Factors associated with Length of Hospital Stay among Under-Five Children Admitted with Severe Acute Malnutrition in St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia

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Abstract

Background: Prolonged hospitalization among children with severe acute malnutrition remains a significant challenge in Ethiopia. While most of these children receive hospital treatment, a substantial proportion experience extended hospital stays. However, there is a paucity of research on the determinants of prolonged hospitalization in this context. Therefore, this study aimed to determine the average length of hospital stay and its determinants among children who recovered from SAM at St. Paul's Hospital Millennium Medical College (SPHMMC), Addis Ababa, Ethiopia.

Methods: An institution-based cross-sectional study was among 466 under-five children admitted to St. Paul's Hospital Millennium Medical College from 2012 to 2019. A retrospective document review was carried out using a standardized data extraction tool. A multiple linear regression model was employed to identify factors associated with length of stay. A Backward stepwise variable selection was employed to determine the final model. The coefficient of determination (R2) was used to assess the model's adequacy, and residual analysis verified the fundamental assumptions of the model.

Results: This study included 466 children aged between 1 and 59 months. The average duration of stay for children in this study was 19.27 ±11.67 days. The main determinants of length of hospital stay were hemoglobin level (β=-0.62, p=6.5E-03), tuberculosis (β=9.05, p=6.1E-09), hospital-acquired infections (β=7.96, p=5.5E-07), meningitis (β=8.38, p=5.4E-03), rickets (β=2.58, p=3.9E-02), hyponatremia (β=9.14, p=4.8E-02) and no impaired level of consciousness (β=-5.04, p=2.4E-02). The coefficient of determination (R2) was found to be 26%.

Conclusion: The typical length of hospital stays for children with SAM fell within the suggested range established by Sphere. However, many children, particularly those with comorbidities including tuberculosis, meningitis, nosocomial infections, and rickets, ended up spending a prolonged time in the hospital. Therefore, promptly treating comorbidities could decrease the duration of hospital stays for children with SAM.

Keywords: Children; severe acute malnutrition; length of hospital stay; St. Paul's Hospital Millennium Medical College; Ethiopia

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Introduction

One of the primary challenges in managing children with severe acute malnutrition (SAM) is the prolonged average hospital stay, particularly in regions where SAM is a significant public health concern (Banga *et al.,* 2020). This issue is especially prevalent in developing countries, with a substantial burden observed in Asia and Africa. As of 2022, an estimated 45 million (6.5%) under-five children were affected by acute malnutrition throughout the globe, of which 13.6 million (2.1%) were affected by severe wasting. Of children with severe wasting, over three-quarters live in Asia, and two-thirds (22%) live in Africa (WHO, 2023). The sub-goal of Sustainable Development Goal (SDG) 2 is to end all forms of malnutrition by 2030 even though a considerable number of low-income countries are off-track from this sustainable development goal (WHO, 2023). The magnitude of SAM sustained remarkably higher, mainly in low-income countries, though the World Health Organization (WHO) protocols to treat SAM have been implemented for years (Tickell and Denno, 2016). This may be due to the high prevalence of comorbidities, which upsurge treatment time both in inpatient and outpatient settings (Topal and Tolunay, 2021, Nigatu *et al.,* 2021).

The average hospital stay for children with SAM was listed as 30 days in the 2013 Ethiopian SAM guidelines (Tesfay *et al.,* 2020). The most recent Ethiopian SAM guideline, published in 2019, recommends a 60-day average length of stay (MOHE, 2019). However,

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previous evidence depicted that the length of stay (LOS) of children with SAM admitted in inpatient departments is dependent on multitudes of factors. Prolonged hospital stay depends on comorbidities such as sepsis, inappropriate feeding practices, unhygienic hospital environments, and poor healthcare services (Niseteo *et al*., 2020, Collins et al., 2006). Previous studies also corroborate that malnutrition itself is the cause of prolonged hospital stays in all population segments (Vong *et al*., 2022, Topal and Tolunay, 2021, Nigatu *et al.,* 2021, Bernardes *et al*., 2023, Abrha *et al*.**,** 2019).

The length of stay in Ethiopia's stabilization centers differs among studies. It ranges from a minimum of one day to a maximum of 130 days (Admasu, 2017, Adimasu *et al.,* 2020, Baraki *et al*., 2020, Bitew *et al.,* 2021b, Kokeb and Mariyo, 2022, Tesfay *et al.,* 2020). This implies that a considerable number of children stay in hospitals above the average length of hospital stay recommended by the Ethiopian SAM protocol. The shortest range of LOS was also reported to be 2 to 29 days (Bizuneh *et al*., 2022). The mean LOS in Ethiopia also ranges from 10±10.4 days (Oumer *et al.,* 2016) to 19.68±13.8 days (Tirore *et al.,* 2017). In contrast to the SPHERE project reference value, which suggests a mean LOS be less than 28 days, these findings showed that the majority of Ethiopian children with SAM had prolonged LOS (Chamois et al., 2007, Thurstans *et al.,* 2011). The findings also pinpointed remarkable variability in the LOS of children with SAM. In Ethiopia, studies on the determinants of length of stay are very limited. This study, therefore, aimed to determine the average length of hospital stay and its determinants among children with severe acute malnutrition in St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia.

