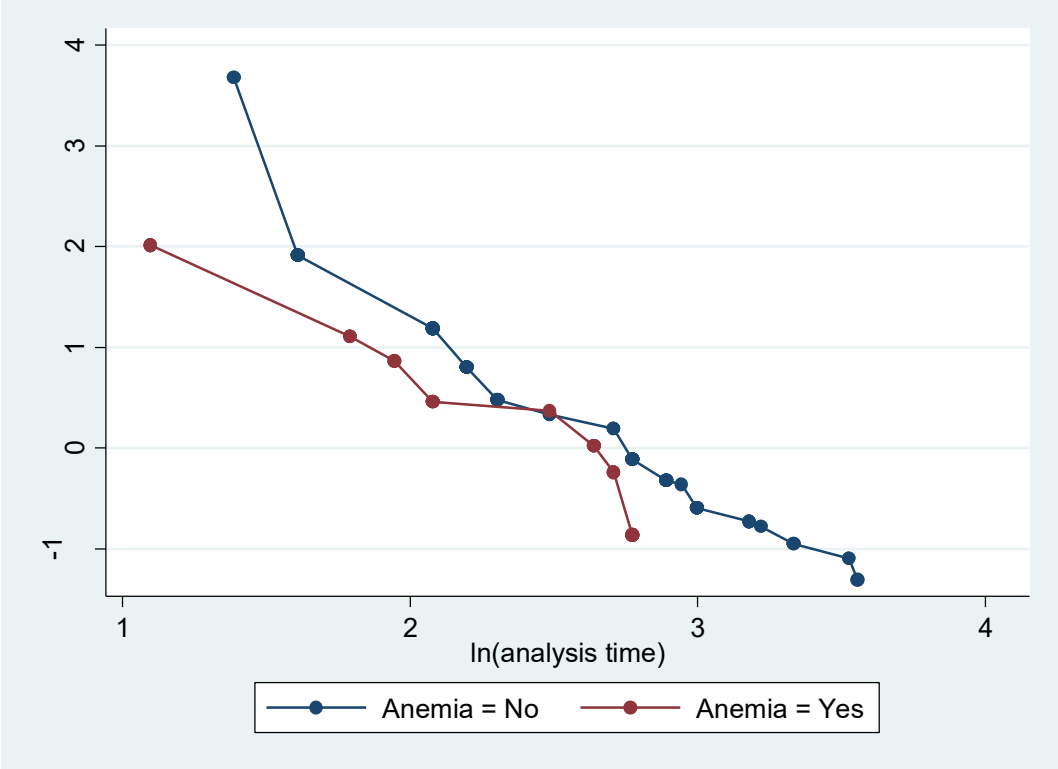


Figure 4: Log-rank survival estimate for time to recovery from severe acute malnutrition by anemia admitted to DBCSH pediatric ward, Debre Berhan, Ethiopia,2024

