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Screening for Pediatric Malnutrition at Hospital Admission: Which Screening Tool Is Best?

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Abstract

Background: Identifying children at malnutrition risk on admission to hospital is considered best practice; however, nutrition screening in pediatric populations is not common. The aim of this study was to determine which screening tool is able to identify children with malnutrition on admission to hospital. *Methods:* A nurse administered 2 pediatric nutrition screening tools, Screening Tool for Risk on Nutritional Status and Growth (STRONGkids) and Pediatric Nutrition Screening Tool (PNST) to patients admitted to medicine and surgery units (n = 165). The Subjective Global Nutritional Assessment (SGNA) was then completed by a dietitian, blinded to the results of the screens. Sensitivity, specificity, and κ were calculated for both screening tools against the SGNA. A receiver operating characteristic (ROC) curve assessed alternate cutoffs for each tool. Length of hospital stay (LOS) was used to assess prospective validity. *Results:* Using the recommended cutoffs, the sensitivity of STRONGkids was 89%, specificity 35%, and κ 0.483. The sensitivity of PNST was 58%, specificity 88%, and κ 0.601. Using adjusted cutoffs, PNST's sensitivity improved to 87%, specificity 71%, and κ 0.681, and STRONGkids specificity improved to 61%, sensitivity 80%, and κ 0.5. Children identified at nutrition risk had significantly longer LOS ($P < 0.05$). *Conclusion:* This study showed neither tool was appropriate for clinical use based on published cutoffs. By adjusting the cutoffs using ROC curve analysis, both tools improved overall agreement with the SGNA without significantly impacting the prospective validity. PNST with adjusted cutoffs is the most appropriate for clinical use in this population. (*Nutr Clin Pract.* 2020;35:951–958)

Keywords

hospitalized child; length of stay; malnutrition; nutrition screening; pediatrics

Introduction

It is well known that children have high protein and energy requirements for growth and development, and malnutrition during childhood can have lifelong effects on health.[1] Malnutrition has been reported in 8%–51% of children admitted to hospital in Canada.[2,3] Malnutrition is associated with increased length of hospital stay (LOS), morbidity and mortality, infection risk, and increased hospital costs when compared with well-nourished children.[2,4-7] Long-term consequences include delayed development, functional impairment, and decreased academic performance.[8,9] The American Society for Parenteral and Enteral Nutrition recommends using a validated screening tool to identify

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nutrition risk on all patients admitted to hospital;[10] however, validated screening tools are not used in many pediatric facilities, leaving a large gap between current and best practice. When selecting a screening tool, the intended purpose, prospective validity, concurrent validity, reproducibility, and practicality must all be considered.[11,12]

Multiple tools have been developed to screen for malnutrition in pediatric inpatient settings, but currently there are insufficient data to select one over the other.[13-15] Despite validation of pediatric nutrition screening tools in multiple centers, there is a large variation in the reported concurrent validity, even within the same populations. This suggests the screening tools may be too specific to the original population and not appropriate for widespread use.[14] Using the framework provided by Elia and Stratton in 2011[11] as a guide, 5 previously validated pediatric screening tools were assessed for practical use in a clinical setting where a nurse would use each tool in the admission process to screen for nutrition risk: Pediatric Nutrition Risk Score (PNRS),[16] Screening Tool for the Assessment of Malnutrition in Pediatrics (STAMP),[17] Pediatric Yorkhill Malnutrition Score (PYMS),[18] Screening Tool for Risk on Nutritional Status and Growth (STRONGkids),[19] and Pediatric Nutrition Screening Tool (PNST).[20] For a tool to be used by nurses on admission, it must be completed quickly and not require expert knowledge in nutrition assessment. The PNRS takes 48 hours to complete, and both STAMP and PYMS require analysis of anthropometrics with a growth curve or percentile chart. Both STRONGkids and PNST consist of 4 "yes-or-no" questions that are completed in a few minutes and do not contain anthropometric measures. Based on the criteria of ease of use, quickness to complete (<5 minutes), and no background knowledge needed in nutrition assessment, PNST and STRONGkids were selected for further validation. Despite both tools being validated in pediatric populations, there is insufficient evidence to choose one over the other and concern that the nutrition-risk cutoffs proposed are too specific to the initial study population.[14] Therefore, adjusted nutrition-risk cutoffs must be assessed to better fit the intended population.

