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Original Article

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Value of Nutritional Screening Tools Versus Anthropometric Measurements in Evaluating Nutritional Status of Children in a Low/Middle-Income Country

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ABSTRACT

Purpose: Pediatric patients in low-income countries are at a high risk of malnutrition. Numerous screening tools have been developed to detect the risk of malnutrition, including the Subjective Global Nutritional Assessment (SGNA), Pediatric Yorkhill Malnutrition Score (PYMS), Screening Tool for the Assessment of Malnutrition in Pediatrics (STAMP), and Screening Tool for Risk of Nutritional Status and Growth (STRONGkids). However, anthropometry remains the main tool for assessing malnutrition. We aimed to identify the value of four nutritional screening tools versus anthropometry for evaluating the nutritional status of children.
Methods: We conducted a cross-sectional study of 1,000 children aged 1–12 years who visited the outpatient clinic of Cairo University Pediatric Hospital. Each participant was evaluated using anthropometric measurements (weight, length/height, and weight for length/height) as well as the PYMS, STAMP, STRONGkids, and SGNA screening tools. The sensitivities and specificities of these four tools were assessed using anthropometry as the gold standard.
Results: Of the patients, 1.7% were underweight, 10.2% were wasted, and 35% were stunted. STRONGkids demonstrated the highest sensitivity (79.4%) and a high specificity (80.2%) for detecting malnutrition compared with weight for height, followed by STAMP, which demonstrated lower sensitivity (73.5%) but higher specificity (81.4%). PYMS demonstrated the lowest sensitivity (66.7%) and the highest specificity (93.5%), whereas SAGA demonstrated higher sensitivity (77.5%) and lower specificity (85.4%) than PYMS.
Conclusion: The use of nutritional screening tools to evaluate the nutritional status of children is valuable and recommended as a simple and rapid method for identifying the risk of malnutrition in pediatric patients.

Keywords: Pediatric malnutrition; Nutritional risk screening tools; Growth disorders; Screening Tool for Risk of Nutritional Status and Growth

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Conflict of Interest
The authors have no financial conflicts of interest.

INTRODUCTION

Childhood malnutrition can have lifelong effects on health [1]. Primary acute malnutrition is common in children in low/middle-income countries (LMIC) such as Egypt [2], owing to an inadequate food supply caused by social, economic, and environmental factors [3].

Anthropometric measurements can be considered the cornerstone of routine nutritional assessments in pediatric patients, especially in LMIC countries [4]. Nevertheless, the nutritional screening tools are preferable in application on a wide scale as they are quick, economical, and validated [5]. Multiple nutritional screening tools have been developed, including Screening Tool for Risk of Impaired Nutritional Status and Growth (STRONGkids) [6]. An Egyptian study has revealed that the STRONGkids screening tool could ensure the early identification of children vulnerable to malnutrition; however, it has not been applied on a wide scale [7].

To the best of our knowledge, no previous reports have compared the use of multiple nutritional screening tools with anthropometry, either in Egypt or elsewhere. Moreover, evidence on the different predictive accuracies is insufficient to justify the application of one nutritional screening tool over another or to conclude which nutritional screening tool is more accurate [8].

This study aimed to assess the validity of four different nutritional screening tools versus anthropometry in evaluating the nutritional status of a large cohort of children attending an outpatient clinic. The secondary aim was to assess the prevalence of underweight, wasting, and stunting in this cohort.

MATERIALS AND METHODS

This cross-sectional study was conducted on 1,000 acutely ill children of both sexes, aged 1–12 years, who visited the general outpatient clinic of Cairo University Pediatric Hospital located in central Cairo, Egypt, which is a country categorized as an LMIC [2]. This study was approved by the Research Ethics Committee of the Faculty of Medicine at the Cairo University (approval code: MS-290-2019).

The inclusion criteria were children of both sexes aged 1–12 years who presented with acute illnesses in the hospital's general outpatient clinic. The exclusion criteria were children with dehydration due to acute enteritis and chronic illness and those who were referred to sub-specialty outpatient clinics.

After explaining the purpose of the study to the parents or guardians and obtaining informed consent, the nutritional status of each participant was evaluated by the same pediatrician.