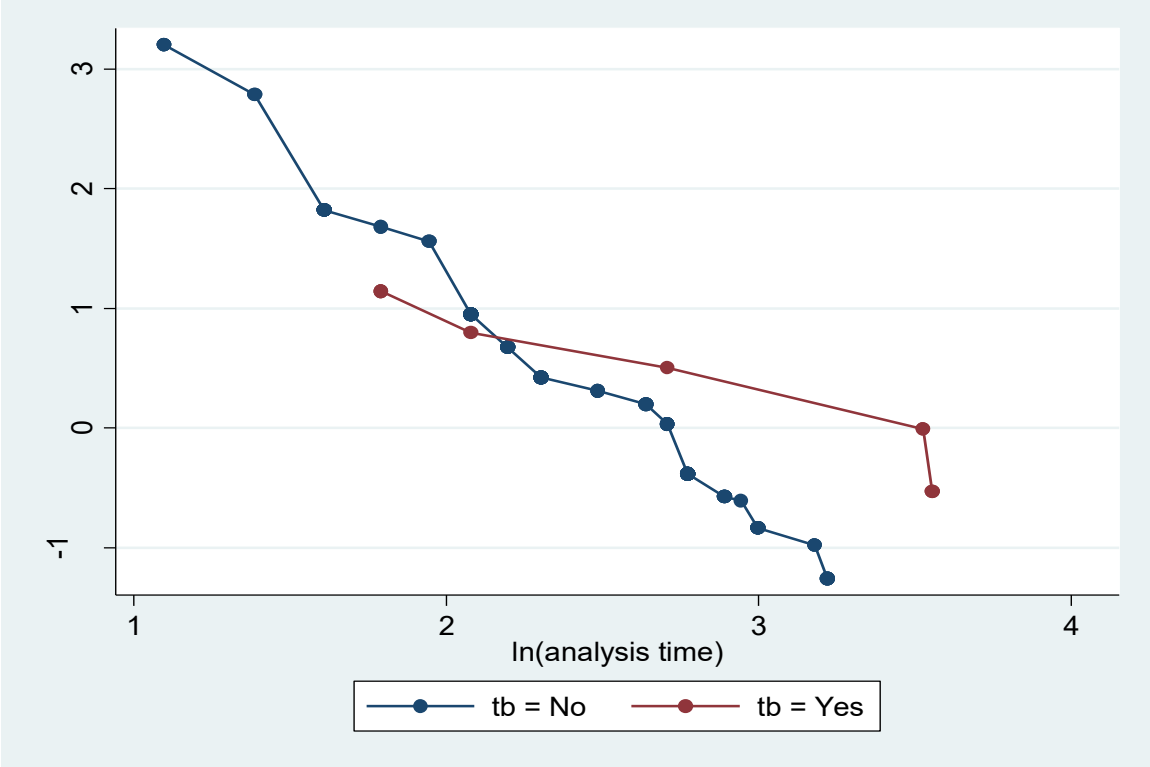


Figure 5: Log-rank survival estimate for time to recovery from severe acute malnutrition by tuberculosis admitted to DBCSH pediatric ward, Debre Berhan, Ethiopia,2024

As stated in the table below, maintaining all other factors constant in the multivariable Cox regression analysis partial immunization, hypothermia, rickets, tuberculosis, anemia, blood transfusion, admission status, deworming and maternal education level were independent predictors for children recovered from severe acute malnutrition. , children who had complete immunization were 88% more likely to recover from SAM as compared to partial immunized children (AHR=0.12, 95% CI:0.03-0.44). Similarly, children with no hypothermia were 53 times more recovered from risk to delayed recovery from SAM than their peers (AHR=53.88, 95% CI:9.40-308.80). Children who hadn't rickets were four times more likely to recover from severe acute malnutrition than their counterparts (AHR=3.61, 95%CI: 0.76-4.67). Furthermore, recovery time was shorter in children who did not develop anemia 14 times than their counterparts (AHR=14.63, 95% CI: 3.47-61.73). Children who had not contracted TB were 99% more likely to

recover faster from severe acute malnutrition than their counterparts (AHR=0.01, 95%CI: 0.00-0.04). In terms of maternal education level, children whose mothers were educated at diploma level 18 times more likely to recover from severe acute malnutrition than their counterparts (AHR=18.84, 95%CI:1.67-211.60). Those children who had not developed oral thrush were 8 times more recover than those who had oral thrush (AHR=8.21, 95%CI: 2.49-27.04). Moreover, those children who hadn't nutritional edema at admission were four times more fast recovery time than their counter parts (AHR=4.25, 95%CI: 1.18-15.28), and child with new admission had 158 times fast recovery time from severely acute malnutrition than those who had repeat admission history (AHR=158.38=95 % CI: 12.76-1964.57)(Fig3,4,5).

Co -variates	**CHR (95%CI)**	**P-value**	**AHR (95%CI)**	**P-value**
Maternal education level				
Degree and above	1		1	
Diploma level	0.16(0.04-0.61)	0.007	**18.84(1.67-211.60)**	**0.017**
Highschool	0.07(0.02-0.26)	0.000	0.45(0.06-3.36)	0.442
Elementary	0.18(0.05-0.56)	0.003	2.15(0.34-13.54)	0.413
Read and write	0.11(0.03-0.36)	0.000	2.52(0.36-17.58)	0.349
Illiterate	0.13(0.04-0.43)	0.000	3.25(0.56-21.03)	0.215
Religion				
Muslim	1		1	
Orthodox	1.71(0.86-3.41)	0.125	**4.81(1.50-15.42)**	**0.008**
Admission status				
New	1		1	
Repeat	3.93(1.40-10.98)	0.009	**158.38(12.76-1964.57)**	**0.000**
MUAC				
<11.5cm	1		1	
>11.5cm	3.97(1.86-8.47)	0.000	2.75(0.66-11.38)	0.163
Hemoglobin label				
<11mg/dl	1		1	
>11mg/dl	1.34(0.91-1.98)	0.134	**0.37(0.18-0.77)**	**0.009**
Hypoglycemia				
No	1		1	
Yes	1.79(0.92-3.49)	0.084	1.87(0.26-13.52)	0.532
Nutritional edema				
No	1		1	
Yes	1.58(0.81-3.06)	0.176	**4.25(1.18-15.28)**	**0.026**
Tuberculosis				
No	1		1	

