Predictors of nutritional recovery time in children aged 6–59 months with severe acute malnutrition in Sofala Province, Mozambique: survival analysis approach

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ABSTRACT

Background Malnutrition is a public health problem that affects physical and psychosocial well-being. It manifests as a rapid deterioration in nutritional status and bilateral edema due to inadequate food intake or illness.
Methods This study is a retrospective cohort of 1208 children with severe acute malnutrition (SAM) in Sofala Province from 2018 to 2022. It includes hospitalized children aged 6–59 months with SAM and related complications. The dependent variable is recovery, and the independent variables include age, sex of the child, vomiting, dehydration, hypoglycemia, nutritional edema and anthropometry. Survival curves were plotted using the Kaplan–Meier method, and bivariable and multivariable Cox regression analyses were performed.
Results The crude analysis revealed significant factors for nutritional recovery in children with SAM, including age, weight, height, malaria, diarrhea and dehydration. Children under 24 months had a 28% lower likelihood of recovery. Weight below 6.16 kg decreased the likelihood by 2%, and height above 71.1 cm decreased it by 20%. Conversely, malaria, diarrhea and dehydration increased the likelihood of recovery. However, after adjustment, only diarrhea remained a significant predictor of nutritional recovery.
Conclusion This study found that diarrhea is a predictor of nutritional recovery in children with SAM.

Keywords children aged 6–59 months, recovery time, severe acute malnutrition, survival

Introduction

Malnutrition is a significant public health issue that has detrimental effects on the physical and psychosocial well-being of individuals, making them more susceptible to diseases and reducing their chances of achieving independence.[1] It occurs when individuals fail to consume or absorb sufficient essential nutrients due to various underlying factors, such as diseases, lack of access to healthcare services, socioeconomic conditions of the household, inadequate sanitation and diet, among others.[2]

Severe acute malnutrition (SAM) is a form of acute malnutrition characterized by a rapid deterioration in nutritional status over a short period of time and/or the presence of

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bilateral edema caused by inadequate food intake and/or recent illness.[3,4] The World Health Organization (WHO) defines SAM as having a very low weight for height (below −3 z-scores/standard deviation of the median according to growth standards or below 70% of the median of the National Centre for Health Statistics standard curves), along with the presence of nutritional edema or a mid-upper arm circumference (MUAC) <11.5 cm for children aged 6–59 months.[5–7] Clinically, SAM can manifest as Marasmus (severe weight loss), Kwashiorkor (bilateral edema) or Kwashiorkor-marasmic (severe weight loss with bilateral edema).[3] Data indicate that the global number of children suffering from acute malnutrition has only decreased by 11% in the past 20 years.[8] According to the latest joint child malnutrition estimates from UNICEF, WHO and the World Bank in 2021, 13.6 million children under the age of five worldwide suffer from SAM, with 2.2 million cases occurring in sub-Saharan African countries.[9,10]

In Africa, evidence has shown a low cure rate for SAM in children aged 6–59 compared with the reference standard (>75–77.9%), with a considerable percentage of children.[10–12] Predictors of recovery from SAM identified in a study conducted in Ethiopia included maternal illiteracy, severe household food insecurity, co-morbidity with diarrhea and the practice of sharing ready-to-use therapeutic food.[13] A retrospective cohort study conducted in southern Ethiopia revealed that malnutrition status (adjusted hazard ratio [AHR] = 1.8, 95% confidence interval [CI]: 1.3–2.4), weight (AHR = 1.5, 95% CI: 1.2–1.9), mid-arm circumference (AHR = 1.4, 95% CI: 1.1–1.9), hospital complications (AHR = 2.2, 95% CI: 1.4–3.5) and failure to lose edema within 4 days of hospital treatment (AHR = 2.3, 95% CI: 1.1–4.8) were significant factors.[14] Another study conducted in Uganda observed that children with SAM who received deworming treatment were 33% more likely to recover faster compared with those who did not receive deworming treatment (AHR = 1.33; CI = 1.01–1.74).[15]

