ORIGINAL ARTICLE

The Prevalence of Malnutrition and Its Relationship with Clinical Outcomes Among Critically Ill Children in PICU and PHDU

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ABSTRACT

INTRODUCTION: Malnutrition is a significant concern in critically ill pediatric patients, as it is associated with increased morbidity, prolonged hospital stays, and higher mortality rates. The aim of this study is to determine the nutritional status of patients in the Pediatric Intensive Care Unit (PICU) and the Paediatric High Dependency Unit (PHDU) of a teaching hospital, and to investigate the effects of malnutrition on clinical outcomes. **MATERIALS AND METHODS:** A retrospective cohort study was conducted, and patients admitted between March 2024 and September 2024 to the Pediatric Intensive Care Unit (PICU) and Pediatric High Dependency Unit (PHDU) were screened based on inclusion and exclusion criteria. The prevalence of malnutrition and its association with clinical outcomes, including length of hospital stay, duration of mechanical ventilation, and mortality risk, were evaluated and assessed. **RESULTS:** This study involved 51 patients aged between 6 months to 17 years old. The prevalence of malnutrition was 54.9%, with the most common forms being underweight (31.4%), followed by stunting (25.5%), wasting (17.6%), and thinness (7.8%). Moreover, this study identified a significant association between undernutrition and longer hospitalisation (P=0.051). However, no significant association was found between undernutrition and the duration of mechanical ventilation (P=0.154) or the risk of mortality (P=0.866). **CONCLUSION:** The prevalence of undernutrition remains high among critically ill children, with the most prevalent forms being underweight, stunting, wasting and thinness. Undernourished children had prolonged hospitalisation, but there was no association with duration of mechanical ventilation and mortality risk.

Keywords
malnutrition, nutrition, intensive care unit, critically ill, children

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INTRODUCTION

Malnourished patients often experience delayed wound healing, impaired immune function, and increased susceptibility to infections, all of which contribute to prolonged recovery periods and extended hospital stays.[1] It is reported that underweight children in PICU exhibited significantly longer hospital stay, highlighting the variability in outcomes based on nutritional status.[2] Nutritional care plays a pivotal role in the management of critically ill children in the PICU, as these patients are at a heightened risk of malnutrition, which can profoundly impact their recovery and overall clinical outcomes.[3] Effective nutritional interventions, such as enteral or parenteral feeding, have been shown to prevent malnutrition, enhance nutritional tolerance, improve calorie and protein intake, and ultimately reduce mortality rates.[4-6]

Numerous studies conducted globally have explored the prevalence, risk factors and the effect of malnutrition on clinical outcomes among critically ill children.[7-10] However, to date, only one study in Malaysia has examined the prevalence of malnutrition in this population. The

study in Malaysia reported that 43.2% of critically ill children were moderately or severely malnourished.[5] Notably, this study did not classify malnutrition based on World Health Organisation (WHO) criteria and primarily focused on enteral nutrition delivery. Furthermore, two studies conducted in Malaysia only involved hospitalised children.[11-12] One of the studies reported that the prevalence of acute and chronic malnutrition was 11% and 14% respectively.[12] Meanwhile, 25.4% of patients in the other study were at high risk of undernutrition.[11]

Consequently, there is a lack of research on the effect of malnutrition on clinical outcomes in Malaysia. Findings from other countries cannot be generalised to Malaysia, as malnutrition is influenced by a country's unique cultural background, economic status and healthcare protocols. Additionally, variations in hospital environments, nutritional support practices, and anthropometric measurement protocols among critically ill children further limit the applicability of these findings across different regions.

This study aims to address these gaps by determining the nutritional status of patients admitted to the PICU and Paediatrics High Dependency Unit (PHDU) and investigating the effects of malnutrition on clinical outcomes, including length of hospital stay, duration on mechanical ventilation and mortality risk.

MATERIALS AND METHODS

The study was conducted at Hospital Tunku Ampuan Besar Tuanku Aishah Rohani (HPKK-UKM). A total of 273 admissions to the PICU and PHDU between March 2024 and September 2024 were screened. Convenience sampling was applied, and patients were evaluated based on inclusion and exclusion criteria outlined in Figure 1.

