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The Prevalence of Malnutrition in critically ill septic Pediatric: Findings from Akbar Children's Hospital in Mashhad

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Abstract

Background: Sepsis is a potentially fatal condition resulting from an infection and is recognized as a critical global health concern. Among children, sepsis causes many deaths and affects one-third of those in Pediatric Intensive Care Units (PICUs). Malnutrition in children, especially those in PICUs, increases susceptibility to sepsis. Critically ill children, especially those with sepsis, are at increased risk of malnutrition. Knowing the nutritional status at the start of hospitalization and patient management, planning and decision-making is particularly important.

Methods: A Cross-sectional study conducted at Akbar Children's Hospital in Mashhad involved 54 children aged one month to 10 years with sepsis. Anthropometric measurements, including weight, height/length, BMI, and Z-scores were evaluated/calculated. Malnutrition was diagnosed using the weight-for-height Z score; a Z-score of -2 or lower was used to indicate moderate or severe malnutrition. Statistical analyses were done using SPSS version 22.0, with a significance level considered at P-values less than 0.05.

Results: The study included 54 septic patients in PICU, including 53.7% girls and 46.3% boys. The mean age was 37 months, and mean body weight and height were 13.62 kg, and 88.85 cm, respectively. Malnutrition was found in 18.5% of the studied patients as moderate and 13% as severe grades, while 68.5% had a normal nutritional status.

Conclusion: Malnutrition is prevalent among critically ill septic patients, indicating a crucial need for prompt intervention. Regular nutritional assessments and early, intensified nutritional support considering evidence-based local protocols, are essential for ensuring adequate energy and nutrients, potentially leading to improved outcomes for these vulnerable patients.

Key Words: Sepsis, Children, Malnutrition, Inflammation, PICU.

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1- INTRODUCTION

Sepsis is a life-threatening condition defined by a systemic inflammatory response syndrome triggered by a confirmed or suspected infection (1, 2). The World Health Organization has classified it as a medical emergency, highlighting the importance of global efforts to prevent, identify, and treat sepsis. Epidemiological data reveal the ongoing worldwide challenge of sepsis, especially the high morbidity and mortality rates among children (3). Sepsis leads to the death of over one million children each year and is responsible for more than one-third of all fatalities in Pediatric Intensive Care Units (PICUs) (4, 5). Moreover, in the past decade, the financial burden of sepsis hospitalizations have risen significantly, reaching approximately one billion dollars (6).

Malnutrition is a concern in critically ill children, especially those in PICU. It leads to adverse outcomes such as electrolyte and fluid imbalances, impaired response to respiratory support, reduced effectiveness of treatments, immune deficiency, and increased rates of sepsis (7). Additionally, sepsis stresses the host's metabolic functions, exacerbating undernutrition, driving massive catabolism, and depleting lean body mass, which can further worsen pre-existing malnutrition (8).

Malnutrition is a prevalent issue among hospitalized patients, particularly in critically ill individuals. It results from factors such as reduced appetite, decreased intake of energy and protein, increased energy demands, and the inflammatory response associated with illness. Children treated in ICUs, particularly those with sepsis, severe trauma, or following major surgery, are at increased risk of malnutrition (9). Malnutrition affects millions of children worldwide and is the third leading cause of childhood mortality globally (10). Despite advancements in intensive care, mortality rates remain high among patients with severe infections and multiorgan failure, with rates reaching up to 40%. Studies suggest that malnutrition affects between 20% and 47% of critically ill children (11). Regular monitoring of nutritional status is crucial in these patients, as hospitalization duration correlates with an increased risk of malnutrition and deterioration in overall health (9). Malnutrition in critically ill patients can lead to a range of complications, including impaired immune function, dysfunction of the intestinal epithelial barrier, and heightened susceptibility to infections and bacterial translocation. These issues contribute to delayed wound healing, higher rates of pneumonia, sepsis, and other conditions that increase mortality, prolonged hospital stays, and escalate healthcare costs (12-14).

Despite the severe consequences of malnutrition in critically ill children, including those with sepsis, it frequently goes undiagnosed and untreated. Early and periodic screening is essential to detect malnutrition, especially in hospitalized patients with sepsis (8, 15). A study conducted in the United Kingdom found that identifying and addressing malnutrition alongside the primary illness could lead to annual savings of millions of pounds and a 50% reduction in mortality rates (16). Children are especially vulnerable to malnutrition due to their limited caloric reserves and increased nutritional requirements for growth and development. Disease-related increases in nutrient requirements can impact long-term growth and cognitive development. Therefore, early identification of malnourished children or those at risk of malnutrition is essential to prevent serious complications (17). Assessing the nutritional status of critically ill children prior to hospitalization is essential for more accurate planning of nutritional support and medical treatment protocols.

