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Research Article

Hospital-acquired infections (HAIs) and delayed recovery in severely malnourished children during stabilization: Evidence from retrospective cohort analysis in Ethiopia

Teshome Bekele Elema[1,2*], Solomon Gebretsadik Bereka[2], Ashenafi Habtamu[2], Tewodros Desalegn Nebi[2], Gemechu Edae[3], Habtamu Guja[1], Kaleab Baye[1]

[1]Centre for Food Science and Nutrition, College of Natural and Computational Sciences, Addis Ababa University, Addis Ababa, Ethiopia; [2]Department of Public Health, College of Health Science & Medicine, Arsi University, Asella, Ethiopia; [3]Department of Pediatrics and Child Health, School of Medicine, College of Health and Medical Science, Arsi university, Asella, Ethiopia

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***Corresponding Author**
Elema T.B.
teshome.bekele_e@aau.edu.et
ORCID: 0000-0001-6791-7153

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Highlights/Key Messages

- Children who acquired infections in the hospital had slower recovery and longer hospital stays compared to those without acquiring infections.
- Bottle-feeding of these children was associated with a higher risk of hospital acquired infections occurring.

Background
Several studies have highlighted the substantial impact of HAIs on pediatric and nutritional recovery in Ethiopia. However, empirical evidence directly quantifying the impact of Hospital-acquired Infections (HAIs) on severe acute malnutrition (SAM) recovery times remains limited.

Objective
To examine the effect of hospital-acquired infections (HAIs) on the recovery of children with severe acute malnutrition (SAM).

Methods
We conducted a retrospective cohort study using medical records of children aged 6–59 months admitted with SAM. We defined HAIs as infections occurring ⩾ 48 hours after admission, diagnosed through routine clinical assessment and available laboratory findings. Of 635 admitted children, 493 with complete documentation met inclusion criteria. Kaplan-Meier survival analysis compared time to nutritional recovery (days to discharge-eligible recovery) between children with and without HAIs; we tested differences using the log-rank test.

Results
Malnourished children without hospital-acquired infections had a higher probability of recovery over time than those with HAIs (log-rank test, $p < 0.001$). This direction is consistent with Ethiopian cohort evidence showing delayed stabilization among children with HAIs and longer recovery among infected SAM inpatients. In addition, bottle-feeding was associated with a higher risk of hospital-acquired infections occurring. HAIs were more frequent among children with incomplete immunization, nasogastric tube feeding, and from rural households.

Conclusions
Hospital-acquired infections are an important complication among children hospitalized with SAM and are associated with delayed nutritional recovery and prolonged hospital stay. Sustained improvements in pediatric recovery and survival in Ethiopian hospitals require integrating reliable water, sanitation, and hygiene (WASH) infrastructure, safe hygiene practices across therapeutic care units, and strengthening infection prevention and control (IPC) practices.

Keywords: severe acute malnutrition (SAM), hospital-acquired infections, WASH, Recovery outcomes, antimicrobial resistance

Introduction

Malnutrition compromises immune function, heightens vulnerability to infectious diseases, and slows recovery from illness. Hospital-acquired infections (HAIs), defined as infections occurring 48 hours or more after hospital admission, further increase this risk. HAIs disproportionately affect malnourished children, prolonging inpatient treatment (Allegranzi et al., 2011). Globally, HAIs are a leading cause of prolonged hospital stay, increasing healthcare costs, and preventable mortality. According to WHO reports, in low-resource settings, at least 15% of hospitalized patients acquire one or more infections during admission, compared to 7% in developed countries (WHO, 2022; WHO, 2024b). Severe acute malnutrition (SAM) remains a major global public health concern and is responsible for an estimated 45% of deaths among children under five, with the burden falling most heavily on low- and middle-income countries (WHO, 2023; WHO, 2024a). Worldwide, roughly 45 million children under the age of five are affected by wasting, including about 13.6 million who are severely wasted and face an immediate risk of death (WHO, 2024a; WHO, 2024b).

