



Pediatric screening tools for malnutrition: an update

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Purpose of review

There is ongoing interest in nutritional screening tools in pediatrics to facilitate the identification of children at risk for malnutrition who need further assessment and possible nutritional intervention. The choice for a specific tool depends on various factors. This review aims to provide an overview of recent progress in pediatric nutritional screening methods.

Recent findings

We present recent studies about newly developed or adjusted tools, the applicability of nutritional screening tools in specific populations, and how to implement screening in the overall process of improving nutritional care in the pediatric hospital setting.

Summary

Three new screening tools have been developed for use on admission to hospital: two for the mixed pediatric hospitalized population and one for infants. A simple weekly rescreening tool to identify hospital-acquired nutritional deterioration was developed for use in children with prolonged hospital stay. Different from most previous studies that only assessed the relationship between the nutritional risk score and anthropometric parameters of malnutrition, new studies in children with cancer, burns, and biliary atresia show significant associations between high nutritional risk and short-term outcome measures such as increased complication rate and weight loss. For implementation of a nutritional care process incorporating nutritional screening in daily practice, simplicity seems to be of great importance.

Keywords

child, malnutrition, nutritional assessment, nutritional screening, undernutrition

INTRODUCTION

There is ongoing interest in nutritional screening tools (NSTs) in pediatrics to facilitate the identification of children at risk for malnutrition who need further assessment and possible nutritional intervention. Several recent (systematic) reviews of various available NSTs in pediatric patients have been published including information about each instrument's practicality, validity, accuracy, and comparison of different tools [1–9]. With this narrative review, we aimed at updating the reader's knowledge on newly developed tools, studies describing adjustments to previously developed NSTs, and their applicability in specific groups. Moreover, we describe studies addressing the use of screening in the process of improving nutritional care in the hospital setting. We selected studies with full-English manuscript available.

NEW TOOLS AND ADAPTATION OF EXISTING TOOLS IN THE GENERAL HOSPITALIZED PEDIATRIC POPULATION

Over the past 10 years, most publications considered the three most cited NSTs used in the general population of children admitted to the hospital: Pediatric

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KEY POINTS

- Three new screening tools have been developed for use in a mixed pediatric population on admission to the hospital; one specific for the Chinese population [Pediatric Nutritional Screening Score (PNSS)], one focused on etiology-based risk factors [Pilot Pediatric Risk-Assessment Tool (PRAT)], and one for use in infants [Infant nutrition early warning score (iNews)].
- A simple, universal weekly rescreening tool to identify hospital-acquired nutritional deterioration [Pediatric Nutritional Rescreening Tool (PNRT)] in children with a prolonged hospital stay was developed, which warrants further validation.
- Studies in children with specific diagnoses show significant associations between having a high nutritional risk score and short-term outcome measures such as increased length of stay, but also increase in complications and greater weight loss.
- Simplicity seems to be of great importance when implementing a nutritional care process in daily practice. Barriers for adequate nutrition support seem to be similar in all hospitals and are mainly issues around time, costs, and resources.

Yorkhill Malnutrition Score (PYMS), Screening Tool for the Assessment for Malnutrition in Pediatrics (STAMP), and Screening Tool for Risk of Impaired Nutritional Status and Growth (STRONGkids) [10–12]. Although the published instruments have shown their clinical use, still new screening instruments are being developed or refined. Four recent studies will be discussed and their most important findings are summarized in Table 1.

In 2018, Lu *et al.* came up with the Pediatric Nutritional Screening Score (PNSS) specifically