In Mozambique, it is estimated that ∼67 500 children under the age of five require treatment for acute malnutrition, with 6500 children suffering from SAM and 61 000 children experiencing moderate acute malnutrition.[16] In the national context, factors such as military insecurity, weak healthcare systems, high prevalence of infectious diseases, particularly among illiterate women, limited access to safe water, inadequate sanitation, and poor quality and quantity of diet among children aged 6–23 months contribute to the prevalence of acute malnutrition.[16,17]

In Sofala, acute malnutrition affects ∼3, 3.6 and 2.20% of children under the age of five in the districts of Nhamatanda, Caia and Búzi, respectively. Unfortunately, there are no published data available for the other districts in the province.[18] Given this concerning situation, several strategies have been implemented to improve the healthcare services provided to children. Therefore, since 2016, the Provincial Directorate of Health, in partnership with the Clinton Health Access Initiative, has been implementing the Nutrition and HIV Program Quality Improvement Strategy known as 'Center of Excellence (CoE's)' in hospitals within the districts under study. Based on the nationally available information, our aim is to study the predictors of recovery from SAM in children aged 6–59 months in Mozambique between 2018 and 2022.

Methods

Study design and population

This retrospective cohort study included children under the age of five and utilized hospital records from the health services in six districts: Nhamatanda, Caia, Chibabava, Buzi, Gorongosa and Marromeu, in the province of Sofala, Mozambique. The data collection period spanned from January 2020 to 30 December 2022. Children with SAM were included in the study, with the exclusion criteria being records that had missing treatment outcomes, admission dates and discharge dates, as these are crucial outcomes that need to be addressed (Fig. 1).

We included records of all children aged 6–59 months who were admitted to hospitals in the study districts due to complications related to SAM. To ensure data quality, health professionals (doctors, nutritionists and nurses) assigned to these health facilities received training on specific issues related to assessment, proper management, nutritional screening and accurate recording of information. Subsequently, the data were cross-referenced with the SAM register and clinical files.

The pediatric ward admits children resulting from a screening process that follows Mozambican protocols for the Management of Malnutrition. This screening utilizes the MUAC and observation of edema to identify severe cases, which receive immediate treatment. Following the screening, an appetite test is conducted while awaiting medical evaluation. During this interval, the healthcare professional assesses the patient's feeding capacity, while the physician investigates any potential medical complications. The process adopts a gradual approach, prioritizing severe cases, evaluating feeding capacity and considering medical complications before determining outpatient or inpatient treatment. The length of hospital stay depends on the patient's recovery and stabilization, allowing for the continuation of outpatient treatment.[3]

Study variables

The dependent variable of this survival study was the time to stabilized recovery of children with SAM. Stabilized recovery was defined as the time a child spends in hospital up to 30 days,