Global efforts to reduce preventable child deaths increasingly link nutrition care with safe healthcare environments, but this integration remains weak in many low-resource hospital settings. In Ethiopia, evidence from multiple facility studies shows persistent water, sanitation, and hygiene (WASH) and infection prevention and control (IPC) deficiencies, including unreliable water supply, limited sanitation services, poor hand-hygiene access, weak waste management, and inadequate implementation capacity (Elema et al., 2024; Girmay et al., 2023; Ayalew, 2025). These conditions are particularly important because HAIs are common among Ethiopian pediatric inpatients and are concentrated in children with malnutrition, prolonged stay, and invasive care exposures, with prospective studies reporting HAI burdens ranging from 12.7% to 23.7% (Sahiledengle et al., 2020). Pediatric intensive care unit (PICU)-specific studies often report substantial burdens, including 20.2% - 37.5% in an Ethiopian PICU cohort (Tesfaye et al., 2024).

Several studies have highlighted the high impact of HAIs and their effects on pediatric recovery in Ethiopia. For instance, HAI prevalence ranges from 10% to 25% in have been documented in referral hospitals (Elema TB et al., 2024; Liben et al., 2025; Sahiledengle et al., 2020; Yallew et al., 2017). They are frequently linked to inadequate hand hygiene, shortages of sterilizing materials, and overcrowded wards. In pediatric populations, infections such as pneumonia, sepsis, and diarrhea remain leading causes of mortality among malnourished children (Jarso, et al., 2015). A more recent study (Elema et al., 2024) found an association between poor WASH infrastructure in Ethiopian healthcare facilities and healthcare-associated antimicrobial-resistant infections. Specifically, 68% of hospitals lacked a continuous water supply, and more than half had inadequate waste management and sanitation systems (Elema et al., 2024). Moreover, these deficiencies create an ideal environment for transmitting multidrug-resistant pathogens, especially in the pediatric population and therapeutic feeding units (TFUs). This suggests that the persistence of HAIs is not solely a clinical challenge but also reflects structural and functional deficiencies in hospital settings in Ethiopia.

Despite the establishment of recent acute malnutrition guidelines (FMOH, 2019) and expanded therapeutic feeding programs, Ethiopian hospitals continue to have recovery rates below international standards, with fatality rates frequently surpassing the acceptable WHO threshold of less than 10% (WHO, 2024b). One of the main reasons for this disparity is thought to be HAIs. However, there is still a lack of empirical data in Ethiopia that quantifies the precise effect of HAIs on children with SAM, especially in hospital settings. Understanding this relationship is critical for developing integrated interventions that combine clinical care with environmental health improvement (Dembele et al., 2010). This study addresses critical evidence gaps by examining the impact of hospital-acquired infections on the recovery of children with severe acute malnutrition.

Methods

Study Area and Design

We conducted an institution-based retrospective cohort study at Asella Referral and Teaching Hospital in the Department of Pediatrics and Child Health. Annually, the hospital receives more than 841,158 patients, including 4,395 pregnant women and 19,452 children under five years of age from the Arsi, West Arsi, and East Shewa Zone. The study included children aged 6–59 months admitted with severe acute malnutrition. We abstracted data from hospital SAM registration records and medical charts during May–June 2023 using a structured extraction tool. We compared time to nutritional recovery between children who developed a hospital-acquired infection during admission and those who did not, using Kaplan–Meier survival curves, the log-rank test, and Cox proportional hazards regression. We used multivariable Cox proportional hazards regression to quantify the association between HAI and recovery rate while adjusting for potential confounders.

