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Original Research Article

Spectrum of Comorbidities and Clinical Complications in Children with Severe Acute Malnutrition: A Cross-sectional Study from Western India

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Abstract

Background: Severe acute malnutrition (SAM) is one of the most pressing health challenges for young children in India. It not only limits growth but also leaves children more vulnerable to infections and complications that can quickly become life-threatening. Understanding how these issues present in local settings is important to improve care and outcomes.

Objectives: This study explored the common comorbidities and complications among children with SAM admitted to a Nutritional Rehabilitation Centre (NRC) in Western India and assessed their short-term recovery during hospital care.

Methods: Over an 18-month period, we enrolled 73 children aged 6–59 months who met WHO criteria for SAM. Information on their age, family background, nutritional status, comorbidities, complications, treatment, and outcomes was collected through a structured form. Data were analyzed using standard statistical methods, with significance set at $p<0.05$.

Results: Most children were very young (three out of four were under two years old) and the majority came from low-income households. Anaemia was the most frequent comorbidity, affecting nearly three-quarters of the children, followed by pneumonia. Hypothermia was the leading complication, while electrolyte imbalances were uncommon. The average hospital stay was nearly 13 days. Encouragingly, children showed steady recovery, with an average weight gain of 8.5 g/kg/day. Overall, 74% were successfully discharged, 26% left treatment early, and no deaths were recorded.

Conclusion: Children with SAM often arrive with multiple health challenges, but with dedicated care at NRCs, recovery and survival are possible. The high number of children defaulting from treatment, however, underlines the need for stronger community support, follow-up, and socioeconomic interventions to ensure lasting recovery beyond hospital walls.

Keywords: Severe acute malnutrition, comorbidities, complications, children, anaemia, pneumonia, Nutritional Rehabilitation Centre.

Introduction

"Good nutrition enables children to survive, grow, develop, learn, play, participate and contribute—while malnutrition robs children of their futures and puts young lives hanging in the balance [1]. Nutrition, defined as the science of food and its impact on health, is vital from the earliest stages of life. The under-five age group represents a particularly critical period, as nearly 40% of physical growth and 80% of mental development are achieved by this time [2]. Adequate nutrition during this window is therefore essential for survival, healthy growth, and the achievement of global child health targets. Globally, malnutrition remains one of the most pressing public health challenges. According to the UNICEF–WHO–World Bank Joint Child Malnutrition Estimates 2023, an estimated 45 million children under five were wasted, of whom 13.6 million were severely wasted [3]. At the same time, 148 million children were stunted, reflecting chronic nutritional deprivation. The double burden of malnutrition is also evident, with 37 million overweight children globally [3]. These figures highlight the persistent inequities in achieving Sustainable Development

Goal (SDG) 2, ending hunger and all forms of malnutrition by 2030.

In India, malnutrition continues to be the leading cause of under-five morbidity and mortality, contributing to nearly 68% of all under-five deaths [4]. The country accounts for the highest number of stunted and wasted children worldwide, with one in five children under five years severely wasted [3]. The Global Nutrition Report 2022 noted that while India has made incremental progress in exclusive breastfeeding and micronutrient supplementation, gaps remain in complementary feeding, maternal nutrition, and health system readiness [4]. Within states, disparities are evident—NFHS-5 data for Gujarat reported high prevalence of stunting (39%), wasting (25.1%), severe wasting (10.6%), and underweight (39.7%), showing stagnation compared with NFHS-4 [5].

Severe acute malnutrition (SAM) represents the most critical form of undernutrition, characterized by marked wasting, anorexia, and frequent association with infections. SAM is not merely a nutritional disorder but also a state of profound metabolic and physiologic compromise [6–9]. Hypoglycemia, hypothermia, cardiac dysfunction, electrolyte imbalances, and sepsis are frequent complications that substantially increase mortality risk. Children with SAM have up to nine times higher mortality than their well-nourished counterparts [10].

