

Neurodevelopmental Status and Developmental Delay in Children With Severe Acute Malnutrition: A Prospective Observational Study

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Abstract

Background: Severe acute malnutrition (SAM) occurs during a period of rapid brain growth and may adversely affect motor and mental development. **Objective:** To describe neurodevelopmental status in hospitalized children with SAM and examine the relationship of developmental quotients with mid-upper arm circumference (MUAC), head circumference, and anemia. **Methods:** This prospective observational study included 204 children aged 6-30 months admitted with SAM to the department of paediatrics, SSG Hospital and Medical College, Vadodara, during 2023-2024. Children with organic causes of malnutrition or known pre-existing developmental delay were excluded. After stabilization and nutritional rehabilitation, neurodevelopment was assessed using the Developmental Assessment Scale for Indian Infants (DASII). Motor developmental quotient (DMoQ), mental developmental quotient (DMeQ), and mean DQ were calculated. **Results:** Mean mental DQ was 62, mean motor DQ was 59, and mean composite DQ was 61.5. Based on mean DQ, 14.7% had no delay, 75.98% had mild delay, and 9.31% had moderate delay; no child had severe delay. Children with MUAC <11.5 cm had lower mental DQ (62.5 ± 24.1 vs 78.5 ± 16.2 ; $p < 0.0001$) and lower mean DQ (63.1 ± 24.5 vs 74.3 ± 17.5 ; $p = 0.0009$) than children with MUAC >11.5 cm. Mental DQ was also lower in children with microcephaly (62.8 ± 14.4 vs 73.2 ± 22.5 ; $p = 0.003$). DQ values declined progressively across increasing grades of anemia; children with severe anemia had mean mental, motor, and composite DQ values of 58.6, 56.5, and 57.9, respectively. **Conclusion:** Developmental delay was common in hospitalized children with SAM, with mild delay predominating. Lower MUAC and smaller head circumference were associated with poorer developmental performance, particularly in the mental domain, while lower DQ values were observed with increasing severity of anemia. Developmental assessment should be incorporated into the clinical care and rehabilitation of young children with SAM.

Keywords: severe acute malnutrition; neurodevelopment; developmental delay; DASII; developmental quotient; MUAC; anemia; microcephaly.

1. Introduction

Severe acute malnutrition is an important cause of morbidity and mortality in young children and is frequently accompanied by infection, micronutrient deficiency, impaired growth, and reduced physiological reserve. The first three years of life are also a critical period for brain growth and acquisition of motor, cognitive, language, and adaptive skills. Nutritional deprivation during this period may therefore affect both physical growth and neurodevelopment [1,2].

The relationship between undernutrition and child development is biologically plausible. Protein-energy deficiency, anemia, micronutrient deficiency, recurrent infection, reduced physical activity, and limited caregiver-child interaction can act together to impair learning, movement, attention, memory, and later school performance. Earlier studies have reported poorer motor and cognitive performance among children who experienced significant malnutrition in infancy and early childhood [3-7].

Developmental Assessment Scales for Indian Infants (DASII), an Indian adaptation of the Bayley approach, provides separate motor and mental developmental ages and developmental quotients for children up to 30 months. This makes it suitable for detailed assessment in Indian clinical settings [8,9]. The present study was undertaken to characterize developmental status in children admitted with SAM and to evaluate whether selected markers of nutritional and hematological compromise were related to developmental performance.

2. Objectives

- To determine mental, motor, and composite developmental quotients in children hospitalized with SAM.
- To describe the severity of developmental delay in mental and motor domains.

- To compare developmental quotients according to MUAC category, head circumference category, and severity of anemia.

3. Materials and Methods

Study design and setting: A prospective observational study was conducted in the Department of Pediatrics, P.D.U. Government Hospital, Rajkot, during 2023-2024. A total of 204 hospitalized children with severe acute malnutrition were included after informed consent from a parent or guardian.