Population and Eligibility Criteria

All children younger than 59 months who were admitted to the TFU with SAM during the study period were eligible. Admission was granted in accordance with Ethiopian National SAM Guidelines: weight-for-height/length z-score < -3, bilateral pitting edema, and mid-upper arm circumference (MUAC) < 11.5 cm (FMOH, 2019; WHO, 2024b). We included admission records between September 9, 2020, and January 20, 2022. We excluded records with incomplete documentation (e.g., missing outcomes or key variables), missing admission criteria on the TFU card, or treatment in hospital Outpatient Therapeutic Program units rather than the inpatient TFU. The study's primary outcome is the time required for nutritional recovery in children with SAM following treatment according to the Ethiopian SAM management guidelines (FMOH, 2019). According to these guidelines, only anthropometric and bilateral pitting edema criteria (excluding percentage weight gain) are used to assess whether the children have reached nutritional recovery.

Exposure Variables and Ascertainment of Hospital-acquired Infections

Hospital-acquired infection was the main dependent variable. We defined HAI according to the WHO definitions:

as any new infection recorded 48 hours or more after admission among children admitted to the inpatient therapeutic feeding unit, thereby distinguishing infections acquired during hospitalization from conditions present at admission (CDC, 2014; Lopez, 2024). We ascertained HAI status retrospectively from patients' medical charts, therapeutic feeding registration records, inpatient multicharts, nursing notes, treatment sheets, and other routine clinical documentation using a structured data abstraction tool adapted from standard SAM management sources (Derseh et al., 2018). Commonly recorded infections in comparable SAM cohorts included pneumonia, sepsis, urinary tract infection, and superficial or skin infection. HAI status was recorded throughout admission until the child recovered, died, defaulted, was transferred, or was otherwise censored at the end of follow-up (as suggested by Derseh et al., 2018).

Diagnosis includes clinical examination, supported by relevant laboratory tests and pediatric treatment guidelines. The HAI status was recorded if it occurred at any time after 48 hours of hospitalization until the patient recovered, died, was transferred, or was lost to follow-up.

Data Collection and Quality Assurance

Data were extracted using a structured data tool adapted from the Ethiopian Federal Ministry of Health SAM Management Protocol (FMOH, 2019) and relevant literature (Gebremichael, 2015; Jarso et al., 2015; Yallew et al., 2017). Two trained pediatric nurses and four administrative staff collected data from patient cards and SAM registry logbooks. The data collection process lasted six weeks, and the principal investigator supervised it daily to ensure completeness, consistency, and protocol adherence. Supervisors cross-checked each completed abstraction form and provided clarification when necessary.

Data Management and Analysis

Data were entered into EpiInfo version 7.2, cleaned, and exported to Stata version 17 for analysis. Time to recovery was analyzed using Kaplan–Meier survival estimates and the log-rank test, with recovery treated as the event of interest. Differences between SAM children with and without HAIs were assessed using the Chi-square (χ^2) test after checking assumptions.

Ethics

The Oromia Regional Health Bureau Ethics Review Committee (Approval No. BEF/IRB/1-16/3022, approved in 2022) and the Institutional Review Board of Arsi University College of Health Sciences (approval granted in 2022) approved this retrospective cohort study. Due to the retrospective design and the use of routinely collected clinical data, the requirement for informed consent was waived. We obtained administrative permission to access medical records from the Clinical Director of Asella Referral and Teaching Hospital. All data were fully anonymized before analysis, and no personal identifiers of patients or healthcare providers were recorded, in accordance with the approved ethical protocol.

Results

Of 635 children admitted during the registry period, 142 were excluded (103 did not meet SAM criteria, 14 were outside the eligible age range, and 25 had incomplete data). A total of 493 children met the inclusion criteria; of these, 190 (38.5%) developed hospital-acquired infections (HAIs). Figure 1 shows the discharge outcomes for each group (HAI vs non-HAI).