Despite India's position as one of the world's largest food producers, the prevalence of SAM remains alarmingly high, and many poor families struggle to bear the cost of prolonged medical care [11]. To address this, the Government of India, in collaboration with UNICEF, has scaled up Nutritional Rehabilitation Centres (NRCs) nationwide to provide inpatient care, therapeutic feeding, and caregiver counselling [12]. The primary goals are to reduce case fatality rates, promote nutritional recovery, and shorten hospital stay [4,13–15]. Yet, high default rates, recurrent infections, and poor follow-up continue to undermine outcomes.

Against this background, the present study was designed to comprehensively assess the spectrum of comorbidities and clinical complications in children with SAM admitted to a tertiary care NRC in Western India. Specifically, the study aimed to: (i) identify the risk factors and comorbidities associated with SAM; (ii) describe the clinical manifestations and complications encountered during hospitalization; and (iii) analyze short-term hospital outcomes in these children. By focusing on this spectrum, the study seeks to generate region-specific evidence that can guide clinical management strategies, strengthen NRC functioning, and inform policy-level interventions to reduce SAM-related morbidity and mortality

Materials and Methods

Study Design and Setting: This was a cross-sectional, observational study conducted at the Nutritional Rehabilitation Centre (NRC) of the Department of Pediatrics, a tertiary care teaching hospital in Vadodara district, Gujarat, Western India. The NRC caters to children from rural, peri-urban, and urban areas and provides facility-based management of severe acute malnutrition (SAM).

Study Period and Participants: The study was carried out over 18 months, from January 2020 to June 2021. All children aged 6–59 months admitted with severe acute malnutrition (as per WHO criteria) were screened for eligibility.

Inclusion criteria:

Children aged 6–59 months with any of the following:

- Weight-for-height/length < –3 SD (severe wasting)
- Mid-upper arm circumference (MUAC) <11.5 cm
- Presence of bilateral pitting oedema of nutritional origin

Exclusion criteria:

- Children younger than 6 months or older than 5 years
- Children with major congenital anomalies or chronic illnesses not related to SAM
- Cases where informed consent was not obtained

Sample Size: The sample size was determined using the formula $n = Z^2pq / L^2$. Considering a 95% confidence level, the value of Z was taken as 1.96. The prevalence of recovery rate (p) was assumed to be 85% based on the study by Panigrahi BK et al. [(26)], with q calculated as 1–p (15%). The absolute precision (L) was set at 10% of p (0.085). Substituting these values yielded a calculated sample size of 66.7. To accommodate possible nonresponse, incomplete responses, refusals, and withdrawals, the sample size was inflated by 10%, resulting in a final sample size of 73. A p-value of less than 0.05 was considered statistically significant.

Data Collection and Variables: After obtaining informed consent from parents or caregivers, data were collected using a pretested structured proforma. Information [Table 1] included:

- Sociodemographic data: age, sex, residence, socioeconomic status (modified Kuppuswamy classification)
- Feeding and immunization history

- Anthropometry: weight, length/height, MUAC, weight-for-age, height-for-age, and weight-for-height Z-scores (WHO growth standards)
- Clinical profile: symptoms, clinical signs of malnutrition, comorbidities (anaemia, pneumonia, septicemia, acute gastroenteritis, tuberculosis, etc.), and complications (hypothermia, electrolyte imbalance, seizures, etc.)
- Management and outcome: initiation of therapeutic feeding (F-75/F-100), requirement of nasogastric feeding, length of hospital stay, weight gain (g/kg/day), discharge, default, or death.

Anaemia was classified based on hemoglobin levels (mild, moderate, severe) using WHO guidelines. Pneumonia, septicemia, and other comorbidities were diagnosed using standard clinical and laboratory criteria.

Operational Definitions

- Good weight gain: >10 g/kg/day
- Moderate weight gain: 5–10 g/kg/day
- Poor weight gain: <5 g/kg/day
- Defaulter: Children discharged on request or against medical advice before completion of NRC protocol

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Epi Info version 7.1. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Comparisons of categorical variables were performed using the chi-square test. Continuous variables across groups were compared using the Z-test or ANOVA, as appropriate. A p-value <0.05 was considered statistically significant.