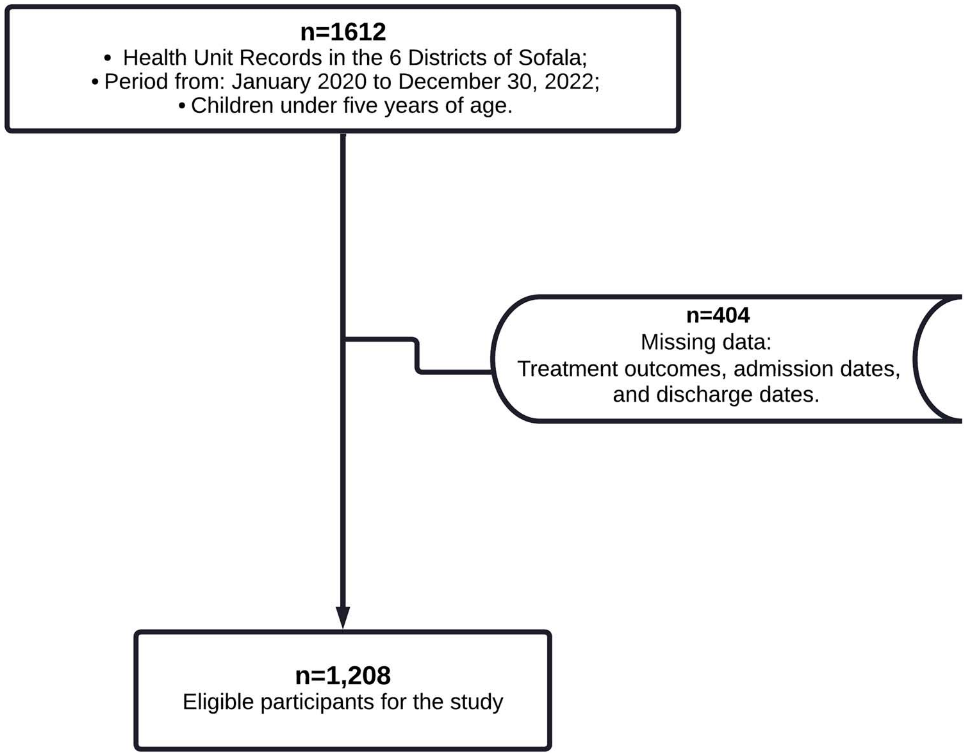

Fig. 1 Selection of the study population.

when the child is treated for acute medical complications in a stabilization center and transferred to outpatient treatment for ongoing SAM care.[19,20] In addition, the child must be free from acute medical complications and have a stable clinical condition, demonstrating clinical stabilization. The absence or significant reduction of edema, which is the accumulation of fluid in the tissues, is also an important criterion for recovery. Finally, good food acceptance, meaning the child's ability to consume an adequate amount of therapeutic foods or recovery foods, is an indicator of improved feeding capacity. These criteria are used to determine when a child with SAM is ready to be transferred from treatment in a stabilization center to ongoing outpatient treatment.

The independent variables included demographic characteristics (age and sex of the child), clinical conditions (vomiting, dehydration and hypoglycemia), presence of nutritional edema, associated comorbidities (pneumonia/bronchopneumonia, maternal and child HIV/AIDS, diarrhea, anemia, malaria and tuberculosis) and anthropometric measures (weight, height and MUAC) upon admission.[14]

Censored observations were defined as those SAM children who were lost to follow-up, transferred, had missing data, deceased or did not have the primary outcome of interest (recovery) observed. Anemia was defined as a hemoglobin level below 5.0 g/dL or a hematocrit level below 12% upon admission,[3] while hypothermia was defined as a rectal or axillary body temperature below 35.5 or 35°C, respectively.

Statistical analysis

Statistical analysis was conducted using various methods. Absolute frequencies, percentages, mean, median and standard deviation were used to present the data. The distribution of ratio scale variables was checked using the Kolmogorov–Smirnov test. Life tables and survival curves were used to show the cumulative function of survival with different patient characteristics. Kaplan–Meier and log–log plot methods were used to plot survival curves, and Schoenfeld's residual test was used to study the proportionality of each covariate. The assumption of Cox proportional hazard was verified graphically and statistically.[21,22]

After verifying the Cox proportional hazard assumption, bivariable and multivariable Cox proportional hazard regression analyses were performed. Crude and AHRs with 95% CI were calculated. Predictor variables with a P-value below 5% in the bivariable Cox regression were considered as candidates for the multivariable Cox regression analysis. All variables with a P-value below 5% (<0.05) were considered statistically significant. The analyses were conducted using the gplot2, survival, and survminer packages in R statistical software,