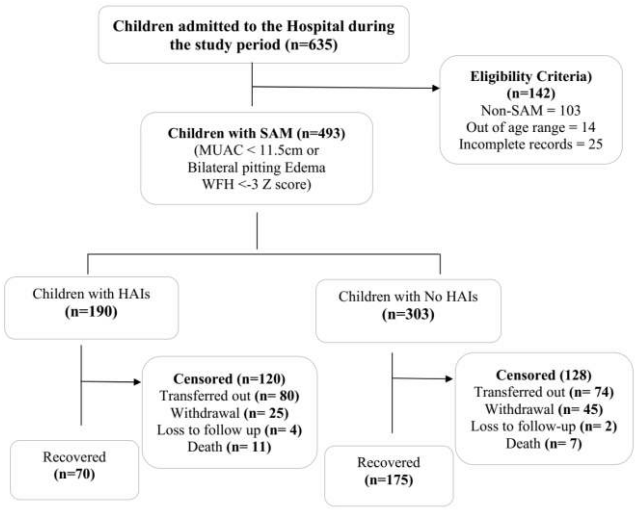


Figure 1. Flowchart of participant selection and classification of hospital-acquired infections (HAIs).

Table 1 presents the baseline characteristics for each group. The cohort was predominantly rural (86.4%) and male (59.2%). Rural residence was significantly associated with HAI development ($\chi^2 = 12.67$, $P < 0.01$), while sex showed no significant difference ($P = 0.356$). Over half the cohort (55.4%) received nasogastric (NG) tube feeding, which was significantly associated with HAIs ($\chi^2 = 16.45$, $P < 0.01$). Only 47.1% were fully immunized for their age, and suboptimal immunization status was significantly associated with HAI ($P = 0.049$).

We assessed conditions present at admission as baseline comorbidities associated with HAI. Cough was the most common symptom (68.6%) and was associated with HAI ($\chi^2 = 62.73$, $P < 0.01$). Fever was also significantly associated ($\chi^2 = 59.93$, $P < 0.01$). Pneumonia affected 62.1% of the cohort and was the strongest predictor of HAI ($\chi^2 = 70.64$, $P < 0.01$), with 52.9% of pneumonia cases developing HAIs. Septic shock (2.6%) and edematous malnutrition (91.3%) showed no significant associations.

Table 1. Baseline characteristics of children by Healthcare-Associated Infections (HAIs)

Characteristics	Total ¥ %)	No HAIs (%)	HAIs (%)	χ^2 test	P-value
Sociodemographic					
Boys	292 (59.2%)	177 (60.6%)	115 (39.4%)	0.71	0.356
Residence (Rural)	426 (86.4%)	275 (64.6%)	151 (35.4%)	12.67	<0.01*
Clinical / Management					
NG Tube Feeding	273 (55.37%)	146 (53.5%)	127 (46.5%)	16.45	<0.01*
Fully Immunized (age-appropriate)	232 (47.05%)	152 (65.5%)	80 (34.5%)	3.04	0.049*
Symptoms / Signs					
Vomiting	328 (66.5%)	204 (62.2%)	124 (37.8%)	0.22	0.353
Blood in stool	6 (1.2%)	4 (66.7%)	2 (33.3%)	0.07	0.575
Anemia (pale conjunctivae)	152 (30.83%)	99 (65.1%)	53 (34.9%)	1.25	0.154
Dehydration	283 (77.69%)	172 (60.8%)	111 (39.2%)	0.31	0.395
Cough	338 (68.56%)	170 (50.3%)	168 (49.7%)	62.73	<0.01*
Fever (altered body temperature)	145 (29.42%)	94 (64.8%)	51 (35.2%)	59.93	<0.01*
Severe Conditions					
Septic Shock	13 (2.64%)	6 (46.1%)	7 (53.8%)	1.32	0.194
Edematous	450 (91.3%)	277 (61.6%)	173 (38.4%)	0.02	0.505
Pneumonia	306 (62.07%)	144 (47.1%)	162 (52.9%)	70.64	<0.01*

* Indicates significant p-values, computed using the Chi-square test. ¥Percentages are based on cases with available data for each variable; therefore, denominators vary because of missing observations. NG: nasogastric

Table 2 presents the baseline characteristics of children by SAM type (Marasmus, Kwashiorkor, or Marasmic-kwashiorkor). Among eligible children, marasmus was the predominant type and accounted for most admissions. Male children predominated across all three SAM types, although this was not statistically significant (χ^2 = 1.36). BF and vaccination or immunization status showed larger chi-square values than other variables, indicating greater variation among the type of malnutrition (SAM). Children aged 6-11.9 months and 12-23.9 months constituted the largest proportion of marasmus cases, whereas relatively fewer children older than 36 months were admitted with any form of malnutrition.