Materials and Methods

Study Setting, Design, and Period

An institution-based cross-sectional study was conducted at St. Paul's Hospital Millennium Medical College. The college has one of the tertiary hospitals in Ethiopia where patients referred from all over the country get advanced treatments. The hospital has a maternal and child health unit where children are treated (SPHMMC, 2025). Severe acute malnutrition is one of the most frequently reported cases in the hospital. As a result, by keeping them at the facility for a long enough time, children with SAM receive both curative and rehabilitation therapy.

Population, Inclusion/ Exclusion Criteria

The source population was under-five children admitted with SAM and the study population was under-five children admitted with SAM during the study period (2012 to 2019) in St. Paul's Hospital Millennium Medical College. Children with unknown treatment outcomes, children referred to other institutions, and children with lost charts were excluded. In this study, only children who were discharged with recovery were included.

Sample size and Sampling Technique

The original sample size was calculated using two population proportions and the Cox proportional assumptions. The sample size was calculated to examine treatment outcomes of SAM and determinants. Recovery from SAM is one of the outcomes. All recovered cases were considered for this work. Thus, the final sample size of this study was estimated to be 466. The details are found in a previously published paper (Bitew *et al.,* 2021a). Medical record numbers were used to select the records from the health information management system registration. The study participants were chosen using a simple random sampling procedure. The participants were selected specifically using a computer-based random number from 1000 eligible participants.

Data Collection Instruments and Procedures

A standardized data extraction tool was developed by analyzing papers. The SAM registration booklet, the health information management system (HMIS) register, the SAM multi-chart, and the national treatment plan for the management of SAM Medical record numbers (MRNs) were used to identify documents containing SAM from the HMIS register. After importing MRNs into Excel and SPPSS version 21, a computer-generated random number was used to choose the final sample. The cards were examined per the selected registration numbers. Co-morbidities, types, anthropometric measurements (height, weight, MUAC, edema), and socio-demographic data (age, sex, residence) were all included in the format utilized for data extraction. For data collection and supervision, six nurses with a Bachelor of Science degree and two with a Master of Science degree in nursing were

hired. The principal investigator and supervisors closely monitored the data collection procedure. Supervisors supervised data collection whereas the principal investigator oversaw the overall data collection process in collaboration with the supervisors.

Operational Definition/Definition of Terms

SAM: SAM is characterized by an extremely low weight relative to height or length (below -3 z-scores of the median WHO growth standard), the presence of bilateral edema, or a mid-upper arm circumference (MUAC) of less than 115 mm in children aged six months or older. For children younger than six months, SAM is primarily diagnosed when their weight-for-length falls below -3 z-scores of the median WHO growth standard (Golden and Grellety, 2011).

LOS: describes the average length of hospital stay from admission to discharge (recovery) in days, which was measured from admission to discharge.

Treatment failure: according to the Ethiopian SAM guideline treatment failure in the stabilization is considered if either of the following findings is observed: failure to regain appetite by day 4 or failure to start to lose edema by day 4, or edema still present by day 10 or failure to gain at least 5 g/kg body weight after the 10th day of hospital admission.

Immunization status: children who have received all immunizations are considered fully immunized, whereas those who have not received any vaccinations, dropouts, and up to-dates are considered incompletely immunized.

Data Processing and Analysis

Data was coded, cleaned, and entered using Epi Info™ 7 software. The data were analyzed using R version 4.2.3 (2023 The R Foundation for Statistical Computing Platform: x86_64-w64-mingw32/x64 (64-bit)). Missing values, possible outliers, and multicollinearity were checked using exploratory analysis. Both simple linear regression and multiple linear regression analyses were performed to verify the determinants of LOS. Variables in multiple linear regression were chosen using backward stepwise variable selection techniques. The regression coefficient (β) is used to signify the amount by which change in independent factors must be multiplied to give the corresponding average change in LOS. $P<0.05$ was used to determine the presence of statistical significance. The variance inflation factor (VIF) was used to test for parameter estimation instability among the variables in the final fitted model. The presence of constant variance in residuals was checked by building the graph of "standardized residuals" against the "standardized predicted value". The variance inflation factors (VIFs) ranged from 1.031 to 2.024, confirming the absence of multicollinearity among the independent variables. Besides, a histogram of residuals was plotted to check the normality assumption. The coefficient of determination (R^2), which is a metric for assessing how well a multiple regression model fits its data, was used to check model fitness. The percentage of the variation of LOS that can be explained by the model's factor regression is shown by the linear determination index R^2.

Data Quality Control

Data quality was ensured using a well-developed data extraction sheet. Before data collection, a pretest was performed, and data collectors and supervisors were trained. Then, appropriate corrective actions were taken. The primary investigator double-checked the patient cards for potential data problems and continuously monitored the completeness and accuracy of the data. A previous article covered the specifics of the data collection process (Bitew *et al*., 2021).

Ethical Consideration

The SPHMMC Institutional Review Board (IRB) approved the study in terms of ethics. Obtaining informed consent was not feasible for this study. According to the Helsinki Declaration, "medical research involving identifiable human material or data, physicians must normally seek consent for the collection, analysis, storage and/or reuse." There can be circumstances when getting consent for the research would be difficult, impractical, or dangerous to the research's validity. Only with the consideration and consent of a research ethics committee is study permitted in such circumstances. The study units (the pediatrics department and card room) were then given a formal letter of participation, and consent was obtained before data collection could begin. The confidentiality and anonymity of the data gleaned from the patient records were upheld.

