

# Substandard feeding in children undergoing mechanical ventilation in pediatric intensive care unit: A retrospective cohort study in China

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## Abstract

**Background:** Enteral nutrition is a common yet vital practice in the pediatric intensive care unit (PICU). However, the status of substandard feeding of enteral nutrition in PICU children undergoing mechanical ventilation remains unclear and can be detrimental to the children's prognosis.

**Objective:** This study aimed to evaluate the incidence, nursing care status, and influencing factors of substandard feeding in children undergoing mechanical ventilation in the PICU.

**Methods:** This study employed a retrospective cohort design. Children undergoing mechanical ventilation and enteral nutrition in the PICU of a public hospital in China from 1 June 2021 to 31 December 2022 were selected using convenience sampling, and their characteristics were collected and evaluated. Pearson correlation analysis and multivariate logistic regression analysis were conducted to assess the influencing factors of substandard feeding in PICU children with mechanical ventilation.

**Results:** A total of 156 PICU children undergoing mechanical ventilation were included for analysis in this study. The rate of substandard feeding in PICU children was 65.38%. Statistically significant differences were observed in diarrhea, vomiting, the use of sedatives, and average infusion speed between the substandard feeding group and the standard group ( $p < 0.05$ ). Pearson correlation results indicated that diarrhea ( $r = 0.595$ ), vomiting ( $r = 0.602$ ), and average infusion speed ( $r = 0.562$ ) were correlated with substandard feeding and characteristics of included ICU children undergoing mechanical ventilation ( $p < 0.05$ ). Logistic regression results found that diarrhea (OR = 2.183, 95%CI: 1.855–2.742), vomiting (OR = 3.021, 95%CI: 2.256–4.294), and average infusion speed  $\leq 40$  mL/h (OR = 2.605, 95%CI: 1.921–3.357) were independent risk factors for substandard feeding in mechanically ventilated children in the ICU ( $p < 0.05$ ).

**Conclusion:** The rate of substandard feeding in children with mechanical ventilation in the PICU was high. Diarrhea, vomiting, and slow infusion speed are important influencing factors for substandard feeding. It is suggested that nurses and other healthcare professionals take targeted measures, including the prevention and care of diarrhea and vomiting, as well as monitoring and adjusting the infusion speed of enteral nutrition, to reduce the occurrence of substandard feeding.

## Keywords


China; enteral nutrition; retrospective studies; intensive care units; feeding; pediatric; risk factors; nursing care; incidence; child

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## Background

Effective nutritional support is crucial for the prognosis of children in the intensive care unit (ICU). At present, enteral nutrition stands as the preferred choice for providing nutritional support to critically ill children (Theodoridis et al., 2023). Previous studies (Elke et al., 2016; Tian et al., 2018) have indicated that, in the absence of contraindications to enteral nutrition, early enteral nutrition for critically ill children is more suitable for the patient's physiological status than parenteral nutrition. This approach is beneficial for improving self-immunity and maintaining normal gastrointestinal function.

It is often recommended to initiate enteral nutrition within 48 hours after admission for the management and care of ICU patients. Since orally consumed food is not feasible for mechanically ventilated patients, they must rely on enteral nutrition to meet their energy and protein requirements (Ortiz-Reyes et al., 2022; Patel et al., 2020). Enteral nutrition plays a significant role in reducing the duration of mechanical ventilation and the incidence of infections (Padar et al., 2021).

It has been reported that 85% of ICU patients intermittently discontinue feeding, leading to patients meeting only 40% to 60% of their energy and protein needs, falling short of the minimum 80% recommended in relevant practice guidelines. This results in substandard feeding (Brierley-Hobson et al.,

2019; Lee et al., 2018). Additionally, various issues related to enteral nutrition, such as abdominal distension, diarrhea, and aspiration, may arise, impacting the progress of enteral nutrition in children (Zaher, 2022; Zhang et al., 2021). Some studies (Chen et al., 2022; Feiyue et al., 2023) have indicated that substandard feeding through early enteral nutrition in critically ill patients can prolong their ICU stay and increase medical expenses.

There is uncertainty about the incidence and influencing factors of substandard feeding in pediatric intensive care unit (PICU) children undergoing mechanical ventilation. Therefore, in this study, we observed and investigated the enteral nutrition practices among children in the PICU of a tertiary children's hospital in China. Our aim was to comprehend the factors associated with substandard enteral nutrition in PICU children undergoing mechanical ventilation, with the goal of providing more reliable evidence for nursing care practices. This research is crucial for optimizing care strategies related to enteral nutrition in the PICU setting, ultimately enhancing the prognosis of PICU children.

## Methods

### Study Design

The design of this study was a retrospective cohort.