To assess the tools' ability to identify children who are malnourished, a reliable method of identifying true nutrition status is required. The Subjective Global Nutritional Assessment (SGNA) is a validated tool that has been shown to accurately identify children who are malnourished.[2] Although anthropometric measures such as weight, height, and body mass index (BMI) are often used to identify and classify the extent of malnutrition in children, the more complex etiology of pediatric malnutrition recently described by Mehta et al (2013) acknowledges that anthropometrics only identify a subset of malnourished patients.[21] The SGNA is a more robust assessment than anthropometrics alone, as it includes weight gain, weight loss, intake, gastrointestinal patterns, functional status, and a nutrition-focused physical exam. Although the SGNA is a validated tool, it takes approximately 20 minutes to complete and can only be used by a trained clinician; therefore, it is not a suitable screening tool for nurses to administer during admission.

The primary aim of this study was to determine which tool, STRONGkids or PNST, is able to identify children with malnutrition on admission to hospital based on original and adjusted nutrition-risk cutoffs as compared to the SGNA. The secondary aim was to determine the prevalence of malnutrition upon admission and impact of malnutrition on LOS.

Methods

This prospective study was conducted on surgery and medicine units at the Stollery Children's Hospital in Edmonton, Alberta, Canada from October to December 2017. Patients aged 1 month to 17 years were approached to participate within 24 hours of admission (72 hours for weekend admission) and were only excluded if the expected LOS was <24 hours. This study was approved by the Human Research Ethics Board of the University of Alberta (REB # Pro00071081).

A research nurse approached parents or guardians to participate and, after receiving consent and assent (when applicable), performed both screening tools consecutively in random order. STRONGkids was initially designed to have a pediatrician complete 2 of the questions (the subjective clinical assessment and disease state); however, for feasibility in a clinical setting, having nurses complete the entire screen has become standard for its use.[22] Each tool took <5 minutes to complete by nurses with the child and their parent or guardian. Once the screening tools were completed, a dietitian blinded to the results of the screens conducted the SGNA on each patient to assess presence and extent of malnutrition. This took between 15 and 30 minutes per patient. The SGNA was used as the reference standard to determine concurrent validity of each screening tool. Age, weight, height, LOS, unit, and reason for admission were then collected from the patient chart. A second nurse repeated both screening tools in a subset of 20 patients, blinded to the results of the initial screens, to assess interrater reliability. *z*-Scores for length/height for age and weight for length (<2 years of age) or BMI (2 years or over) were calculated using World Health Organization Anthro software (version 3.2.2, January 2011, Geneva, Switzerland).

SGNA results were categorized as well nourished, moderately malnourished, or severely malnourished, with the moderate and severe categories combined into a "malnourished" category for statistical analysis. Malnutrition was classified as a *z*-score of ≤ -2 in either length/height for

age, weight for length, or BMI.[23,24] The STRONGkids and PNST tools were first evaluated based on the recommended cutoffs from their original studies.[19,20] Adjusted cutoffs were also analyzed to determine the impact changing the cutoffs would have on the agreement of the tools with the SGNA.[25]

Statistical Analysis

A receiver operating characteristic (ROC) curve analysis was used to create adjusted nutrition-risk cutoffs and to assess both tools ability to identify nutrition risk with original and adjusted cutoffs. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were derived from 2×2 crosstab tables and used to compare the screening tools' original and alternate cutoff points to the SGNA for concurrent validity. κ Analysis was also used to determine the overall agreement of each tool to the reference standard of the SGNA. Prospective validity was assessed by determining the difference in LOS between the nutrition-risk categories for each screening tool using the Mann-Whitney U test and the independent-sample Kruskal-Wallis test. Demographics were compared with the SGNA and screening tools using χ^2 analysis and the Mann-Whitney U test. All statistics were performed by SPSS for Windows version 24 (IBM Corp, 2016, Armonk, NY, USA: IBM Corp). A value of $P < 0.05$ was considered statistically significant.