Yes	2.64(0.76-4.67)	0.001	**0.01(0.00-0.04)**	**0.000**
Rickets				
No	1		1	
Yes	0.22(0.08-0.56)	0.001	**0.008(0.00-0.04)**	**0.000**
Anemia				
No	1		1	
Yes	1.54(1.01-2.35)	0.043	**14.63(3.47-61.73)**	**0.001**
Oral thrush				
No	1		1	
Yes	1.94(1.14-3.32)	0.014	**8.21(2.49-27.04)**	**0.001**
Hypothermia				
No	1		1	
Yes	1.96(0.79-4.84)	0.144	**53.88(9.40-308.80)**	**0.000**
Vitamin A supplement				
No	1		1	
Yes	3.38(1.82-6.27)	0.000	**0.23(0.07-0.71)**	**0.011**
Folic acid supplement				
No	1		1	
Yes	1.98(1.08-3.62)	0.026	**10.44(3.30-33.05)**	**0.006**
Immunization				
Fully immunized	1		1	
Partially immunized	0.35(0.21-0.59)	0.000	**0.12(0.03-0.44)**	**0.001**
unimmunized				
Blood transfusion given				
No	1		1	
Yes	0.72(0.47-1.08)	0.121	0.85(0.45-1.63)	0.642

Discussion

The present study assessed the treatment outcomes and time to nutritional recovery among children with severe acute malnutrition (SAM) admitted to a nutritional rehabilitation center and identified factors associated with recovery. The overall recovery rate was 77.68%, which was above the internationally recommended minimum recovery threshold of 75% for children with SAM receiving appropriate treatment [24]. Although this finding indicates that the nutritional rehabilitation center achieved the minimum recommended performance standard, further improvements are necessary to optimize treatment outcomes. The observed recovery rate may be influenced by several factors, including delayed presentation to health facilities, late diagnosis and referral, inadequate adherence to standard treatment protocols, and the presence of concurrent medical complications [25, 26]. In addition, insufficient clinical assessment, inadequate management of associated illnesses, and inconsistencies in the provision of essential medications may compromise treatment effectiveness. Therefore, strengthening early case identification, timely referral, adherence to national and international SAM management protocols, and comprehensive management of medical complications is essential to improve recovery outcomes.

The median time to nutritional recovery among children with SAM was 12 days (95% CI: 10.00–15.00). This finding was comparable to results reported by studies conducted in different parts of Ethiopia [13, 25, 27]. However, the median recovery time in the present study was shorter than that reported in studies conducted in Addis Ababa, Bahir Dar, Karat, and Fasha stabilization centers, which documented median recovery times of 17, 16, 26, and 36 days, respectively [6, 26, 28, 29]. Such variations may be attributable to differences in the quality of nutritional and medical care, healthcare workers' professional experience and training, availability of essential nutritional supplies and medications, and differences in the clinical characteristics of admitted children. Furthermore, variations in the severity of malnutrition at admission, the prevalence of comorbidities, and the timeliness of diagnosis and referral may contribute to differences in recovery duration across healthcare settings. These findings highlight the importance of strengthening the quality and consistency of nutritional rehabilitation services to facilitate timely recovery among children with SAM.

In the multivariable Cox proportional hazards regression analysis, several sociodemographic, clinical, and treatment-related factors were independently associated with nutritional recovery. Maternal educational status was one of the factors associated with recovery. Specifically, children whose mothers had diploma-level education had a significantly higher rate of recovery than those whose mothers had degree-level education and above (AHR = 18.84, 95% CI: 1.67–211.60; p = 0.017). However, no statistically significant associations were observed among the other maternal educational categories. Although maternal education is generally recognized as an important determinant of child health and healthcare utilization, the unusually large adjusted effect estimate observed in this study should be interpreted cautiously. The wide confidence interval suggests considerable statistical uncertainty, potentially reflecting a small number of observations or recovery events in some educational categories. Differences in healthcare-seeking behavior, maternal understanding of treatment recommendations, and adherence to nutritional rehabilitation procedures may partly explain this association; however, these potential mechanisms require further investigation.

