Section: Paediatrics

Original Research Article

GROWTH AND NUTRITIONAL RECOVERY AMONG CHILDREN WITH MODERATE ACUTE MALNUTRITION FOLLOWING NUTRITIONAL INTERVENTION: A PROSPECTIVE LONGITUDINAL STUDY

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Received : *14/06/2026*
Received in revised form : *04/08/2026*
Accepted : *19/08/2026*

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DOI: 10.70034/ijmedph.2026.3.606

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2026; 16 (3); 3887-3899

ABSTRACT

Background: Moderate acute malnutrition is associated with impaired growth, recurrent infection, progression to severe acute malnutrition and increased childhood mortality. Nutritional recovery may be influenced by baseline nutritional status, dietary practices, adherence, concurrent illness and household conditions. This study evaluated growth, nutritional recovery and determinants of recovery among children with moderate acute malnutrition following a structured nutritional intervention. The aim is to assess growth and nutritional recovery among children with moderate acute malnutrition following a structured nutritional intervention.

Materials and Methods: This prospective longitudinal study included 260 children aged 6-59 months diagnosed with moderate acute malnutrition. Moderate acute malnutrition was defined by a weight-for-height/length Z-score between −3 and <−2 and/or mid-upper-arm circumference between 11.5 and <12.5 cm, without bilateral pitting oedema. Children received structured nutritional intervention, dietary counselling, management of concurrent illnesses and scheduled growth monitoring. Weight, length/height, MUAC and anthropometric Z-scores were assessed at baseline and at 4, 8 and 12 weeks. Nutritional recovery was defined as attaining WHZ/WLZ ≥−2 and MUAC ≥12.5 cm without oedema. Repeated-measures analysis, Kaplan-Meier survival analysis and multivariable logistic regression were performed. A p value <0.05 was considered statistically significant.

Results: The mean age was 27.84±12.63 months, and 52.7% were male. Rural residence, low socioeconomic status and inadequate dietary diversity were present in 61.2%, 65.8% and 64.2% of children, respectively. The mean weight increased from 8.71±1.73 kg at baseline to 9.91±1.82 kg at week 12, with a mean increase of 1.20 kg (95% CI: 1.13-1.27; p<0.001). Mean MUAC increased by 0.65 cm, WHZ/WLZ by 0.79 Z-score units and WAZ by 0.54 Z-score units (all p<0.001). Nutritional recovery was achieved by 203 children (78.1%; 95% CI: 72.7%-82.7%), with a mean recovery time of 8.27±2.36 weeks. Non-response occurred in 11.2%, progression to severe acute malnutrition in 4.2%, and default in 6.5%. Adequate adherence was the strongest positive predictor of recovery (adjusted OR=5.12; 95% CI: 2.39-10.97; p<0.001). Dietary diversity, adequate meal frequency, favourable baseline MUAC and WHZ/WLZ, maternal education, complete immunization and regular follow-up also independently predicted recovery. Household food insecurity (adjusted OR=0.43; p=0.018) and diarrhoea during follow-up (adjusted OR=0.36; p=0.003) reduced the likelihood of recovery.

Conclusion: Structured nutritional intervention produced significant anthropometric improvement and satisfactory nutritional recovery among

children with moderate acute malnutrition. Recovery depended on adherence, dietary quality, baseline nutritional status, caregiver education, infection control and continuity of follow-up. Comprehensive nutrition programmes should integrate nutrient-dense feeding, caregiver counselling, regular growth monitoring, immunization, prompt management of diarrhoea and support for food-insecure households.
Keywords: Moderate acute malnutrition; Nutritional recovery; Child growth.

INTRODUCTION

Moderate acute malnutrition (MAM), also termed moderate wasting, remains an important cause of childhood morbidity, impaired development and increased vulnerability to severe acute malnutrition and death. Among children aged 6-59 months, MAM is generally identified by a weight-for-length/height Z-score (WLZ/WHZ) between −3 and <−2 standard deviations of the WHO Child Growth Standards and/or a mid-upper-arm circumference (MUAC) between 11.5 and <12.5 cm, without bilateral pitting oedema.[1,2] Children with MAM have inadequate energy and nutrient reserves and are consequently more susceptible to diarrhoeal diseases, respiratory infections, micronutrient deficiencies, poor linear growth and developmental impairment. Malnutrition and infection often form a vicious cycle: inadequate nutrition weakens immunity, while recurrent infections reduce appetite, impair nutrient absorption and increase metabolic requirements.

The management of MAM aims not merely to increase body weight but to achieve sustained nutritional recovery, appropriate linear growth, restoration of body tissue and prevention of progression to severe wasting. The WHO recommends that affected children receive a comprehensive assessment and management plan that includes nutrient-dense diets, breastfeeding support, age-appropriate complementary feeding, identification and treatment of concurrent illnesses, appropriate micronutrient support, immunization review and regular growth monitoring.[1] The nutritional intervention should be individualized according to the child’s age, anthropometric deficit, dietary practices, clinical condition, household food security and underlying risk factors.

Anthropometric monitoring using weight, length or height, MUAC and standardized Z-scores provides an objective method of evaluating treatment response. Important outcomes include weight gain, improvement in MUAC and WHZ, time to nutritional recovery, non-response, default, relapse and progression to severe acute malnutrition. Previous prospective studies have demonstrated considerable variation in recovery rates and duration of treatment. Children presenting with lower MUAC, recurrent diarrhoea, poor access to supplementary feeding and inadequate adherence have been shown to experience delayed recovery or deterioration.[3-5] Continued follow-up is therefore necessary to identify children with inadequate growth at an early stage.

Evidence regarding growth trajectories and determinants of nutritional recovery following routine nutritional intervention remains limited in many local healthcare settings. A prospective longitudinal assessment can document within-child changes over time and determine the clinical, nutritional and sociodemographic factors associated with successful recovery. The present study was therefore undertaken to evaluate growth and nutritional recovery among children with MAM following a structured nutritional intervention.

Aim: To assess growth and nutritional recovery among children with moderate acute malnutrition following a structured nutritional intervention.

Objectives:

1. To measure changes in weight, length/height, MUAC and anthropometric Z-scores following nutritional intervention among children with MAM.
2. To determine the proportion of children achieving nutritional recovery and the time required for recovery during follow-up.
3. To identify sociodemographic, dietary and clinical factors associated with nutritional recovery, non-response and progression to severe acute malnutrition.

MATERIALS AND METHODS

Source of Data: The study data were obtained from children aged 6-59 months diagnosed with moderate acute malnutrition who attended the paediatric outpatient department, nutrition clinic, immunization clinic or associated community-based child-health services of the study institution. Information was obtained through interviews with parents or primary caregivers, clinical examination, anthropometric assessment, dietary evaluation, treatment records and scheduled follow-up assessments.

Study Design: This was a hospital-based prospective longitudinal observational study. Eligible children with MAM were enrolled at baseline, received nutritional and medical management according to the prevailing institutional protocol, and were followed prospectively to evaluate growth and nutritional recovery.

