Evaluating the Effectiveness of STRONGkids in Identifying Nutritional Risk in Outpatients of Child Health Care Clinics

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Abstract: *Aim*: To investigate the value of the STRONGkids tool for screening malnutrition risk among pediatric outpatients in China.

Methods: This multicenter, cross-sectional, observational study included pediatric outpatients at the Maternity and Child Health Care Hospital in Changzhou, China, from March 2021 to March 2022. More specifically, we performed anthropometric assessments and screened pediatric patients under 2 years of age for nutritional risk using the STRONGkids tool.

Results: The total number of samples assessed for malnutrition risk was 1,062, of which 81.4% (n = 865) were low risk, 16.4% (n = 174) were medium risk, and 2.2% (n = 23) were high risk. In terms of sex, 81.2% (n = 448) of all males included in the present study were classified as low risk, while 16.5% (n = 91) and 2.3% (n = 13) were medium and high risk, respectively. Furthermore, the sensitivity and specificity of STRONGkids were 0.906 and 0.837, respectively, and the AUC was 0.872 ($p < 0.01$).

Conclusion: Although our findings failed to reveal any significant association between malnutrition risk and sex, malnutrition risk was significantly associated with age category and was more likely to occur within the first year of life. The STRONGkids tool demonstrated diagnostic efficacy in screening outpatient children for nutritional risk and could accurately identify children at risk of malnutrition. It promotes children's growth and development, reduces the risk of disease, and is beneficial to long-term health.

Keywords: Malnutrition, nutrition assessment, child health, growth and development, specificity, sensitivity.

1. INTRODUCTION

Pediatric malnutrition can be detrimental to patient outcomes and result in decreased lean body mass, developmental and intellectual delays, increased risk of infections, delayed wound healing, increased mortality, longer hospital stay, higher cost of care, and poor quality of life [1, 2]. The prevalence of pediatric malnutrition in healthcare settings is high and often underestimated [3]. Consequently, various tools have been developed for assessing the nutritional status of pediatric patients. The Screening Tool for Risk of Impaired Status and Growth (STRONGkids) is a validated malnutrition risk assessment tool for children that can be used by nursing staff in medical and surgical settings at the time of admission without any special measurements [4]. More specifically, STRONGkids is a simple, safe, sensitive, specific, low-cost questionnaire that is widely used to identify nutritional risk in different populations worldwide [5]. In clinical practice, nutritional risk screening is usually not performed in children requiring treatment in an outpatient clinic or primary care setting. However, combined with anthropometric measurements, a recent single-center study demonstrated that nutritional screening could add significant value in assessing the nutritional status of pediatric patients [6].

The double burden of malnutrition, the coexistence of undernutrition, overweightness, obesity, and diet-related noncommunicable diseases are highlighted as emerging public health concerns in many countries experiencing socioeconomic transition. To achieve proclamation, early life nutrition, particularly during the first 1000 days of life, has been identified as one of the primary targets of intervention [7]. The latest national and international surveys demonstrate a slowly declining percentage of childhood stunting, a high prevalence of iron deficiency, and rapidly increasing proportions of overweight, obesity, and diet-related noncommunicable diseases at the population level [8]. STRONGkids is very practical and easier to use compared with other screening tools because it is rapid and can be implemented by any healthcare professional in an outpatient setting [9, 10].

This study aimed to investigate the nutritional risk of children under 2 years old in the Changzhou Maternal and Child Health Hospital. STRONGkids has expanded to outpatient nutritional risk screening. Therefore, this study aimed to use STRONGkids to screen for nutritional risk in outpatient children to evaluate its clinical diagnostic value.

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2. SUBJECTS AND METHODS

2.1. Material Collection

The present study included 1062 children aged 1-24 months from the greater area of Changzhou who visited a pediatrician for routine physical examinations at the Department of Child Health Care in the ten hospitals of this study between March 2021 and March 2022.

2.2. Research Tool

We used the STRONGkids tool to assess the nutritional risk of the children included in the present study. This tool consists of four items whose total score may range from 0 to 5 points: (1) subjective clinical assessment, namely diminished subcutaneous fat and/or muscle mass and\or hollow face (0 or 1 point); (2) occurrence of high-risk disease or major surgery planned (0 or 2 points); (3) decreased food intake and/or loss assessment, including diarrhea, nausea, vomiting, and pain or pre-existing, dietetically advised nutrition intervention (0 or 1 point); and (4) weight loss or absence of weight gain (0 or 1 point). Consequently, pediatric nutritional risk varies according to the total score, with children classified as high risk (4-5 points), moderate risk (1-3 points), and low risk (0 points) [11].