Table 2: Baseline characteristics of children according to their type of Severe acute malnutrition

		Type of SAM (N = 493)			Chi-Square	P-value
Variables		**Marasmus**	**Kwashiorkor**	**Marasmic-Kwash**		
Sex of child	Male	262	19	11	1.36	0.506
	Female	185	12	4		
Exclusive	Yes	42	4	1	0.561	0.755
Breastfeeding	No	405	27	14		
Residence (Rural)	Rural	390	22	14	7.175	0.028
	Urban	57	9	1		
NG Tube Feeding	Yes	254	13	6	4.08	0.130
	No	193	18	9		
Bottle feeding (BF)	Yes	205	22	8	7.524	0.23
	No	242	9	7		
Fully Immunized	Yes	225	6	1	21.3	< 0.001
	No	222	25	14		
Vomiting	Yes	306	14	8	8.275	0.016
	No	141	17	7		
Anemia (Pale conjunctivae)	Yes	130	13	9	8.418	0.015
	No	317	18	6		
Cough	Yes	312	17	9	3.536	0.171
	No	135	14	6		
TB Infection	Yes	418	31	15	3.171	0.205
	No	29	0	0		
Healthcare-Acquired Infections	Yes	172	11	7	0.541	0.763
	No	275	20	8		
Age Category	0-5.9	101	4	1	23.67	
	6-11.9	144	3	2		0.003
	12-23.9	138	15	7		
	24-35.9	58	7	5		
	above 36	6	2	0		

Figure 2 shows the percentage distribution of SAM discharge outcomes for HAI and non-HAI groups. Higher recovery was observed among children who did not acquire HAI (59.2%) than among those with HAI (37.8%). Conversely, unfavorable outcomes (death, withdrawal, transfer, loss to follow-up) were relatively more frequent among children with HAIs.

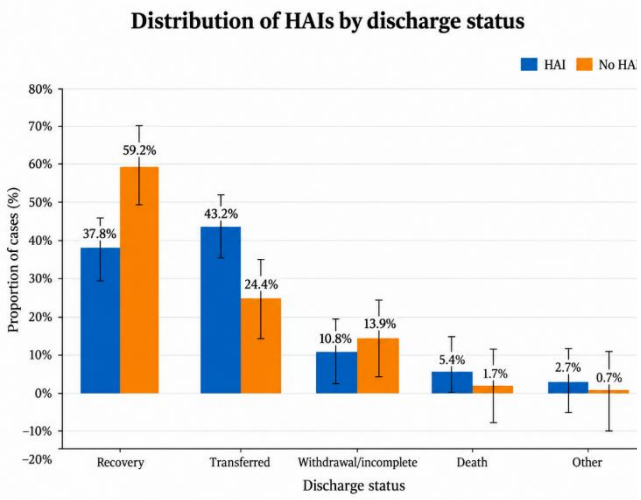


Figure 2. Distribution of discharge status among children with severe acute malnutrition (SAM), by hospital-acquired infections (HAIs) status (N= 493)

Figure 3 shows the Kaplan–Meier survival analysis. Children without hospital-acquired infections had a higher probability of recovery over time compared to those with HAIs (log-rank test, $p < 0.001$).