Study Location: The study was conducted in the Department of Paediatrics and its associated Nutrition Rehabilitation/Nutrition Clinic services at a tertiary-care teaching hospital. Children referred from nearby Anganwadi centres, primary health centres and community outreach services were also screened for eligibility.

Study Duration: The study was conducted over 18 months. The initial 14 months were used for participant recruitment, and every enrolled child was followed for up to 12 weeks or until nutritional recovery, progression to severe acute malnutrition, withdrawal or loss to follow-up. The remaining period was used for data verification, analysis and report preparation.

Study Population: The study population comprised children aged 6-59 months diagnosed with MAM according to WHO anthropometric criteria and whose parents or legally authorized representatives provided written informed consent.

Sample Size: A total of 260 children with moderate acute malnutrition were included in the study. Children were recruited consecutively until the required sample size was achieved. Children lost to follow-up were documented and included in the analysis according to the availability of outcome data.

Operational Definitions

Moderate acute malnutrition: A WHZ/WLZ between −3 and <−2 standard deviations and/or MUAC between 11.5 and <12.5 cm, without bilateral pitting oedema.

Nutritional recovery: Attainment of WHZ/WLZ ≥−2 and MUAC ≥12.5 cm, with absence of bilateral pitting oedema, confirmed during follow-up. Where applicable, recovery was confirmed at two consecutive assessments.

Non-response: Failure to meet the recovery criteria after completing the defined 12-week follow-up despite receiving the prescribed intervention.

Progression to severe acute malnutrition: Development of WHZ/WLZ <−3, MUAC <11.5 cm or bilateral pitting oedema at any follow-up visit.

Default/loss to follow-up: Failure to attend scheduled follow-up visits despite reasonable attempts to contact the caregiver.

Inclusion Criteria

1. Children aged 6-59 months.
2. Children diagnosed with MAM based on WHZ/WLZ between −3 and <−2 and/or MUAC between 11.5 and <12.5 cm.
3. Children without bilateral pitting oedema.
4. Children who were clinically stable and suitable for outpatient nutritional management.
5. Children residing within the defined study area and likely to remain available during follow-up.
6. Parents or legally authorized representatives who provided written informed consent.

Exclusion Criteria

1. Children with severe acute malnutrition at enrolment.
2. Children with bilateral pitting oedema.
3. Children requiring emergency admission or inpatient stabilization.
4. Children with congenital anomalies or genetic disorders significantly affecting growth.
5. Children with chronic renal, hepatic, cardiac, neurological or gastrointestinal disorders affecting nutritional status.
6. Children with known endocrine or metabolic disorders influencing growth.
7. Children receiving long-term medications known to affect growth or nutritional status.
8. Children already enrolled in another therapeutic or supplementary feeding study.
9. Parents or caregivers who declined consent or were unable to comply with follow-up.

Procedure and Methodology: Eligible children were screened using a structured screening form. After obtaining written informed consent from the parent or caregiver, baseline sociodemographic, clinical, dietary and anthropometric information was recorded.

Age was verified from the birth certificate, immunization card, hospital record or another reliable document. Weight was measured using a calibrated electronic paediatric weighing scale with minimal clothing and without footwear, to the nearest 0.1 kg. Recumbent length was measured for children younger than 24 months using an infantometer, while standing height was measured for children aged 24 months or older using a stadiometer, to the nearest 0.1 cm. MUAC was measured on the left upper arm at the midpoint between the acromion and olecranon using a non-stretchable MUAC tape, to the nearest 0.1 cm. Each measurement was obtained twice, and the mean value was recorded. When the two measurements differed beyond the acceptable range, the measurement was repeated. The children were examined for bilateral pitting oedema, pallor, dehydration, skin or hair changes, oral lesions and evidence of systemic infection. WHZ/WLZ, weight-for-age Z-score and height-for-age Z-score were calculated using the WHO Child Growth Standards.

A structured interview was used to obtain information regarding breastfeeding, complementary feeding, meal frequency, dietary diversity, food quantity, feeding during illness, recent infections, immunization status, vitamin A supplementation, deworming, household food security, caregiver education, family income, sanitation and drinking-water facilities.

Each child received a structured nutritional intervention according to age, nutritional deficit and institutional protocol. The intervention included individualized dietary counselling, continued breastfeeding, age-appropriate energy- and protein-dense complementary feeding, increased meal frequency and dietary diversity. Locally available and culturally acceptable foods were emphasized. Supplementary foods or fortified nutritional products were prescribed to eligible children according to the applicable programme protocol. Caregivers were counselled regarding hygiene, responsive feeding, feeding during illness and recognition of danger signs.

Concurrent illnesses were evaluated and treated according to standard paediatric guidelines. Immunization status was assessed and missed vaccines were advised according to the national immunization schedule. Micronutrient supplementation, vitamin A, iron-folic acid and deworming were provided when indicated and in accordance with national guidelines.

Follow-up assessments were conducted at approximately 2, 4, 8 and 12 weeks. At every visit, weight, length/height and MUAC were reassessed; oedema and intercurrent illness were documented; and adherence to dietary advice or supplementary feeding was evaluated. Caregivers of children who missed appointments were contacted by telephone or through community health workers whenever feasible.

Children who developed severe wasting, nutritional oedema, persistent weight loss, poor appetite, medical complications or other danger signs during follow-up were referred promptly for appropriate facility-based management.

Sample Processing: The principal outcomes were based primarily on anthropometric and clinical assessments; therefore, routine biological sample collection was not mandatory for every participant. When clinically indicated, blood samples were collected under aseptic precautions for investigations such as complete blood count, peripheral smear, serum ferritin, blood glucose, serum electrolytes, liver function tests or other relevant investigations.

Blood specimens were labelled using unique participant identification numbers and transported promptly to the institutional laboratory. Samples were processed using standardized laboratory procedures and calibrated equipment. Laboratory results were entered in the case-record form and used to identify associated illnesses or micronutrient deficiencies. No additional invasive sample was collected solely for research purposes unless separately approved by the Institutional Ethics Committee.

Data Collection:

Data were collected using a predesigned, pretested, semi-structured case-record form. The form included:

- Sociodemographic characteristics
- Birth and feeding history
- Immunization and supplementation history
- Recent morbidity and treatment history
- Household and environmental characteristics
- Baseline and follow-up anthropometric measurements
- Dietary intake and dietary-diversity indicators
- Details of nutritional intervention
- Adherence and missed follow-up visits
- Laboratory findings, when available
- Recovery, non-response, default, progression to severe malnutrition and hospitalization

All measurements were performed by trained investigators using standardized techniques. Weighing scales and anthropometric instruments were checked and calibrated regularly. Completed forms were reviewed for completeness and consistency before data entry. Each participant was assigned a unique study code, and personally identifying information was kept confidential.

Outcome Measures: The primary outcome was the proportion of children who achieved nutritional recovery during the follow-up period.

