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Bacterial Infections in Malnourished Versus Well-Nourished Children: A Comparative Study

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ABSTRACT

Background: Acute malnutrition remains a major public health challenge in developing countries and is associated with impaired immunity, increased susceptibility to infections, prolonged hospitalization, and higher mortality. Bacterial infections are important contributors to adverse outcomes among malnourished children. This study was conducted to compare the burden and spectrum of bacterial infections among hospitalized children with and without acute malnutrition.

Methods: A prospective case-control study was conducted in the Department of Paediatrics, GMERS Medical College and Civil Hospital, Ahmedabad, Gujarat, India, from September 2022 to August 2023. Children aged 6–60 months admitted to the paediatric ward were enrolled. Cases included children with moderate acute malnutrition (MAM) or severe acute malnutrition (SAM), while children with normal nutritional status served as controls. Blood, urine, stool, and other clinically indicated specimens were collected for microbiological evaluation. Data were analysed using SPSS version 25, and $p<0.05$ was considered statistically significant.

Results: A total of 219 children were enrolled, including 124 cases and 95 controls. Most participants belonged to the 6–24 months age group. Blood culture positivity was significantly higher among malnourished children than controls (21.0% vs. 10.5%; p=0.035). Age-stratified analysis demonstrated a significantly higher blood culture positivity among malnourished children aged 6–24 months (p=0.007), whereas no significant difference was observed among older children. Urine culture positivity did not differ significantly between the groups (p=0.10). Coagulase-negative Staphylococci was the predominant isolate among malnourished children, while Salmonella Typhi was the most common organism isolated among controls. Gram-positive organisms predominated among malnourished children, whereas gram-negative organisms were more common among controls.

Conclusion: Hospitalized children with acute malnutrition had a significantly higher burden of culture-confirmed bacteremia compared with well-nourished children, particularly in the 6–24 months age group. The findings highlight the increased vulnerability of malnourished children to bacterial infections and underscore the importance of early microbiological evaluation and timely antimicrobial therapy in this high-risk population.

Keywords: Acute malnutrition; Severe acute malnutrition; Bacteremia; Blood culture; Bacterial infections; Hospitalized children; Under-five children.

INTRODUCTION

Malnutrition, defined as deficiencies, excesses, or imbalances in energy and nutrient intake, remains a major public health challenge and is one of the leading causes of morbidity and mortality among children worldwide, particularly in developing countries such as India [1,2]. Children with severe acute malnutrition (SAM) and moderate acute malnutrition (MAM) are

reported to have a significantly higher risk of mortality from common childhood illnesses compared to their well-nourished peers [4].

The World Health Organization (WHO) defines moderate acute malnutrition as a weight-for-height between −2 and −3 Z-scores of the WHO growth standards or a mid-upper arm circumference (MUAC) between 11.5 and 12.5 cm. Severe acute malnutrition is characterized by a weight-for-height below −3 Z-scores, MUAC less than 11.5 cm, visible severe wasting, and/or bilateral pedal oedema [5].

Malnutrition adversely affects the immune system and weakens the body's natural mechanisms, making children more susceptible to infections and leading to more frequent, severe, and prolonged episodes of illness [6]. Furthermore, severely malnourished children often exhibit atypical or masked clinical manifestations of infectious diseases, which may delay diagnosis and treatment.

Bacterial infections are among the most important contributors to morbidity and mortality in hospitalized malnourished children. In addition, nosocomial infections represent a common complication among hospitalized pediatric patients, particularly among children younger than five years of age, who have a significantly increased risk of acquiring hospital-associated infections [8,9]. Identification of common bacterial pathogens and understanding their microbiological profile among malnourished children are essential for early diagnosis, timely initiation of appropriate antimicrobial therapy, and improved clinical outcomes. Therefore, the present study was undertaken to compare the burden and spectrum of bacterial infections among hospitalized children with acute malnutrition and those with normal nutritional status admitted to a tertiary care hospital.

MATERIALS AND METHODS

Study Design and Setting: A prospective case-control study was conducted in the Department of Paediatrics at a tertiary care hospital in Ahmedabad Gujarat.

Study Duration: - From September 2022 to August 2023.

Study Population: The study included children aged 6–60 months admitted to the paediatric ward during the study period. A total of 219 children were enrolled, comprising 124 cases and 95 controls.

Cases included children diagnosed with moderate acute malnutrition (MAM) or severe acute malnutrition (SAM), while controls comprised same age-group children with normal nutritional status admitted during the same period.

Inclusion Criteria

1. Children aged 6–60 months admitted to the paediatric ward and diagnosed with moderate acute malnutrition (MAM) or severe acute malnutrition (SAM) were included as cases.
2. Children with normal nutritional status admitted during the same period were included as controls.