Results

Socio-demographic characteristics of participants

A total of 466 children who recovered from SAM were included in the study. The age of study participants ranged from 1 to 59 months with a median age of 13 months (interquartile range: 8-21 months). The majority (87.6%) of children were new admissions and a considerable proportion (12.2%) of children were not vaccinated. In this study, the majority (81.5%) of children with SAM had impaired pulse rate (either bradycardic or tachycardia) at admission. Similarly, nearly half of the children (49.8%) had impaired respiratory rate at admission (bradypnea or tachypnea). Besides, more than three-fourths (78.5%) of the study participants had non-edematous SAM.

Table 1: Socio-demographic and admission-related characteristics of under-five children recovered from SAM at SPHMMC, Addis Ababa, Ethiopia (n=466).

Variables	Categories	Frequency	Percent (%)
Gender	Male	240	51.5
	Female	226	48.5
Age group	0-5	67	14.4
	6-11	115	24.7
	12-23	178	38.2
	24-35	63	13.5
	36-47	19	4.1
	48-59	24	5.2
Residence	Addis Ababa	140	30.0
	Out of Addis Ababa	326	70.0
Admission status	New	408	87.6
	Readmission	58	12.4
Level of consciousness (LOC)	Impaired	23	4.9
	Not Impaired	443	95.1
Admission season	Spring	113	24.2
	Summer	96	20.6
	Autumn	114	24.5
	Winter	143	30.7
Vaccination status	Up to date	101	21.7
	Defaulters	100	21.5
	Complete	208	44.6
	Unvaccinated	57	12.2
Pulse Rate	Normal	380	81.5
	Impaired	86	18.5
Respiratory Rate	Normal	234	50.2
	Impaired	232	49.8
Type of SAM	Edematous	100	21.5
	Non-edematous	366	78.5
Oxygen saturation status	>=95	128	27.5
	90-94.99	252	54.1
	lower than 90	86	18.5
Bottle Feeding	Yes	169	36.3
	No	297	63.7
Exclusive breastfeeding	Yes	281	60.3
	No	185	39.7

The average length of hospital stays

The children were followed for a minimum of three days and a maximum of 71 days. The mean LOS was 19.27 $\pm$11.67 days (95% CI: 18.27, 20.27 days). The mean LOS was computed for selected independent variables. Thus, the maximum mean of LOS was documented among children who had a history of treatment failure (32.92 + 15.11 days) followed by children with hyponatremia which was 30.00 + 9.54 days. In contrast, the shortest mean LOS was found among children who were not put on IV antibiotics (15.48 + 8.03 days) (Table 2).

Table 2: Mean length of hospital stays (LOS) of selected characteristics of children with SAM at SPHMMC, Addis Ababa, Ethiopia (n=466)

Variables	Categories	Frequency	Mean LOS	95% CI of Mean of LOS	Mean Difference	p-value for independent t-test
Gender	Male	240	20.04 ± 12.07	18.63, 21.51	1.599	0.140
	Female	226	18.44 ±11.21	17.00, 20.15		
Immunization status	Incomplete	157	21.58 ± 13.43	19.32, 23.67	-3.489	0.002
	Complete	309	18.09 ± 10.50	17.00, 19.32		
Admission Type	New	408	19.26 ±11.73	18.10, 20.42	-0.011	0.998
	Readmission	58	19.28 ±11.39	16.67, 22.21		
Anemia	Yes	152	22.44 ±12.86	20.42, 24.64	4.711	<0.001
	No	314	17.73 ±10.74	16.56, 18.99		
Type of SAM	Edematous	100	22.31 ±12.17	20.29, 24.77	3.876	0.003
	Non-edematous	366	18.43 ±11.41	17.28, 19.66		
TB	Yes	55	29.62 ±17.67	25.23, 34.49	11.737	<0.001
	No	411	17.88 ± 9.85	16.99, 18.76		
Rickets	Yes	95	21.55 ±10.60	19.39, 23.72	2.865	0.033
	No	371	18.68 ± 11.87	17.55, 19.86		
CHF	Yes	37	24.32 ± 16.39	19.84, 29.05	5.494	0.006
	No	429	18.83 ± 11.09	17.83, 19.91		
Dermatosis	Yes	50	23.04 ± 13.68	19.17, 27.45	4.228	0.015
	No	416	18.81 ± 11.34	17.76, 20.02		
HAIs	Yes	52	29.37 ± 13.94	25.78, 33.14	11.368	<0.001
	No	414	18.00 ± 10.72	17.00, 19.12		
Hyponatremia	Yes	5	29.60 ± 17.39	17.00, 44.72	10.446	0.046
	No	461	19.15 ± 11.57	18.09, 20.19		
Candidiasis	Yes	18	25.28 ± 17.62	18.20, 33.29	6.253	0.026
	No	448	19.02 ± 11.33	18.07, 19.87		
Meningitis	Yes	13	33.54 ± 22.63	21.10, 46.25	14.682	<0.001
	No	453	18.86 ± 10.98	17.91, 19.81		
Hypothyroidism	Yes	3	30.00 ± 9.54	24.00, 41.00	10.803	0.110
	No	463	19.20 ± 11.66	18.18, 20.36		
Vitamin A	Yes	220	18.10 ± 11.55	16.61, 19.83	1.080	0.041
	No	246	20.31± 11.71	18.88, 22.02		
IV fluid	Yes	76	21.64 ± 13.22	18.92, 24.59	2.842	0.052
	No	390	18.80 ± 11.31	17.61, 19.89		
IV Antibiotic	Yes	439	19.50 ± 11.83	18.41, 20.54	4.017	0.083
	No	27	15.48 ± 8.03	12.54, 18.69		
Level of consciousness	Impaired	23	26.78 ± 20.24	19.08, 34.61	7.907	0.001
	Not impaired	443	18.88 ± 10.95	17.94, 19.88		
Treatment failure	Yes	78	32.92 ±15.11	29.50, 36.58	16.402	<0.001
	No	388	16.52 ± 8.55	15.71, 17.35		