Participants: Children aged 6-30 months who fulfilled World Health Organization-based criteria for SAM were eligible. The source thesis lists admission criteria including MUAC <115 mm, weight-for-height below -3 SD, bilateral pitting edema, or visible severe wasting in the presence of clinical complications requiring inpatient care. Children with malnutrition due to organic causes such as congenital heart disease, cerebral palsy, malabsorption syndromes, or genetic syndromes, and children with known developmental delay before enrollment, were excluded.

Developmental assessment: After stabilization and the rehabilitation phase, neurodevelopment was assessed by the principal investigator with a psychologist using DASII. The scale contains 67 motor and 163 mental items. Motor age and mental age were converted to DMOQ and DMeQ using developmental age divided by chronological age $\times 100$. The composite DQ was the average of motor and mental DQ. The thesis defined developmental delay as $DQ \leq 70$ in either scale and classified delay as mild (50-70), moderate (35-50), or severe (<35).

Nutritional and clinical variables: MUAC and head circumference were recorded, and anemia was categorized by hemoglobin level as no anemia (>11 g/dL), mild anemia (10-10.9 g/dL), moderate anemia (8-9.9 g/dL), or severe anemia (<8 g/dL). All children received standard SAM management according to WHO-based protocols.

Statistical approach: The thesis reports means, standard deviations, proportions, and p values for selected comparisons. The specific statistical test names were not stated in the source document; therefore, the present manuscript reports the comparisons and p values exactly as documented and does not infer unreported tests.

4. Results

A total of 204 children with SAM were assessed. Mean mental DQ was 62 (SE 0.6), mean motor DQ was 59 (SE 0.7), and mean composite DQ was 61.5 (SE 0.6).

Developmental measure	Mean	SE
Mental DQ	62	0.6
Motor DQ	59	0.7
Mean/Composite DQ	61.5	0.6

Developmental delay was common. For mental DQ, 164 children (80.39%) had mild delay and 12 (5.88%) had moderate delay. For motor DQ, 150 children (73.52%) had mild delay and 21 (10.29%) had moderate delay. Using mean DQ, 155 children (75.98%) had mild delay and 19 (9.31%) had moderate delay. No child had severe developmental delay in the reported assessment.

Domain	No delay >70	Mild 50-70	Moderate 35-50	Severe <35
Mental DQ	28 (13.72%)	164 (80.39%)	12 (5.88%)	0
Motor DQ	33 (16.17%)	150 (73.52%)	21 (10.29%)	0
Mean DQ	30 (14.70%)	155 (75.98%)	19 (9.31%)	0

Children with MUAC <11.5 cm had significantly lower mental and mean DQ values than those with MUAC >11.5 cm. The difference in motor DQ did not reach statistical significance in the thesis ($p=0.056$).

MUAC category	Mental DQ mean $\pm$ SD	Motor DQ mean $\pm$ SD	Mean DQ mean $\pm$ SD
>11.5 cm (n=68)	78.5 $\pm$ 16.2	71.4 $\pm$ 22.0	74.3 $\pm$ 17.5
<11.5 cm (n=136)	62.5 $\pm$ 24.1	64.2 $\pm$ 26.8	63.1 $\pm$ 24.5
p value	<0.0001	0.056	0.0009

Head circumference was associated primarily with mental development. Children categorized as microcephalic had a mean mental DQ of 62.8 ± 14.4 compared with 73.2 ± 22.5 among those categorized as normocephalic ($p=0.003$). Motor DQ and mean DQ differences were not statistically significant at the conventional 0.05 threshold in the source table.

Head circumference	Mental DQ	Motor DQ	Mean DQ
Microcephaly (n=46)	62.8 ± 14.4	60.5 ± 17.3	62.1 ± 15.5
Normocephaly (n=158)	73.2 ± 22.5	67.5 ± 24.2	68.45 ± 20.5
p value	0.003	0.06	0.053

Developmental quotients decreased as anemia became more severe. Children without anemia had mean mental, motor, and composite DQ values of 70.2, 68.6, and 69.9, whereas children with severe anemia had corresponding values of 58.6, 56.5, and 57.9. The thesis states that severe anemia was associated with significantly lower DQ values than no anemia, although exact p values were not presented in the anemia table.