Results

Patient Characteristics

One hundred seventy-seven patients consented to participate. Twelve were discharged prior to any data collection and were therefore excluded; a further 11 were discharged after the screening tools were completed but before the SGNA was able to be performed. These patients were included for LOS and demographic analysis to avoid bias. In total, 154 patients were included for the full analysis, and 165 were included for LOS and demographic analysis.

The median age was 5.7 years (1 month–16.9 years), and median LOS was 3 days (1–47 days) (Table 1). The SGNA classified 71% of the patients as well nourished, 25% as moderately malnourished, and 4% as severely malnourished for an overall malnutrition rate of 29% (Table 2). There was no difference in malnutrition rates for age or gender ($P = 0.128$, 0.767, respectively), but those admitted to medicine units were 3 times more likely to be malnourished (moderate or severe) than those admitted to the surgery unit (odds ratio [OR] = 3.03, CI 1.452–6.335, $P = 0.003$). Anthropometric measures classified 33 (20%) of patients as being malnourished.

Table 1. Patient Demographics.

Demographics	n (%)[a]
Patients	165 (100)
Gender	
Male	90 (55)
Female	75 (45)
Age, median (range), years	5.7 (0.1–16.9)
Unit of admission	
Surgery	84 (51)
Medicine	81 (49)
Reason for admission	
General medicine	45 (27)
Neurology	15 (9)
Other medicine	21 (13)
General surgery	25 (15)
Neurosurgery	14 (9)
Orthopedic surgery	17 (10)
ENT surgery	21 (13)
Other surgery	7 (4)
LOS, median (range), days	3 (1–47)

ENT, ear, nose, and throat; LOS, length of stay.
[a]Unless otherwise indicated.

Based on original cutoffs, PNST identified 25% of the population as being at nutrition risk, whereas STRONGkids identified 72% as at nutrition risk (56% at moderate risk and 16% at high risk). There was no difference in rates of nutrition risk for either tool based on which screening tool was performed first ($P = 0.094$, 0.468 for PNST and STRONGkids, respectively).

Concurrent Validity

ROC curve analysis of area under the curve (Figure 1) showed significant agreement between the SGNA and both STRONGkids and PNST. Based on the results of the ROC curve analysis, adjusted cutoff points were analyzed for both screening tools (Table 3). These changes improved the sensitivity of PNST and the specificity of STRONGkids, and both tools showed better overall agreement with the SGNA (Table 4). With original and adjusted cutoffs, both screening tools were able to identify all patients classified as severely malnourished by the SGNA. There was slightly lower agreement, although still significant, in the surgery population as compared with the medicine population (Table 5).

Patients admitted under specialty medicine programs (neurology, cardiology, gastrointestinal, metabolics, oncology, and nephrology) showed a high prevalence of malnutrition; therefore, results from both screening tools were assessed in this population alone. Using the adjusted cutoffs, PNST had a sensitivity of 88%, specificity of 78%, PPV of 79%, NPV of 88%, κ 0.658 ($P < 0.001$). STRONGkids had a sensitivity of 94%, specificity of 44%, PPV of 62%, NPV of 89%, κ 0.38 ($P = 0.009$).

Table 2. Prevalence of Malnutrition Based on the SGNA.

Population	Total	Well Nourished n (%)	Moderate Malnutrition n (%)	Severe Malnutrition n (%)
Total	154	109 (71)	38 (25)	7 (4)
Gender				
Male	86	62 (72)	21 (24)	3 (4)
Female	68	47 (69)	17 (25)	4 (6)
Unit				
Surgery	77	63 (82)	12 (16)	2 (2)
Medicine	77	46 (60)	26 (34)	5 (6)
Reason for admission				
General medicine	42	28 (67)	11 (26)	3 (7)
Neurology	14	10 (71)	4 (29)	0 (0)
Other medicine	21	8 (38)	11 (52)	2 (10)
General Surgery	22	17 (77)	5 (23)	0 (0)
Neurosurgery	13	11 (84)	1 (8)	1 (8)
Orthopedic surgery	15	12 (80)	2 (13)	1 (7)
ENT surgery	20	17 (85)	3 (15)	0 (0)
Other surgery	7	6 (86)	1 (14)	0 (0)

Based on the 154 patients who had the SGNA performed.
ENT, ear, nose, and throat; SGNA, Subjective Global Nutritional Assessment.