TB: tuberculosis; CHF: congestive heart failure; HAIs: hospital-acquired infections; IV: intravenous

Correlation between continuous variables

The "cor ()" function from the R package was used in this study to calculate the correlation coefficients of a few chosen variables. Continuous variables were consequently associated with a wide range in the correlation coefficients. The strongest correlation was observed between length/height and weight of children (r=0.8147). The children's age and length/height were also found to be strongly correlated (r=0.8093). The scatter plots, which confirmed that a strong link (high degree of correlation) was only found between length/height and children's ages, also support these findings. A very weak correlation between LOS and all continuous variables was found in this investigation (Figure 1).

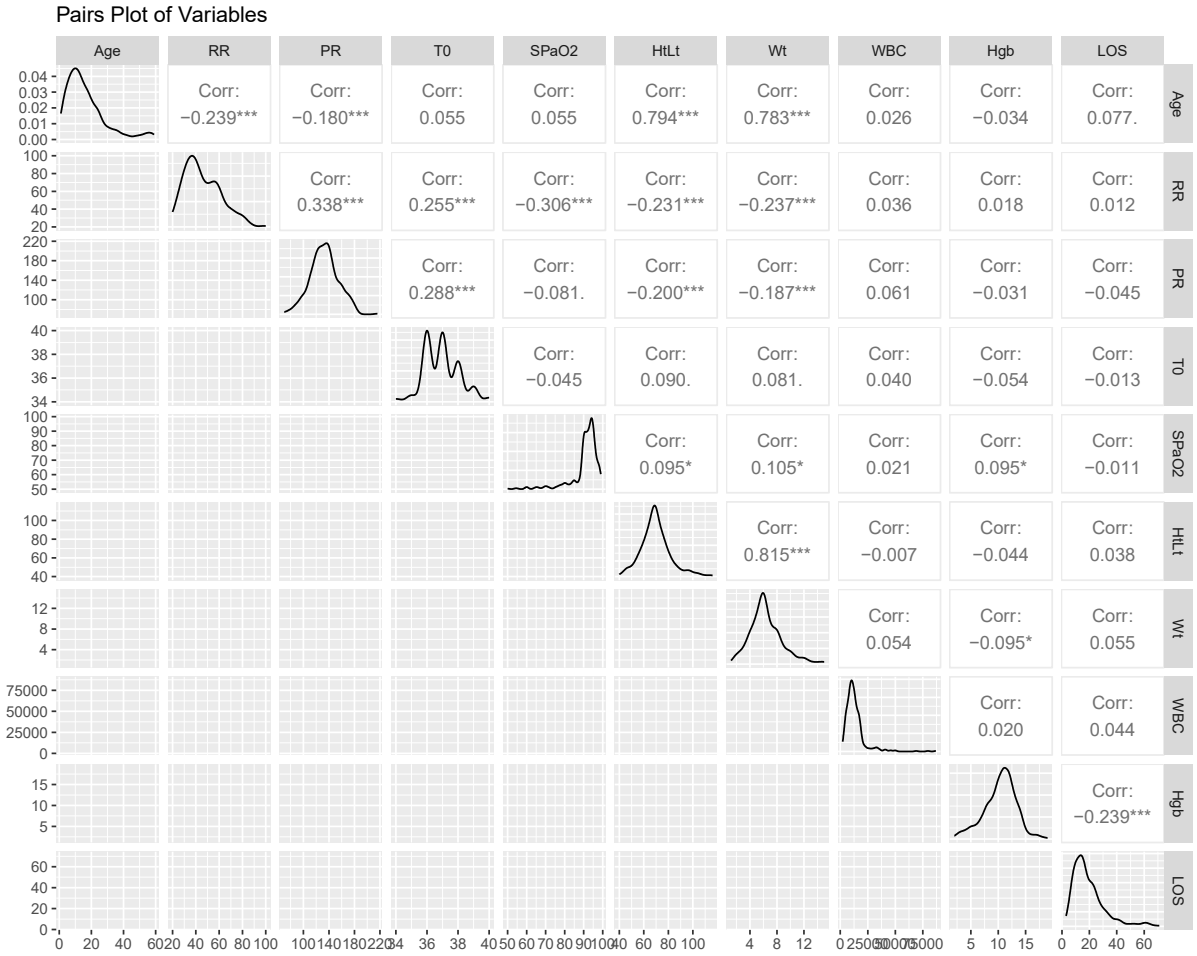

Figure 1: scatter plot matrix showing the correlation between selected continuous variables (RR: respiratory rate, PR: pulse rate, T0: body temperature, SPaO2: oxygen saturation, HtLt: height or length, Wt: weight, WBC: white blood cells, Hgb: hemoglobin, LOS: length of stay).