developed for the Chinese population. It was stated by the authors that STRONGkids, PYMS, and STAMP were developed by European researchers, but the selection and interpretation of these nutritional screening tools may differ among different racial and ethnic groups [13]. They also stated that it has been reported that the types and severity of diseases included in these screening tools are not sufficient to account for clinical diagnoses in China [14]. Therefore, they developed and validated the PNSS to assess undernutrition risk among hospitalized children in China. The development of the PNSS was based on the nutritional screening guidelines ESPEN [15] and modified according to Chinese clinical practice. PNSS consisted of three elements: disease with malnutrition risks (none or slight, moderate, severe); changes in food intake during the previous week; and nutritional status (assessed by anthropometric measurements). Each element received a score of 0–2, with maximum total score of 6. Interestingly, the authors classified diseases into three different risk categories for malnutrition based on the presumed protein needs for the disease and the ability to be met with standard diet. From the 847 children included, 42.6% were at risk of undernutrition based on the PNSS results (cut-off score ≥ 2). The score system of PNSS was calibrated following the assessment of body composition (using bio-impedance analysis). The sensitivity, specificity, and negative predictive value of PNSS using a complete dietetic assessment as reference method were 82, 71, and 92%, respectively. Results were also compared with the three European screening tools. The sensitivity of PNSS was similar to that of STRONGkids, but higher than that of STAMP and PYMS.

Wong Vega *et al.* [16[■]] stated that there is a lack of inclusion of cause-based risk factors in the

Table 1. Overview of new tools and adaptation of existing tools in the mixed pediatric hospitalized population

Study	Screening tool	Considerations using screening tools
Lu <i>et al.</i> , 2018 [13]	PNSS	Type and severity of disease with consequences for protein intake; newly developed for Chinese population
Wong Vega <i>et al.</i> , 2019 [16 [■]]	PRAT	Focus on cause-based risk factors: wasting, hypermetabolism, increased nutrient losses, altered absorption of nutrients, inflammation
White <i>et al.</i> , 2019 [17 [■]]	PNRT	Rescreening tool to be used weekly, starting 7 days after admission (two questions): Has the child had reduced nutritional intake in the last 7 days Has the child lost weight or had poor weight gain
Carter <i>et al.</i> , 2019 [20]	STRONGkids and PNST	Use of different cut-offs to achieve a better risk classification

PNRT, Pediatric Nutritional Rescreening Tool; PNSS, Pediatric Nutritional Screening Score; PNST, Pediatric Nutrition Screening Tool; PRAT, Pilot Pediatric Risk Assessment Tool; STRONGkids, Screening Tool for Risk on Nutritional Status and Growth.

previously published instruments and tested a Pilot Pediatric Risk Assessment Tool (PRAT). Therefore, a study in 528 hospitalized children was conducted to identify the prevalence of malnutrition and characterize mechanisms of malnutrition risk, and to relate these to outcome measures. Malnutrition was assessed by weight for length (WFL) and BMI/age z-score, and overall prevalence was 19.7%; 11.9% mild, 5% moderate, and 2.8% severe. Anthropometric z-scores were not associated with length of stay (LOS). Using the PRAT showed that altered absorption of nutrients and increased nutrient losses upon admission were independently associated with malnutrition on admission. Wasting, hypermetabolism, increased nutrient losses, and inflammation were associated with longer LOS. Interestingly, those with hypermetabolism had significant z-score improvements if followed by a dietician. The authors concluded that identification of risk factors beyond anthropometrics to define malnutrition and risk is important in prioritizing care.

White *et al.* designed and validated a simple, quick, and universal weekly rescreening tool to identify hospital acquired nutritional deterioration in 61 children with a prolonged LOS (≥ 7 days) [17²²]. Nutritional deterioration markers were collected by one investigator and two rescreening questions were asked by another investigator. Agreement between nutritional deterioration markers of reduction in weight (kg), BMI (kg/m^2), energy intake (kcal/day), and protein intake (g/day), and the two rescreening questions was determined. The sensitivity and specificity of the rescreening question '*Has the child had reduced nutritional intake in the last 7 days*' for identifying children with an at least 25% reduction in energy intake over the previous 7-day period were 61.9 and 82.2%, respectively. The sensitivity of '*Has the child lost weight or had poor weight gain*' at detecting weight loss was 71.4% and specificity 87.8%. The authors concluded that the pediatric nutrition rescreening questions provided a valid and simple tool to detect nutritional deterioration in long-stay pediatric patients and should be an integral part of the nutrition care process. The authors raised an important issue because no studies so far have been done that look at the validity of rescreening. The designers of the STRONGkids tool previously advised to repeat screening 1 week after admission, but no data of this rescreening have been published so far [18].