Interrater Reliability

In the subset of 20 patients who had both screening tools completed twice by different nurses, Cohen's κ analysis showed moderate agreement for STRONGkids ($\kappa = 0.483$, $P = 0.028$) and substantial agreement for PNST ($\kappa = 0.601$, $P = 0.002$).[26] With the adjusted cutoffs, there was minimal improvement in the agreement of both tools, with STRONGkids increasing to $\kappa = 0.5$ ($P = 0.01$) and PNST increasing to $\kappa = 0.681$ ($P = 0.002$).

Prospective Validity

The median LOS for well-nourished patients (based on the SGNA) was 2 days and 5 days for those malnourished ($P < 0.005$). When classified based on original and adjusted cutoffs, both screening tools showed a significant difference in median LOS between those at "no nutrition risk" and those "at nutrition risk" (Figure 2).

Discussion

The consequences of malnutrition on hospitalized children are increasingly recognized; however, nutrition-risk screening in pediatric hospitals has yet to receive widespread use. This is partly due to the lack of validated tools that meet all the requirements of a practical screening tool.[27] Evidence suggests that over half of pediatric patients lose weight while in hospital and those who were malnourished on admission are being discharged with no improvement in nutrition status.[28,29] These concerning findings highlight the importance of early identification of malnutrition to enable timely interventions and nutrition management. This study is the first, to our knowledge, to compare 2 previously validated screening tools with the SGNA in a Canadian pediatric population. Neither screening tool, when used as recommended, was able to identify children at risk for malnutrition with acceptable concurrent validity. The PNST had a low sensitivity; it correctly identified malnourished children only 58% of the time. STRONGkids had a poor specificity at 35%, suggesting it falsely identified (false positive) children at nutrition risk when they were well nourished 65% of the time. During the initial development of both screening tools, their nutrition-risk cutoffs were derived from different methods. STRONGkids based their nutrition-risk cutoffs on groupings that had similar mean weight for height z-scores,[19] whereas the PNST looked at the cumulative percentage of affirmative responses that most closely matched the SGNA.[20] As suggested by Huysentruyt et al, the choice of cutoff points can have a great impact on the tools' performance and needs to be evaluated closely.[13] By adjusting the risk classifications based on ROC curve analysis, both tools improved overall agreement with the SGNA without significantly impacting the prospective validity or interrater reliability. Both tools have the ability to identify children who are malnourished on admission; however, further validation of adjusted cutoffs may be warranted.

STRONGkids is the most thoroughly investigated of the 2 screening tools. It has been found to have the best correlation with anthropometric measures[30] and often found to perform best over other screening tools when compared.[31] However, similar to the findings of this study, STRONGkids