In this study, the correlation between the research participants' height and age was found to be strong (r=0. 0.8093), suggesting that as age increases, so does height. Similarly, a strong correlation was observed between height and weight of children (r= 0.8147) (Figure 2).

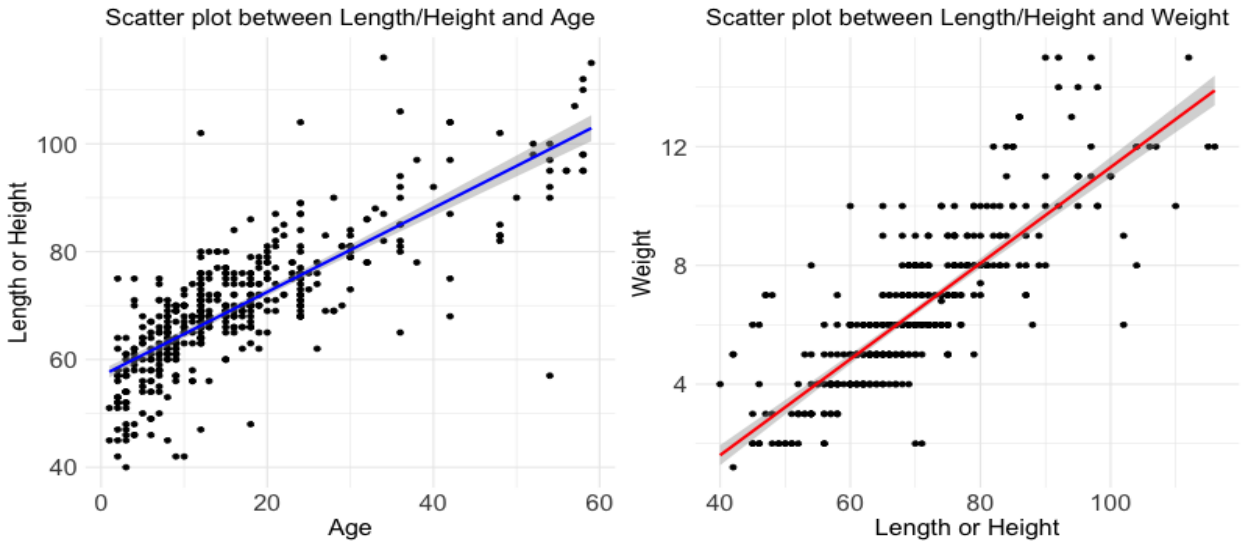

Figure 2: Scatter plot showing the correlation between age and length/height; length/height and weight of children.

Factors associated with LOS among children recovered from SAM

The backward stepwise linear regression approach, a stepwise regression approach that begins with a full (saturated) model and at each step gradually eliminates variables from the regression model to find a reduced model that best explains the data, was employed to identify factors associated with LOS. Therefore, only 18 variables were included in the final model with an adjusted R2 of 26%. This implies that 26% of the length of hospital stay variation was explained by multiple linear regression (the final regression model). Just seven of the 18 independent variables Hgb, rickets, TB, HAIs, hyponatremia, meningitis, and impaired level of consciousness were shown to be significantly associated with the average length of stay (LOS) of children who were discharged from SPHMMC after demonstrating recovery.An increase of 1 mg/dL in hemoglobin (Hgb) level was associated with a reduction in the average length of stay (LOS) by approximately one day (β= -0.62, p=6.5E-03). Children who had TB during admission were found to have an increased length of hospital stay than children who were free from TB. The average LOS of children with TB was found to increase by nine days (β=9.05, p=6.1E-09). The average LOS of children with rickets was 2.58 days higher than the counterpart children (β=2.58, p=3.9E-02). Likewise, the average LOS children who developed HAIs during hospital admission increased by eight days as compared to those who were free from HAIs (β= 7.96, p=5.5E-07). Children with hyponatremia stayed in the hospital for approximately 9 days longer compared to children without hyponatremia (β=9.14, p=4.8E-02). The average LOS of children who had meningitis along with SAM were found to have prolonged LOS than their counterparts. The co-incidence of meningitis with SAM increased the average LOS of children by eight days (β =8.38, p=5.4E-03). Besides, the average LOS of children who did not have an impaired level of consciousness at admission was decreased by five days (β= -5.04, p=2.4E-02) as compared to children with impaired level of consciousness (Table 3).

Table 3: Factors associated with LOS among children recovered from SAM in SPHMMC from 2012-2019 (N=466)