### Samples/Participants

In this study, children admitted to the public hospital undergoing mechanical ventilation and enteral nutrition between 1 June 2021 and 31 December 2022 were identified. The samples were selected using convenience sampling. The inclusion criteria for the children were as follows: the child's age ranged from 3 to 12 years old, mechanical ventilation was initiated within 72 hours after admission to the ICU, enteral nutrition support was commenced within 48 hours after admission, and the Acute Physiology and Chronic Health Evaluation (APACHE) II score was more than 8. The exclusion criteria for children included those undergoing long-term use of hormones or immunosuppressive drugs and those receiving radiotherapy, chemotherapy, or special treatment.

### Instruments

All the children received early enteral nutrition within 48 hours of admission to the ICU, and the speed was adjusted according to the feeding volume to ensure feeding continuity. An enteral nutrition pump was used for continuous infusion, and the nutrient temperature was controlled from 39 °C to 41 °C. In this study, referencing previous guidelines and reports (Kalaiselvan et al., 2021; Xiuqin et al., 2021; Zhengying et al., 2021), standard feeding was defined as actual calorie intake/target intake  $\geq 60.0\%$  on the 3rd day of ICU stay, i.e., (actual feeding/target feeding)  $\geq 60.0\%$ . Less than 60.0% indicated that the children had substandard feeding. Based on whether the enteral nutrition met the standard, the included children were divided into two designated groups: the standard group and the substandard group.

### Data Collection

The two researchers (ML and YW) conducted a review of the medical and nursing records, collecting the following information about the children: age, gender, body mass index

(BMI), hyperglycemia, Glasgow Coma Scale score, the APACHE II score, diarrhea, vomiting, surgery treatment, use of sedatives, ventilation type, types of nutrient solutions, average infusion speed, and length of ICU stay. To ensure the accuracy of the collected data, the two researchers performed a double screening and comparison of all the data.

### Data Analysis

Data analysis was performed using SPSS 23.0 software. Measurement data conforming to a normal distribution were expressed as mean  $\pm$  standard deviation, and *t*-tests were conducted accordingly. For skewed data distribution, the M (Q1 ~ Q3) table was used for presentation, and the Wilcoxon rank-sum test was employed for group comparisons. Counting data were presented as percentages, and the chi-square test was used to compare the two groups. Pearson correlation analysis was conducted on substandard feeding and the characteristics of included ICU children undergoing mechanical ventilation. Multivariate logistic regression was adopted to analyze the influencing factors of substandard feeding. Statistical significance was considered if  $p < 0.05$ .

### Ethical Consideration

All methods in this study were conducted in accordance with relevant guidelines and regulations. The study has been reviewed and approved by the ethics committee of the Children's Hospital of Nanjing Medical University (approval number: 202204035-2). Written informed consent was obtained from all the legal guardians of the included children. All guardians were aware of the purpose and significance of this study and the possible benefits or risks. At the same time, the data collected in this study were used only for research, and all personal information was anonymized.

## Results

A total of 156 PICU children undergoing mechanical ventilation were included, of whom 102 experienced substandard feeding. The incidence of substandard feeding in this group was 65.38%. As depicted in **Table 1**, statistical differences were observed in diarrhea, vomiting, the use of sedatives, and average infusion speed between the substandard feeding group and the standard group ( $p < 0.05$ ). However, no significant differences were found in age, gender, BMI, hyperglycemia, Glasgow Coma Scale score, surgery treatment, ventilation type, APACHE II score, types of nutrient solution, and length of ICU stay between the substandard feeding group and the standard group ( $p > 0.05$ ).

As shown in **Table 2**, the results of Pearson correlation analysis revealed correlations between diarrhea ( $r = 0.595$ ), vomiting ( $r = 0.602$ ), and average infusion speed ( $r = 0.562$ ) with substandard feeding and the characteristics of included ICU children undergoing mechanical ventilation ( $p < 0.05$ ).

Diarrhea, vomiting, and average infusion speed were included for variable assignment (**Table 3**). The results of logistic regression indicated that diarrhea (OR = 2.183, 95%CI: 2.256~4.294) and average infusion speed  $\leq 40$  mL/h (OR = 2.605, 95%CI: 1.921~3.357) were statistically significant risk factors for substandard feeding in PICU children undergoing mechanical ventilation ( $p < 0.05$ ) (**Table 4**).