Secondary outcomes included:

- Mean change in body weight
- Average weight-gain velocity in g/kg/day
- Mean change in MUAC
- Changes in WHZ/WLZ, weight-for-age and height-for-age Z-scores
- Median time to nutritional recovery
- Proportion progressing to severe acute malnutrition
- Proportion showing non-response, default, hospitalization or death
- Factors independently associated with nutritional recovery

Statistical Methods: Data were entered in Microsoft Excel and analysed using an appropriate statistical software package. Continuous variables were summarized as mean and standard deviation when normally distributed and as median and interquartile range when non-normally distributed. Categorical variables were expressed as frequencies and percentages. All estimates were reported with 95% confidence intervals where appropriate.

Changes in normally distributed anthropometric measurements between baseline and individual follow-up visits were assessed using the paired Student's t-test. Repeated-measures analysis of variance was used to compare measurements recorded at more than two follow-up points. The Wilcoxon signed-rank test or Friedman test was applied to non-normally distributed repeated measurements.

The chi-square test or Fisher's exact test was used to examine associations between categorical variables and recovery status. Independent-samples t-test or Mann-Whitney U test was used to compare continuous variables between children who recovered and those who did not recover.

Kaplan-Meier analysis was used to estimate the probability and median time to nutritional recovery, with loss to follow-up and completion without recovery treated as censored observations as appropriate. The log-rank test was used to compare recovery curves. Cox proportional-hazards regression was used to identify independent predictors of time to recovery. Alternatively, binary logistic regression was performed to determine factors associated with recovery by the end of follow-up. Adjusted effect estimates were presented with 95% confidence intervals. A two-sided p value <0.05 was considered statistically significant.

Ethical Considerations: Approval was obtained from the Institutional Ethics Committee before commencement of the study. Written informed consent was obtained from the parent or legally authorized representative. Participation was voluntary, confidentiality was maintained, and refusal to participate did not affect the child's routine treatment. Children who developed severe malnutrition or medical complications were referred immediately for appropriate management.

RESULTS

Table 1: Baseline characteristics and overall nutritional outcomes of children with moderate acute malnutrition following structured nutritional intervention (N=260)

Parameter	n (%) or Mean (SD)	95% CI	Test of significance	P value
Age, months	27.84 (12.63)	26.30-29.38	One-sample t=3.62†	<0.001*
Age 6-23 months	117 (45.0%)	39.1%-51.1%	Proportion z=−1.61‡	0.107
Age 24-59 months	143 (55.0%)	48.9%-60.9%	Proportion z=1.61‡	0.107
Male sex	137 (52.7%)	46.6%-58.7%	Proportion z=0.87‡	0.385
Female sex	123 (47.3%)	41.3%-53.4%	Proportion z=−0.87‡	0.385
Rural residence	159 (61.2%)	55.1%-66.9%	Proportion z=3.60‡	<0.001*
Low socioeconomic status	171 (65.8%)	59.8%-71.3%	Proportion z=5.08‡	<0.001*
Low birth weight	93 (35.8%)	30.2%-41.8%	Proportion z=−4.59‡	<0.001*
Continued breastfeeding among children <24 months (n=117)	79 (67.5%)	58.6%-75.4%	Proportion z=3.79‡	<0.001*
Inadequate dietary diversity	167 (64.2%)	58.2%-69.8%	Proportion z=4.59‡	<0.001*
Recent diarrhoeal illness	81 (31.2%)	25.8%-37.0%	Proportion z=−6.05‡	<0.001*
Recent acute respiratory infection	107 (41.2%)	35.3%-47.2%	Proportion z=−2.85‡	0.004*
Anaemia	151 (58.1%)	52.0%-63.9%	Proportion z=2.61‡	0.009*
Baseline weight, kg	8.71 (1.73)	8.50-8.92	One-sample t=−2.70§	0.007*
Baseline length/height, cm	78.63 (9.84)	77.43-79.83	One-sample t=1.03¶	0.305
Baseline MUAC, cm	12.03 (0.27)	12.00-12.06	One-sample t=1.79#	0.075
Baseline weight-for-height Z-score	−2.46 (0.29)	−2.50 to −2.42	One-sample t=2.22††	0.027*
Baseline weight-for-age Z-score	−2.71 (0.61)	−2.78 to −2.64	One-sample t=−5.55‡‡	<0.001*
Baseline height-for-age Z-score	−2.08 (0.87)	−2.19 to −1.97	One-sample t=−1.48§§	0.140
Completed scheduled follow-up	243 (93.5%)	89.8%-95.9%	Proportion z=14.02‡	<0.001*
Achieved nutritional recovery	203 (78.1%)	72.7%-82.7%	Proportion z=9.06‡	<0.001*
Mean weight gain, g/kg/day	3.47 (1.26)	3.32-3.62	One-sample t=6.02¶¶	<0.001*
Progressed to severe acute malnutrition	11 (4.2%)	2.4%-7.4%	Exact binomial test	<0.001*
Non-response at 12 weeks	29 (11.2%)	7.9%-15.6%	Proportion z=−12.52‡	<0.001*
Lost to follow-up/defaulted	17 (6.5%)	4.1%-10.2%	Exact binomial test	<0.001*

†Reference mean age=25 months; ‡compared with 50%; §reference mean weight=9 kg;
¶reference mean height=78 cm; #reference mean MUAC=12 cm;
††reference WHZ=−2.50;
‡‡reference WAZ=−2.50;
§§reference HAZ=−2.00;
¶¶reference weight gain=3 g/kg/day.
*Statistically significant at p<0.05.

[Table 1] presents the baseline characteristics and overall nutritional outcomes of 260 children with moderate acute malnutrition. The mean age was 27.84±12.63 months (95% CI: 26.30-29.38), which was significantly higher than the reference mean of 25 months (t=3.62, p<0.001). Children aged 24-59 months constituted 55.0% of the cohort, while 45.0% were aged 6-23 months; this difference was not statistically significant (p=0.107). Males represented 52.7% and females 47.3%, with no significant sex difference (p=0.385). A significantly high proportion of children belonged to rural areas (61.2%, p<0.001) and low socioeconomic households (65.8%, p<0.001). Low birth weight was reported in 35.8% of children. Among children younger than 24 months, 67.5% continued to receive breastfeeding (p<0.001). Inadequate dietary diversity was observed in 64.2%, indicating an important feeding-related deficiency. Recent diarrhoeal illness was reported in 31.2%, acute respiratory infection in 41.2%, and anaemia in 58.1% of children, with all these proportions showing statistical significance relative to the specified reference proportion.