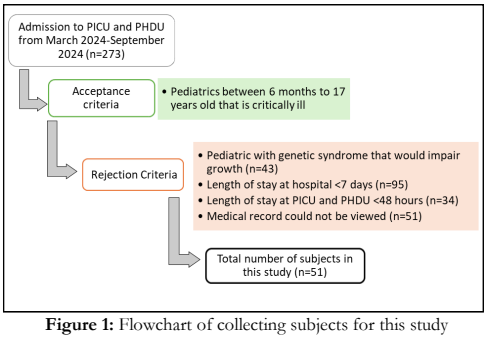

Figure 1: Flowchart of collecting subjects for this study

Data collection was conducted by using the electronic medical record system, IQVIA Hospital Information System (Aircus Air). The collected data included patients' demographics, pre-existing comorbidities, anthropometric measurements during admission, biochemical data, nutritional supports received during hospitalisation and duration of mechanical ventilation. The Pediatric Risk of Mortality III (PRISM III) is a validated mortality prediction tool with ROC curve of 0.927 and highly sensitive in PICU patients with acute respiratory distress syndrome (ARDS) who represented majority of subjects in this study.[13] PRISM III score predicts mortality based on the combination of physiological parameters, including vital signs, Glasgow Comma Scale (GCS), laboratory values (full blood count and kidney function) and arterial blood gas (ABG) during first 24 hours of PICU admission score was calculated using biochemical data and vital signs to assess the severity of illness. [13-14]

The Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP) tool was used to evaluate patients' current diagnoses that may impact nutritional intake, changes in nutritional intake and anthropometric measurements based on nutritional status criteria established by the WHO.[15] It is also a validated screening tool for hospitalised children, demonstrating high diagnostic accuracy with a Receiver Operating Characteristics (ROC) curve of 0.952, 0.846 and 0.818 for detecting underweight, stunting and wasting.[16] Finally, the relationship between these parameters and clinical outcomes was examined.

Terminology and definition

The classification of nutritional status in this study was based on the criteria established by WHO.[15,16] According to WHO guidelines, malnutrition is classified into six categories, which are stunting, wasting, underweight, thinness, overweight and obesity. These categories were determined using the WHO Child Growth Standards (0-5 years old) published in 2006 and the WHO Growth Reference 2007 (5-19 years old). Weight and height measurements taken during hospital admission were plotted against the WHO growth charts. Stunting, which

reflects chronic malnutrition and impaired growth, is defined as a length-for-age or height-for-age z-score of less than -2 standard deviations (SD). Underweight is classified as a weight-for-age z-score below -2 SD, indicating a deficit in overall body mass relative to age. Wasting, indicative of acute malnutrition, is determined by a weight-for-length or weight-for-height z-score below -2 SD for children under five years of age. Thinness is characterised by a body mass index (BMI) z-score below -2 SD in children aged 5-19 years. Overweight and obesity are identified based on age-specific growth references. In children aged 0-5 years, overweight is defined by a weight-for-length or weight-for-height z-score above +2 SD, while a z-score above +3 SD signifies obesity. In children aged 5-19 years, a BMI z-score above +1 SD is classified as overweight, and a z-score above +2 SD indicates obesity.

Statistical analysis

The data collected for this study were analysed using the Statistical Package for the Social Sciences (SPSS) version 27. A p-value <0.05 was considered statistically significant. The normality of quantitative data was assessed using the Shapiro-Wilk test and visual inspections, including histograms and probability plots. For normally distributed data, results were expressed as mean ± SD. For non-normally distributed data, results were presented as median with interquartile range (IQR). Categorical data were summarised as frequencies and percentages. To evaluate the relationship between categorical variables, the Pearson chi-square test or Fisher's exact test was applied, depending on the data distribution and sample size, to assess the association between undernutrition and the clinical outcomes.

RESULTS

In this retrospective, single-centre study that was conducted in Malaysia, data from 273 patients admitted to the PICU and PHDU between March 2024 and September 2024 were screened. Eligible subjects included critically ill pediatric patients aged 6 months to 17 years. Patients were excluded based on exclusion criteria as presented in Figure 1. After applying these criteria, a total of 51 subjects were included in the study. Descriptive statistics for age groups, gender distribution and medical diagnoses are summarised in Table I**.** Medical diagnoses were classified according to the International Classification of Diseases, 11th Revision (ICD-11).