Hemoglobin category	Mental DQ	Motor DQ	Mean DQ
No anemia (>11 g/dL)	70.2 ± 8.5	68.6 ± 12.3	69.9 ± 11.25
Mild anemia (10-10.9 g/dL)	67.7 ± 15.4	66.5 ± 18.6	67.2 ± 16.6
Moderate anemia (8-9.9 g/dL)	62.2 ± 22.3	60.8 ± 18.5	61.5 ± 19.3
Severe anemia (<8 g/dL)	58.6 ± 24.6	56.5 ± 18.6	57.9 ± 22.6

5. Discussion

The principal finding of this study was the high burden of developmental impairment among young hospitalized children with SAM. The mean composite DQ was 61.5, and more than four-fifths of the cohort had a mean DQ in the delayed range. Mild delay predominated over moderately and severely delayed cases. Based on mean DQ, 75.98% had mild delay and 9.31% had moderate delay. Severe delay was not detected. These results confirm earlier observations that early childhood undernourishment is often associated with deficits in psychomotor and cognitive development [3-7].

It was found that the motor DQ was lower than the mental DQ at the group level. It may be explained by combined effects of muscle wasting, decreased physical activity, repeated illnesses, and reduced environmental stimuli. The source thesis also stated that skills learned earlier in infancy were relatively preserved whereas developmental domains acquired later were more frequently affected. This pattern could be explained by nutritional deprivation occurring during the second year of life when the study cohort was most heavily represented.

MUAC was significantly associated with developmental performance, especially with respect to the mental domain since children with MUAC <11.5 had considerably lower mental DQ and mean DQ than their counterparts. MUAC is an appropriate indicator of acute nutritional status, and it is a predictor of poor outcome in children with severe malnutrition [10]. The lack of a significant difference in the motor domain should be interpreted cautiously considering the sample size and the degree of clinical variation.

Head circumference was also associated with mental DQ. Microcephalic children had lower mental score whereas the motor and composite differences were borderline or not significant. Since head growth during infancy is closely related to brain growth, decreased head circumference in a severely malnourished child may indicate a group of children who could be at greater developmental risk. Similar findings have been reported previously in children with microcephaly [11].

A downward trend in developmental quotients was seen with increasing degrees of anemia. Anemia may exacerbate the effects of malnutrition by reducing oxygen supply, capacity for work and by deficiency of iron and other nutrients necessary for neurodevelopment. As the source table did not give exact p values for all categories of anemia, the trend should be viewed as a strong descriptive gradient rather than an exact dose response.

These findings have important implications for practice. Nutritional rehabilitation programs for children with SAM should include not only the restoration of weight and management of infection but also developmental screening, counselling, play and language stimulation activities, and follow up. The initial thesis proposed simple play therapy, parent/caregiver involvement and early intervention as a means of preventing long term developmental disabilities and

this proposal is borne out in the results.

6. Limitations

The study was conducted at a single hospital and included only 204 children. Children with known developmental delays before enrollment were excluded, thus potentially underestimating the overall developmental burden for children with SAM. There was no nutritionally normal comparative group and no follow-up after nutritional rehabilitation. Psychosocial factors such as home stimulation and overcrowding were not fully evaluated. In addition, the thesis does not indicate the specific statistical tests used for each comparison, and p values for the analysis of anemia were not reported.

7. Conclusion

Developmental delay was common among hospitalized children with severe acute malnutrition, typically of mild severity. Lower MUAC and lower head circumference were associated with lower mental developmental scores, and lower developmental quotients were observed with increasing severity of anemia. The study suggests that developmental assessment using an age-appropriate standardized instrument, along with nutritional rehabilitation and early intervention services, should be a routine part of the management of children with severe acute malnutrition.

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