Variables	Categories	Estimate, β (95% CI)	Standard error	t value	P value
Intercept (constant)		28.154 (20.59, 35.72)	3.85	7.32	1.2E-12
Hgb		-0.62 (-1.07, -0.18)	0.23	-2.73	6.5E-03*
Admission type	new	1			
	Readmission	0.17 (-2.65, 2.99)	1.44	0.12	9.1E-01
Anemia	Yes	-1.11 (-3.91, 1.69)	1.42	-0.78	4.4E-01
	No	1			
Sex	Male	-1.49 (-3.38, 0.41)	0.96	-1.54	1.2E-01
	Female	1(ref)			
Immunization status	Incomplete	1.75 (-0.25, 3.75)	1.02	1.72	8.6E-02
	Complete	1			
Type of SAM	Edematous	-2.18 (-4.62, 0.25)	1.24	-1.76	7.9E-02
	Non-Edematous	1(ref)			
TB	Yes	9.05 (6.05, 12.06)	1.53	5.93	6.1E-09***
	No	1			
Rickets	Yes	2.58 (0.13, 5.03)	1.25	2.07	3.9E-02*
	No	1			
CHF	Yes	2.62 (-0.84, 6.08)	1.76	1.49	1.4E-01
	No	1			
Dermatosis	Yes	2.62 (-0.47, 5.70)	1.57	1.67	9.7E-02
	NO	1			
HAIs	Yes	7.96 (4.88, 11.04)	1.57	5.08	5.5E-07***
	No	1			
Hyponatremia	Yes	9.14 (0.08, 18.19)	4.61	1.98	4.8E-02*
	No	1			
Candidiasis	Yes	3.31 (-1.65, 8.27)	2.52	1.31	1.9E-01
	No	1			
Meningitis	Yes	8.38 (2.48, 14.27)	2.99	2.79	5.4E-03**
	No	1			
Level of consciousness	Impaired	1			
	Not impaired	-5.04 (-9.41, -0.67)	2.22	-2.27	2.4E-02*
Vitamin A	Yes	1			
	No	1.82 (-0.11, 3.76)	0.99	1.85	6.5E-02
IV Fluid	Yes	0.31 (-2.29, 2.92)	1.33	0.24	8.1E-01
	No	1			
IV antibiotic	Yes	-1.68 (-5.66, 2.31)	2.03	-0.83	4.1E-01
	No	1			

*Signif. codes: 0 '***' 0.001 '**' 0.01 '*'; Residual standard error: 10.06 on 447 degrees of freedom; Multiple R-squared: 0.29; Adjusted R-squared: 0.26; F-statistic: 9.94 with a p-value: < 2.2e-16*

The residuals of the final model ranged from -24.60 to 37.02, with a median residual of -1.158 (IQR: -6.01, 3.45). Lastly, the linear model's homoscedasticity assumption (constant variance) was verified by displaying the residuals; the resulting figure indicates that the assumption was satisfied. As shown in the residual's vs fitted values plot, the homoscedasticity assumption is met because the residuals display a constant spread around zero across the range of fitted values. The plot of fitted values and the square root of residuals pinpoint a random scatter without any clear patterns, indicating that the model assumptions are met. The leverage vs. normalized residuals plot indicates that relatively few observations were outliers (Figure 3). This finding was also supported by a histogram plot of the residuals, which had a normal distribution (Figure 4). In general, the assumption of homoscedasticity is fulfilled.