**Table 1** Characteristics of PICU children undergoing mechanical ventilation

Variables	Substandard Feeding Group (n = 102)	Standard Group (n = 54)	t/ $\chi^2$	p
	Mean $\pm$ SD / n (%)	Mean $\pm$ SD / n (%)		
Age (year)	9.09 $\pm$ 3.54	9.11 $\pm$ 4.07	2.116	0.067
Male/female	61 / 41	33 / 21	1.095	0.103
BMI (kg/m <sup>2</sup> )	20.17 $\pm$ 2.62	20.14 $\pm$ 2.81	3.189	0.088
Hyperglycemia	19 (18.63%)	10 (18.51%)	1.376	0.142
Glasgow coma score	8.08 $\pm$ 3.47	9.75 $\pm$ 3.25	1.264	0.105
APACHE II score	22.15 $\pm$ 5.39	20.09 $\pm$ 4.41	4.181	0.216
Diarrhea	30 (29.41%)	6 (11.11%)	1.559	0.037
Vomiting	21 (20.59%)	3 (5.56%)	1.436	0.025
Surgery treatment	19 (18.63%)	8 (14.81%)	1.308	0.117
Use of sedative	90 (88.24%)	43 (79.63%)	1.885	0.046
Ventilation type			1.254	0.098
Endotracheal intubation	87 (85.29%)	48 (88.89%)		
Tracheotomy	15 (14.71%)	6 (11.11%)		
Types of nutrient solution			1.833	0.114
Predigested type	58 (56.86%)	30 (55.55%)		
Whole protein type	15 (14.71%)	6 (%)		
Disease-specific type	29 (28.43%)	18 (%)		
Average infusion speed (mL/h)	36.98 $\pm$ 11.05	53.01 $\pm$ 13.89	10.233	0.016
Length of ICU stay (days)	11.21 $\pm$ 3.07	10.15 $\pm$ 1.83	2.606	0.153

**Table 2** Correlation between the substandard feeding and characteristics of PICU children undergoing mechanical ventilation (Pearson correlation)

Variables	r	p
Age (year)	0.112	0.106
Gender	0.109	0.083
BMI (kg/m <sup>2</sup> )	0.053	0.127
Hyperglycemia	0.108	0.113
Glasgow coma score	0.094	0.124
APACHE II score	0.102	0.068
Diarrhea	0.595	0.014*
Vomiting	0.602	0.021*
Surgery treatment	0.166	0.143
Use of sedative	0.185	0.079
Ventilation type	0.071	0.105
Types of nutrient solution	0.141	0.179
Average infusion speed (mL/h)	0.562	0.013*
Length of ICU stay (days)	0.049	0.118

Note: \*significance ( $p < 0.05$ )

**Table 3** Assignment details of the variable used for multivariate logistic regression

Factors	Variables	Assignment
Substandard feeding	Y	Yes = 1, No = 2
Diarrhea	X <sub>1</sub>	Yes = 1, No = 2
Vomiting	X <sub>2</sub>	Yes = 1, No = 2
Average infusion speed (mL/h)	X <sub>3</sub>	$\leq 40 = 1, > 40 = 2$

**Table 4** Risk factors of substandard feeding and characteristics of included ICU children undergoing mechanical ventilation (Logistic regression)

Variables	$\beta$	Wald	OR	95%CI	p
Diarrhea	0.123	0.107	2.183	1.855–2.742	0.015*
Vomiting	0.101	0.242	3.021	2.256–4.294	0.007*
Average infusion speed $\leq 40$ mL/h	0.146	0.105	2.605	1.921–3.357	0.014*

Note: \*significance ( $p < 0.05$ )

## Discussion

Early enteral nutrition for critically ill patients is beneficial, providing adequate energy and nutrients, maintaining the normal intestinal physiological function, and significantly reducing infection complications and mortality (Lee et al., 2018; Yip et al., 2014). Although the early use of enteral nutrition for PICU children is widely acknowledged and valued, the practical application often sees limited utilization (Xingxia et al., 2021; Xuemei et al., 2019). Among the 156 mechanically ventilated children in this study, only 54 cases (34.62%) met the early enteral nutrition standard, a much lower proportion compared to the 102 cases (65.38%) that did not meet the standard feeding.

Enteral nutrition has the potential to reduce ventilator-associated pneumonia in mechanically ventilated patients, but enteral nutrition intolerance is relatively common (Jing et al., 2022). A previous report (Tension & Liang, 2015) indicated that the rate of intolerance increased from 1% on the first day to 6% on the 4th and 5th days. Coupled with factors such as feeding intolerance, interruptions, and complications, the standard feeding rate of mechanically ventilated patients significantly decreases. Patients undergoing mechanical ventilation often experience severe illness, repeated changes, and poor baseline conditions, which frequently impact the smoothness and completion rate of the feeding process (Li et al., 2021; Yuanyuan et al., 2019).