Exclusion Criteria

Children with any of the following conditions were excluded from the study:

1. Congenital abnormalities.
2. History of birth asphyxia.
3. Chronic liver disease.
4. Chronic kidney disease.
5. Malignancy.
6. Congenital heart disease.
7. Acquired or congenital immunodeficiency disorders.

Sampling Technique: A consecutive sampling technique was employed for participant recruitment throughout the study period.

Data Collection : Following admission, all eligible children underwent clinical assessment and nutritional evaluation. Children fulfilling the criteria for MAM or SAM were enrolled as cases, whereas children with normal nutritional status were enrolled as controls. After obtaining informed consent from parents or guardians, relevant clinical details were recorded. Microbiological investigations were performed by collecting appropriate specimens at the time of admission, including venous blood, stool, and mid-stream urine samples. Additional specimens such as cerebrospinal fluid and pus swabs were collected when clinically indicated. Chest radiography and sputum examination for acid-fast bacilli were performed in children presenting with respiratory symptoms. All samples were sent to the Departments of Microbiology and Pathology for culture and sensitivity testing.

Outcome Measures: The primary outcome was the proportion of culture-confirmed bacterial infections among children with acute malnutrition compared with children having normal nutritional status. The bacteriological profile of isolated organisms and their association with clinical presentations were also evaluated.

Statistical Analysis: Data were entered and analysed using Statistical Package for Social Sciences (SPSS) version 25. Categorical variables were expressed as frequencies and percentages. Statistical comparisons between cases and controls were performed using appropriate tests, and a p-value of less than 0.05 was considered statistically significant.

Ethical Considerations: The study protocol was reviewed and approved by the Institutional Scientific and Ethics Committee.

RESULTS

A total of 219 children aged 6–60 months were enrolled in the study, including 124 children with acute malnutrition (cases) and 95 children with normal nutritional status (controls). Most participants belonged to the 6–24 months age group, and the gender distribution was comparable between the two study groups.

Table 1. Baseline characteristics of study participants

Variable	Cases (n=124)	Controls (n=95)	Total (n=219)
Age 6–24 months	110 (88.7%)	59 (62.1%)	169 (77.2%)
Age 25–60 months	14 (11.3%)	36 (37.9%)	50 (22.8%)
Male	62 (52.5%)	52 (51.5%)	114 (52.1%)
Female	56 (47.5%)	49 (48.5%)	105 (47.9%)
Rural residence	89 (71.8%)	64 (67.4%)	153 (69.9%)
Urban residence	35 (28.2%)	31 (32.6%)	66 (30.1%)

The most common presenting complaints were fever and loose stools with vomiting. The distribution of presenting symptoms in the two groups is shown in Table 2.

Table 2. Presenting symptoms among study participants

Symptom	Cases (n=124)	Controls (n=95)	Total (n=219)
Fever	64 (51.6%)	70 (73.7%)	134 (61.2%)
Loose stools and vomiting	82 (66.1%)	51 (53.7%)	133 (60.7%)
Cough and cold	27 (21.8%)	19 (20.0%)	46 (21.0%)
Convulsions	13 (10.5%)	11 (11.6%)	24 (11.0%)

Blood culture positivity was significantly higher among malnourished children than among controls. However, urine culture positivity did not differ significantly between the groups.

Table 3. Comparison of blood and urine culture positivity between cases and controls

Investigation	Cases Positive n (%)	Controls Positive n (%)	p-value
Blood culture	26 (21.0%)	10 (10.5%)	0.035
Urine culture	6 (4.8%)	10 (10.5%)	0.10

Age-stratified analysis demonstrated a significant difference in blood culture positivity among children aged 6–24 months, whereas no significant difference was observed in the older age group.

Table 4. Age-wise distribution of blood culture positivity

Age Group	Cases Positive n (%)	Controls Positive n (%)	p-value
6–24 months	23 (19.7%)	3 (4.8%)	0.007
25–60 months	3 (17.6%)	7 (21.2%)	0.76

Among malnourished children with positive blood cultures, severe acute malnutrition constituted the majority of cases. Coagulase-negative Staphylococci was the most frequently isolated organism.

Table 5. Distribution of blood culture isolates

Organism	Cases (n=26)	Controls (n=10)
Coagulase-negative Staphylococci	10	0
Salmonella Typhi	2	6
Alpha haemolytic Streptococci	2	1
Bacillus subtilis	3	0
Staphylococcus aureus	1	0
Escherichia coli	1	0
Klebsiellapneumoniae	3	1
Acinetobacterbaumannii	1	2
Pseudomonas spp.	1	0
Gram-negative bacilli	1	0

Gram-positive organisms predominated among isolates recovered from malnourished children, whereas gram-negative organisms were more commonly isolated from controls.