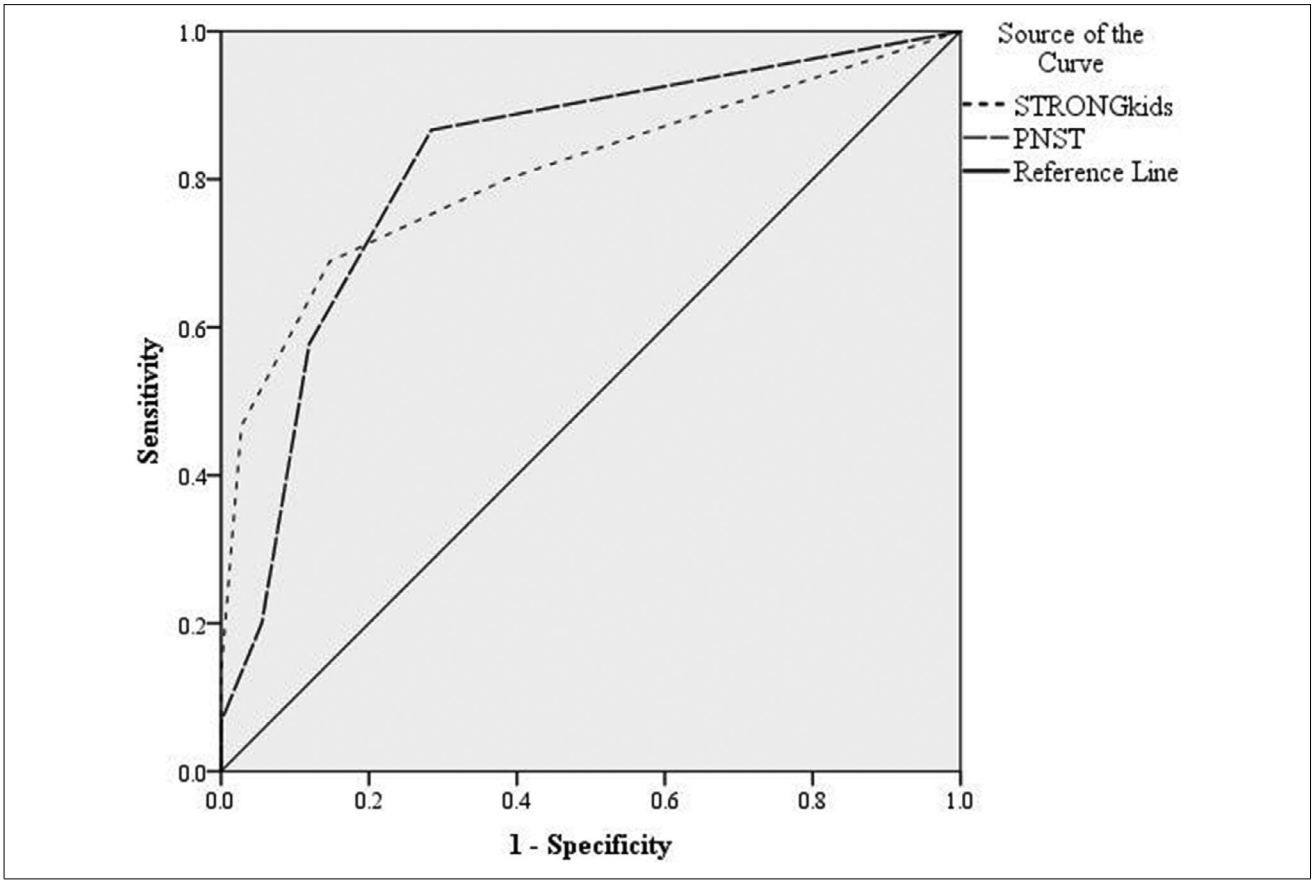

Figure 1. ROC curve analysis of STRONGkids and PNST compared with the SGNA for the whole population. AUC for PNST: 0.819 (0.745–0.894), $P < 0.001$. AUC for STRONGkids: 0.809 (0.723–0.894), $P < 0.001$. AUC, area under the curve; PNST, Pediatric Nutrition Screening Tool; ROC, receiver operating characteristic; SGNA, Subjective Global Nutritional Assessment; STRONGkids, Screening Tool for Risk on Nutritional Status and Growth.

Table 3. Screening Tools Original and Adjusted Nutrition-Risk Cutoffs.

	Original Cutoffs		Adjusted Cutoffs	
Screening Tool	Score	Nutrition risk	Score	Nutrition risk
STRONGkids	0 points	No risk	0–1 points	No risk
	1–3 points	Moderate risk[a]	2–3 points	Moderate risk[a]
	4–5 points	Severe risk[a]	4–5 points	Severe risk[a]
PNST	0–1 yes answers	No risk	0 yes answers	No risk
	2–4 yes answers	At risk	1–4 yes answers	At risk

PNST, Pediatric Nutrition Screening Tool; STRONGkids, Screening Tool for Risk on Nutritional Status and Growth.
[a]Grouped into "at nutrition risk" for statistical analysis.

has been shown to have poor specificity, ranging from 7.7% to 53%.[22,32,33] Teixeira et al argues sensitivity is more important than specificity when it comes to nutrition-risk screening, as the only downside to overidentification is exposing children to an in-depth nutrition assessment, which is better than the alternative of missing a child who is malnourished.[34] However, excessive unnecessary referrals to a dietitian could put stress on an already overburdened healthcare system. Both sensitivity and specificity must be considered when selecting a nutrition-risk screening tool.