In the multivariable Cox proportional hazards model, after adjustment for other covariates, exclusive breastfeeding, immunization status, TB infection, edematous malnutrition, and HAI were associated with shorter time to recovery. Children who were exclusively breastfed had a 60% higher rate of recovery (AHR = 1.60, 95% CI: 1.25–1.84) compared with the reference group, indicating a shorter time to recovery. Fully immunized children had a 10% higher recovery rate (AHR = 1.10, 95% CI: 1.00–1.98).

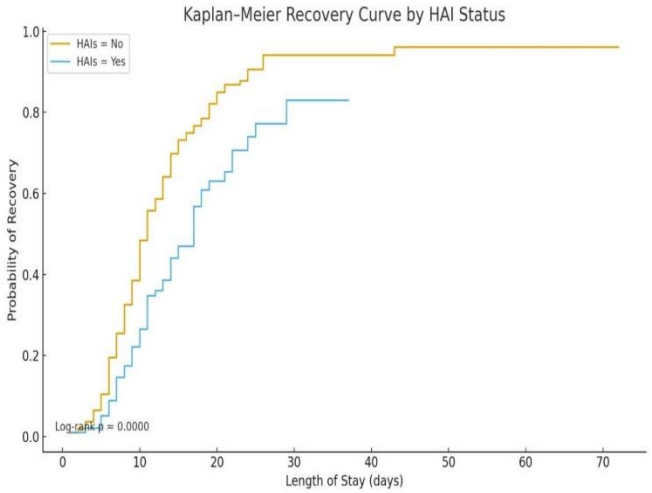


Figure 3. The Kaplan-Meier recovery curves for children with severe acute malnutrition (SAM), stratified by hospital-acquired infections (HAIs) status

In contrast, children with TB infection had a 9% lower recovery rate (AHR = 0.91, 95% CI: 0.83–0.93), those with edematous malnutrition had a 21% lower recovery rate (AHR = 0.79, 95% CI: 0.56–0.90), and children who developed HAI had a 39% lower recovery rate (AHR = 0.61, 95% CI: 0.45–0.83), indicating longer times to recovery as presented in Table 3. We assessed the proportional hazards assumption using Schoenfeld residuals and found it was satisfied.

Table 3. Univariate and multivariate Cox regression hazard analysis of factors associated with shorter time to recovery among children with SAM

Variables	Categories	CRH (95%: CI)	SE (Coeff)	P-value	AHR (95%: CI)	SE (Coeff)	P-value
Sex of child	Male/Female	0.801 (0.5591.147)	0.183	0.226	1.219 (0.934-1.592)	.136	.145
Exclusive Breastfeeding	Yes/No	2.835 (1.457-5.517)	0.340	0.002	1.458 (1.249-1.841)	.310	.012*
Bottle feeding (BF)	Yes/No	0.505 (0.353-0.723)	0.183	0.000	1.134 (0.841-1.528)	.152	.409
Fully Immunized	Yes/No	0.990 (0.695-1.411)	0.180	0158	1.005 (1.00-1.975)	.151	.034*
Blood in the stool	Yes/No	0.502 (0.091-2.767)	0.871	0.229	2.785 (0.644-12.047)	.747	.171
TB Infection	Yes/No	0.813 (0.382-1.727)	0.385	0.189	0.906 (0.834-0.928)	.298	.038*
Edematous	Yes/No	0.963 (0.515-1.801)	0.319	0.206	1.177 (0.445-3.116)	.496	.742
Intravenous fluids	Yes/No	0.593 (0.298-1.181)	0.352	0.137	0.793 (0.561-0.903)	.288	.006*
HAIs	Yes/No	0.459 (0.316-0.664)	0.189	0.000	0.607 (0.445-0.829)	.159	.002*
Type of HAIs/UTI	Yes/No	0.885 (0.353-2.217)	0.469	0.194	0.827 (0.404-1.692)	.365	.602
Formula 75	Yes/No	0.730 (0.478-1.113)	0.215	0.413	1.194 (0.713-1.998)	.263	.501
Formula 100	Yes/No	1.220 (0.802-1.856)	0.214	0.233	1.374 (0.831-2.274)	.257	.216
RUTF	Yes/No	0.947 (0.652-1.376)	0.191	0.176	.952 (0.706-1.283)	.152	.747
ResoMal fluid	Yes/No	1.121 (0.782-1.606)	0.184	0.234	.984 (0.751-1.289)	.138	.904
Antibiotics	Yes/No	0.712 (0.320 -1.582)	0.408	0.204	1.173 (0.684-2.012)	.275	.562