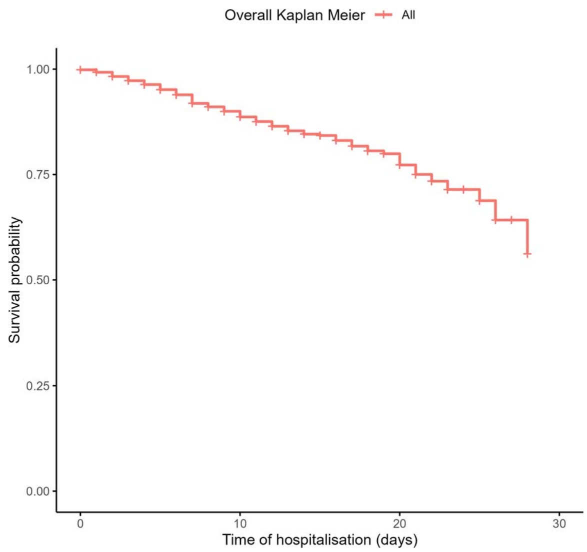

Fig. 2 Overall Kaplan Meier survival estimate of SAM 6–59 months for predictors for recovery rate in six districts of Solfa, Mozambique, 2018/22.

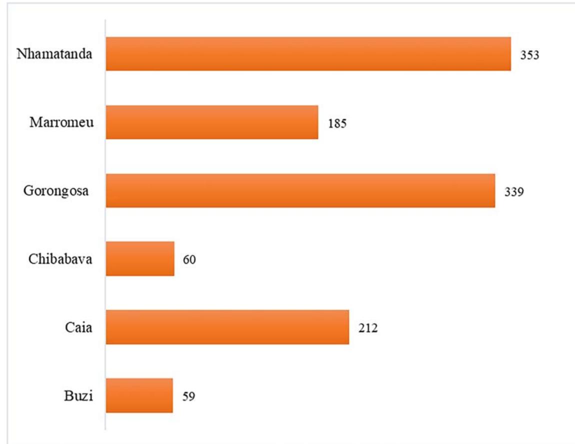

Fig. 3 Frequency indicator of the distribution of SAM inpatients in the six study districts from 2018 to 2022.

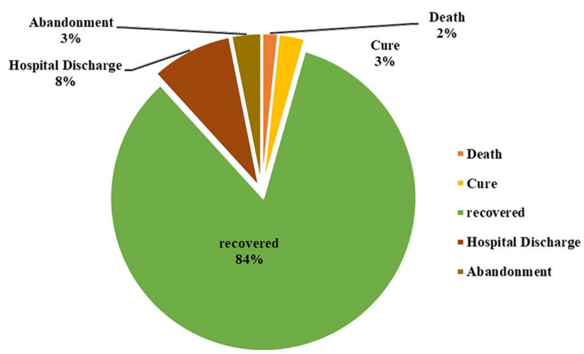

Fig. 4 Outcome of SAM treatment.

version 3.6.1 (http://www.r-project.org) and RStudio software, version 1.2.1335.

Results

Socio-demographic and anthropometric features of the participants

A total of 1208 children diagnosed with SAM were monitored in inpatient clinics across six districts of Sofala Province from 2018 to 2022. The median recovery time was 11 days with an interquartile range (IQR) of 8–14 days (Fig. 2). The distribution of children from each district was as follows: Nhamatanda (29.2%, n = 353), Marromeu (15.3%, n = 185), Gorongosa (28.1%, n = 339), Chibabava (5%, n = 60), Caia (17.5%, n = 212) and Buzi (4.9%, n = 59) (Fig. 3). The majority (67%) of the participants were male and aged ≤24 months. The IQR for age (months), height (cm) and weight (kg) were 21 (IQR:14–27), 74 (IQR: 69–80), 7.5 (IQR:5.7–8.4) and 10.9 (IQR:10–11.5), respectively. Among those admitted, 72.3% were new cases, 19.4% were transferred and 39% were diagnosed with Marasmus (Table 1). Of the children followed up, 84% recovered from SAM (Fig. 4). The recovery rate after treatment was statistically associated with age (Logrank, $P = 0.011$; Breslow, $P = 0.011$ and Tarone, $P = 0.011$), weight (Logrank, $P = 0.02$; Breslow, $P = 0.02$ and Tarone, $P = 0.01$), height (Logrank, $P = 0.04$; Breslow, $P = 0.04$ and Tarone, $P = 0.04$), malaria (Logrank, $P = 0.004$; Breslow, $P = 0.004$ and Tarone, $P = 0.004$), diarrhea (Logrank, $P < 0.0001$; Breslow, $P < 0.0001$ and Tarone, $P < 0.0001$) and dehydration (Logrank, $P = 0.0019$; Breslow, $P = 0.0019$ and Tarone, $P = 0.0007$) (Table 1 and Fig. 5).