Table I: Patient characteristics, nutritional status and clinical parameters

Demographics	Frequency (n=51)	%
Age		
6 months-2 years	28	54.9
3-17 years	23	45.1
Gender		
Male	38	74.5
Female	13	25.5
Race		
Malay	49	96.1
Chinese	1	2.0
Indian	1	2.0
Medical diagnoses		
Neoplasm	6	11.7
Endocrine, nutritional or metabolic disease	2	3.9
Respiratory diseases	23	45.1
Digestive system diseases	1	2.0
Infectious or parasitic diseases	4	7.8
Nervous system diseases	2	3.9
Other diseases	13	25.5
Enteral Nutrition (EN)		
No	20	39.2
Yes	31	60.8
Mechanically ventilated		
No	8	15.7
Yes	43	84.3
Length of hospital stay		
Days (mean ± SD)	12.92 ± 10.32	
Duration of mechanical ventilation		
Days (mean ± SD)	13.06 ± 10.25	
PRISM III*		
Score (mean ± SD)	4.76±6.245	
STAMP**		
Score (median (IQR))	4.00 (3.00-5.00)	
Nutritional status		
Stunting	13	25.5
Underweight	16	31.4
Wasting (< 5 years of age)	9	17.6
Thinness (> 5 years of age)	3	5.9
Overweight	2	3.9
Obesity	1	2.0

* Pediatric Risk of Mortality III
**Screening Tool for the Assessment of Malnutrition in Pediatric

From the 273 medical records that were screened, only 51 patients met the inclusion criteria, of whom 74.5% (n=38) were male, and the majority were Malay (96.1%, n=49). 54.9% (n=28) of patients were aged between 6 months to 2 years, and 45.1% (n=23) were 3-17 years old. The most common medical conditions were respiratory diseases (45.1%, n=23), followed by other diseases (25.5%, n=13) and neoplasms (11.7%, n=6). In addition, 43.1% (n=22) of patients had underlying conditions such as cancer and chronic heart disease during admission to the PICU or PHDU. Among the 51 patients, 60.8% (n=31) were

initiated on enteral nutrition (EN) during hospitalisation. Of these, 64.5% (n=20) began EN within 24 hours of admission, and 35.5% (n=11) started after more than 48 hours. The median estimated calorie intake provided through EN alone was 624.00 (496.80-828.00) kcal/day. Only 58.1% (n=18) of patients received an estimated calorie intake above 65% from EN alone, while 41.9% (n=13) received an estimated calorie intake of less than 65%. Additionally, 84.3% (n=43) of patients required mechanical ventilation, with a mean duration of 13.06±10.25 days.

A malnutrition screening using the STAMP score was conducted, and a score of 0 to 1 is categorised as low risk, while a score of 2 to 3 indicates medium risk. The STAMP score above 4 signified a high risk of malnutrition. The median STAMP 4.00 (3.00-5.00), indicating that subjects in this study were at high risk of malnutrition. Furthermore, the PRISM III score averaged 4.76±6.245, signifying a low risk of mortality in this cohort. In general, a higher PRISM III score correlates with an increased risk of mortality. The PRISM III score of less than 10 is indicative of a low mortality risk, whereas a score between 11 and 20 signifies a moderate risk. A score exceeding 20 is associated with a significant risk of mortality.

In general, 54.9% (n=28) of patients admitted to the PICU and PHDU experienced malnutrition. Among these, the most prevalent forms were underweight (31.4%, n=16), followed by stunting (25.5%, n=13), wasting (17.6%, n=9), thinness (7.8%, n=4), overweight (3.9%, n=2), and obesity (2.0%, n=1). Furthermore, 19.6% (n=10) of patients were classified as having more than one form of malnutrition. Among these, 30% (n=3) were categorised as both stunted and underweight, 30% (n=3) as underweight and wasted, 20% (n=2) as stunted, underweight and thinness and 20% (n=2) were underweight, stunted and wasted.