Regarding religion, children from Orthodox Christian households had a significantly higher rate of nutritional recovery than those from Muslim households (AHR = 4.81, 95% CI: 1.50–15.42; p = 0.008). This association should be interpreted cautiously because religion itself is unlikely to represent a direct biological determinant of nutritional recovery. Rather, it may reflect underlying differences in socioeconomic circumstances, geographical access to healthcare, household characteristics, dietary practices, or other contextual factors that were not fully captured in the analysis. Further research is required to explore the potential social and contextual mechanisms underlying this association.

Admission status was also significantly associated with nutritional recovery. Children admitted for repeat treatment had a substantially higher rate of recovery than those admitted for the first time (AHR = 158.38, 95% CI: 12.76–1964.57; p < 0.001). This finding may suggest that children with previous treatment experiences and their caregivers had greater familiarity with nutritional rehabilitation procedures, follow-up requirements, and recommended healthcare practices. Previous contact with health services may also facilitate earlier recognition of nutritional deterioration and more timely treatment-seeking behavior. Nevertheless, the extremely large adjusted hazard ratio and its wide confidence interval indicate substantial imprecision, and the

finding should be interpreted with caution. Further investigation is warranted to determine whether this association reflects differences in previous treatment experience, referral patterns, patient characteristics, or sparse observations in the relevant categories.

With respect to nutritional status at admission, children with a mid-upper arm circumference (MUAC) greater than 11.5 cm had a higher crude rate of recovery than those with MUAC below 11.5 cm (CHR = 3.97, 95% CI: 1.86–8.47; $p < 0.001$). However, this association was no longer statistically significant after adjustment for potential confounders (AHR = 2.75, 95% CI: 0.66–11.38; $p = 0.163$). This suggests that the observed crude association may partly be explained by differences in other clinical and sociodemographic characteristics. Although better anthropometric status may facilitate nutritional rehabilitation, the adjusted finding indicates that MUAC category was not an independent predictor of recovery in the present analysis.

Hemoglobin status was significantly associated with nutritional recovery. Children with hemoglobin levels above 11 g/dL had a significantly lower rate of recovery than those with hemoglobin levels below 11 g/dL (AHR = 0.37, 95% CI: 0.18–0.77; $p = 0.009$). This finding suggests that children in the higher hemoglobin category experienced a lower instantaneous recovery rate after adjustment for other variables. However, this direction of association requires careful interpretation, particularly because the study also identified anemia as a significant predictor of recovery. The relationship between hemoglobin concentration, anemia, and nutritional recovery may be influenced by underlying infections, micronutrient deficiencies, and other clinical conditions. Therefore, further investigation is necessary to clarify these findings and establish the clinical relevance of the observed associations.

Nutritional edema was another significant independent predictor of recovery. Children presenting with nutritional edema had a significantly higher rate of recovery than those without edema (AHR = 4.25, 95% CI: 1.18–15.28; $p = 0.026$). Although nutritional edema is generally considered a manifestation of complicated SAM and may be associated with severe clinical conditions, its association with a higher recovery rate in this study should not be interpreted as evidence of a protective effect. Differences in admission characteristics, clinical management, nutritional rehabilitation pathways, and the distribution of other prognostic factors may have contributed to this finding. Moreover, edema resolution and anthropometric recovery may follow different

clinical trajectories. This finding warrants further investigation, particularly in relation to the clinical severity and management of edematous SAM.

Tuberculosis (TB) was strongly associated with a reduced rate of nutritional recovery. Children with TB comorbidity had a substantially lower rate of recovery than those without TB (AHR = 0.01, 95% CI: 0.00–0.04; $p < 0.001$). This finding is consistent with studies conducted in southern Ethiopia [30] and northwestern Ethiopia [25], which identified TB as an important determinant of unfavorable treatment outcomes among children with SAM. The association may be explained by the bidirectional interaction between malnutrition and tuberculosis. Severe malnutrition impairs immune function and increases susceptibility to infections, while TB may further aggravate nutritional depletion through chronic inflammation, increased metabolic demands, reduced appetite, and impaired nutrient utilization. The coexistence of these conditions may consequently complicate clinical management and prolong nutritional recovery [31, 32]. These findings emphasize the importance of routine TB screening, early diagnosis, timely initiation of appropriate treatment, and integrated management of infectious diseases among children admitted with SAM.