Predictors of nutritional recovery

Through crude analysis, several factors were found to be significant predictors of the recovery rate from SAM. Children aged below 24 months were 28% less likely to recover (HR = 0.72, 95% CI: 0.57–0.93), those with a weight below 6.16 kg were 23% less likely (HR = 0.77, 95% CI: 0.61–0.96) and those with a height above 71.1 cm were 20% less likely to recover (HR = 0.80, 95% CI: 0.64–0.99). However, children with malaria (HR = 1.48, 95% CI: 1.13–1.92), diarrhea (HR = 1.96, 95% CI: 1.14–2.71) and dehydration (HR = 1.66, 95% CI: 1.20–2.30) were more likely to recover from SAM.

After adjustment, only diarrhea remained a significant predictor of the nutritional recovery rate. Children without diarrhea were 1.68 times more likely to recover nutrition (Table 2).

Discussion

The main finding of this study is that diarrhea was found to be a significant predictor of nutritional recovery in children

Table 1 Analysis of factors associated with treatment recovery rate of SAM in Sofala, Mozambique 2018/22 (N = 1208)

Characteristics	*Total*	*Median recovery time (in days)*		*Log rank X2-value*	*P-values*	*Tarone ware X2-value*	*P-values*	*Breslow X2-value*	*P-values*
	n (%)	*Estimate*	*95% CI*						
Sex									
Male	628 (52)	10	(8–14)	0.19	0.15	2.13	0.14	2.07	0.15
Female	580 (48)	11	(8–15)						
Age (months)									
≤24	809 (67)	10	(8–14)	4.22	**0.011***	6.41	**0.011***	6.41	**0.011***
>24	399 (32)	11	(8–15)						
Weight (kg)									
≤6.16	431 (35.7)	11	(8–14)	5.51	**0.02***	6.07	**0.01***	5.51	**0.02***
>6.16	754 (62.5)	10	(8–15)						
Missing	9 (1.91)								
MUAC (cm)									
≤10.5	308 (25.5)	11	(8–15)						
>10.5	368 (30.5)	9	(7–12)	0.43	0.51	0.49	0.48	0.43	0.51
Missing	532 (44.1)								
Height (cm)									
≤71.1	431 (35.7)	10	(8–14)						
>71.1	754 (62.5)	11	(8–14)	4.06	**0.04***	4.28	**0.04***	4.06	**0.04***
Missing	23 (1.91)								
Admission category									
New case	874 (72.3)	11	(8–14)						
Referred from TDA	56 (4.6)	11.5	(9–15.8)						
Transferred from the other sector or hospital	234 (19.4)	9	(7–14)	2.10	0.72	1.92	0.75	2.10	0.72
Abandoned who took up again	5(0.41)	11	(6–11)						
Re-admitted	41 (3.4)	13	(9.25–18)						
Malnutrition type									
Marasmus	470 (39.0)	10	(7–13)						
Kwashiorkor	396 (32.8)	11	(8–15)	4.10	0.13	4.76	0.09	4.10	0.13
Kwashiorkor-marasmic	342 (28.4)	11	(8–15)						
Maternal HIV status									
No	1008 (83.6)	11	(8–14)	1.65	0.2	1.64	0.2	1.65	0.2
Yes	200 (16.5)	11	(8–14)						
Child HIV status									
No	1034 (85.6)	10.5	(8–14)	1.39	0.24	1.38	0.24	1.39	0.24
Yes	174 (14.4)	11	(8–14)						
Malaria									
No	1038 (85.9)	11	(8–15)		**0.004***	7.98	**0.004***	8.39	**0.004***
Yes	170 (14.1)	10	(7–13)	8.39					
Tuberculosis									
No	1190 (98.5)	11	(8–14)	2.72	0.099	2.3	0.13	2.72	0.099
Yes	18 (1.5)	9	(7–13)						
Bronchopneumonia/Pneumonia									
No	1131 (93.6)	11	(8–14)	0.54	0.46	0.44	0.46	0.54	0.46
Yes	77 (6.4)	11	(8–13)						