This early evaluation helps identify children at high risk of malnutrition, allowing for prompt and appropriate nutritional intervention to prevent both short- and long-term effects on growth and development. Additionally, it aids in preventing complications such as sepsis (16).

The aim of this study is to examine the prevalence of malnutrition in children hospitalized with sepsis in the PICU of Akbar Hospital in Mashhad.

2- MATERIALS AND METHODS

2-1. Design and Participants

In this cross-sectional study, a total of 54 children aged 1 month to 10 years were hospitalized in the PICU of Akbar Children's Hospital in Mashhad from November 2023 to June 2024 and were diagnosed with sepsis according to the diagnostic criteria and the confirmation of experts.

2-1-1. Inclusion and exclusion criteria

The criteria considered for the inclusion and exclusion of participants are summarized in Table 1 below.

Table-1: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Patients hospitalized in the pediatric intensive care unit diagnosed with sepsis (clinical or microbiological)	Patient discharge or transfer to other hospital departments
Age ranging from 1 month to 10 years	
Parental consent for participation in the study	

2-2. Procedure and measurements

2-2-1. Diagnosis of sepsis

Sepsis diagnosis established based on the presence of infection, supported by clinical or microbiological evidence, along with the Presence of at least two of the four Systemic Inflammatory Response Syndrome (SIRS) criteria:

Body temperature >38°C or <36°C

Heart rate >90 beats per minute

Respiratory rate >20 breaths per minute or PaCO2 <4.3 kPa

Neutrophil count >12,000/mm³ or <4,000/mm³ with ≥10% immature neutrophils (18).

The diagnosis was confirmed by a pediatrician who reviewed the clinical presentation and laboratory results.

2-2-2. Anthropometric variables

Anthropometric measurements were conducted to evaluate the nutritional status of the participants. The following methods were used:

a) Height/length: Measured in a standing position using a stadiometer with a precision of 0.1 cm. For non-standing patients, whereas for those connected to ventilators, height was measured while lying down.

b) Weight: Measured with a calibrated digital scale (seca) to the nearest 0.1 kg. In cases where direct measurement was not possible, the last known weight reported by parents or estimated by the researcher was used.

c) Body Mass Index (BMI): BMI was calculated by dividing body weight (kg) by the square of height (m²) (19).

These measurements were compared with the 2000 reference population provided by the US Centers for Disease Control (CDC) (www.cdc.gov) and were expressed as standard deviation scores (Z-scores) and

percentiles to account for both age and gender.

2-2-3. Diagnosis of malnutrition

In diagnosing malnutrition in children, there are multiple methods such as growth charts, weight for length index (WLI), height standard weight, body mass index, and skin fold thickness. However, in this research, z-scores were utilized for increased precision. To diagnose malnutrition, we assessed the nutritional status using the weight for height Z score in all admitted patients during this period. Research indicates that the Z-score index is a more precise indicator to assess the severity of malnutrition in children compared to other methods (20). A Z score of (2) or lower was classified as moderate or severe malnutrition. It's worth mentioning that a Z score between -1 and 2 is considered normal (21).

2-3. Data Analysis

The statistical analyses were performed using SPSS version 22.0 (Chicago, IL, USA). Quantitative variables were expressed as mean, standard deviation, and range, while qualitative variables were presented as descriptive statistics such as numbers and percentages. The Normality of variables was assessed using the Kolmogorov-Smirnov test, and the chi-square test used to compare background qualitative characteristics between groups. Statistical significance was defined as P-values below 0.05.

3- RESULTS

As indicated in Table 2, our study included a total of 54 septic patients hospitalized in PICU, consisting of 29 (53.7%) girls and 25 (46.3%) boys. The mean (±SD) age was 37 (±39.15) months and the mean body weight and Height were 13.62 ± 8.97 kg and 88.85 ± 3.55 cm respectively. Further demographic details are delineated in Table 2.

According to the data in Table 2, the average BMI, WAZ, WHZ, and BMI for age z score in patients were 15.83 ± 3.55 kg/m2, -9.98 ± 1.63, -1.03 ± 2.45 and -0.91± 2.29, respectively.