2.3. Diagnostic Criteria for Malnutrition

We used the Z-value scoring method, which is widely used worldwide [12]. Data on children's height and weight were collected upon admission and analyzed using WHO's statistical software Anthro (<5 years old) to obtain Z values, including "Weight for age Z-value" (WAZ), "height for age Z-value" (HAZ), "weight for height Z-value" and "BMI Z-value for age" (BAZ). Malnutrition was diagnosed if any of the above Z values were less than -2.

2.4. Statistical Method

The statistical analysis was conducted using the SPSS v.22.0 software. Descriptive statistics were used to present the counting data in terms of frequency and percentage, while measurement data were presented as mean values with their corresponding 95% confidence intervals. The predictive performance of STRONGkids was assessed using parameters such as sensitivity, specificity, positive predictive value, negative predictive value, and the area under the receiver operating characteristic curve.

3. RESULTS

3.1. Demographic Characteristics

Pertaining to pediatric malnutrition status, the total number of samples was 1062, of which 81.4% (n = 865) were low risk, 16.4% (n = 174) were medium risk, and 2.2% (n = 23) were high risk. In terms of gender, the number of males was 552, of which 81.2% (n = 448) were classified as low risk, 16.5% (n = 91) as medium risk, and 2.3% (n = 13) as high risk. The Pearson Chi-square test for gender yielded a P-value of 0.901, indicating that there was no significant association between gender and malnutrition risk. The Pearson Chi-square tests for age categories resulted in a P-value of 0.045, suggesting that there was indeed a significant association between age categories and malnutrition risk.

3.2. Sensitivity and Specificity of STRONGkids

Using the Z-score scoring method as the gold standard, we compared the screening results of Z-scores and STRONGkids by combining medium and high risks and setting the critical point of STRONGkids to 1. As a result, we identified 32 malnourished and

Table 1: Demographic Characteristics of the Screened Children in this Study

Characteristics	Total	Malnutrition	risk, n(%)	p-value
		Low risk	Moderate risk	High risk
	1062	865(81.4)	174(16.4)	23(2.2)
Sex				0.901
Male	552	448(81.2)	91(16.5)	13(2.3)
Female	510	417(81.8)	83(16.3)	10(1.9)
Age category				0.045
<12m	745	594(79.7)	131(17.6)	20(2.7)
≥12m	317	271	43	3

Table 2:   Z-score STRONGkids Crosstabulation

		Z-score		Total
		Malnutrition	non-malnutrition	
STRONGkids	low-risk	3	862	865
	moderate-/high-risk	29	168	197
	Total	32	1030	1062

1030 non-malnourished children, as shown in Table **2**. According to the screening results of STRONGkids, 865 children were evaluated as no risk, of which 3 were actually malnourished (n = 2 false negative). Furthermore, there were 197 children assessed as being at risk, of whom 29 were actually malnourished (true positive), while 168 were non-malnourished (false positive). The sensitivity and specificity of STRONGkids were 0.906 and 0.837, respectively, thereby demonstrating good diagnostic efficacy.

3.3. STRONGkids Area under the ROC Curve

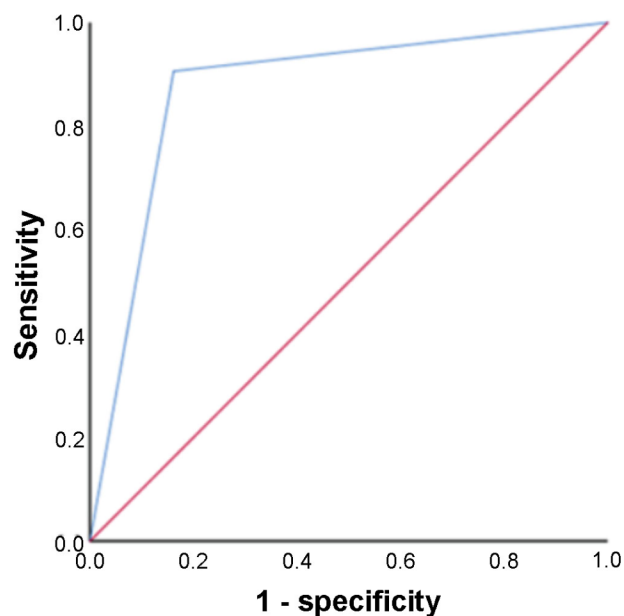In Figure **1** and Table **3**, the STRONGkids tool demonstrated an AUC of 0.872 with a P-value less

Figure 1: Receiver operation characteristic (ROC) curve of STRONGkids against acute malnutrition.

than 0.001, signifying its high accuracy in distinguishing between malnourished and non-malnourished children. Furthermore, with a 95% confidence interval spanning from 0.812 to 0.933, there was a strong indication that the true value of the AUC falls within this range, further affirming the diagnostic effectiveness of STRONGkids.