Similarly, rickets was significantly associated with a markedly reduced rate of nutritional recovery. Children diagnosed with rickets had a lower rate of recovery than those without the condition (AHR = 0.008, 95% CI: 0.00–0.04; $p < 0.001$). This association may be related to underlying micronutrient deficiencies, particularly vitamin D and calcium deficiencies, which can adversely affect bone mineralization, skeletal development, and overall physiological functioning. The coexistence of rickets and SAM may indicate multiple nutritional deficiencies and a more complex clinical condition requiring comprehensive nutritional and medical management. This finding underscores the importance of assessing and appropriately managing micronutrient deficiencies and associated nutritional disorders during the treatment of children with SAM.

Anemia was also significantly associated with nutritional recovery. Children diagnosed with anemia had a substantially higher rate of recovery than those without anemia (AHR = 14.63, 95% CI: 3.47–61.73; $p = 0.001$). This finding is consistent with previous studies conducted in Ethiopia, which identified anemia as an important predictor of SAM treatment outcomes [25, 26, 31, 33]. However, the direction and magnitude of this association are unexpected from a conventional clinical perspective and should be interpreted cautiously. Anemia is commonly associated with

micronutrient deficiencies, chronic infections, and impaired physiological functioning, which may complicate nutritional rehabilitation. Differences in anemia diagnosis, clinical management, underlying causes, and the distribution of other prognostic characteristics may partly explain the observed association. Therefore, further investigation is needed to establish the underlying mechanisms and clinical significance of this finding.

Oral thrush was another significant clinical predictor of nutritional recovery. Children with oral thrush had a higher rate of recovery than those without oral thrush (AHR = 8.21, 95% CI: 2.49–27.04; p = 0.001). Oral candidiasis may interfere with feeding and nutrient intake because of oral discomfort and difficulty swallowing. Therefore, the observed positive association is not readily explained by the expected clinical effects of this condition. Differences in the timing of diagnosis, treatment provision, clinical surveillance, or other unmeasured characteristics may have contributed to this finding. Nevertheless, the result highlights the importance of systematic assessment and appropriate management of oral infections during nutritional rehabilitation.

Hypothermia was also significantly associated with nutritional recovery. Children presenting with hypothermia had a substantially higher rate of recovery than those without hypothermia (AHR = 53.88, 95% CI: 9.40–308.80; p < 0.001). Although hypothermia is a recognized complication of severe malnutrition and may indicate impaired thermoregulation and severe physiological compromise, the observed association with a higher recovery rate is unexpected. This result may reflect differences in clinical recognition, early intervention, monitoring, or other characteristics of the admitted children. The wide confidence interval further indicates considerable uncertainty in the magnitude of the association. Accordingly, this finding should be interpreted cautiously and requires confirmation in further studies.

Regarding micronutrient supplementation, vitamin A supplementation was significantly associated with a lower rate of nutritional recovery. Children who received vitamin A supplementation had a lower rate of recovery than those who did not receive supplementation (AHR = 0.23, 95% CI: 0.07–0.71; p = 0.011). This finding should not be interpreted as evidence that vitamin A supplementation adversely affects nutritional recovery. Vitamin A supplementation may have been preferentially administered to children with specific clinical indications, underlying deficiencies, or more complicated nutritional conditions. Such differences in clinical

characteristics and treatment indications may have contributed to the observed association. Considering the established role of vitamin A in immune function, epithelial integrity, and child health, further studies are necessary to clarify this relationship.

In contrast, folic acid supplementation was significantly associated with an increased rate of nutritional recovery. Children who received folic acid supplementation had approximately ten times the rate of recovery compared with those who did not receive supplementation (AHR = 10.44, 95% CI: 3.30–33.05; p = 0.006). This finding is consistent with studies conducted at Finote Selam Hospital and Debre Markos [13]. The observed association may be explained by the essential role of folic acid in DNA synthesis, cellular division, and erythropoiesis. Adequate folate availability is particularly important during periods of rapid growth and tissue regeneration, potentially supporting hematological function and nutritional rehabilitation. Nevertheless, the magnitude of this association should be interpreted cautiously, as folic acid supplementation may also be associated with differences in clinical care, treatment adherence, and the underlying nutritional status of children. These findings support the importance of appropriate micronutrient assessment and adherence to recommended supplementation protocols during SAM management.