Carter *et al.* [20] wanted to determine which tool that can be easily used by nurses (STRONGkids [10] or PNST [19]) was able to identify children with malnutrition on hospital admission based on original and adjusted nutrition-risk cut-offs as compared to the subjective global nutritional

assessment (SGNA). The reason to test STRONGkids and PNST was that these instruments consist of four 'yes-or-no' questions that can be completed in a few minutes and do not contain anthropometric measures. Compared to the 'golden standard' SGNA alternative cut-off points were derived, and using these alternative cut-off points, it was possible to achieve a better nutritional risk classification.

USE OF NUTRITIONAL SCREENING TOOLS IN SPECIFIC PATIENT POPULATIONS

Most studies on NSTs were performed in heterogeneous populations of hospitalized children with a variety of diseases [21]. Some studies have been performed in specific populations (disease, age, setting; see overview in Table 2); some of the new studies will be discussed in more detail below.

Cancer

In pediatric cancer, malnutrition is still a common complication and is related to outcome [22–25]. A recent single-center study [26²³] showed that performing a nutritional screening score had added value on top of anthropometric measurements only. Moreover, it is one of first studies to show a relationship between mortality, readmission rate, and nutritional status/risk. The study recruited 126 newly diagnosed cancer patients aged 3–18 years over a period of 5 years, and used STRONGkids to assess nutritional risk at diagnosis. The risk score was evaluated not only against nutritional status parameters (BMI z-score) but also importantly against outcome parameters such as survival and number of hospitalizations because of febrile neutropenia. At diagnosis, 28.6% of patients were at high risk of malnutrition, whereas 4.7% others were malnourished (BMI Z-score ≤ -2.0). The risk of mortality and the rate of infections (\geq three hospitalizations for febrile neutropenia episodes) were significantly increased by malnutrition and rapid weight loss in the initial phase of treatment (3–6 months after diagnosis). The authors concluded that personalized evaluation of nutritional risk at diagnosis and close monitoring of nutritional status during the initial phase of treatment are crucial for ensuring appropriate intervention. This may potentially improve tolerance to chemotherapy and survival, and prevent prolonged hospitalization for infections in childhood cancer patients.

Another study in 70 pediatric patients (aged 1 month to 18 years) with recent cancer diagnosis [27] looked at the usefulness of a simplified and adapted version of the adult patient-generated

Table 2. Overview of nutritional screening tools used in specific pediatric populations (diagnoses, settings, and age; 'X' and names in bold font refer to the recent studies that came out in the review period; 'x' refers to previously published studies)

	PNRS	STAMP	PYMS	STRONGkids	SGNA	iNews	Other
Diagnoses							
Anesthesia	x[31]						
Biliary atresia				x[30]			
Burns		x[29 ^a]	x[29 ^a]	x[29 ^a]			
Cancer				x[26 ^{a,b}]	x (PG-SGA) [27]		SCAN tool [43]
Cerebral palsy					x[44]		Malnutrition Risk Score [45]
Cystic fibrosis							2 NST [46,47]
IBD		x[48]	x[48]	x[48]			
Spinal cord injury		x[49]/x[50]					
Surgical patients				x[51]			
Setting							
Chronic illness (mixed)-special schools				x[52]			
Ambulatory clinic		x[53]					
Age							
Infants		x[54]		x[36]	x[35]	x[33 ^{a,b}]	NNST[55]

iNews, Infant Nutrition Early Warning Score; NNST, Neonatal Nutritional Risk Score; PG-SGA, Patient-generated Subjective Global Assessment; PNRS, Pediatric Nutritional Risk Screening; PYMS, Pediatric Yorkhill Malnutrition Score; SCAN, Nutrition Screening Tool for Childhood Cancer; SGNA, subjective global nutritional assessment; STAMP, Screening Tool for the Assessment for Malnutrition in Pediatrics; STRONGkids, Screening Tool for Risk on Nutritional Status and Growth.

subjective global assessment (PG-SGA) [28] to identify nutritional risk. The PG-SGA consisted of information about weight, height, food intake, gastrointestinal symptoms, functional capacity, physical exploration, and also the presence of ascites and edema. It divided the patients into four groups: well nourished (78.6%), mildly (17.1%), moderately (4.3%), and severely (0%) malnourished. The authors concluded that the PG-SGA is a valid tool because the correlations and the concordance between the PG-SGA, and anthropometric indicators were moderate and significant.