*Indicates significant p-values, computed using the Chi-square test. NG: nasogastric; BF: Bottle feeding; CF: complementary feeding; T: Tuberculosis; HAIs: Hospital acquired infections; UTI: Urinary tract infection; RUTF: Ready to use therapeutic food

Discussion

The study aimed to assess the extent of HAIs and their effect on the recovery time of children with SAM admitted to the hospital, as well as to determine the impact of other contributing factors. Our reported 38.5% HAI burden is higher than pooled estimates from Africa overall (Allegranzi et al., 2011), which are about 13%, and also higher than one Ethiopia-wide estimate of 17.0% (Abubakar et al., 2022), although it is close to a newer Ethiopian pooled estimate of 37% (Gedefie et al., 2025). This supports the view that children admitted with SAM represent a particularly high-risk inpatient group rather than an average hospitalized population (Melariri et al., 2024; Sahiledengle et al., 2020;

Andersen et al., 2022). In Jimma, children with HAIs had a median recovery time of 18 days, compared with 11 days without HAIs (Fedlu et al., 2025). Other Ethiopian SAM cohorts also show that pneumonia, TB, NG tube insertion, and facility-level differences are associated with longer recovery periods, reinforcing that intercurrent infection worsens inpatient outcomes and increases treatment complexity (Abdi et al., 2025).

HAIs significantly delayed recovery from SAM. The delayed recovery observed may be explained by the metabolic stress, increased energy expenditure, and impaired nutrient absorption that accompany infection (Dembele & Traore, 2010; Victora et al., 2010). When these biological stresses are coupled with environmental contamination and antimicrobial resistance, the challenges become even more severe, undermining the effectiveness of therapeutic feeding and antibiotic treatment (Elema et al., 2024). Children in remote rural settings often experience delayed diagnosis and treatment, increasing their susceptibility to infection. Unfortunately, by the time they reach health facilities, they may also encounter a health system with significant WASH deficiencies (Elema TB et al. 2024).

Children with SAM in Ethiopia often appear to face a double burden: higher infection vulnerability before admission and additional exposure to unsafe hospital environments after admission (Karunaratne et al., 2020). The strongest evidence supports three linked claims: SAM and clinical severity raise HAI risk, invasive care such as nasogastric tube feeding is more common among high-risk children, and weak WASH and infection-control conditions in Ethiopian facilities plausibly amplify transmission and antimicrobial resistance (Sahiledengle et al., 2020; Mohamed et al., 2022; Elema et al., 2024).

Our KM survival analysis showed slower recovery of SAM among those with HAI than among those without. This may reflect the additional clinical burden imposed by infections during hospitalization. However, baseline differences in clinical severity between groups may also influence the observed association. This is consistent with studies from Jimma and Gondar that reported poorer survival among malnourished children with secondary infections (Gebremichael, 2015; Jarso et al., 2015).

Our findings are situated within Ethiopia's ongoing efforts to improve hospital quality. Building on the findings of (Elema et al., 2024) and other national studies, this study emphasizes the critical need for continuous sanitation, expanded IPC programs, and nutrition-sensitive facility improvements. These findings reinforce that preventing and managing HAIs must be a core component of SAM care. Beyond adhering to clinical protocols, consistent monitoring and strengthening of supplies, WASH infrastructure, and IPC practices should receive equal priority within the health system.