Notably, the most prevalent form of malnutrition among patients aged 6 months to 2 years old was stunting (32.1%, n=9), followed by underweight (32.1%, n=9), and wasting (10.7%, n=3). Meanwhile, undernutrition remained the primary malnutrition issue among patients aged 3 to 17 years. The most prevalent form was underweight (30.4%, n=7), followed by wasting (26.1 %, n=6), stunting (17.4%, n=4) and thinness (13.0%, n=3). A comparison of the nutritional status of patients aged 6 months to 2 years and 3 to 17 years is presented in Figure 2.

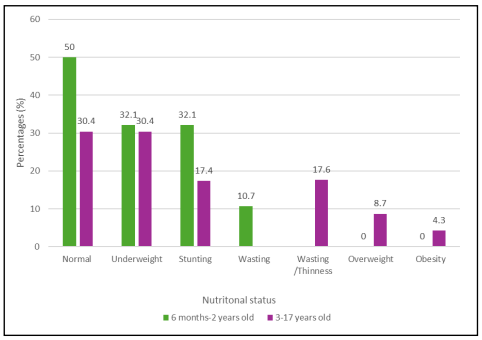

Figure 2: Comparison of nutritional status between children 6 months to 2 years and 3-17 years

This study also examined the effect of undernutrition on length of stay, duration of mechanical ventilation and mortality risk, as determined by PRISM III score. Pearson's chi-square test was used to assess the association between undernutrition and these outcome parameters. The test results are presented in Table II.

Table II: Effects of undernutrition towards clinical outcomes

Parameters	Value	P-value
Length of stay		
≤7 Days	3.803	0.051
≥8 Days		
Duration of mechanical ventilation		
≤8 Days	2.035	0.154
≥9 Days		
Risk of mortality (PRISM III score)		
≤4 scores	0.029	0.866
≥5 scores		

Undernutrition was found to be independently associated with a longer length of hospitalisation (P=0.051). However, no statistically significant association was observed between undernutrition and the duration of mechanical ventilation (P=0.154) or mortality risk (P=0.866).

DISCUSSION

The present study found that the prevalence of malnutrition among critically ill children admitted to the PICU and PHDU was 58.0% (n=29), whereas a systematic review reported a prevalence of 38.3% among critically ill children in middle-income countries.[19] The difference in prevalence in both studies is due to the fact that the current study is retrospective and relied on limited anthropometry assessments in the medical

records, whereas the systematic review involved previous prospective studies that allowed more comprehensive anthropometry measurements and a diverse sample size, which reduced bias. This study also revealed that the primary issue is undernutrition, with the most prevalent form being underweight (31.4%, n=16), followed by stunting (25.5%, n=13), wasting (17.6%, n=9) and thinness (7.8%, n=4). The high prevalence of malnutrition is due to the heightened stress response, which increases the cortisol levels, catecholamines and glucagon. This will cause hypercatabolism, resulting in elevated muscle protein breakdown and lipolysis.[1] Furthermore, the presence of comorbidities among patients in this study (43.1%, n=22) may exacerbate the stress response and further increase the severity of the malnutrition.[21,22]

Notably, the primary issue among patients aged 6 months to 2 years old and 3 to 17 years old is undernutrition. Between the ages of 6 months and 2 years, children undergo a transition to complementary feeding and develop their oral food processing skills. Feeding difficulties are common among 2-year-old children, particularly those who have acute or chronic illnesses, undergone multiple surgeries at an early age, require long-term enteral nutrition and parenteral nutrition or are mechanically ventilated. This can delay the maturity of mastication, swallowing and gag reflexes.[1,23] Moreover, undernutrition is likely due to muscle atrophy caused by a hypercatabolic state during critical illness, which can begin as early as 3 days of ICU admission.[23] Furthermore, the percentage of weight loss experienced by critically ill children who were diagnosed with respiratory diseases can be up to 18%.[24]

In addition, a significant association was identified between undernutrition and length of hospitalisation (P=0.051). Similar to the previous study, the majority of subjects in this cohort were diagnosed with respiratory diseases, a condition that frequently necessitates mechanical ventilation.[25] Notably, malnutrition in these patients is often attributed to loss of muscle mass, which can result from increased metabolic demands, prolonged immobilisation and inadequate nutritional intake.[24] The respiratory system relies on the diaphragm muscle for breathing. A reduction in diaphragm muscle strength weakens lung contraction and expansion, delaying weaning from ventilation and a slower transition to spontaneous breathing.[24,26] Prolonged weaning from mechanical ventilation results in a longer hospitalisation. Additionally, prolonged hospitalisation may also be due to the severity of the illnesses upon admission into the PICU and PHDU.