Anthropometric measurements

Body weight, length, and height were measured. The weight for height measurement was recorded for patients aged <2 years. Body mass index (BMI) was calculated for patients aged >2 years as follows: weight in kilograms/squared height in meters [9]. Body weight was measured in kilograms using a scale that had been properly calibrated [10]. Weight was recorded to the nearest 0.1 kg. Length was measured in infants aged <2 years using a length board with a solid headboard and moveable footboard. Height was measured in children aged >2 years

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using a right-angled headboard and a non-stretchable tape measure fixed to a vertical surface. Measurements were recorded in centimeters to the last completed 0.1 cm [11].

The measurements were then plotted on the World Health Organization (WHO) growth charts [12]. Anthropometric measurements were interpreted according to the WHO classification as follows [13]: a standard deviation (SD) score between −1 and +1 was considered normal;

SD score below −2 was considered underweight, a score below −3 was considered severely underweight in terms of weight for age; SD score below −2 was considered wasted, a score below −3 was considered severely wasted, a score above 2 was considered overweight, and a score above 3 was considered obese based on BMI for age; and a score below −2 was considered stunted, a score below −3 was considered severely stunted, a score above 2 was considered tall, and a score <3 was considered very tall concerning height for age.

Evaluation of nutritional status by Subjective Global Nutritional Assessment (SGNA)

SGNA comprises a nutrition-focused medical history and physical examination, yielding an overall ranking of class A for well-nourished (normal), class B for mildly/moderately malnourished, and class C for severely malnourished [14].

Applying Pediatric Yorkhill Malnutrition Score (PYMS)

The PYMS includes four steps as follows: BMI below (−2 SD); history of recent weight loss; recent change in nutritional intake for at least the past week; and the likely effect of the current medical condition on the patient's nutritional status for at least the following week.

Each step had a score of 0–2, and the total score reflected the degree of nutritional risk in the patient. Scores 0, 1, and ≥2 indicates a low, moderate, and high risk of malnutrition, respectively [15].

Applying the Screening Tool for the Assessment of Malnutrition in Pediatrics (STAMP)

The STAMP consists of three questions evaluating the medical condition, nutritional intake, and anthropometry of a child that yield a sum to calculate the overall risk of malnutrition, which is divided into three categories: 0 to 1, low risk; 2 to 3, medium risk; and ≥4, high risk [16].

Applying the Screening Tool for Risk on Nutritional Status and Growth (STRONGkids)

The STRONGkids screens for four items: high-risk disease; subjective clinical assessment; nutritional intake and losses; and weight loss or poor weight gain.

Subsequently, each item was assigned a score of 1 or 2 points with a maximum total score of 5 points, resulting in an overall classification as follows: 0, low risk; 1–3, medium risk; and 4–5, high risk of malnutrition [17].

After completing each participant's nutritional status evaluation, the results of each screening tool were compared with anthropometric measurements to determine the most reliable screening tool and validate its use as a rapid and simple method for evaluating nutritional status in children.

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Statistical analysis

The collected data were revised, coded, tabulated, and introduced into a PC using the IBM SPSS Statistics for Windows, Version 22.0 (IBM Co.). The Chi-square test was used to calculate the differences between categories. To determine the sensitivity and specificity of each screening tool, 2×2 tables were created to compare the results from the low- and moderate-high risk malnutrition categories to the results from the no malnutrition and moderate–severe malnutrition categories. Receiver operating characteristic (ROC) curves were constructed to determine the sensitivity and specificity of the screening tools. Univariate and multivariate logistic regression analyses were performed to detect different risk factors for malnutrition using each screening tool. The *p*-value level of significance was considered non-significant if $p>0.05$, significant if $p<0.05$, and highly significant if $p<0.01$.

RESULTS

The current study included 1,000 children who presented to the general outpatient clinic of Cairo University Pediatric Hospital for common acute pediatric illnesses, such as the common cold, pharyngitis, and bronchitis. Of the patients, 541 (54.1%) were girls, and 459 (45.9%) were boys. The median age was 68.5 months (range, 12–144 months). The median weight of the patients was 19 kg (range, 7.5–46.2 kg). The mean±SD height of the participants was 110.47±21.52 cm (range, 69–153 cm).