At baseline, the mean weight was 8.71±1.73 kg, significantly lower than the reference value of 9 kg (t=−2.70, p=0.007), whereas the mean length/height of 78.63±9.84 cm did not differ significantly from the reference value (p=0.305). The mean MUAC was 12.03±0.27 cm (p=0.075). The mean weight-for-height Z-score was −2.46±0.29 and differed significantly from the reference WHZ of −2.50 (p=0.027). The mean weight-for-age Z-score was −2.71±0.61, demonstrating substantial underweight (p<0.001), while the mean height-for-age Z-score was −2.08±0.87 and did not differ significantly from the reference value of −2.00 (p=0.140). Overall, 243 children (93.5%) completed the scheduled follow-up, and 203 (78.1%; 95% CI: 72.7%-82.7%) achieved nutritional recovery (p<0.001). The mean weight-gain velocity was 3.47±1.26 g/kg/day, significantly exceeding the reference rate of 3 g/kg/day (t=6.02, p<0.001). Nevertheless, 29 children (11.2%) showed non-response, 11 (4.2%) progressed to severe acute malnutrition, and 17 (6.5%) were lost to follow-up.

Table 2: Changes in anthropometric measurements following structured nutritional intervention among children with MAM (N=260)

Anthropometric parameter	Baseline Mean (SD)	Week 4 Mean (SD)	Week 8 Mean (SD)	Week 12 Mean (SD)	Mean change: baseline to week 12 (95% CI)	Test of significance	P value
Weight, kg	8.71 (1.73)	9.12 (1.76)	9.53 (1.79)	9.91 (1.82)	1.20 (1.13-1.27)	Repeated-measures F=384.72	<0.001*
Length/height, cm	78.63 (9.84)	79.06 (9.82)	79.51 (9.79)	79.92 (9.76)	1.29 (1.20-1.38)	Repeated-measures F=269.43	<0.001*
MUAC, cm	12.03 (0.27)	12.24 (0.32)	12.47 (0.39)	12.68 (0.44)	0.65 (0.60-0.70)	Repeated-measures F=246.81	<0.001*
Weight-for-height/length Z-score	−2.46 (0.29)	−2.19 (0.36)	−1.91 (0.43)	−1.67 (0.51)	0.79 (0.73-0.85)	Repeated-measures F=298.56	<0.001*
Weight-for-age Z-score	−2.71 (0.61)	−2.53 (0.62)	−2.34 (0.64)	−2.17 (0.66)	0.54 (0.49-0.59)	Repeated-measures F=231.64	<0.001*
Height-for-age Z-score	−2.08 (0.87)	−2.04 (0.86)	−1.99 (0.85)	−1.94 (0.84)	0.14 (0.11-0.17)	Repeated-measures F=57.38	<0.001*
Weight-gain velocity, g/kg/day	—	3.81 (1.48)	3.39 (1.31)	3.21 (1.18)	−0.60 (−0.74 to −0.46)†	Repeated-measures F=31.72	<0.001*
Children with MUAC ≥12.5 cm, n (%)	0 (0.0%)	47 (18.1%)	139 (53.5%)	207 (79.6%)	79.6% (74.3%-84.1%)‡	Cochran's Q=417.63	<0.001*
Children with WHZ/WLZ ≥−2, n (%)	0 (0.0%)	57 (21.9%)	151 (58.1%)	211 (81.2%)	81.2% (76.0%-85.5%)‡	Cochran's Q=438.26	<0.001*
Children satisfying both anthropometric recovery criteria, n (%)	0 (0.0%)	31 (11.9%)	127 (48.8%)	203 (78.1%)	78.1% (72.7%-82.7%)‡	Cochran's Q=389.74	<0.001*

†Change from week 4 to week 12;
‡absolute increase from baseline.
*Statistically significant at p<0.05.

[Table 2] demonstrates progressive and statistically significant improvement in all anthropometric measurements during the 12-week nutritional intervention. Mean body weight increased steadily from 8.71±1.73 kg at baseline to 9.12±1.76 kg at week 4, 9.53±1.79 kg at week 8 and 9.91±1.82 kg at week 12. The mean increase of 1.20 kg (95% CI: 1.13-1.27) was statistically significant (repeated-measures F=384.72, p<0.001). Mean length/height increased from 78.63±9.84 cm to 79.92±9.76 cm, representing an increase of 1.29 cm (95% CI: 1.20-1.38; F=269.43, p<0.001). Similarly, mean MUAC improved from 12.03±0.27 cm at baseline to 12.68±0.44 cm at week 12, with a significant mean increase of 0.65 cm (95% CI: 0.60-0.70; F=246.81, p<0.001).

A significant improvement was also observed in all anthropometric Z-scores. The mean WHZ/WLZ improved from −2.46±0.29 to −1.67±0.51, with a mean increase of 0.79 Z-score units (95% CI: 0.73-0.85; F=298.56, p<0.001). The mean weight-for-age Z-score increased from −2.71±0.61 to −2.17±0.66, whereas the mean height-for-age Z-score improved from −2.08±0.87 to −1.94±0.84. These changes were statistically significant (both p<0.001), although the improvement in height-for-age was comparatively smaller, as expected during a relatively short follow-up period. Weight-gain velocity was highest during the first four weeks at 3.81±1.48 g/kg/day and subsequently declined to 3.39±1.31 at week 8 and 3.21±1.18 g/kg/day at week 12. This reduction of 0.60 g/kg/day between weeks 4 and 12 was significant (F=31.72, p<0.001), suggesting more rapid catch-up growth during the early phase of intervention.

The proportion of children achieving MUAC ≥12.5 cm increased from 0% at baseline to 18.1% at week 4, 53.5% at week 8 and 79.6% at week 12 (Cochran's Q=417.63, p<0.001). Similarly, the proportion achieving WHZ/WLZ ≥−2 increased to 21.9%, 58.1% and 81.2% at weeks 4, 8 and 12, respectively (Q=438.26, p<0.001). The proportion satisfying both anthropometric recovery criteria rose from 11.9% at week 4 to 48.8% at week 8 and 78.1% at week 12 (Q=389.74, p<0.001). Thus, the structured nutritional intervention resulted in sustained and clinically meaningful improvements in body weight, MUAC and anthropometric Z-scores.

Table 3: Nutritional recovery and time-to-recovery outcomes during follow-up (N=260)
A. Final nutritional outcomes

Outcome	n (%)	95% CI	Test of significance	P value
Nutritional recovery	203 (78.1%)	72.7%-82.7%	Proportion z=9.06†	<0.001*
Non-response at 12 weeks	29 (11.2%)	7.9%-15.6%	Proportion z=−12.52†	<0.001*
Progression to severe acute malnutrition	11 (4.2%)	2.4%-7.4%	Exact binomial test	<0.001*

Lost to follow-up/defaulted	17 (6.5%)	4.1%-10.2%	Exact binomial test	<0.001*
Hospitalization during follow-up	7 (2.7%)	1.3%-5.5%	Exact binomial test	<0.001*
Death during follow-up	1 (0.4%)	0.1%-2.1%	Exact binomial test	<0.001*

†Compared with an expected proportion of 50%.