Table-2: Patients' characteristics

Variable		Number (%)	Mean±SD	Median	Minimum	Maximum
Sex	Male	29(53.7)	---	---	---	---
	Female	25(46.3)	---	---	---	---
	Total	54(100)	---	---	---	---
Age(month)		N=54	37.86±39.15	19	2	120
Weight(kg)		N=54	13.62±8.97	10	4.1	47
height/length(cm)		N=54	88.85±3.55	85	51	136

Table-3: Variables indicating the state of malnutrition in the participants

Variable	Mean	Median	Minimum	Maximum
BMI (kg/m^2)	15.83±3.55	15.35	10.6	29.1
Weight. for. age. zscore	-0.98±1.63	-0.71	-4.84	3.22
Weight. for. height. z score	-1.03±2.45	-0.89	-7	4
BMI. for. age. z score	-0.91±2.45	-0.79	-6	5.3

Table 3 illustrates the occurrence of malnutrition within the participant group, revealing that 10 (18.5%) individuals were classified as Moderately malnourished and 7 (13%) individuals as Severely malnourished, while 37 (68.5%) exhibited a normal nutritional status. Severe malnutrition was the most frequent in boys and children aged 1-2 years and its lowest frequency was in those above 6 years.

Table-4: Prevalence of Malnutrition according to sex and age (n=54)

Variable			N	Normal	Moderate malnutrition	Severe malnutrition
Frequency (%)	Sex	Male	29	22(40.7)	3(5.6)	4(7.4)
		Female	25	15(27.8)	7(13)	3(5.6)
	Age	1-2 years	30	19(35.2)	5(9.3)	6(11.1)
		2-6 years	11	8(14.8)	2(3.7)	1(1.9)
		>= 6 years	13	10(18.5)	3(5.6)	0
Total			54	37(68.5)	10(18.5)	7(13)

4- DISCUSSION

This study aimed to evaluate the prevalence of malnutrition in critically ill septic patients admitted to the Pediatric Intensive Care Unit (PICU) in Akbar Children's Hospital of Mashhad. Based on the weight-for-height Z-score at admission, 68.5% of the children were classified as having normal nutritional status, 18.5% as moderately malnourished, and 13% as severely malnourished. These findings offer valuable insights into the nutritional status of critically ill pediatric patients in this particular setting.

Our results show a lower prevalence of malnutrition compared to some previous studies. For instance, a study conducted by Teka et al. from January 2016 to December 2018 aimed to determine the prevalence of malnutrition in 243 critically ill children, aged 1 month to 15 years, hospitalized in intensive care units in Ethiopia. The study found that 83.5% of the children had moderate or severe malnutrition, a notably higher prevalence than that observed in our study (22). This may be attributable to differences in diagnostic criteria, population characteristics, or regional factors. In another study by Delgado et al., the prevalence of malnutrition in critically ill children was found to be 53%. This study included 1,077 children and adolescents admitted to a level III pediatric ICU from March 2002 to February 2005. The nutritional status of all patients admitted during this period was classified based on the Z score for weight-for-age (21), while a systematic review and meta-analysis conducted in 2023 by Abra et al. on 15 studies reported a prevalence of malnutrition in critically ill children as 37.19%. A limitation of the study was that the determinants of malnutrition were not considered (23). These variations underscore the influence of sample size, study duration, and regional differences on malnutrition prevalence.

Severely ill children are often affected by malnutrition, which worsens their prognosis by elevating the risk of complications, morbidity, and mortality (24). Therefore, targeted interventions should be incorporated into existing healthcare services and nutritional programs to prevent malnutrition in this vulnerable population. Children and infants are especially prone to nutritional deficiencies due to their lower muscle and fat percentages compared to adults, which leads to reduced nutritional reserves and

higher resting energy expenditure (23). Consequently, children are less able to tolerate fasting, more susceptible to protein depletion, and at a higher risk of malnutrition during serious illnesses (25). It is important to recognize that children are in a constant state of growth and development, and their nutritional needs differ from those of adults, varying according to their developmental stage. Undernutrition or malnutrition can be a significant complication in children with severe medical conditions (26).

Metabolic homeostasis is significantly disrupted during sepsis, a syndrome marked by an abnormal inflammatory response that causes organ damage following a microbial infection. Sepsis induces a catabolic state, resulting in the breakdown of carbohydrates, lipids, and proteins. Despite increased nutritional requirements, patients with sepsis often suffer from anorexia or are unable to eat due to conditions such as encephalopathy or respiratory failure, which may necessitate mechanical ventilation. This results in a considerable energy deficit, which can exacerbate outcomes in critically ill patients. The resulting energy deficit contributes to severe skeletal muscle wasting and delays recovery (27).

Scrimshaw described the reciprocal relationship between malnutrition and infection, illustrating how malnutrition can both contribute to and be a consequence of acquired immune deficiency (28). The findings of this study highlight the crucial role of nutritional status in critically ill children with severe sepsis, with significant implications for clinical outcomes. Undernutrition is primarily driven by reduced nutrient intake, increased metabolic demands due to underlying infections, and comorbidities such as malabsorptive disorders, chronic lung disease, and congenital heart disease, all of which can predispose children to critical illness. The metabolic changes that occur during critical illness can further exacerbate pre-illness nutritional deficiencies, increasing susceptibility to infection and sepsis. Moreover, both undernutrition and overnutrition can impair immune function, glucose regulation, and the inflammatory response in severe sepsis, further hindering recovery and survival (29-32).