The assessment of anthropometric measurements of the included children revealed that 35% were stunted, 1.7% were underweight, and 10.2% were wasted according to the WHO Z-scores. According to the WHO, the malnutrition (wasting) classification for weight and height revealed that malnutrition was mild in 57 (5.7%), moderate in 40 (4.0%), and severely malnourished in 5 (0.5%) patients.

In the current study, we used the screening tools SGNA, PYMS, STAMP, and STRONGkids to determine the risk of malnutrition, and the risk of malnutrition was classified as low, medium, or high (**Fig. 1**).

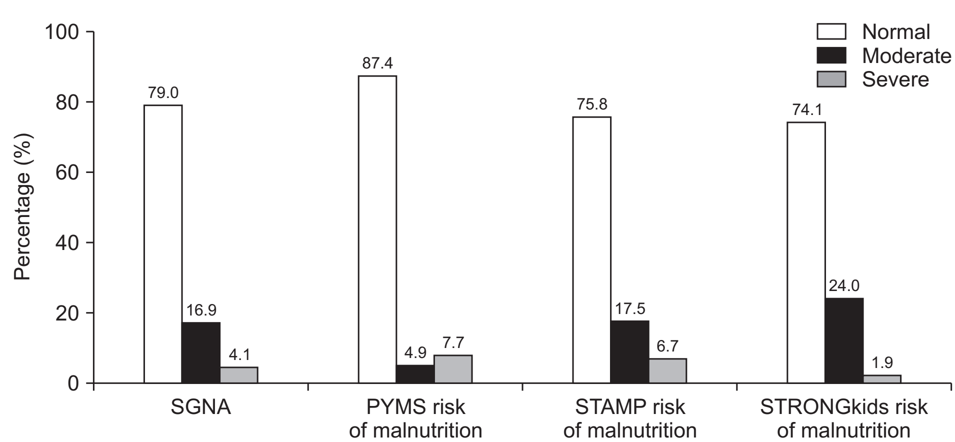

Fig. 1. Risk of malnutrition according to SGNA, PYMS, STAMP and STRONGkids scores.
SGNA: Subjective Global Nutritional Assessment, PYMS: Pediatric Yorkhill Malnutrition Score, STAMP: Screening Tool for the Assessment of Malnutrition in Pediatrics, STRONGkids: Screening Tool for Risk on Nutritional Status and Growth.

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Table 1. Relationship between risk of malnutrition according to SGNA, PYMS, STAMP, and STRONGkids scores with anthropometric measurements (SD)

Risk of malnutrition	Weight for age (SD)			Height for age (SD)			Weight for height (SD)		
	Normal	Underweight+ severely underweight	*p*-value*	Normal	Underweight+ severely underweight	*p*-value*	Normal	Underweight+ severely underweight	*p*-value*
SGNA			<0.001			<0.001			<0.001
Normal	772 (79.7)	4 (23.5)		569 (88.4)	216 (61.5)		767 (85.4)	23 (22.5)	
Moderate+high	197 (20.3)	13 (76.5)		75 (11.6)	135 (38.5)		131 (14.6)	79 (77.5)	
PYMS			<0.001			0.021			<0.001
Low	856 (88.3)	4 (23.5)		574 (89.1)	295 (84.0)		840 (93.5)	34 (33.3)	
Moderate+high	113 (11.7)	13 (76.5)		70 (10.9)	56 (16.0)		58 (6.5)	68 (66.7)	
STAMP			<0.001			<0.001			<0.001
Low	744 (76.8)	0 (0.0)		560 (87)	193 (55.0)		731 (81.4)	27 (26.5)	
Moderate+high	225 (23.2)	17 (100.0)		84 (13)	158 (45.0)		167 (18.6)	75 (73.5)	
STRONGkids			<0.001			<0.001			<0.001
Low	727 (75.0)	0 (0.0)		548 (85.1)	188 (53.6)		720 (80.2)	21 (20.6)	
Moderate+high	242 (25.0)	17 (100.0)		96 (14.9)	163 (46.4)		178 (19.8)	81 (79.4)	

Values are presented as number (%).
SD: standard deviation, SGNA: Subjective Global Nutritional Assessment, PYMS: Pediatric Yorkhill Malnutrition Score, STAMP: Screening Tool for the Assessment of Malnutrition in Pediatrics, STRONGkids: Screening Tool for Risk on Nutritional Status and Growth.
*Probability value.