4. DISCUSSION

Clinical utilization of nutrition risk stratification remains limited within Chinese outpatient settings, while standardized protocols for managing pediatric patients suffering from chronic illnesses or post-discharge malnutrition unrelated to disease etiology are absent.

In our study, the total sample size was 1062, with 81.4% of pediatric patients (n = 865) being at low risk, 16.4% (n = 174) at risk, and 2.2% (n = 23) at high risk of malnutrition. Although our findings did not reveal any significant association between gender and malnutrition risk, we did find a significant association between age category and malnutrition risk. STRONGkids hospitalized can not only determine the patient's nutritional risk but also effectively predict clinical outcomes associated with nutrition and nutrition support effects. In addition, its clinical operation is simple, practical, and widely used [13]. The STRONGkids scale holds scientific significance for assessing nutrition risk in the rehabilitation department of hospitals. It can identify nutritional risks at an early stage and, when combined with biochemical indicators, timely nutritional interventions, and auxiliary training, plays a positive role in improving clinical outcomes [14].

Table 3:   Area Under the Curve

Area	Std. Error	Asymptotic Sig.	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
0.872	0.031	0	0.812	0.933

When setting the cutoff value to 2, the Jorden index reached a value of 0.161, indicating that the STRONGkids tool could efficiently distinguish malnourished from non-malnourished children. STRONGkids exhibited a sensitivity of 24.8%, suggesting that it could correctly identify ~25% of the malnourished children, whereas its specificity was 91.3%, indicating that the tool was more accurate in identifying non-malnourished children. Although the positive prediction rate was 21.1%, meaning that approximately one in five children diagnosed with malnutrition was actually malnourished, the negative prediction rate was as high as 94.5%, indicating that most children diagnosed as non-malnourished were indeed well-nourished. The specificity and positive predictive value of STRONGkids increased. This improvement shows that the accuracy and reliability of the STRONGkids tool in the diagnosis of malnutrition can be further improved by adjusting the cutoff value. This finding has important implications for clinical practice, helping physicians more accurately identify malnourished children and enabling timely measures to improve their nutritional status.

The lack of long-term nutritional monitoring and individualized intervention after discharge is particularly concerning, especially in relation to the risk of malnutrition in children with chronic diseases. In China, only a few children's hospitals have conducted nutritional risk surveys for hospitalized children despite the prevalence of chronic diseases among pediatric patients [15, 16].

Study limitations are: 1）Our study was a single-center study with a limited sample size. 2) Z scores show realized malnutrition. The STRONGkids return the risk of malnutrition, not exactly malnutrition. We use the Z-score scoring method as the gold standard; the screening results of the Z-score gold standard and STRONGkids tool were compared when the medium risk and high risk were combined, and the critical point of STRONGkids was 1. 3) The study population was concentrated in the child health care clinics, and the healthy children were the majority. The proportion of malnourished children caused by disease factors was low.

The STRONGkids offers a simple, rapid, highly sensitive, and effective method for early nutritional risk screening and malnutrition identification that applies not only to hospitalized but also to outpatient children. Therefore, implementing nutritional risk screening in outpatient departments can help identify potential nutritional dysfunction in children. Furthermore, comprehensive nutritional assessment and corresponding nutrition management for children at moderate to severe nutritional risk levels can promote their growth and development, reduce disease risks, and improve their long-term health outcomes. Achieving these goals requires standardized clinical management strategies within pediatric healthcare settings.

CONFLICT OF INTEREST

It is declared that there is no conflict of interest in this study.

ETHICS

We conduct all clinical investigations according to the Declaration of Helsinki principles. The study was approved by the Medical Ethics Committee of Children's Hospital Affiliated to Nanjing Medical University (Approve number 202009072-1). The children's guardian approved all information in the manuscript, and informed consent was signed.

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