(*Continued*)

Table 1 Continued

Characteristics	Total n (%)	Median recovery time (in days) Estimate	95% CI	Log rank X2-value	P-values	Tarone ware X2-value	P-values	Breslow X2-value	P-values
Diarrhea									
No	1135 (94)	11	(8–14)	18.02	<**0.0001***	18.89	<**0.0001***	18.02	<**0.0001***
Yes	73 (6.0)	11	(8–14)						
Anemia									
No	961 (79.6)	11	(8–14)	1.32	0.25	1.51	0.22	1.32	0.25
Yes	247 (20.4)	10	(8–15)						
Dehydration									
No	1133 (93.8)	11	(8–14)	9.68	**0.0019***	11.33	**0.0007***	9.68	**0.0019***
Yes	75 (6.2)	14	(9–19)						
Hypoglycemia									
No	1183 (97.9)	11	(8–14)	1.57	0.21	1.78	0.18	1.57	0.21
Yes	25 (2.1)	11	(8–14)						
Sepsis									
No	1173 (97.1)	10	(8–14)	2.03	0.15	2.42	0.12	2.03	0.15
Yes	35 (2.9)	9	(7–13)						

CI, confidence intervals; SAM, severe acute malnutrition; MUAC, mid-upper arm circumference; TMO, treatment of malnutrition in outpatients.
*P values < 0.05.

Table 2 Crude and adjusted multivariate cox regression for predictors of nutritional recovery among SAM managed children in Sofala, Mozambique 2018 to 2022 ($N = 1208$)

Predictors	No. at risk	Recovered	Crude HR (95% CI)	Adjusted HR (95% CI)
Age (months)				
>24	809	688	1	1
≤24	399	358	0.72 (0.57–0.93)	0.83(0.62–1.10)
Weight (kg)				
>6.16	431	342	1	1
≤6.16	754	699	0.77 (0.61–0.96)	0.88 (0.66–1.21)
Height (cm)				
>71.1	431	362	1	1
≤71.1	754	667	0.80 (0.64–0.99)	0.92 (0.68–1.23)
Malaria				
Yes	1038	910	1	1
No	170	136	1.48 (1.13–1.92)	1.22(0.91–1.64)
Diarrhea				
Yes	1131	981	1	1
No	77	65	1.96 (1.14–2.71)	1.68 (1.16–2.43)
Dehydration				
Yes	1133	992	1	1
No	75	54	1.66 (1.20–2.30)	1.30 (0.89–1.90)