A significant relationship between the risk of malnutrition calculated by the SGNA, PYMS, STAMP, and STRONGkids and the weight of the studied patients was identified, which indicates that the patients who were severely underweight were more likely to have advanced grades of malnutrition according to all the screening tools ($p<0.05$; **Table 1**).

In addition, a significant relationship was observed between the risk of malnutrition calculated by the SGNA, PYMS, STAMP, and STRONGkids and height and weight for height of the studied patients, thus indicating that patients who had severe stunting and severe wasting were more likely to have advanced grades of malnutrition according to all the screening tools ($p<0.05$) (**Table 1**).

Univariate and multivariate logistic regression analyses

Univariate and multivariate logistic regression analyses were performed to detect different risk factors for malnutrition using each questionnaire (**Table 2**).

SGNA

The univariate logistic regression analysis revealed that weight-for-age, weight-for-height, and height-for-age were associated with the risk of malnutrition by SGNA, with *p*-values of 0.005, <0.001, and <0.001, respectively. In addition, the multivariate logistic regression analysis demonstrated that weight-for-height and height-for-age were the most important factors affecting the risk of malnutrition by SGNA, with *p*-values <0.001 and <0.001, respectively.

PYMS

The univariate logistic regression analysis revealed that weight-for-age, weight-for-height, and height-for-age were associated with the risk of malnutrition according to PYMS, with *p*-values <0.001, <0.001, and 0.001, respectively. In addition, the multivariate logistic regression analysis demonstrated that weight-for-height was the most important factor associated with the risk of malnutrition according to PYMS, followed by weight-for-age and height-for-age, with corresponding *p*-values of <0.001, 0.021, and 0.037, respectively.

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Table 2. Univariate and multivariate logistic regression for anthropometric measures affecting the risk of malnutrition using SGNA, PYMS, STAMP, and STRONGkids

Anthropometry	Univariate				Multivariate			
	p-value*	OR	95% CI for OR		*p*-value*	OR	95% CI for OR	
			Lower	Upper			Lower	Upper
SAGA								
Weight for age	0.005	2.830	1.363	5.875	0.302	1.539	0.678	3.493
Weight for height	<0.001	2.576	1.689	3.929	0.000	4.580	2.044	10.264
Height for age	<0.001	4.286	2.823	6.509	0.000	4.020	2.613	6.183
PYMS								
Weight for age	<0.001	5.471	2.611	11.465	0.021	2.624	1.156	5.959
Weight for height	<0.001	5.149	3.284	8.073	0.000	5.232	2.255	12.140
Height for age	0.001	2.273	1.379	3.745	0.037	1.767	1.036	3.012
STAMP								
Weight for age	<0.001	4.015	1.949	8.273	0.213	1.712	0.735	3.988
Weight for height	<0.001	3.223	2.141	4.850	0.000	4.650	2.152	10.048
Height for age	<0.001	8.162	5.283	12.610	0.000	7.603	4.863	11.887
STRONGkids								
Weight for age	<0.001	3.648	1.772	7.511	0.056	2.130	0.981	4.625
Weight for height	0.002	1.947	1.286	2.948	0.051	1.557	0.998	2.429
Height for age	<0.001	3.648	2.416	5.506	0.000	3.262	2.141	4.969

Malnutrition in Pediatrics, STRONGkids: Screening Tool for Risk on Nutritional Status and Growth.
*Probability value.

STAMP

The univariate logistic regression analysis demonstrated that weight-for-age, weight-for-height, and height-for-age were associated with the risk of malnutrition using STAMP with *p*-values of <0.001, <0.001, and <0.001, respectively. In addition, the multivariate logistic regression analysis revealed that height-for-age and weight-for-height were the most important factors affecting the risk of malnutrition using STAMP, with *p*-values of <0.001 and <0.001, respectively.

STRONGkids

The univariate logistic regression analysis revealed that weight-for-age, weight-for-height, and height-for-age were associated with the risk of malnutrition using STRONGkids, with *p*-values of <0.001, <0.001, and <0.001, respectively. In addition, the multivariate logistic regression analysis demonstrated that height for age was the most important factor affecting the risk of malnutrition using STRONGkids (*p*<0.001).