However, in this study, no significant association was found between undernutrition and the duration of mechanical ventilation (P=0.154). The lack of association could be attributed to the small sample size and the influence of confounding factors, such as disease diversity, management protocols, and comorbidities. Previous studies have shown an association between malnutrition and longer duration of mechanical ventilation.[25-27] In contrast, a study suggested that disease severity and underlying conditions may affect ventilation duration.[28] Critically ill children often require prolonged ventilation due to conditions like severe respiratory infections, neurological impairment or sepsis, which could obscure the impact of malnutrition.[29] ARDS or severe infections are often the primary reasons for a longer duration of mechanical ventilation.[25] Variability in ventilation weaning protocols, sedation practices, and intensive care management may also have contributed to the lack of association. Larger studies with controlled cofounders are necessary to investigate the relationship between nutritional status, ventilation duration and disease severity.

Although malnutrition is well known to be linked to mortality in critically ill children, this study found no significant association between undernutrition and mortality risk (P=0.866), based on the PRISM III score. A possible reason is the low mortality risk in this population, with an average PRISM III score of 4.76±6.245. Malnutrition can increase mortality risk through various mechanisms, including immune system suppression, which causes pneumonia and sepsis. Additionally, malnutrition disrupts metabolic balance and impairs organ function, particularly in the heart, liver and kidneys, potentially leading to fatal outcomes if not promptly managed. However, since mortality in critically

ill children is influenced by multiple factors, such as disease severity, comorbidities, and intensive care interventions, malnutrition alone may not have been the key determinant in this study.

The findings of previous studies also support the current research, which shows no association between malnutrition and mortality risk among critically ill children.[26-29] Additionally, the early initiation of enteral nutrition in more than 60% of patients in this study might have reduced the adverse effects of undernutrition, mitigating its direct impact on mortality.[5] However, a larger cohort might be necessary to confirm whether a true association exists. It is worth noting that mortality in critically ill children is multifactorial, influenced by underlying diagnoses, severity of illness and access to timely and adequate interventions.

One of the key strengths of this study is its focus on critically ill children in a tertiary referral centre, providing insights into a high-risk population that is often underrepresented. Additionally, this study utilised an electronic medical record for data collection, allowing for standardised retrieval of demographic, anthropometric and clinical information. This facilitated a comprehensive evaluation of malnutrition prevalence and potential contributing factors, even within the constraints of a retrospective design.

However, this study has several limitations. It was conducted in a single centre, which restricts the generalizability of the findings to other PICUs. The small sample size was another major limitation, reducing the statistical power to detect associations. Additionally, weight and height measurements were not routinely performed during hospitalisation due to heavy caseloads, which may have impacted the accuracy of the malnutrition assessment.

CONCLUSIONS

This study highlights that malnutrition remains a significant concern among critically ill children admitted to PICU and PHDU, with a prevalence of 58.0% (n=29). The predominant forms of malnutrition identified in this study were underweight, stunting, wasting, and thinness. Malnutrition also contributes to longer hospitalisation due to a hypercatabolic state that causes prolonged recovery during critical illness.

From a clinical perspective, the findings served as a primary source for prevalence data and nutritional status assessment, using criteria established by the WHO, due to a shift in pediatric nutritional status trends towards triple-burden malnutrition (where undernutrition, overnutrition, and micronutrient deficiencies coexist within the same population) in Malaysia. Furthermore, the use of the WHO criteria ensures comparability with the national annual report. In addition, the study also underscores the need for routine nutritional screening using validated tools such as STAMP in a clinical setting. Routine nutritional assessment allows for early detection of malnutrition risk and early nutritional intervention, further improving patients' clinical outcomes. This study is significant in providing essential guidance for large-scale and multicenter studies to strengthen the current evidence base in developing nutritional protocols for critically ill pediatric patients.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

INSTITUTIONAL REVIEW BOARD (ETHICS COMMITTEE)

The study was approved by the Universiti Kebangsaan Malaysia Research Ethics Committee (JEPUKM), Kuala Lumpur, under the ethics application code JEP-2024-265.

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