B. Cumulative nutritional recovery according to follow-up duration

Follow-up time	Newly recovered, n	Cumulative recovered, n (%)	95% CI	Comparison with previous visit	Test of significance	P value
By week 4	31	31 (11.9%)	8.5%-16.4%	Reference	—	—
Weeks >4-8	96	127 (48.8%)	42.8%-54.9%	36.9% increase	McNemar χ^2=94.01	<0.001*
Weeks >8-12	76	203 (78.1%)	72.7%-82.7%	29.2% increase	McNemar χ^2=74.01	<0.001*

C. Time and rate of recovery

Recovery indicator	Estimate	95% CI	Test of significance	P value
Mean time to recovery, weeks	8.27 (2.36)	7.95-8.59	One-sample t=−4.99†	<0.001*
Kaplan-Meier median time to recovery, weeks	8.43	8.07-8.79	Log-rank χ^2=24.76‡	<0.001*
Recovery incidence rate	9.84 per 100 child-weeks	8.55-11.28	Incidence-rate test§	<0.001*
Mean time to recovery among children with baseline MUAC 12.1-12.4 cm	7.61 (2.13)	7.31-7.91	Independent t=5.73	<0.001*
Mean time to recovery among children with baseline MUAC 11.5-12.0 cm	9.31 (2.47)	8.82-9.80	Reference	—
Mean time to recovery with adequate adherence	7.82 (2.19)	7.52-8.12	Independent t=6.46#	<0.001*
Mean time to recovery with inadequate adherence	10.06 (2.48)	9.36-10.76	Reference	—

†Compared with an expected recovery time of 9 weeks;
‡comparison of recovery curves by baseline MUAC category;
§compared with a reference rate of 5 per 100 child-weeks;
¶MUAC categories;
#adherence categories.
*Statistically significant at p<0.05.

[Table 3] summarizes the final outcomes, cumulative recovery and time required for nutritional recovery. Of the 260 children, 203 (78.1%; 95% CI: 72.7%-82.7%) achieved nutritional recovery, a proportion significantly greater than the reference value of 50% (z=9.06, p<0.001). Twenty-nine children (11.2%) remained non-responsive at 12 weeks, 11 (4.2%) progressed to severe acute malnutrition, and 17 (6.5%) defaulted or were lost to follow-up. Seven children (2.7%) required hospitalization during follow-up, and one child (0.4%) died. Recovery, non-response, progression and default were treated as mutually exclusive final outcomes, whereas hospitalization and death were recorded separately.

The cumulative recovery pattern showed that 31 children (11.9%; 95% CI: 8.5%-16.4%) had recovered by week 4. A further 96 children recovered between weeks 4 and 8, increasing cumulative recovery to 127 children (48.8%; 95% CI: 42.8%-54.9%). This represented a significant absolute increase of 36.9 percentage points (McNemar χ^2=94.01, p<0.001). An additional 76 children recovered between weeks 8 and 12, bringing cumulative recovery to 203 children (78.1%), a further significant increase of 29.2 percentage points (McNemar χ^2=74.01, p<0.001). These findings indicate that most recovery occurred after the fourth week and continued substantially through week 12.

The mean time to recovery was 8.27±2.36 weeks (95% CI: 7.95-8.59), which was significantly shorter than the reference duration of nine weeks (t=−4.99, p<0.001). Kaplan-Meier analysis estimated a median recovery time of 8.43 weeks (95% CI: 8.07-8.79), while the overall recovery incidence rate was 9.84 per 100 child-weeks (95% CI: 8.55-11.28). Children with a baseline MUAC of 12.1-12.4 cm recovered significantly earlier than those with a MUAC of 11.5-12.0 cm (7.61±2.13 versus 9.31±2.47 weeks; t=5.73, p<0.001). Similarly, children with adequate adherence recovered in 7.82±2.19 weeks, compared with 10.06±2.48 weeks among those with inadequate adherence (t=6.46, p<0.001).

Table 4: Sociodemographic, dietary and clinical predictors of nutritional recovery among children with MAM (N=260)

Predictor	Recovered n/N (%)	Unfavourable outcome n/N (%)	Crude OR (95% CI)	Adjusted OR (95% CI)	Test of significance	P value
Age ≥24 months	119/143 (83.2%)	24/143 (16.8%)	1.95 (1.08-3.52)	1.63 (0.86-3.11)	Wald χ^2=2.26	0.133
Female sex	98/123 (79.7%)	25/123 (20.3%)	1.17 (0.65-2.12)	1.09 (0.57-2.08)	Wald χ^2=0.07	0.792

Rural residence	119/159 (74.8%)	40/159 (25.2%)	0.51 (0.27-0.97)	0.71 (0.35-1.44)	Wald χ^2=0.89	0.346
Maternal education ≥secondary level	112/129 (86.8%)	17/129 (13.2%)	2.90 (1.54-5.46)	2.08 (1.03-4.19)	Wald χ^2=4.16	0.041*
Low socioeconomic status	126/171 (73.7%)	45/171 (26.3%)	0.44 (0.22-0.87)	0.58 (0.27-1.23)	Wald χ^2=1.99	0.158
Household food insecurity	82/121 (67.8%)	39/121 (32.2%)	0.29 (0.15-0.55)	0.43 (0.21-0.87)	Wald χ^2=5.60	0.018*
Adequate dietary diversity during intervention	151/171 (88.3%)	20/171 (11.7%)	5.37 (2.87-10.04)	3.48 (1.74-6.96)	Wald χ^2=12.42	<0.001*
Adequate meal frequency	163/187 (87.2%)	24/187 (12.8%)	5.61 (2.96-10.64)	3.11 (1.53-6.34)	Wald χ^2=9.73	0.002*
≥80% adherence to nutritional intervention	181/211 (85.8%)	30/211 (14.2%)	7.40 (3.68-14.88)	5.12 (2.39-10.97)	Wald χ^2=17.69	<0.001*
Baseline MUAC 12.1-12.4 cm	127/143 (88.8%)	16/143 (11.2%)	3.88 (2.05-7.33)	2.79 (1.38-5.64)	Wald χ^2=8.18	0.004*
Baseline WHZ/WLZ >−2.5	139/163 (85.3%)	24/163 (14.7%)	2.98 (1.64-5.43)	2.21 (1.13-4.32)	Wald χ^2=5.35	0.021*
Low birth weight	63/93 (67.7%)	30/93 (32.3%)	0.43 (0.24-0.78)	0.59 (0.30-1.15)	Wald χ^2=2.41	0.121
Anaemia at enrolment	108/151 (71.5%)	43/151 (28.5%)	0.35 (0.18-0.68)	0.51 (0.25-1.02)	Wald χ^2=3.64	0.056
Diarrhoea during follow-up	43/71 (60.6%)	28/71 (39.4%)	0.24 (0.13-0.44)	0.36 (0.18-0.71)	Wald χ^2=8.62	0.003*
Acute respiratory infection during follow-up	57/79 (72.2%)	22/79 (27.8%)	0.61 (0.33-1.13)	0.74 (0.37-1.48)	Wald χ^2=0.71	0.399
Complete immunization for age	169/203 (83.3%)	34/203 (16.7%)	3.37 (1.75-6.50)	2.16 (1.04-4.49)	Wald χ^2=4.29	0.038*
Regular follow-up attendance	189/229 (82.5%)	40/229 (17.5%)	5.74 (2.61-12.61)	3.72 (1.56-8.86)	Wald χ^2=8.77	0.003*

*Statistically significant at p<0.05.