Table 6. Distribution of blood culture isolates according to bacterial category

Bacterial Category	Cases (n=26)	Controls (n=10)
Gram-positive isolates	18 (69.2%)	1 (10.0%)
Gram-negative isolates	8 (30.8%)	9 (90.0%)

Overall, culture-confirmed bacteremia was more frequent among children with acute malnutrition, particularly among those aged 6–24 months. Gram-positive organisms, especially coagulase-negative Staphylococci, were the predominant isolates among malnourished children, while Salmonella Typhi was the most common isolate among controls.

DISCUSSION

In the present study, the majority of participants belonged to the 6–24 months age group. This finding is consistent with previous studies that reported a higher burden of acute malnutrition among younger children, which may be attributed to inadequate complementary feeding practices, recurrent infections, and increased nutritional requirements during this period of rapid growth [10,11]. The predominance of younger children among malnourished cases highlights the vulnerability of this age group to both nutritional deficiencies and infectious diseases.

Blood culture positivity was significantly higher among children with acute malnutrition compared with well-nourished controls. This observation supports the established relationship between malnutrition and impaired immune function, resulting in increased susceptibility to invasive bacterial infections. Similar findings have been reported by Noorani et al., who observed severe bacterial infections in nearly one-third of severely malnourished children, with bacteremia being the predominant manifestation [12]. Likewise, Idris et al. reported a significantly higher prevalence of bacteremia among malnourished children compared with well-nourished controls [13]. The higher frequency of bloodstream infections among malnourished children in the present study further emphasizes the need for early microbiological evaluation in this vulnerable population.

Age-stratified analysis demonstrated a significant difference in blood culture positivity among children aged 6–24 months, whereas no significant difference was observed among older children. Younger children have relatively immature immune responses and are more susceptible to both malnutrition and severe infections. This finding is supported by previous observations that the majority of children admitted with severe acute malnutrition are below two years of age and experience a higher burden of infectious complications [12].

The microbiological profile observed in the present study showed that both gram-positive and gram-negative organisms were isolated from blood cultures. Coagulase-negative Staphylococci constituted the most common isolate among malnourished children, while Salmonella Typhi was the predominant isolate among controls. Previous studies have reported variable bacterial profiles across different settings. Noorani et al. found that gram-negative organisms were the

major pathogens among severely malnourished children [12]. Similarly, Mwambazi-Mweene et al. identified Escherichia coli, Staphylococcus aureus, Salmonella species, Pseudomonas species, and Klebsiellapneumoniae among the common bloodstream isolates in children with severe acute malnutrition [11]. Singh et al. also reported Staphylococcus aureus, coagulase-negative Staphylococci, Escherichia coli, and Klebsiella species as important pathogens among malnourished children admitted to a tertiary care hospital [14]. The diversity of bacterial isolates across studies may reflect regional differences in pathogen distribution, healthcare practices, and antimicrobial exposure.

Urine culture positivity did not differ significantly between cases and controls in the present study. In contrast, Ibrahim et al. reported a significantly higher prevalence of urinary tract infection among children with protein-energy malnutrition compared with healthy controls [15]. Differences in study design, patient characteristics, sample size, and local epidemiological patterns may account for the variation in findings.

The predominance of culture-confirmed infections among malnourished children observed in this study is consistent with previous reports demonstrating the close association between severe malnutrition and bacterial infections [16-18]. Ashraf et al. reported a substantial burden of bacteremia among hospitalized children with severe acute malnutrition, including those presenting primarily for nutritional rehabilitation [18]. Similarly, Page et al. highlighted that clinical manifestations alone are often poor predictors of infection in severely malnourished children, emphasizing the importance of microbiological investigations for accurate diagnosis [16].

The findings of the present study underscore the importance of maintaining a high index of suspicion for bacterial infections in hospitalized children with acute malnutrition. Early identification of bacterial pathogens and timely institution of appropriate antimicrobial therapy may contribute to improved clinical outcomes and reduced morbidity in this high-risk population.

CONCLUSION

The present study demonstrated that hospitalized children with acute malnutrition had a significantly higher prevalence of culture-confirmed bacterial infections, particularly bloodstream infections, compared with children having normal nutritional status. The association was most evident among children aged 6–24 months, highlighting the increased susceptibility of younger malnourished children to invasive bacterial disease. Coagulase-negative Staphylococci emerged as the predominant isolate among malnourished children, whereas Salmonella Typhi was the most common organism isolated among controls. Although urine culture positivity did not differ significantly between the study groups, the overall burden of bacteremia was considerably greater among malnourished children. These findings reinforce the close relationship between malnutrition and infection and emphasize the importance of maintaining a high index of suspicion for bacterial infections in hospitalized children with acute malnutrition. Early microbiological investigations and prompt institution of appropriate antimicrobial therapy may contribute to improved clinical outcomes and reduced morbidity in this vulnerable population.

Ethical Approval and Consent to Participate: The study was approved by the Institutional Ethics Committee Written informed consent was obtained from the parents or legal guardians of all participants prior to enrolment.
Availability of Data and Materials: The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.
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