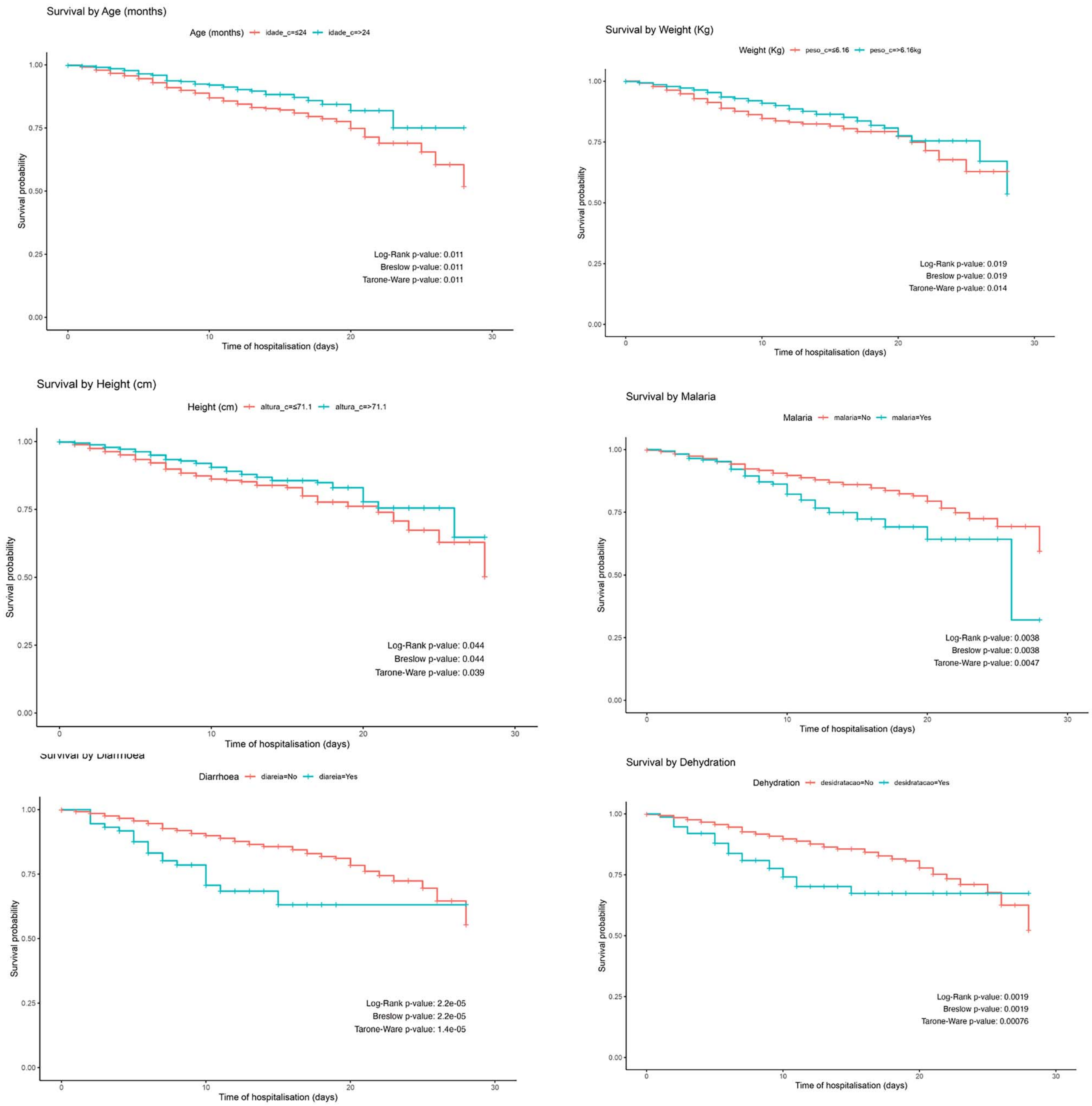

Fig. 5 Kaplan Meier survival plots for different significant prognostic predictor in six districts of Solfa, Mozambique, 2018/22.

aged 6–59 months with SAM. Children without diarrhea were 1.68 times more likely to recover nutritionally. The study followed a total of 1208 children from 2018 to 2022, and 84% of them recovered from SAM, meeting the recommended recovery rate of 75%.[23,24]

The study's results were similar to findings from other studies conducted in Ethiopia, which also reported high recovery rates.[25,26]

In the crude analysis, age, weight, height, malaria, diarrhea and dehydration were considered significant factors. Children below 24 months, with weight below 6.16 kg, and height above 71.1 cm were less likely to recover. On the other hand, children with malaria, diarrhea and dehydration were more likely to recover.