Burns

A prospective study [29^a] assessed the nutritional risk of 100 children hospitalized with acute burn injuries and their associated clinical outcomes using STRONGkids, PYMS, and STAMP. The screening tools identified varying percentages of high-risk patients (16, 45, and 46% by STRONGkids, PYMS, and STAMP, respectively). Interestingly, after adjusting for confounding factors, high-risk patients using either tool had significantly longer median LOS and greater median weight loss. Worse-than-average clinical outcomes were better predicted by the NRS tools than BMI z-score and burn severity.

Biliary atresia

In a study [30] among 106 patients diagnosed with biliary atresia type III, which aimed to explore the effect of preoperative nutritional status on cholangitis of a Kasai portoenterostomy, STRONGkids identified 46.2% of patients with moderate nutritional risky and 53.8% patients with high risk preoperatively. The moderate-risk group had shorter postoperative LOS than the high-risk group, later initial occurrence of postoperative cholangitis and lower incidence of early cholangitis compared to the high-risk group. The ratio of jaundice clearance and 2-year native liver survival were significantly higher in moderate-risk group than in high-risk group.

Patients undergoing general anesthesia

A large French cross-sectional observational study including 985 patients (<18 years) aimed to estimate the frequency of malnutrition and identify associated factors in children undergoing anesthesia [31]. Malnutrition rates were found to be 7.6, 8.1, and 11% when based on Waterlow index below 80%, clinical signs, and when defined by a BMI less than P3, respectively. In multivariate analysis, a premature birth, a lower birth weight, and a

higher Pediatric Nutritional Risk Score [32] were significantly associated with a higher odds of malnutrition when defined by BMI. No information was given on the outcome of the patients or on association between nutritional risk/status and outcome.

Infants

Because malnutrition during infancy can have long-term adverse consequences for both physical and psychological development, and most previously described screening tools exclude infants and children below 30 days of age (STRONGkids, PediSmart) or under 1 year (PYMS) or 2 years (STAMP) of age, there is interest in looking at infant age separately. Recent studies in infants have used three different nutritional risk tools, that is, newly developed Infant Nutrition Early Warning Score (iNews) [33²²], SGNA [34], and STRONGkids [10]. The iNews tool [33²²] was studied in 499 hospitalized infants in the United Kingdom, Greece, and Iran, and aimed to develop a tool to identify sick infants in need of dietetic input. Simple screening questions were used in the UK cohort to formulate iNEWS, which was then validated in the other groups. Based on dietetic assessment, 9.6 and 22% of UK and Greek infants, respectively, were rated as needing dietetic input. Being underweight, having poor weight gain/loss, and reduced intake were all independent predictors of perceived need for dietetic input. The iNEWS based on these items had 84% sensitivity, 91% specificity, and 49% positive predictive value to predict need for dietetic input in the UK cohort, which seems promising. In another study, 110 hospitalized infants were investigated using SGNA and z-scores based on anthropometric measurements [35]. Based on SGNA, 27.3% were classified as moderately malnourished and 1.8% as severely malnourished, whereas acute (WFL z-score < -2) and chronic (LFA z-score < -2) malnutrition was found in 16.4 and 3.6%, respectively. Lower z-scores were found in infants identified as malnourished using SGNA. Decrease in serial weight, having prolonged gastrointestinal symptoms, and reduced nutrition-related functional capacity were associated with malnutrition after adjusting for other factors.