In this study, anthropometric measurements were used as the gold standard for assessing malnutrition. Consequently, the results of the SGNA, PYMS, STAMP, and STRONGkids, divided into low- and medium-high-risk groups to determine sensitivity and specificity, were compared to anthropometric measurements to identify the most reliable screening tool for predicting malnutrition risk. The gold standard was determined using a ROC curve for the risk of malnutrition by applying the SGNA, PYMS, STAMP, and STRONGkids on weight for height (an indicator of chronic malnutrition or wasting). The STRONGkids score demonstrated the highest sensitivity of 79.4%, specificity of 80.2%, and accuracy of 80.1% in predicting wasting among the other tools (**Fig. 2**).

DISCUSSION

Early detection of malnutrition is critical. This facilitates the identification of children at risk of malnutrition [18]. Several validated screening tools are recommended by the

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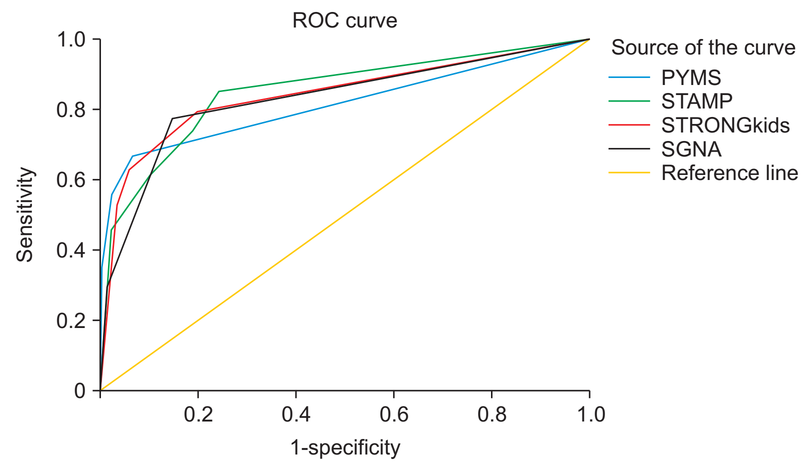

Parameter	TP	TN	FP	FN	Sensitivity	Specificity	AUC	PPV	NPV	Accuracy
SGNA	79	767	131	23	77.5%	85.4%	0.814	37.6%	97.1%	84.6%
PYMS	68	840	58	34	66.7%	93.5%	0.801	54.0%	96.1%	90.8%
STAMP	75	731	167	27	73.5%	81.4%	0.775	31.0%	96.4%	80.6%
STRONGkids	81	720	178	21	79.4%	80.2%	0.798	31.3%	97.2%	80.1%

Fig. 2. ROC curve for risk of malnutrition using SGNA, PYMS, STAMP, and STRONGkids on anthropometry (weight for height) as the gold standard.
ROC: Receiver operating characteristic, SGNA: Subjective Global Nutritional Assessment, PYMS: Pediatric Yorkhill Malnutrition Score, STAMP: Screening Tool for the Assessment of Malnutrition in Pediatrics, STRONGkids: Screening Tool for Risk on Nutritional Status and Growth, SD: standard deviation, TP: true-positives,TN: true-negatives, FP: false-positives, FN: false-negatives, AUC: area under the curve, PPV: positive predictive value, NPV: negative predictive value.

European Society for Clinical Nutrition and Metabolism [19]. The usefulness of these tools is conditioned by their predictive validity in detecting nutritional risk, reliability, and ease of use in clinical practice [20].