Ethical Considerations: The study was approved by the Institutional Ethics Committee. Written informed consent was obtained from parents or caregivers prior to enrolment. Confidentiality of patient data was strictly maintained.

Table 1: Study variables and operational definitions with references

Category	Variable / Measure	Definition / Criteria Used
Sociodemographic [16]	Age, sex, socioeconomic status	Age in months; sex (male/female); socioeconomic status by Modified Kuppuswamy classification
Anthropometry [17]	Weight-for-height/length (WHZ)	Severe wasting: WHZ < –3 SD (WHO Growth Standards)
	Height/length-for-age (HAZ)	Stunting: HAZ < –2 SD; severe stunting < –3 SD
	Weight-for-age (WAZ)	Underweight: WAZ < –2 SD; severe underweight < –3 SD
	Mid-upper arm circumference	Severe malnutrition: MUAC <11.5 cm
	Nutritional oedema	Symmetrical bilateral pitting oedema of nutritional origin
Feeding practices [18]	Exclusive breastfeeding	Exclusive breastfeeding till 6 months (Yes/No)
	Complementary feeding	Initiation after 6 months
Immunization [19]	Status	Fully, partially, or unimmunized (per National Immunization Schedule)
Comorbidities [20–22]	Anaemia	Hb <11 g/dL: Mild (10–10.9), Moderate (7–9.9), Severe (<7)
	Pneumonia	Diagnosed clinically and/or radiologically
	Septicemia	Clinical diagnosis supported by laboratory findings
	Acute gastroenteritis (AGE)	≥3 loose stools/day with or without dehydration
	Tuberculosis	Diagnosed using clinical, radiological, or microbiological confirmation
Complications [7,23]	Hypoglycemia	Blood glucose <54 mg/dL
	Hypothermia	Axillary temperature <35 °C
	Electrolyte imbalance	Hyponatremia (<135 mmol/L), hypernatremia (>145 mmol/L), hypokalemia (<3.5 mmol/L), hyperkalemia (>5.5 mmol/L)
	Refractory status epilepticus	Prolonged seizure unresponsive to first-line treatment
Outcome measures [13,24]	Weight gain (g/kg/day)	Poor: <5, Moderate: 5–10, Good: >10
	Duration of hospital stay	Recorded in days from admission to discharge
	Treatment outcome	Discharged (recovered), defaulter (DOR/DAMA), or death

Results

Baseline Characteristics: A total of 73 children aged 6–59 months with severe acute malnutrition (SAM) were enrolled. The mean age at presentation was 18.9 ± 12.3 months, with 75.7% (n=56) being under 24 months. There was no statistically

significant difference in gender distribution, with males comprising 53.4% (n=39) and females 46.6% (n=34) (χ^2=0.34, p=0.56). Socioeconomic status analysis revealed that 76.7% (n=56) of children belonged to the lower class (Class V), followed by 15.1% (n=11) in the upper-lower class and 8.2% (n=6) in the lower-middle class. The difference in distribution across socioeconomic strata was statistically significant (χ^2=65.2, p<0.001), indicating a higher burden of SAM among children from economically disadvantaged families.

Table 2: Baseline characteristics of children with SAM (n=73)

Variable	Frequency (n)	Percentage (%)
Age group (months)		
6–12	35	47.9
13–24	21	28.8
25–36	6	8.2
37–48	10	13.7
49–60	1	1.4
Gender		
Male	39	53.4
Female	34	46.6
Socioeconomic status		
Lower (Class V)	56	76.7
Upper-lower (Class IV)	11	15.1
Lower-middle (Class III)	6	8.2

Nutritional Status: Severe wasting (WHZ < –3 SD) was observed in 80.8% (n=59) of children, severe stunting in 39.7% (n=29), and severe underweight in 86.3% (n=63).

Additionally, MUAC <11.5 cm was recorded in 58.9% (n=43). These differences between indices were statistically significant (χ^2=72.8, p<0.001).