Kebede *et al*.[25] observed that age was the only significant predictor for recovery from SAM, where for each 1-month increase in the child's age, the nutritional recovery rate increased by 14.6% (AHR = 1.146; 95% CI: 1.052–1.249), may be explained by the fact that children under 24 months with severe malnutrition are more vulnerable to infections because of depressed immunity leading to malabsorption of nutrients due to insufficient or inappropriate feeding practices.[26,27] Another study that assessed recovery time and its predictors among children aged 6–59 months with acute malnutrition admitted to an outpatient clinic in southwestern Ethiopia observed that the independent predictors of nutritional recovery time were not having diarrhea (AHR = 1.9, 95% CI: 1.52–2.42) and not having malaria (AHR = 1.75, 95% CI: 1.32, 2.32),[28] another study observed that chance of recovery was found among children who had no anemia (AHR: 1.66, 95% CI: 1.23–2.23), and malaria infection (AHR: 1.54, 95% CI: 1.09–2.17) at admission,[29] probably because malaria decreases appetite, increases body temperature, causes anemia due to hemolysis and hypoglycemia thus contributing to decreased recovery rate when compared with a child without malaria.

After adjustment, diarrhea was a significant predictor of nutritional recovery rate. Children without diarrhea were 1.68 times more likely to recover nutritionally. A similar result was found in other studies that observed that diarrhea was a negative predictor of recovery time from SAM, the recovery rates were lower among children who had diarrhea during SAM treatment.[13,30] Another study that assessed predictors of time to recovery from SAM treated in an outpatient treatment program in Arba Minch Zuria Woreda health posts, Gamo zone, southern Ethiopia showed that after adjustment diarrhea (AHR = 0.22, 95% CI (0.13, 0.39) and anemia (AHR = 0.64, 95% CI: (0.42, 0.98) were found to be predictors of time to recovery from SAM.[31] This association may be explained by the fact that children with malnutrition and diarrhea probably present a loss of intestinal mucosal barrier resulting from systematic immunosuppression, which takes longer for children in this condition to recover than those admitted without diarrhea; on the other hand, children admitted with diarrhea lose more weight due to impaired absorption and increased nutrient demand.[32,33] One of the biggest challenges for the successful treatment of malnourished children with diarrhea is the management of severe dehydration and/or shock, according to current guidelines for severely malnourished children, dehydration is treated with replacement with low-sodium rehydration solution.[30]

The study contributes to the existing literature by providing data on predictors of time to nutritional recovery in children with SAM in Mozambique. It is the first retrospective cohort study in Mozambique to use survival analysis approaches for this purpose. The study's strengths include its longitudinal design and relatively large sample size. However, there are limitations to consider, such as the study being conducted in only six districts of Sofala Province, limiting the generalizability of the results. Additionally, important predictors like paternal education, maternal breastfeeding history, vaccination and family income were not explored due to a lack of data. Future studies should aim to include these variables in their analyses.

Conclusion

The study identified diarrhea as a significant predictor of nutritional recovery in children aged 6–59 months with SAM. We emphasize the importance of diagnosing and treating cases of diarrhea among children diagnosed with SAM in Sofala. It is crucial to implement public health and nutrition interventions aimed at preventing or reducing the occurrence of SAM and diarrhea in children, as both conditions can hinder proper growth and development and lead to negative outcomes, including death.

Therefore, we recommend that governmental and non-governmental organizations working in the health sector provide regular training for community health agents and healthcare professionals. This will enable early identification and treatment of diarrhea before it develops complications, thereby contributing to an increased recovery rate among hospitalized children.

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Supplementary data

Supplementary data are available at the *Journal of Public Health* online.

Conflict of interest

The authors declare no conflicts of interest.

Funding

Not applicable.

Authors' contributions

AV, BCA, ARMG and MM designed the study. AV and BCA collected data and constructed the database. AV, SPX, AF and OASR outlined the analytical strategy. AV, AF, ARMG, PR and OASR performed the statistical analyses, interpreted the results and drafted the manuscript. PR, MO and AF interpreted the results and critically reviewed the manuscript.

As this is secondary and anonymous data in the public domain, free and informed consent, and approval by the Research Ethics Committee were exempted.

Data availability

Data described in the manuscript, codebook and analytical code can be provided on request.

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