PNST is a more recently proposed tool and has not, to our knowledge, been further validated beyond the original population. Our study revealed suboptimal sensitivity

Table 4. Concurrent Validity of STRONGkids and PNST as Compared With the SGNA.

Screening Tool	Nutrition Risk, n (%)	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	κ	*P*
Original cutoffs							
STRONGkids	119 (72)	89 (75–96)	35 (26–45)	36 (27–46)	88 (74–96)	0.166	0.003[a]
PNST	42 (25)	58 (42–72)	88 (80–93)	67 (50–80)	83 (75–90)	0.477	<0.005[a]
Adjusted cutoffs							
STRONGkids	85 (51)	80 (65–90)	61 (52–70)	46 (35–58)	88 (78–94)	0.341	<0.005[a]
PNST	74 (45)	87 (73–94)	71 (62–80)	56 (43–67)	93 (85–97)	0.501	<0.005[a]

CI, confidence interval; NPV, negative predictive value; PNST, Pediatric Nutrition Screening Tool; PPV, positive predictive value; SGNA, Subjective Global Nutritional Assessment; STRONGkids, Screening Tool for Risk on Nutritional Status and Growth.
[a]Statistically significant ($P \leq 0.05$).

Table 5. ROC Curve Analysis.

Screening Tool	n	Area Under the Curve (95% CI)	*P*
Whole population	154		
STRONGkids		0.809 (0.723–0.894)	<0.001
PNST		0.819 (0.745–0.894)	<0.001
Medicine	77		
STRONGkids		0.826 (0.722–0.929)	<0.001
PNST		0.816 (0.718–0.914)	<0.001
Surgery	77		
STRONGkids		0.735 (0.595–0.912)	0.003
PNST		0.786 (0.647–0.926)	0.001

The closer the area under the curve is to 1, the stronger the agreement between the screening tool and the SGNA.
CI, confidence interval; PNST, Pediatric Nutrition Screening Tools; ROC, receiver operating characteristic; STRONGkids, Screening Tool for Risk on Nutritional Status and Growth.

at 58%, with an improvement to 87% by adjusting the cutoffs. There was an associated decrease in specificity, but it remained higher than that of STRONGkids. One major difference between PNST and STRONGkids is the omission of disease state, a category of nutrition screening recommended by the European Society for Enteral and Parenteral Nutrition.[35] Despite this, the PNST performed better in the specialty medicine population, which includes children admitted with underlying medical diagnoses such as cardiac, gastrointestinal, nephrotic, metabolic, and oncologic. In this population with the highest prevalence of malnutrition, both tools performed just as well as they did in the population as a whole. Additionally, neither tool missed any child who was severely malnourished based on the SGNA. Despite its omission of disease state, PNST was able to identify malnutrition in high-risk children who were admitted for chronic disease concerns. Overall, the PNST