Feeding and Immunization: Exclusive breastfeeding up to 6 months was reported in 72.6% (n=53) of children. Regarding immunization, 61.6% (n=45) were fully immunized, 34.2% (n=25) partially immunized, and 4.1% (n=3) unimmunized. The proportion of unimmunized children was significantly lower compared to partially or fully immunized (χ^2=48.7, p<0.001).

Clinical Presentation: The most common presenting symptoms were cough in 43.8% (n=32), fever in 38.4% (n=28), and failure to gain weight in 38.4% (n=28). On examination, the most frequent clinical signs were sparse hair (21.9%), knuckle hyperpigmentation (20.5%), and loss of subcutaneous fat (19.2%). Differences in the frequency of presenting symptoms compared to less frequent symptoms (diarrhea, vomiting) were statistically significant (χ^2=21.4, p<0.01).

Table 3: Clinical features of SAM children (n=73)

Symptom / Sign	Frequency (n)	Percentage (%)
Symptoms		
Cough	32	43.8
Fever	28	38.4
Failure to gain weight	28	38.4
Diarrhea	7	9.6
Vomiting	6	8.2
Signs		
Sparse hair	16	21.9
Knuckle hyperpigmentation	15	20.5
Loss of subcutaneous fat	14	19.2
Oedema	10	13.7
Flag sign	11	15.1

Spectrum of Comorbidities: Anaemia was the most common comorbidity, affecting 74% (n=54) of children, of which 27.4% were severe, 37% moderate, and 9.6% mild. Pneumonia was present in 24.7% (n=18), septicemia in 9.6% (n=7), and acute gastroenteritis in 6.8% (n=5). Only one child (1.4%) had tuberculosis. The overall difference in distribution of comorbidities was statistically significant (χ^2=88.6, p<0.001).

Table 4: Comorbidities among children with SAM (n=73)

Comorbidity	Frequency (n)	Percentage (%)
Anaemia	54	74.0
– Severe	20	27.4
– Moderate	27	37.0
– Mild	7	9.6
Pneumonia	18	24.7
Septicemia	7	9.6
Acute gastroenteritis	5	6.8
Upper respiratory tract infection	4	5.5
Tuberculosis	1	1.4
Others (ITS, empyema, seizures, etc.)	4	5.5

Clinical Complications: The most common complication was hypothermia (8.2%, n=6). Electrolyte imbalances (hyperkalemia, hypokalemia, hyponatremia, hypernatremia) were observed in 1.4% (n=1) each.

While hypothermia was the predominant complication, the overall frequency of complications remained low (χ^2=12.2, p<0.05).

Management and Outcomes: Nasogastric (Ryle's tube) feeding was required in 41.1% (n=30) of children. The mean duration of hospitalization was 12.8 ± 4.8 days, with 71% (n=52) staying 7–15 days, 17.8% staying >15 days, and 11% staying <7 days.

Of the total, 74% (n=54) of children were successfully discharged, whereas 26% (n=19) defaulted (discharged on request or against medical advice). Importantly, no in-hospital deaths occurred.