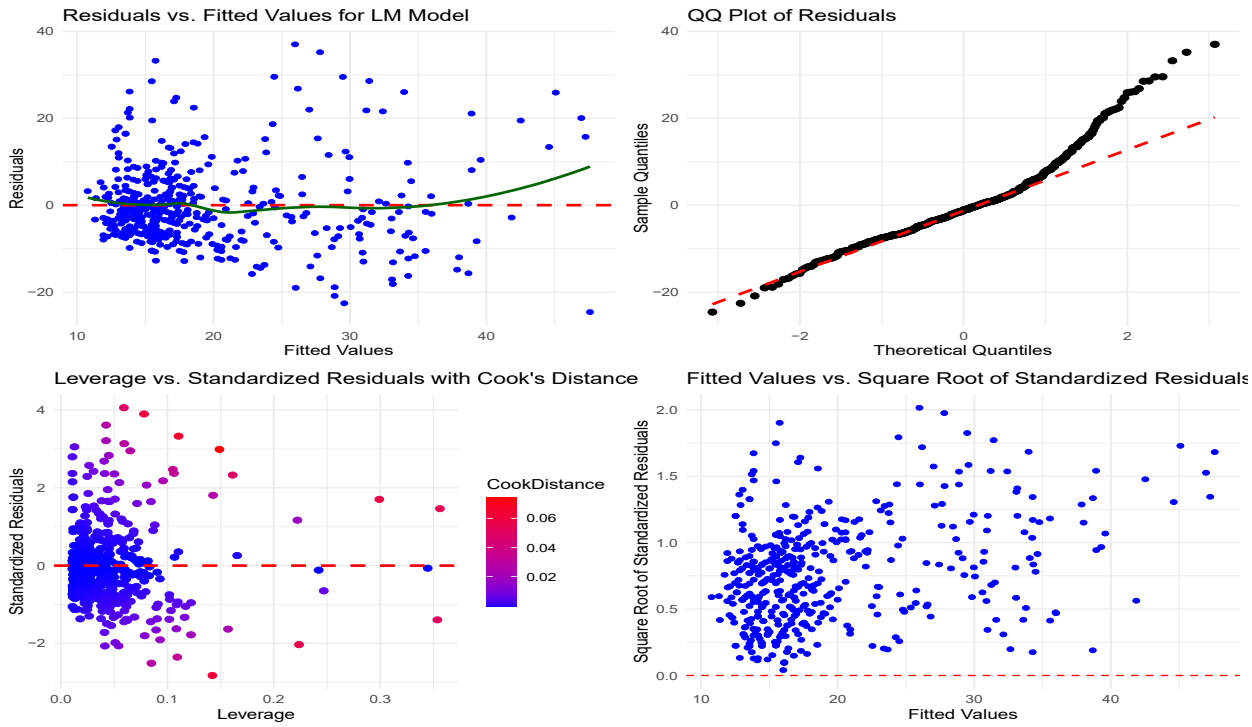

Figure 3: Homoscedasticity plot of the residuals

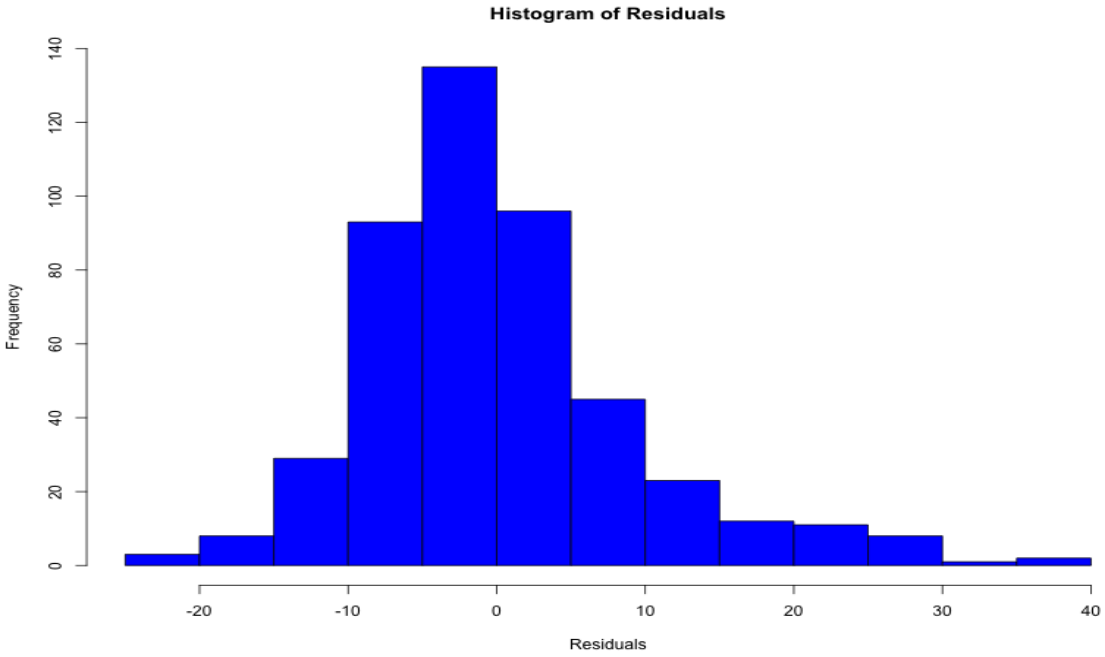

Figure 4: Histogram of residuals

Discussion

The present study sought to compute the main determinants of the average length of stay among under-five children with SAM who were discharged as recovered from the stabilization center of SPHMMC. Thus, the mean LOS is 19.27 ±11.67 days, indicating that it is within the sphere recommended ranges. Comorbidities such as TB, hospital-acquired infections, meningitis, TB, rickets, hyponatremia and impaired level of consciousness are the main determinants of average LOS.

In the current study, the mean LOS (19.27 days) is comparable with the sphere standard (Thurstans et al. 2011). This could be associated with the standardized care provided in the hospital. This finding is higher than the mean LOS (12 ±5.26 days) of study participants by Hassen *et al*. in South Wollo Zone, Ethiopia (Hassen *et al*., 2019). However, the mean LOS of this study is lower than the findings in Ayder Hospital, the general hospital of Tigray region, Dilchora Hospital, and Gedeo Zone where the mean survival days were 21.56, 41, 69.28, and 79.6 (Guesh *et al*., 2018, Tirore *et al*., 2017, Girum *et al.,* 2017, Oumer *et al.,* 2016) days, respectively. These variations could be explained by differences in sample size, study aims, and study settings.

In the present study, the median LOS is 16 days. This recovery time falls within the acceptable sphere standard (<28.00 days). This finding is also comparable with study findings at selected stabilization centers of Amhara Regional State, where the median recovery date was 16 days (Asres *et al*., 2018, Baraki *et al*., 2020). However, the current LOS is higher than the results from the University of Gondar Hospital, Yekatit 12 Hospital, Asosa General Hospital, public hospitals in Aksum, selected North Shewa Zone Hospitals, and Pawi General Hospital where the median recovery dates were 13 (Kokeb and Mariyo, 2022),15 (Adimasu *et al.,* 2020), 15 (Bizuneh et al., 2022), 15(Tesfay et al., 2020), 12 (Derseh *et al.,* 2018), and 14 days (Wondim *et al*., 2020), respectively. Likewise, the results from studies carried out at the University of Gondar Hospital (Wagnew et al., 2019), South Wollo Zone (Hassen *et al.,* 2019), selected hospitals in Northwest Ethiopia (Mekuria *et al*., 2017), WagHimra Zone (Tadesse *et al.,* 2021), and Eastern Amhara Hospitals (Tefera *et al.,* 2020), where the median recovery time was each 11 days, are also lower than the findings from the present study. Conversely, the median LOS of the results from Hawassa University Comprehensive Specialized Hospital (17 days) (Fikrie *et al*., 2019), Southern Ethiopia (29 days) (Gebremichael, 2015), Jimma University Specialized Hospital (17.4 days) (Jarso *et al.*, 2015), Dubti Referral Hospital (21 days) (Tegegne and Belay, 2021), and Shebedino, Southern Ethiopia (36 days) (Teshome *et al*., 2019) are higher than the current finding. Differences in sample sizes, organizational infrastructures, and participant demographics could all be contributing factors to the inconsistencies found in the studies. Particularly, comparative studies included children with SAM exhibiting all conceivable outcomes, whereas this study only included children with SAM who had recovered from it. Differences in the inclusion criteria may also account for the variations.