Immunization status was also significantly associated with nutritional recovery. Compared with fully immunized children, partially immunized children had a substantially lower rate of recovery (AHR = 0.12, 95% CI: 0.03–0.44; p = 0.001). This finding suggests that incomplete immunization may be associated with delayed nutritional recovery. Children who are not fully immunized may have greater susceptibility to vaccine-preventable infections, which can increase metabolic demands, reduce appetite, and interfere with nutritional rehabilitation. Furthermore, immunization status may reflect broader differences in healthcare access, utilization of preventive services, and caregiver health-seeking behavior. Therefore, integrating routine immunization assessment, catch-up vaccination where appropriate, and nutritional rehabilitation services may contribute to improving overall child health outcomes.

Finally, blood transfusion was not significantly associated with nutritional recovery after adjustment for potential confounders (AHR = 0.85, 95% CI: 0.45–1.63; p = 0.642). Although blood transfusion may be clinically indicated in selected children with severe anemia and other complications, the present findings do not provide evidence of an independent association between

transfusion and the rate of nutritional recovery. This may be partly explained by the fact that transfusion is generally provided according to specific clinical indications, and its relationship with recovery may be influenced by the severity of the underlying condition and other concurrent complications.

Overall, the findings of this study demonstrate that nutritional recovery among children with SAM is influenced by a combination of sociodemographic, clinical, and treatment-related factors. In particular, TB, rickets, and incomplete immunization were associated with substantially lower rates of recovery, whereas folic acid supplementation was associated with a higher rate of recovery. The findings also indicate that several other clinical and sociodemographic characteristics were independently associated with recovery, although some of the observed associations were unexpected and require cautious interpretation. These results emphasize the importance of comprehensive clinical assessment, early identification and management of comorbidities, appropriate micronutrient supplementation, immunization services, and consistent implementation of standard SAM management protocols. Strengthening these interventions may contribute to improved treatment outcomes and timely nutritional recovery among children with SAM.

Table 3:Life table of survival rate of SAM among children admitted to DBCSH, Debre Berhan, Ethiopia,2024(n=112)

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. ltable LOS event, survival

                Beg.                                Std.
  Interval      Total   Deaths   Lost   Survival    Error    [95% Conf. Int.]
-------------------------------------------------------------------------------
     3     4      112        4      0     0.9643   0.0175    0.9076   0.9864
     4     5      108        2      0     0.9464   0.0213    0.8846   0.9756
     5     6      106        9      0     0.8661   0.0322    0.7877   0.9170
     6     7       97        5      0     0.8214   0.0362    0.7370   0.8809
     7     8       92        2      0     0.8036   0.0375    0.7172   0.8660
     8     9       90       14      0     0.6786   0.0441    0.5835   0.7564
     9    10       76        8      0     0.6071   0.0461    0.5104   0.6906
    10    11       68        8      0     0.5357   0.0471    0.4392   0.6228
    12    13       60        5      0     0.4911   0.0472    0.3957   0.5795
    14    15       55        4      0     0.4554   0.0471    0.3614   0.5444
    15    16       51        7      0     0.3929   0.0461    0.3026   0.4818
    16    17       44       15      0     0.2589   0.0414    0.1820   0.3425
    18    19       29        6      0     0.2054   0.0382    0.1363   0.2843
    19    20       23        1      0     0.1964   0.0375    0.1289   0.2745
    20    21       22        6      0     0.1429   0.0331    0.0857   0.2141
    24    25       16        3      0     0.1161   0.0303    0.0652   0.1829
    25    26       13        4      0     0.0804   0.0257    0.0395   0.1399
    28    29        9        3      0     0.0536   0.0213    0.0220   0.1061
    34    35        6        2      0     0.0357   0.0175    0.0117   0.0824
    35    36        4        2      0     0.0179   0.0125    0.0035   0.0572
    60    61        2        2      0     0.0000        .         .        .
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Limitations and Strength of the study

The model was fitted using the predictor variables, and the study's primary strengths are the use of the Cox proportional hazards assumptions and a prospective follow-up study design. The inability to include other comprehensive hospitals data in the study is a limitation for comparison of a result in the aspect of severe acute malnutrition management, survival and its predictors.