[Table 4] presents the univariate and multivariable predictors of nutritional recovery, comparing 203 recovered children with 57 children who experienced an unfavourable outcome. After adjustment for potential confounders, maternal education at or above the secondary level was independently associated with approximately two-fold higher odds of recovery (adjusted OR [aOR]=2.08; 95% CI: 1.03-4.19; p=0.041). Household food insecurity reduced the odds of recovery by 57% (aOR=0.43; 95% CI: 0.21-0.87; p=0.018). Adequate dietary diversity (aOR=3.48; 95% CI: 1.74-6.96; p<0.001) and adequate meal frequency (aOR=3.11; 95% CI: 1.53-6.34; p=0.002) were significant positive dietary predictors.

Adherence to at least 80% of the prescribed nutritional intervention was the strongest independent predictor, increasing the odds of recovery more than five-fold (aOR=5.12; 95% CI: 2.39-10.97; p<0.001). Children with a baseline MUAC of 12.1-12.4 cm had 2.79 times greater odds of recovery than those with lower MUAC values (95% CI: 1.38-5.64; p=0.004). Similarly, a baseline WHZ/WLZ above −2.5 was associated with significantly higher recovery odds (aOR=2.21; 95% CI: 1.13-4.32; p=0.021). Diarrhoea during follow-up was an adverse predictor and reduced the odds of recovery by 64% (aOR=0.36; 95% CI: 0.18-0.71; p=0.003). Complete age-appropriate immunization (aOR=2.16; 95% CI: 1.04-4.49; p=0.038) and regular follow-up attendance (aOR=3.72; 95% CI: 1.56-8.86; p=0.003) were also independently associated with better recovery.

Although age ≥24 months, female sex, rural residence, low socioeconomic status, low birth weight, anaemia and acute respiratory infection showed variations in recovery rates, they were not statistically significant after adjustment (all p>0.05). Anaemia showed a borderline negative association with recovery (aOR=0.51; p=0.056), but its confidence interval included unity. The Hosmer-Lemeshow test was non-significant (χ^2=6.27, p=0.617), indicating an acceptable model fit. The model explained approximately 41.8% of the variation in recovery according to the Nagelkerke R^2 and correctly classified 84.2% of participants. Overall, the results identify adherence, adequate diet, favourable baseline nutritional status, maternal education, immunization and regular follow-up as important facilitators of recovery, whereas food insecurity and diarrhoea were major barriers.

DISCUSSION

The present prospective longitudinal study evaluated the growth and nutritional recovery of 260 children with moderate acute malnutrition (MAM) following a structured nutritional intervention. The principal findings were a nutritional recovery rate of 78.1%, significant improvements in weight, MUAC and anthropometric Z-scores, a mean recovery time of 8.27 weeks, and relatively low rates of progression to severe acute malnutrition (SAM), default and mortality. Recovery was independently promoted by maternal education, dietary diversity, adequate meal frequency, adherence, favourable baseline MUAC and WHZ/WLZ, complete immunization and regular follow-up. Conversely, household food insecurity and diarrhoea during follow-up reduced the probability of recovery.

Baseline characteristics and nutritional vulnerability: The mean age of the children was 27.84±12.63 months, with 55.0% aged 24-59 months and 45.0% aged 6-23 months. The predominance of children older than two years may reflect continuing exposure to inadequate complementary feeding, recurrent infections and household food insecurity after infancy. Rashid et al. (2022).[1] similarly included children aged 6-59 months in a targeted supplementary feeding programme and reported that age was associated with recovery time. Their children aged 24-59 months had a 24% greater recovery rate than younger children. However, after adjustment, age ≥24 months was not independently associated with recovery in the present study (aOR=1.63, p=0.133). This indicates that the apparent effect of age may have been mediated by dietary intake, infection, adherence and baseline nutritional status.

The nearly equal sex distribution—52.7% males and 47.3% females—suggested that MAM affected both sexes without a marked difference. Female sex was also not an independent predictor of recovery (aOR=1.09, p=0.792). Melaku et al. (2024).[2] observed a slightly shorter median recovery time among male children, but sex was not among the strongest determinants after other factors were considered. Thus, sex differences may be context-dependent and influenced by household feeding practices, care-seeking behaviour and baseline severity.

In the present study, 61.2% of children were from rural areas, 65.8% belonged to a low socioeconomic group and 64.2% had inadequate dietary diversity. These observations demonstrate that MAM was closely embedded within socioeconomic and dietary deprivation. Kisenge et al. (2024).[3], in an analysis involving children from India and Tanzania, identified poverty-related conditions, feeding inadequacy and illness as important contributors to MAM. Kristjansson et al. (2015).[4] concluded that food supplementation among socioeconomically disadvantaged children could produce improvements in growth, although the magnitude of benefit varied according to programme design, food availability and adherence. Rural residence and low socioeconomic status were associated with reduced recovery in the unadjusted analysis of the present study, but neither remained statistically significant after adjustment. Household food insecurity, however, remained independently associated with 57% lower odds of recovery. This suggests that immediate household access to adequate food was more influential than residence or socioeconomic classification alone.

Low birth weight was present in 35.8% of children and was associated with a lower crude probability of recovery, although the relationship was attenuated following adjustment (aOR=0.59, p=0.121). Low-birth-weight children may enter infancy with reduced nutritional reserves and may remain vulnerable to growth faltering, particularly when followed by inadequate breastfeeding, poor complementary feeding or recurrent infection. Bourdon et al. (2024).[5] demonstrated that growth following acute illness was heterogeneous and influenced by pre-existing anthropometric deficits, illustrating how early nutritional disadvantages can persist during later recovery.

Among children younger than 24 months, 67.5% continued breastfeeding. Continued breastfeeding likely provided nutritional and immunological benefits, although breastfeeding alone would not correct the energy and micronutrient deficit of MAM without adequate complementary feeding. The high frequency of inadequate dietary diversity supports this interpretation. Das et al. (2020).[6] emphasized that successful management of acute malnutrition requires an integrated approach involving appropriate supplementary food, caregiver counselling, treatment of infection and continued follow-up rather than reliance on a single intervention.

Recent diarrhoea was recorded in 31.2%, acute respiratory infection in 41.2% and anaemia in 58.1% of the children. These findings demonstrate the coexistence of undernutrition, infection and micronutrient deficiency. James et al. (2016).[7] reported that children with MAM had increased risks of infection, progression to SAM and death, particularly when nutrition-specific treatment was unavailable. Diarrhoea can impair nutrient absorption, reduce appetite and increase intestinal nutrient losses, whereas respiratory illness increases metabolic requirements. Anaemia was associated with poorer crude recovery in the present study, although it narrowly missed statistical significance after adjustment (aOR=0.51, p=0.056). Delimont et al. (2019).[8] demonstrated that fortified blended foods could support iron, vitamin A and anthropometric outcomes, highlighting the importance of micronutrient adequacy alongside energy supplementation.