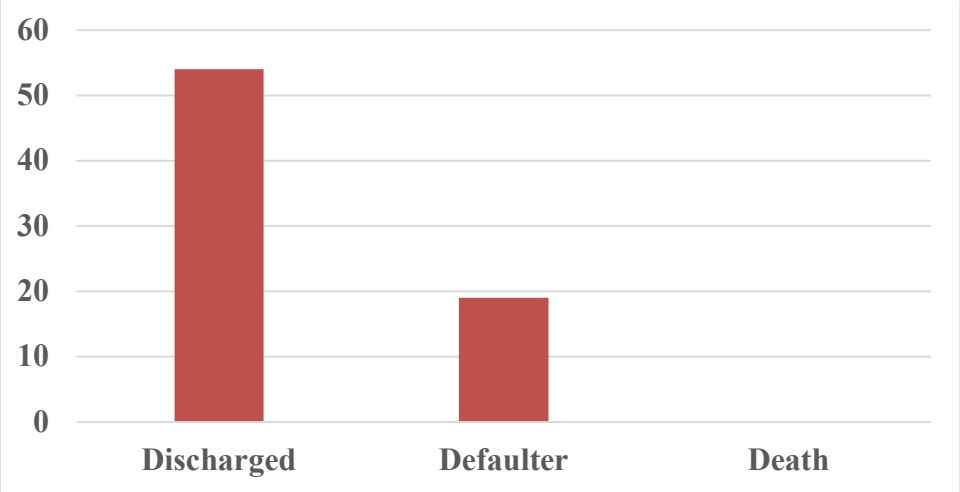

Figure 1. Bar Chart Showing Outcomes of SAM children (n=73)

Weight gain analysis was performed in 63 children (excluding oedematous cases). The mean weight gain was 8.5 ± 4.3 g/kg/day.

A total of 41.3% (n=26) achieved good weight gain (>10 g/kg/day), 31.7% (n=20) moderate gain (5–10 g/kg/day), and 27% (n=17) poor gain (<5 g/kg/day). The difference between children with good versus poor weight gain was statistically significant (ANOVA F=6.42, p=0.003).

Discussion

Severe acute malnutrition (SAM) continues to be one of the leading causes of childhood morbidity and mortality in India and worldwide.

Despite decades of government nutrition programs and the establishment of Nutritional Rehabilitation Centres (NRCs), SAM remains a persistent burden.

The present study from Western India adds region-specific evidence, describing comorbidities, complications, and short-term outcomes of children admitted with SAM.

Age and Socioeconomic Profile: In our cohort, more than three-fourths (75.7%) of children were under two years of age. Similar age clustering was reported by Tiwari et al. in Patna, Bihar [25], Panigrahi et al. in Odisha [26], and Tariq et al. in Srinagar, Kashmir [27], all of whom observed that most SAM admissions occurred below 24 months. This age group is particularly vulnerable due to the transition from breastfeeding to complementary

feeding; a period associated with poor dietary diversity and infection risk.

Socioeconomic disadvantage was also a strong determinant: 76.7% of our children belonged to the lowest class. This finding echoes Panigrahi et al. in Odisha [26] and Tariq et al. in Kashmir [27], where more than 70% of SAM children were from below-poverty-line families. Gragnolati and colleagues [28] have similarly emphasized the role of poverty, food insecurity, and maternal illiteracy in perpetuating SAM in India.

Nutritional Status: Severe wasting (80.8%) and underweight (86.3%) were highly prevalent in our study, while 39.7% were severely stunted. Comparable trends have been observed by Mathur et al. in Delhi [15] and Choudhary et al. in Rajasthan [29]. In Patna, Tiwari et al. reported 75% wasting [25], and Panigrahi et al. in Odisha found a high overlap of wasting and anaemia [26]. Globally, Hossain et al. in Bangladesh [14] and Bizuneh et al. in Ethiopia (30) have reported wasting rates of 70–80% among hospitalized SAM cohorts.

Spectrum of Comorbidities: Anaemia was the leading comorbidity in our cohort (74%), similar to Odisha (Panigrahi et al.: 94%) [26], Patna (Tiwari et al.: 53%) [25], and Delhi (Mathur et al.: >50%) [15]. Internationally, Hossain et al. in Dhaka, Bangladesh [14] and Workie et al. in Ethiopia [31] also found anaemia to be highly prevalent.

Pneumonia was the next major comorbidity (24.7%), comparable to Patna (33%, Tiwari et al.) [25], Odisha (28%, Panigrahi et al.) [26], and Kashmir (26%, Tariq et al.) [27]. Septicemia (9.6%) and gastroenteritis (6.8%) mirrored patterns from Kashmir (Tariq et al.: 30% diarrhoea, 15% sepsis) [27]. Bizuneh et al. in Ethiopia [30] and Hossain et al. in Bangladesh [14] also highlighted diarrhoea and pneumonia as common comorbidities. Oumer et al. in Ethiopia [32] further confirmed that infection burden significantly predicts mortality.