Conclusion

The recovery rate for children with SAM is consistent when compared to both the Ethiopian national standard and the Sphere norm. A higher cure rate necessitates correct administration of

the SAM standard technique. Nonetheless, the SAM standard approach must be appropriately maintained in order to get a better cure rate. Co-morbidities must be managed early, and medications must be administered carefully during SAM therapy.

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Author's contributions

SGY: conceptualization, methodology, writing proposal, original draft and thesis, software analysis, formal analysis, Manuscript writing. DAE: supervised the design of the study, validation, data curation, writing, and editing. MBT: supervised the design of the study, validation, data collection, participating in analysis, ZAG: participate in software analysis, data extraction, and analysis. Finally, all authors approved the manuscript.

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Availability of data and materials

Upon a reasonable request, the corresponding author will make the data utilized and/or analyzed for this study available

Ethics approval and consent to participate

The Amhara Public Health Institute Dessie Branch Institutional Review Board (APHIDBIRB) ,(APHI-DW/R/T/T/D-990) granted ethical approval, and the approval period began on June 10, 2024, prior to the start of data collection. Before the interview started, the data collectors provided the interviewees with an explanation of the study's purpose, benefits, risks, discomfort, and right to withdraw or refuse at any time for any reason. Because the data was primary, we obtained direct

informed consent from each participant (parents and legal guardians), and privacy and confidentiality were protected during data collection. The survey responses were anonymous because the individual's identity was kept hidden. The institution review board committee did not approve the waiver. Regretfully, the hospital received verbal approval to waive it, and it was carried out.

Ethical Guidelines and Regulation

This research was carried out following the ethical guidelines specified in the Declaration of Helsinki, relevant to studies involving human health information. The research employed secondary data obtained from medical records of hospitals. Confidentiality and privacy of patients were preserved during the collection, management, and analysis of data. Personal identifiers were removed from the analytical dataset to ensure the patients' confidentiality. Approval for ethical considerations was secured from the appropriate institutional research ethics review committee before data gathering commenced. The requirements for informed consent were handled in line with the decision of the ethics review board and relevant institutional protocols.

Subject selection

The primary justification for enrolling participants should be the study's scientific aims, rather than vulnerability, privilege, or other irrelevant characteristics. Participants who accept the risks of research should be able to reap its rewards. Specific categories of volunteers (for example, women or children) should not be excluded from research opportunities unless there is a compelling scientific rationale or a particular risk tolerance.

Potential risk-benefit ratio

Uncertainty about the level of risk and reward associated with a clinical research trial is inevitable. Research dangers might be minor or severe, short or long-term. Physical, psychological, financial, and social risks might all exist. Everything should be done to reduce the risks and inconvenience to study participants in order to maximize the possible benefits and ensure that the potential advantages are proportionate to, or surpass, the hazards.

Informed consent

Potential volunteers should make their own decisions regarding whether or not to continue engaging in research. This is accomplished through an informed consent process in which individuals (1) are accurately informed of the research's purpose, methods, risks, benefits, and alternatives, (2) understand this information and how it relates to their own clinical situation or interests, and (3) make a voluntary decision to participate.

Respect for potential and enrolled participants.

Individuals should be treated with dignity from the moment they are approached about prospective involvement even if they decline enrollment in research until their participation concludes. Provide therapy and, if required, remove participants from the study while telling them about the research findings. This includes respecting participants' privacy, keeping their private information confidential, respecting their right to withdraw without penalty, informing them of new information that may change their assessment of the risks and benefits of participating, monitoring their welfare, and addressing any adverse reactions or unexpected effects.

Declaration of informed voluntary consent

I look over the participant data sheet. I am aware of the goals, methods, advantages and disadvantages, concerns about confidentiality, and contact details in case I have any questions about the research. I have the chance to ask questions to get clarification. In the event that unethical data collection practices are discovered on hospital property, the hospital maintains the right to terminate the study. On behalf of the management of Debre Berhan Comprehensive Specialized Hospital (DBCSH), I hereby consent to the conduct of this study in the medical facilities.

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Thank you.!!!

Consent of publication

Not applicable

Competing interests

Regarding the research, writing, and/or publication of this article, the author(s) have declared that they have no potential conflicts of interest.

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