Baseline anthropometry and overall recovery: The mean baseline weight was 8.71±1.73 kg, mean MUAC was 12.03±0.27 cm, mean WHZ/WLZ was −2.46±0.29 and mean WAZ was −2.71±0.61. The mean HAZ of −2.08±0.87 indicated that many children had concurrent linear growth impairment in addition to acute wasting. This coexistence suggests prolonged nutritional deprivation rather than an isolated short-term episode of weight loss. Lelijveld et al. (2020).[9] noted considerable heterogeneity among children classified as having MAM because WHZ, MUAC, underweight and stunting identify overlapping but not identical nutritional deficits. Consequently, monitoring several anthropometric indicators provides a more comprehensive assessment than relying exclusively on weight gain.

The scheduled follow-up completion rate was 93.5%, while 78.1% achieved nutritional recovery. This recovery rate exceeded the 73% reported by Rashid et al. (2022),[1] and was substantially higher than the 54.2% recovery without an episode of SAM reported by James et al. (2016),[7] among Ethiopian children without access to supplementary feeding. However, it was lower than the 87.5% recovery observed by Melaku et al. (2024).[2] in a targeted supplementary feeding programme. Differences among studies may be attributable to admission criteria, severity of wasting, food formulation, duration of treatment, food sharing, infection burden, adherence and accessibility of follow-up services.

Medoua et al. (2016),[10] reported recovery rates of 85% with ready-to-use supplementary food (RUSF) and 73% with improved corn-soy blend after 56 days. The present recovery rate of 78.1% lies between these estimates. Medoua et al. also suggested that repeated nutrition education may have contributed to favourable recovery even when the supplied ration provided only part of the child's energy requirement. This supports the present structured approach, in which caregiver counselling and improved household feeding were combined with nutritional supplementation.

Stobaugh et al. (2016),[11] found that a whey-containing RUSF improved recovery among children with MAM, indicating that food quality and protein composition may influence tissue restoration. Similarly, Gera et al. (2017),[12] in a systematic review of lipid-based nutrient supplements, concluded that these products modestly increased recovery and weight gain compared with blended foods, although effects on mortality and long-term growth were less certain. Teshome et al. (2023),[13] likewise found that RUSF produced a higher overall probability of recovery than corn-soy blend, but noted heterogeneity between programmes.

The mean weight-gain velocity in the present study was 3.47±1.26 g/kg/day, significantly exceeding the specified reference of 3 g/kg/day. This rate was compatible with moderate catch-up growth in an outpatient MAM programme. The relatively high recovery accompanied by low progression and mortality suggests that the intervention achieved clinically meaningful improvement without requiring the very rapid weight gain expected during inpatient treatment of complicated SAM.

Nevertheless, 11.2% remained non-responsive, 4.2% progressed to SAM, and 6.5% defaulted. Medoua et al. (2016),[10] reported non-response in 15% of the RUSF group and 20% of the corn-soy blend group, with 3% and 5%, respectively, deteriorating to SAM. Thus, the progression rate in the present study was comparable. James et al. (2016),[7] reported that 9.3% developed at least one episode of SAM when supplementary feeding was unavailable, more than twice the rate in the present study. These comparisons support the protective effect of timely nutritional intervention, while also showing that some children require intensified evaluation for infection, feeding difficulty, malabsorption or household food insecurity.

Longitudinal changes in anthropometric measurements: A consistent improvement was observed across all four assessment points. Mean weight increased by 1.20 kg, from 8.71 kg at baseline to 9.91 kg at week 12. Mean MUAC increased by 0.65 cm, while WHZ/WLZ and WAZ improved by 0.79 and 0.54 Z-score units, respectively. All changes were statistically significant. Azimi et al. (2020),[14] similarly reported improvement in growth indicators among children with mild-to-moderate malnutrition receiving a specially developed RUSF. Talavera et al. (2020).[15] also demonstrated favourable growth effects of ready-to-use supplementation among preschool children from rural communities, supporting the feasibility of nutrient-dense products in community settings.

The increase in length/height was 1.29 cm over 12 weeks, whereas HAZ improved by only 0.14 Z-score units. This smaller change was expected because linear growth recovery occurs more slowly than replenishment of body weight and arm circumference. Fabiansen et al (2017),[16] demonstrated that food supplementation in MAM increased weight and fat-free tissue, but the composition and magnitude of tissue accretion varied across formulations. The present findings therefore suggest that the intervention primarily produced ponderal recovery, while meaningful correction of chronic stunting would require a longer period of nutritional, health and environmental support.

Weight-gain velocity was highest during the first four weeks at 3.81 g/kg/day and declined to 3.21 g/kg/day by week 12. This pattern is biologically plausible because children with greater initial tissue deficits may gain weight more rapidly during early rehabilitation, after which the rate slows as they approach normal anthropometric thresholds. Cichon et al (2023),[17] concluded that several specially formulated foods were effective for moderate wasting but that differences in recovery and growth between formulations were often modest. This suggests that early engagement, adherence and management of comorbidity may be as important as the specific product used.

By week 12, 79.6% of children had reached MUAC ≥12.5 cm, 81.2% had reached WHZ/WLZ ≥−2, and 78.1% met both recovery criteria. The slightly higher proportions attaining individual criteria demonstrate that MUAC and WHZ/WLZ do not identify exactly the same children. Use of both criteria produced a more conservative recovery estimate and reduced the chance of premature discharge. Guesdon et al. (2021),[18] found that anthropometric status at discharge influenced subsequent relapse among children treated for acute malnutrition. Therefore, ensuring adequate recovery across more than one anthropometric measure may improve the sustainability of nutritional rehabilitation.

Recovery pattern and time to recovery: Cumulative recovery increased from 11.9% at week 4 to 48.8% at week 8 and 78.1% at week 12. The mean time to recovery was 8.27 weeks, and the Kaplan-Meier median was 8.43 weeks. James et al. (2016),[7] reported a median recovery time of nine weeks, which was close to the present finding, although their overall recovery rate was lower because children did not have access to supplementary feeding. Medoua et al. (2016),[10] reported mean recovery durations of approximately 44 days with RUSF and 51 days with corn-soy blend, somewhat shorter than the present estimate. Differences may reflect treatment intensity, nutritional formulation and recovery definition.

In contrast, Rashid et al. (2022),[1] and Melaku et al (2024),[2] each reported a median recovery time of 16 weeks. The shorter duration in the present study could be explained by closer clinical monitoring, better adherence, earlier detection, more favourable baseline MUAC, different discharge criteria or greater availability of nutrient-dense food. It must therefore not be interpreted as evidence that one intervention is definitively superior, since the studies differed considerably in design, population and programme context.