Clinical Complications: Hypothermia (8.2%) was the most frequent complication in our study, similar to Kashmir (11%, Tariq et al.) [27] and Bengaluru (Dhanalakshmi et al.) [33]. Electrolyte imbalances were less frequent but remain clinically significant; both WHO guidelines (1999) [13] and Indian NRC protocols [24] highlight their role as hidden contributors to mortality.

Treatment Outcomes: Our mean weight gain (8.5 g/kg/day) is comparable to Delhi (Mathur et al.: 8.5 g/kg/day) [15] and Rajasthan (Choudhary et al.: 8.1 g/kg/day) [29]. Higher gains were reported in Patna (Tiwari et al.: 14 g/kg/day) [25] and Odisha (Panigrahi et al.: 12 g/kg/day) [26], while lower gains were observed in Kashmir (5.5 g/kg/day, Tariq et al.) [27] and Bengaluru (4.4 g/kg/day, Dhanalakshmi et al.) [33]. Internationally, Hossain et al. in Bangladesh reported 10.6 g/kg/day [14]. Ethiopian studies have shown wide variation, with Bizuneh et al. [30] and Workie et al. [31] noting recovery durations strongly influenced by comorbidities.

Mortality in our cohort was zero, meeting WHO standards (<10%) [13]. This compares favourably with Kashmir (0.7%, Tariq et al.) [27], Patna (2%, Tiwari et al.) [25], Bengaluru (6.9%, Dhanalakshmi et al.) (33), and Bangladesh (>10%, Hossain et al.) [14]. African cohorts such as Oumer et al. in Ethiopia report even higher case fatality rates (>12%) [32]. The absence of inpatient deaths underscores the effectiveness of NRC-based care when protocols are rigorously applied.

However, our default rate (26%) was much higher than Patna (4%, Tiwari et al.) [25] and Odisha (5.8%, Panigrahi et al.) [26]. Defaulting reflects socioeconomic hardship, caregiver fatigue, and lack of support, as echoed in Singh et al. in Uttar Pradesh [10].

Broader Implications: Although immediate recovery outcomes were satisfactory, SAM carries long-term risks. Kirolos et al. (Lancet, 2024) highlighted that SAM survivors are predisposed to stunting, impaired cognition, and chronic disease in adulthood [34]. Victora et al. (2008) also linked early malnutrition with reduced productivity and higher cardiometabolic risk later in life [35].

Thus, management must go beyond inpatient recovery to include long-term follow-up and integration with community nutrition programs.

Strengths, Limitations, and Future Directions: The strengths of this study include comprehensive evaluation of comorbidities, standardized WHO-based definitions, and the addition of region-specific evidence from Gujarat. Zero inpatient mortality demonstrates the success of NRC care when implemented systematically.

Limitations include single-center design, modest sample size, and restriction to short-term outcomes. High default rates reduce generalizability, and unmeasured determinants such as maternal education and micronutrient intake were not captured.

Future studies should be multicentric and longitudinal, assessing relapse and long-term outcomes. Interventions such as conditional cash transfers, caregiver incentives, mobile reminders, and community worker follow-up should be evaluated. Integration of anaemia control and infection prevention into NRCs, along with research into epigenetic and metabolic

programming of SAM survivors, will help frame long-term policy responses.

Conclusion

In our study, we found that most children with severe acute malnutrition were younger than two years and came from families facing significant economic hardship, showing how poverty and early childhood remain key drivers of vulnerability. Anaemia and pneumonia were the most common health problems seen alongside malnutrition, while hypothermia was the leading complication, with electrolyte imbalances appearing only occasionally.

During treatment, many children showed promising recovery with an average weight gain of 8.5 g/kg/day, and importantly, no child died during their hospital stay. At the same time, a high default rate of 26% revealed the ongoing challenges families face in continuing care. Together, these findings point to the importance of not only effective hospital-based management but also stronger community follow-up and social support to ensure lasting recovery.

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