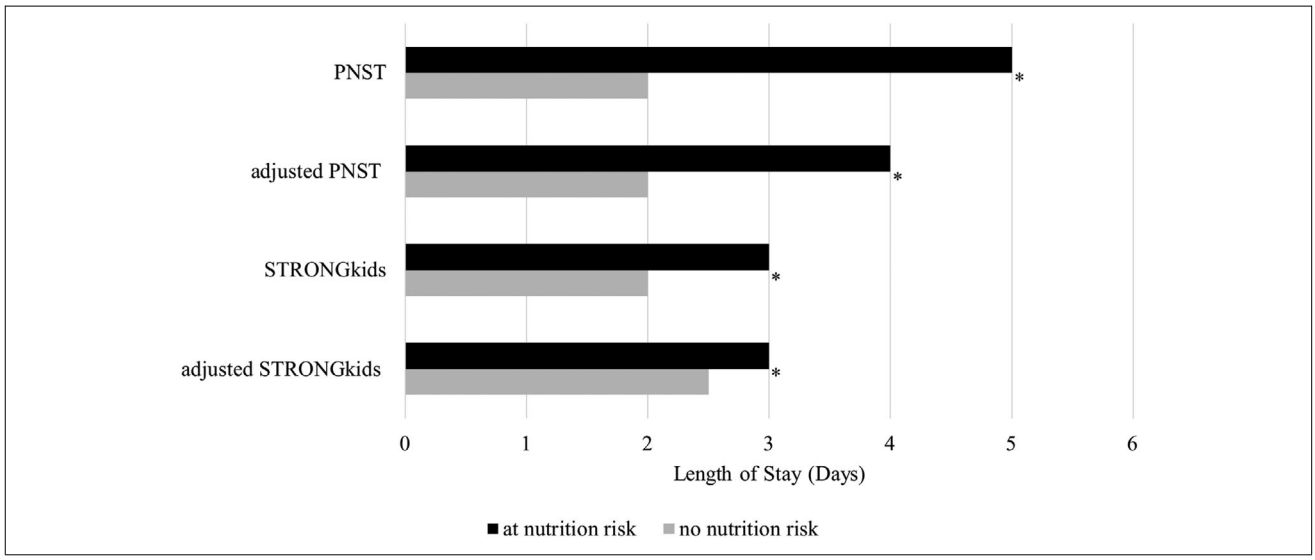

Figure 2. Median length of hospital stay based on STRONGkids and PNST with original and adjusted cutoffs. *Statistically significant ($P < 0.05$) based on Mann-Whitney *U* test. PNST, Pediatric Nutrition Screening Tool; STRONGkids, Screening Tool for Risk on Nutritional Status and Growth.

with adjusted cutoffs has the strongest agreement with the SGNA for this population and should be considered for routine clinical use.

Another important finding is the association between nutrition risk and LOS. Similar to other studies,[2,4,22,30] there was a significantly longer median LOS for those who were admitted to hospital malnourished vs well nourished. Not only does malnutrition on admission impact LOS, but the inverse is true also. Days of hospital admission is an independent risk factor for nutrition deterioration in children.[36,37] This presents a concerning cycle of worsening nutrition status and longer hospital stay. Identification of nutrition risk on admission will allow for dietitian interventions to aid in prevention of further nutrition deterioration throughout hospital admission.[38] Nutrition interventions can prevent nutrition decline in children, adding urgency to the need for nutrition-risk screening at admission and ensuring children at nutrition risk are identified. Further investigation into the impact of nutrition screening on outcomes of children during their hospital stay is warranted, including weight changes, morbidity, mortality, and readmission rates.

This study compared 2 previously validated nutrition screening tools in a tertiary Canadian pediatric hospital and was able to validate alternate cutoff points for nutrition-risk classification in this population. Although further research is needed to validate these findings in other pediatric inpatient populations, these results can be used to guide future research and clinical implementation. A limitation of this study is the use of a convenience sample, although limited exclusion criteria allowed for a sample that appears representative of the population studied. There was a potential recruitment bias, as only those present in their room with a parent or guardian were approached to participate. Additional prospective validation including weight loss and clinical course in hospital was not assessed but should be included in future studies in this population.

Conclusion

Nutrition-risk screening has the potential to identify children who are malnourished on admission to hospital. Through the early detection and treatment of malnutrition, nutrition screening aims to improve the health outcomes for children admitted to hospital. Both STRONGkids and PNST were adapted to better fit our population by adjusting the cutoff values for nutrition risk. The PNST with adjusted cutoffs had the strongest concurrent validity and interrater reliability and was found to be the most appropriate tool for routine use.

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Statement of Authorship

L. E. Carter, M. K. BrunetWood, and V. C. Mazurak contributed to the conception and design of the research; L. E. Carter, G. Shoyele, and S. Southon contributed to the acquisition and analysis of the data; L. E. Carter, A. Farmer, R. Persad, V. C. Mazurak, and M. K. BrunetWood contributed to the analysis and interpretation of the data. All authors drafted the manuscript, critically revised the manuscript, gave final approval, and agree to be accountable for all aspects of work ensuring integrity and accuracy.

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