Another cross-sectional study performed in 500 hospitalized children aged below 3 years in a children's hospital in Egypt found that 37.8% of patients were high risk according to STRONGkids, 62.4% were underweight, 58.4% were stunted, and 57.8% were wasted according to WHO criteria [36]. The STRONGkids score was found to be higher among those who deteriorated in nutritional status, which, together with its significant positive

correlation with the duration of hospital stay, emphasized that STRONGkids score could be a predictive tool.

SCREENING AND HOSPITAL NUTRITION CARE PROCESS

Nutritional screening is considered a key part of the hospital nutrition care process and pediatric nutritional care algorithm [37]. A number of recent studies have focused on the organizational aspect of nutritional screening, focusing on auditing local or national practices [38,39²³,40], describing barriers hindering optimal nutrition care [39²³,40,41], and propositions to simplify or improve current practices [38,39²³,42]. In a 1-day cross-sectional audit, it was found that only 17% of the 113 admitted children had all phases ('diagnosis,' current intake, anthropometry) of their NST, which is an adapted version of the STAMP, completed. The authors identified the acquisition and plotting of growth parameters as one of the barriers (although compliance with height measurements were significantly improved compared to similar audits 5 years and a decade ago) and implemented automatically calculated z-scores into their electronic medical record system as a response to this. Furthermore, the use of a 'score' for nutritional screening was abandoned and replaced by clinical assessment in the hope of including the whole team into the screening process [38]. A Belgian study investigated their nutrition care process and more specifically their locally designed 'EvalNut' software program that combines the use of the PNRS screening tool with recommendations for nutritional management, including weekly follow-up [39²³]. When reviewing the nutritional care data of 2657 pediatric inpatients, 35% of the evaluations were found to be incomplete or incorrect due to ambiguity of entrance data required for the software, missing/erroneous anthropometric recordings and too demanding nature of the amount of input needed. Simplification measures (reduction of the amount, internal validation and standardization of input needed, integration into the electronic medical health records, and automated alerts) were proposed to improve compliance.

A nationwide survey sent out to all members of the Korean Society of Pediatric Gastroenterology, Hepatology and Nutrition working in pediatric inpatient care revealed that only 52.5% of 40 participating hospitals had a nutrition support team [40]. Nutritional screening practices were less commonly performed for pediatric (55% of the centers) than adult patients (65.8% of the centers). Most pediatric centers used a locally developed screening tool, although two centers implemented a validated screening tool (PNRS

and STRONGkids). The survey identified a lack of time and manpower, inexperience, low financial reimbursement for nutrition care, and unavailable resources as the main barriers for nutritional support [40]. The same main barriers were named in a multicenter international survey among 693 pediatric gastrointestinal doctors and dietitians: low staff awareness on nutrition, lack of time and lack of local guidelines for nutrition screening, but also the absence of local guidelines or policy to screen [41]. This survey also showed that overall only 23% of the responders used validated nutritional screening tools in their clinical practice, although depending on the country, this could go up to 50%.

Most recently, the impact of the introduction of STAMP on nutritional status awareness among the medical staff was investigated by interpreting nutrition-related and anthropometric data from 182 medical records before and after implementing STAMP. No significant increase in acquisition of anthropometric data was found and moreover, virtually none of the patients were getting height measurements before or after the introduction of STAMP [42]. This shows that implementing a screening tool is not enough to acquire a mentality change in daily practice. It needs to be imbedded in a broader package of measures and training for the entire medical staff.

CONCLUSION

Over the past years, three NSTs used for children admitted to hospital were most frequently cited: PYMS, STAMP, and STRONGkids [10–12]. Although these published tools have shown their clinical use, these and other NSTs are studied in disease-specific populations, and are being refined or further developed for specific groups (infants) or populations (Chinese). All studies about previously and newly developed tools have shown their usefulness but also their limitation in clinical practice. There are numerous barriers hindering the routine use of NSTs, which hinders also appropriate nutritional support. Creating further awareness and simplification of the overall nutritional care process, which may include a NST, seems to be very important and the focus of future studies in order to improve nutritional care in hospitals.

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Conflicts of interest

There are no conflicts of interest.

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- of special interest
- of outstanding interest

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