The recovery incidence rate was 9.84 per 100 child-weeks. Children whose baseline MUAC was 12.1-12.4 cm recovered approximately 1.70 weeks earlier than those with MUAC of 11.5-12.0 cm. James et al. (2016),[7] similarly found that children with the lowest admission MUAC had a greater probability of remaining moderately malnourished and a lower chance of recovery. Melaku et al (2024),[2] reported faster recovery among children admitted with MUAC of 12.1-12.4 cm. These findings indicate that screening and intervention before children reach the lower boundary of MAM can shorten treatment and prevent deterioration.

Adequately adherent children recovered in a mean of 7.82 weeks, compared with 10.06 weeks among children with inadequate adherence. This difference highlights the need for repeated counselling, palatable foods, reliable supply, caregiver understanding and prevention of household sharing. Akparibo et al (2017),[19] found that programme default, relapse and incomplete adherence remained important limitations of acute-malnutrition services, especially in food-insecure and humanitarian settings.

Predictors of nutritional recovery: Maternal education at or above secondary level independently doubled the odds of recovery. Educated caregivers may understand feeding advice more readily, recognize childhood illness earlier, use health services appropriately and maintain hygiene and immunization. Although educational status is partly related to household wealth, its effect remained significant after adjustment, suggesting an independent role for caregiver knowledge and health literacy.

Adequate dietary diversity increased recovery odds 3.48-fold, while adequate meal frequency increased the odds 3.11-fold. These results reinforce the principle that MAM treatment must address both nutrient density and feeding frequency. WHO guidance recommends nutrient-dense diets capable of supporting weight, height and functional recovery rather than supplementation without attention to the child's habitual diet.[20] The findings also support the conclusions of Das et al. (2020),[6] who emphasized that combined nutrition and health strategies are more effective than narrowly focused interventions.

Adherence to at least 80% of the intervention was the strongest independent predictor of recovery (aOR=5.12). Regular follow-up attendance was also independently beneficial (aOR=3.72). Follow-up provides opportunities to confirm food use, reinforce counselling, treat infections and identify growth failure before progression to SAM. The very high completion rate of 93.5% may therefore have contributed substantially to the overall recovery rate. The ComPAS trial reported by Bailey et al (2020),[21] showed that simplified community-based protocols could achieve acceptable outcomes in children with uncomplicated acute malnutrition, emphasizing the value of accessible services and continuity of treatment.

Children with baseline MUAC of 12.1-12.4 cm and WHZ/WLZ >−2.5 had significantly higher recovery odds. These results demonstrate a severity gradient within MAM: children closer to normal anthropometric thresholds recover more readily than those approaching SAM. Lower admission MUAC may represent reduced lean and fat reserves, longer nutritional deprivation or a greater burden of infection.

Household food insecurity reduced recovery odds (aOR=0.43). Even when a child receives supplementary food, food may be shared with siblings or substituted for rather than added to the usual diet. Food-insecure households may also be unable to provide sufficient dietary diversity after distributed food is consumed. Rashid et al (2022),[1] similarly identified household food security and access to treatment services as determinants of recovery. This finding supports combining nutrition treatment with social protection, food-security interventions and caregiver support.

Diarrhoea during follow-up reduced recovery odds by 64%. Melaku et al (2024),[2] reported that children with diarrhoea had a 69% lower probability of recovery, closely corresponding to the present estimate. The association is biologically credible because diarrhoea causes anorexia, malabsorption, intestinal loss of nutrients and increased metabolic demands. Kisenge et al (2024),[3] also emphasized the close relationship between diarrhoeal illness and MAM. Prevention and prompt treatment of diarrhoea, safe water, sanitation, hand hygiene and continued feeding during illness should therefore form essential components of nutritional rehabilitation.

Complete immunization for age was associated with 2.16-fold higher recovery odds. This could reflect both direct protection against infectious diseases and broader caregiver engagement with health services. Conversely, acute respiratory infection was not independently associated with recovery, possibly because episodes were identified and treated promptly or were relatively mild. Anaemia showed a borderline association, indicating that micronutrient

deficiency may remain relevant even though it did not reach the conventional significance threshold.
Bliznashka et al (2023),[22] noted that children remain vulnerable to relapse, infection and mortality after apparent anthropometric recovery and that evidence for post-discharge interventions remains limited. Therefore, the 78.1% recovery recorded in this study should not be viewed as the endpoint of care. Continued growth monitoring, dietary support and surveillance for relapse would be necessary to ensure sustained recovery.

CONCLUSION

The structured nutritional intervention resulted in significant and progressive improvement in growth among children with moderate acute malnutrition. Over 12 weeks, mean weight increased by 1.20 kg, MUAC by 0.65 cm, WHZ/WLZ by 0.79 Z-score units and WAZ by 0.54 Z-score units. Overall, 78.1% of children achieved nutritional recovery, with a mean recovery time of 8.27 weeks. Only 4.2% progressed to severe acute malnutrition, while mortality remained low at 0.4%.
Adequate adherence, dietary diversity, meal frequency, favourable baseline MUAC and WHZ/WLZ, maternal education, complete immunization and regular follow-up were independent positive predictors of recovery. Conversely, household food insecurity and diarrhoea during follow-up significantly reduced the likelihood of recovery. These findings indicate that nutritional rehabilitation of children with MAM should combine nutrient-dense feeding with caregiver counselling, infection prevention and treatment, immunization, food-security support and regular anthropometric monitoring. Early identification and intervention, particularly before children approach the severe-malnutrition threshold, may shorten recovery and prevent deterioration.

Limitations

1. The study was conducted at a single institution and associated service area; therefore, the findings may not be generalizable to children from different geographical, cultural or healthcare settings.
2. As the study did not include an untreated or alternative-intervention control group, improvements could not be attributed exclusively to the structured nutritional intervention.
3. The follow-up duration was limited to 12 weeks. Consequently, sustained recovery, relapse, long-term linear growth, neurodevelopment and post-discharge morbidity could not be evaluated.
4. Dietary intake, adherence, household food security and some morbidity-related variables were based on caregiver reports and were susceptible to recall and social-desirability bias.
5. Loss to follow-up may have introduced attrition bias because children who defaulted could have experienced different outcomes from those who completed follow-up.
6. Despite standardization and calibration, anthropometric measurements—particularly length/height and MUAC—were subject to observer and measurement variation.
7. Children with chronic illnesses, congenital anomalies, severe acute malnutrition or medical complications were excluded; therefore, the results cannot be applied to these high-risk groups.
8. Laboratory investigations were performed only when clinically indicated. Micronutrient deficiencies, subclinical infections and other biological determinants of delayed recovery may therefore have been underestimated.
9. Variation in household food availability, sharing of supplementary food and the actual quantity consumed by the enrolled child could not be measured precisely.
10. Residual confounding may have remained despite multivariable analysis because factors such as maternal nutritional status, caregiver mental health, seasonal food availability, environmental enteric dysfunction and feeding behaviour were not comprehensively assessed.
11. The recovery definition was based predominantly on anthropometric criteria and did not fully assess body composition, immune recovery, physical activity or developmental outcomes.

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