Anthropometry is used worldwide to assess nutritional status worldwide [21]. Our findings of the anthropometric measurements were different from the global prevalence of malnutrition estimated by the WHO in 2020, which revealed that approximately 22% of children aged <5 years were stunted, and approximately 6.7% were wasted [22]. Stunting may indicate chronic malnutrition or hidden hunger, both of which are associated with an increased risk of recurrent infections and hospital admission, or may be caused by pathological conditions such as endocrine abnormalities or celiac disease. A demographic and health survey conducted in Egypt in 2014 indicated that the proportions of children aged <5 years with stunting, wasting, and underweight were 21%, 8%, and 6%, respectively [23]. The difference between the two studies might be explained by the sample size, time difference, environmental factors, socioeconomic differences, cultural differences of the study participants, and study setting. Specifically, Cairo University Children's Hospital acts as a tertiary healthcare unit for complicated and severe cases. Another Egyptian study by El Koofy et al. [24] has reported that children having normal weight and height were 73.9% and 69.3%, respectively, while 26% had wasting according to the WHO Z scores, which may be attributed to the type of included patients who suffered from gastroenteritis and might have zinc or other micronutrient deficiencies.

The ROC curves were used to determine the sensitivity and specificity of each screening tool. When compared to using the weight for height as the gold standard, the STRONGkids demonstrated a sensitivity of 79.4%, specificity of 80.2%, and accuracy of 80.1% for predicting wasting, whereas the STAMP has a sensitivity of 73.5%, specificity of 81.4%, and accuracy of 80.6% for predicting wasting.

A study conducted by Tuokkola et al. [6], compared the PYMS, STAMP, and STRONGkids to anthropometric measurements and demonstrated that the PYMS had a 100% sensitivity and 60% specificity. The STAMP demonstrated a sensitivity of 100% and specificity of 69%, and the STRONGkids had 100% sensitivity and 89% specificity. However, sensitivity, specificity, and positive and negative predictive values may vary according to the prevalence of malnutrition [25], which could explain the differences between the current study results and those of other studies.

In the current study, STRONGkids was identified as the screening tool with the best accuracy and highest sensitivity, with the highest negative predictive value compared to weight for height as the gold standard. Consequently, we considered STRONGKids to be the most reliable screening tool. Some researchers prefer using the STRONGkids because of its greater simplicity and speed of application and the lower number of patients classified as high-risk compared to the STAMP [26-28]. Although initially designed for different health professionals (STAMP for nurses and STRONGkids for physicians), both demonstrated good agreement when used by health professionals [8].

In line with these results, several other studies comparing screening tools favored STRONGkids, such as Moeeni et al. [29], who evaluated children with PYMS, STAMP, and STRONGkids with a full nutritional assessment, and concluded that STRONGkids was the most reliable tool. Another study conducted by Moeeni et al. [30], compared PYMS, STAMP, and STRONGkids with a full nutritional assessment, and supported the finding that STRONGkids was the most useful and reliable tool. The two previous studies were similar in design and population. Both were cross-sectional studies conducted in a tertiary hospital and excluded children with known chronic diseases.

Furthermore, a study conducted by Tuokkola et al. [6], recommended that STRONGkids was the most accurate screening tool for detecting acute malnutrition and was therefore selected as the primary screening method in their hospital.

Asystematic review by Becker et al. [31] examined the validity and reliability of nutritional screening tools in the pediatric population in inpatient, outpatient, and community settings. This study stratified the validity and reliability results into low, medium, and high, while classifying the quality of the evidence into limited, fair, and good. This study concluded that STRONGkids had moderate validity and reliability with fair evidence.

Meanwhile, another study recommended PYMS as the most reliable screening tool [25]. This diagnostic test study used the likelihood ratio to determine the most reliable test. By contrast, our cross-sectional study used sensitivity, specificity, and positive and negative predictive values to determine the most reliable test.

Nevertheless, a large European multicenter study in 2016 [27] and a meta-analysis in 2015 [32] did not support using one screening tool over another due to insufficient evidence. However, a more recent systematic review conducted in 2018 and published in 2020 by Becker et al. [31] concluded that STRONGkids has moderate validity and reliability, with fair evidence.

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In conclusion, the use of nutritional screening tools to evaluate the nutritional status of children is valuable and recommended as a simple, rapid, and inexpensive method for the early identification of malnutrition risk in pediatric patients in LMIC. The nutritional risk scores SNGA, PYMS, STAMP, and STRONGkids are feasible and can identify children at risk of malnutrition but with different utilities. Moreover, stunting was a common problem in our cohort of 1–12-year-old children.

Future studies in outpatient settings are required to confirm these results because published studies evaluating nutritional risk scores in outpatient settings are limited.

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