Limitations and Strengths

This study has several strengths and limitations that need to be considered when interpreting our findings. The study was conducted as part of comprehensive assessments of WASH in hospitals and its impact on health outcomes. It retrospectively assessed SAM recovery time and how it can be affected by HAI. However, these findings may be affected by the quality of the hospital records used. To achieve an adequate sample size, we extended the study period to 16 months (September 2020–January 2022). While this duration captures seasonal variations in food security and WASH conditions, it may also obscure secular changes during this period related to SAM or HAIs.

In addition, this design also does not allow us to establish causality, and the treatment delays observed for HAI can only be considered as associations. Although the study presents data from only one hospital, the findings may be broadly generalizable to conditions found in many health care settings in rural Ethiopia, and beyond.

Conclusions

In the present study, HAI affected nearly two in five hospital-admitted children with SAM, further complicating the treatment and management, as well as slowing recovery and prolonging hospital stays. Bottle-feeding was associated with HAIs. These findings underscore the importance of strengthening infection prevention and clinical management practices in hospital settings to improve outcomes among vulnerable children. However, interpret the results with caution because of the retrospective design and the lack of data on certain potential determinants. Further prospective studies are needed to better understand the underlying risk factors and mechanisms of hospital-acquired infections in this population.

HAIs disproportionately affected children from rural households, who may also have limited access to preventive services such as vaccination or timely malnutrition screening. Poor WASH conditions in hospitals, combined with the high proportion of microbial pathogens with antimicrobial resistance, likely contribute to increased morbidity. Improving child survival and treatment outcomes requires a comprehensive approach that strengthens IPC systems, ensures safe clinical procedures, and guarantees reliable WASH services within therapeutic feeding facilities. Finally, sustainable investments in healthcare infrastructure, safe water supply, waste management, and antimicrobial resistance surveillance should be considered essential components of high-quality SAM care.

Recommendations

Hospitals and regional health authorities should strengthen IPC programs by ensuring continuous staff training, strict adherence to hand hygiene, and routine disinfection of wards and equipment. In rural regions, routine community-based screening and monitoring are crucial for early detection, prompt referral, and addressing household and environmental variables that may cause malnutrition and delayed recovery. Special attention should be given to the hygienic handling of nasogastric (NG) tubes and therapeutic foods. To identify infections early, improve patient care, and stop the spread of antibiotic-resistant organisms in

hospitals, establish routine screening and monitoring of HAIs. Additionally, minimizing cross-contamination in TFUs requires regular supervision of cleaning procedures.

At the system and policy level, the Ministry of Health and regional bureaus should invest in upgrading WASH infrastructure across hospitals, ensuring uninterrupted water supply, safe sanitation, and proper medical waste disposal. Integrating WASH and nutrition interventions into national child health and hospital quality-improvement strategies would help address the root causes of infection and poor recovery. Policymakers should also support community-level education on hygiene, immunization, and early health-seeking behavior to reduce pre-admission infection risks, especially among rural populations.

Finally, further research should identify specific pathogens, evaluate antimicrobial resistance patterns, and assess the effectiveness of integrated WASH–IPC interventions. Taken together, these actions would greatly improve treatment outcomes for Ethiopia's most vulnerable children and help create infection-free, nutrition-supportive hospital environments.

Author Contributions

TBE: conceived and designed the study, coordinated data collection, conducted data analysis, interpreted the findings, and drafted the manuscript. SGB and AH contributed to the supervision role, study design, data acquisition, and critical review of the manuscript. GE and TDN supported data collection, quality assessment, data management and interpretation of the results. KB and HG provided senior scientific oversight, contributed to the understanding of findings, and critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript and agree to be accountable for all aspects of the work.

Declaration of Generative AI and AI-Assisted Technologies in Scientific Writing

Artificial intelligence (large language model) was used only for language editing and polishing.

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Data Availability Statement

The data used in this study are not publicly available due to institutional and ethical restrictions. Still, they may be made available from the corresponding author upon reasonable request and with permission from the Oromia Regional Health Bureau.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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