In this study, the factors associated with average LOS are determined. Of the main determinants, TB, HAI, meningitis, Hgb level, rickets, hyponatremia, and impaired level of consciousness are independently associated with increased average LOS. The coincidence of TB with SAM increased the average length of hospital stay by six days. This could be corroborated by the fact that TB is one of the catabolic diseases that leads to undesirable treatment outcomes, including prolonged hospital stay and death among children with SAM (Munthali *et al.,* 2017). The higher prevalence of TB among children with SAM supports the idea that TB is the major opportunistic disease among immunosuppressed children with SAM (Vonasek *et al.,* 2022). Thus, performing TB screening among children with SAM and prompt treatment could improve the treatment outcomes, including shorter hospital stays. Similarly, the occurrence of HAIs while children are on treatment for SAM increased the average length of hospital stay. Those with HAIs have an average LOS of eight days longer than those without HAIs. This is supported by previous findings that HAIs are significantly associated with prolonged LOS in the general patient population, including children with SAM (Jia *et al.,* 2019, Barnett *et al*., 2013). Prolonged hospital stays and HAIs are vicious. Long-term hospitalization increases the risk of HAI development and vice versa. The average LOS could be increased by up to 9.32 days due to HAIs (Hassan *et al*., 2010). Meningitis is another important factor that raised the LOS of SAM-

affected children. The average LOS of children is extended by eight days due to the meningitis and SAM coincidence. This prolonged LOS could be associated with the long-term treatment that is provided for children with meningitis. This is because a minimum of 14 to 21 days is required to treat children with bacterial meningitis (Van Hentenryck *et al.,* 2022), which prolongs LOS. The duration of average LOS could increase when it happens along with SAM. In the present study, a one-unit increase in hemoglobin level was associated with a decrease in the average LOS among children with SAM. This finding aligns with the fact that low hemoglobin levels indicate anemia, a major comorbidity among children with SAM (Takele *et al.,* 2021). Consequently, the coexistence of anemia and SAM contributes to a prolonged LOS. Rickets is another factor that contributes to the prolonged length of stay among children with SAM. This may be attributed to its association with other comorbidities, such as pneumonia, a major cause of extended hospital stays in this population (Ngari *et al.,* 2018). Hyponatremia, characterized by low sodium levels, is associated with an increased LOS among children with SAM. It often results from comorbidities such as diarrheal diseases common in this population. Therefore, addressing both hyponatremia and its underlying causes could help reduce the average LOS for these children (Zogg *et al.,* 2013). Similarly, an impaired level of consciousness is associated with an increased LOS. Previous evidence suggests that an altered level of consciousness is linked to a higher likelihood of poor treatment outcomes, including prolonged hospital stays (Kassaw *et a*l., 2021).

Besides, the development of treatment failure upsurges the length of hospital stay among children with SAM. This finding is supported by a previous finding that treatment failure is the main determinant of prolonged hospital stay (Adem *et al.,* 2020). A longer hospital stay for children with treatment failure is justified by the fact that if therapy fails in any of the three phases (phase I, transition phase, and phase II), the child will either be returned to the previous phase or retained in the same treatment phase. This consequently increases the LOS for SAM children.

In general, the average length of hospital stay among children with SAM is within the recommended sphere standard. However, a considerable number of children are found to have prolonged LOS, ranging from a minimum of three days to a maximum of 71 days.

Strength and Limitation

This study has several key strengths and limitations. On the positive side, it is the first of its kind to explore the main determinants of Length of Stay (LOS) using a linear regression model, providing a novel approach in the field. Additionally, all possible analytical methods were employed to ensure the final model was optimally fitted, enhancing the reliability of the findings. However, despite these strengths, the study had limitations. The variables in the final model explained only 26% of the variability ($R^2 = 0.26$), which may be due to the retrospective nature of the data and could impact the generalizability of the results. Furthermore, the scarcity of similar studies using linear regression models limited our ability to compare our findings with those from previous comparable studies, restricting broader validation and context.

Conclusion

While the average length of hospital stays for many children recovering from severe acute malnutrition was significantly higher, the overall duration aligned with the Sphere standard. This study identified comorbidities as key contributors to increased average hospital stays. Therefore, timely treatment of comorbidities and the prevention of HAIs could help reduce the average length of stay for children with SAM. Future prospective longitudinal studies are recommended to identify plausible risk factors influencing hospital stay duration.

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Competing Interests

The author declare that they have no competing interests.

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List of Abbreviations

CHF: Congestive heart failure, HAIs: Hospital-acquired infections, Hgb: Hemoglobin, IQR: Inter quartile range, IV: Intravenous, LOC: Level of consciousness, LOS: Length of hospital stay, Lt/Ht: Height or length, MLRM: Multiple linear regression model. PR: Pulse rate, RR: Respiratory rate, SAM: Severe acute malnutrition, SPHMMC: St. Paul's, Hospital Millennium Medical College, SPO2: Oxygen saturation, T^0: Temperature, TB: Tuberculosis, VIF: Variance inflation factor, WBC: White blood cells, Wt: Weight

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