The complications arising from malnutrition in critically ill patients are due to systemic functional alterations. These changes encompass a weakened immune response, muscle atrophy, and increased intestinal epithelial barrier permeability, which promotes infection and bacterial translocation. Malnourished patients also experience delayed wound healing, a higher incidence of pneumonia, sepsis, and other complications, all of which contribute to increased mortality, extended hospital stays, and higher healthcare costs (33, 34).

Research has indicated that inflammation may play a central role in the pathogenesis of kwashiorkor malnutrition. The systemic inflammatory response leads to metabolic dysregulation, resulting in muscle proteolysis (hypercatabolism) and the release of cytokines and chemokines in critically ill patients (32). The primary trigger for this inflammatory response may be microbial invasion, the translocation of bacterial products, or other yet-to-be-identified stimuli that interact with environmental factors during periods of nutritional stress, leading to an uncontrolled inflammatory reaction. Previous studies have shown that malnutrition impairs various immune functions, including phagocytosis, the chemotactic ability of neutrophils and monocytes, the complement system—particularly the C3 protein responsible for opsonization—and the function of antigen-presenting cells. Conversely, sepsis can worsen immune dysfunction by promoting the apoptosis of immune cells, especially

those other than neutrophils (9). The findings of this research highlight an elevated concentration of pro-inflammatory proteins, such as IL-6 and TNF-α, along with an increase in anti-inflammatory cytokines, such as IL-1Ra, in malnourished patients. Malnutrition exacerbates these conflicting processes, leading to immunosuppression. It has been demonstrated that malnutrition negatively impacts hematopoiesis and impairs the production and function of immune cells. Given the significant effect of malnutrition on sepsis outcomes, targeted interventions are crucial. Nutritional programs should be incorporated into critical care protocols to effectively prevent and address malnutrition. Further research is necessary to investigate the specific mechanisms by which malnutrition worsens sepsis and to develop tailored nutritional strategies for this vulnerable population.

4-1. Strengths and limitations

This was the first study focusing on the prevalence of malnutrition in children with sepsis hospitalized in the PICU of Akbar Hospital. To diagnose malnutrition, we utilized z-scores and several variables, enhancing the accuracy of the study. To strengthen the research, a diverse team consisting of nutritionists, pharmacologists, and pediatricians was involved. However, this study has limitations, including being conducted at a single center, which means the results may not apply to other ICUs with different attributes. Additionally, the sample size was small, so further research is necessary to validate the applicability of the findings to the broader population.

5- CONCLUSIONS

Our findings indicate that malnutrition is highly prevalent in critically ill septic patients. Given the critical importance of childhood for growth and development, proper nutritional management of critically ill children admitted to the intensive care unit is essential. Effective nutritional support can help shorten the acute phase of illness, reduce the recovery period, and enable discharge with minimal complications and in the shortest time possible. Additionally, it is crucial to address the delayed growth that may occur during the illness and ensure its compensation after recovery. However, this process is both necessary and challenging. Regular assessment of nutritional status and the provision of early and enhanced nutritional support considering evidence-based local protocols are essential steps to ensure adequate energy and nutrient supply, potentially improving outcomes for these vulnerable patients. Additional research is necessary to confirm these findings across different settings and populations, and to explore the effectiveness of various nutritional strategies in improving patient outcomes. Additionally, future research focusing on the effectiveness of tailored nutritional interventions for septic patients with malnutrition, along with longitudinal studies to assess the long-term impact of malnutrition on recovery, would be highly valuable.

6- ETHICAL CONSIDERATIONS

The study received approval from the Ethical Committee of Mashhad University of Medical Sciences (IR.MUMS.MEDICAL.REC.1402.352). Medical care for all study participants was provided in accordance with hospital management protocols. Written consent was obtained from the guardians of all participants, and confidentiality of the information was strictly maintained throughout the study.

7- AVAILABILITY OF DATA AND MATERIALS

The final dataset is available at Mashhad University of Medical Sciences. Upon request, an email should be sent to the corresponding author. The dataset will

be provided to individuals following a decision by the research team.

8- COMPETING INTERESTS

The authors declare that they have no competing interests in this section.

9- AUTHORS´ CONTRIBUTION

Ali Chamani, Faezeh Mashhadi, and Fatemeh Roudi conceptualized the idea, developed the text, and conducted the final revision. Maryam Emadzadeh contributed to the methodology and revised the manuscript. Mohammad Safarian, Gholamreza Khademi, Mohsen Nematy, and Majid Sezavar assisted in the development and revision of the text. All authors approved the final manuscript and are accountable for all aspects of the work.

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