Diarrhea and vomiting emerge as risk factors for substandard feeding and are characteristics of included ICU children undergoing mechanical ventilation. This occurrence may be attributed to the extended bedridden state of most children in the PICU, leading to a deficiency in gastrointestinal motility (BaiNu et al., 2018). Complications associated with enteral nutrition primarily involve gastrointestinal issues such as diarrhea and aspiration, which can result in inadequate feeding and prolonged hospitalization. When a patient experiences diarrhea, clinical nurses may harbor concerns that these symptoms could give rise to additional nursing problems, such as an elevated risk of pressure sores on the

buttocks. This heightened concern often leads to suspending enteral nutrition, contributing to substandard feeding (Skillman & Mehta, 2012; Skillman & Wischmeyer, 2008). Diarrhea in patients can also result from feeding tube contamination due to bacterial infection or incorrect nursing care. Consequently, when a patient develops diarrhea, clinical nurses should promptly report the condition to the doctor and collaborate to identify the cause, ensuring better progress in enteral nutrition (Brown et al., 2015).

Two studies (Elke et al., 2015; Wiese et al., 2020) have identified that discontinuing gastric residue monitoring can reduce gastrointestinal complications. Prior research (Abukari & Acheampong, 2021; Kunrong et al., 2019) has suggested that routine monitoring of gastric residue may lead to feeding interruptions, and patients who do not routinely monitor gastric residuals experience a lower incidence of feeding intolerance. Furthermore, it can enhance calorie intake to meet feeding standards (Bagci et al., 2018). However, some people advocate for gastric residue monitoring, especially through bedside ultrasound monitoring, which has demonstrated improvements in patients' albumin levels, reduced rates of feeding intolerance, and decreased occurrences of nutritional interruptions. Therefore, it is essential to dynamically assess whether patients experience complications such as abdominal distension, nausea, vomiting, and diarrhea during the feeding process. Gastric residue should be monitored promptly to adjust the feeding plan accordingly.

A less than 40 ml feeding rate was significantly associated with substandard feeding. The primary cause of the slow infusion speed is feeding intolerance (Kayastha et al., 2022; Marino et al., 2020). The incidence of feeding intolerance in critically ill children undergoing enteral nutrition can be as high as 74.67%, preventing critically ill children from reaching the feeding target within the planned time and prolonging the duration of mechanical ventilation (Wong et al., 2016). Previous studies recommended an initial infusion speed of 20 ml/h, with increases of 15 to 20 ml every 4 to 12 hours after tolerance, gradually reaching the target feeding speed.

### Implications of this Study for Nursing Practice

In clinical practice, nurses typically initiate the infusion speed based on the doctor's treatment protocols. However, simultaneously, nurses should maintain sensitivity, dynamically adjusting the infusion speed in accordance with the patient's tolerance to enteral nutrition and promptly documenting the feeding outcomes (Du et al., 2021; Kerklaan et al., 2016). In light of patients' feeding intolerance, some scholars (Bixia et al., 2019; Minmin et al., 2020) have compiled several best practices for enteral nutrition care, including daily evaluations, post-pyloric feeding, syndrome differentiation, and complementary treatment with traditional Chinese medicine. These practices may prove beneficial in improving enteral nutrition outcomes.

Through this study, it is evident that the status of early enteral nutrition in PICU children requires further enhancement, and multiple factors influence the early implementation of enteral nutrition. As crucial implementers, managers, and participants in enteral nutrition, nurses play a vital role in providing nursing care for enteral nutrition. It is recommended that in the nursing care of enteral nutrition, judicious use of enteral nutrition is employed, and

individualized enteral nutrition support should be adopted based on the actual situation of the children.

### Limitations

Several limitations in this retrospective cohort study must be considered. Firstly, despite checking the normality and linearity of data before Pearson correlation analysis, the results of the correlation analysis might be biased due to the small sample size. Therefore, caution must be exercised in interpreting the findings of the correlation analysis. Secondly, as a single-center investigation, the sample size in this study was small. Thirdly, there might be other factors influencing substandard feeding that we have not included for analysis. It should be noted that this study only represented a preliminary investigation and analysis of the status of enteral nutrition in children with PICU. In future investigations and studies, the sample size needs to be increased to assess further the status and related influencing factors of substandard feeding, providing valuable insights for pediatric nursing care of enteral nutrition.

### Conclusion

The findings of this study indicated that the rate of substandard feeding in PICU children was 65.38%. Substandard feeding was primarily associated with diarrhea, vomiting, and average infusion speed. It is particularly crucial to dynamically adjust the infusion speed and promptly assess the occurrence of complications to offer personalized feeding programs for children in the PICU.

### Declaration of Conflicting Interest

The authors declare that they have no conflicting interests in this study.

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None.

### Authors' Contributions

ML and YW contributed equally to designing and conducting research, analyzing data, and writing the first draft of the manuscript. QC contributed to conducting research and was primarily responsible for the final content. All authors read and approved the final manuscript and were accountable for each step of the study.

### Authors' Biographies

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### Data Availability

The datasets generated during and analyzed during the current study are available from the corresponding author upon reasonable request.

### Declaration of Use of AI in Scientific Writing

Nothing to declare.

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