

# Accuracy of Nutritional Screening Tools in Assessing the Risk of Undernutrition in Hospitalized Children

\*Koen Huysentruyt, \*Thierry Devreker, †Joachim Dejonckheere, \*Jean De Schepper, \*Yvan Vandenplas, and ‡Filip Cools

## ABSTRACT

**Objective:** The aim of the present study was to evaluate the predictive accuracy of screening tools for assessing nutritional risk in hospitalized children in developed countries.

**Methods:** The study involved a systematic review of literature (MEDLINE, EMBASE, and Cochrane Central databases up to January 17, 2014) of studies on the diagnostic performance of pediatric nutritional screening tools. Methodological quality was assessed using a modified QUADAS tool. Sensitivity and specificity were calculated for each screening tool per validation method. A meta-analysis was performed to estimate the risk ratio of different screening result categories of being truly at nutritional risk.

**Results:** A total of 11 studies were included on  $\geq 1$  of the following screening tools: Pediatric Nutritional Risk Score, Screening Tool for the Assessment of Malnutrition in Paediatrics, Paediatric Yorkhill Malnutrition Score, and Screening Tool for Risk on Nutritional Status and Growth. Because of variation in reference standards, a direct comparison of the predictive accuracy of the screening tools was not possible. A meta-analysis was performed on 1629 children from 7 different studies. The risk ratio of being truly at nutritional risk was 0.349 (95% confidence interval [CI] 0.16–0.78) for children in the low versus moderate screening category and 0.292 (95% CI 0.19–0.44) in the moderate versus high screening category.

**Conclusions:** There is insufficient evidence to choose 1 nutritional screening tool over another based on their predictive accuracy. The estimated risk of being at “true nutritional risk” increases with each category of screening test result. Each screening category should be linked to a specific course of action, although further research is needed.

## What Is Known

- The American Society for Parenteral and Enteral Nutrition and the European Society of Pediatric Gastroenterology, Hepatology, and Nutrition have recommended screening for undernutrition in hospitalized children.
- Different screening tools have been developed, but no consensus has been reached on which to use in clinical practice.

## What Is New

- This is the first systematic review to investigate the diagnostic performance of pediatric nutritional screening tools, which identified 4 validated screening tools.
- There is insufficient evidence to choose 1 nutritional screening tool over another based on their predictive accuracy.
- Results from our meta-analysis suggest that each screening category should be linked to a specific course of action.

**Key Words:** child, hospitalized, malnutrition, screening tool, systematic review, undernutrition

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From the \*Department of Pediatrics, Universitair Ziekenhuis Brussel, Vrije Universiteit Brussel (VUB), Brussels, the †SGS Life Science Services, Mechelen, and the ‡Department of Neonatology, Universitair Ziekenhuis Brussel, Vrije Universiteit Brussel (VUB), Brussels, Belgium.

Address correspondence and reprint requests to Koen Huysentruyt, MD, Department of Pediatrics, Universitair Ziekenhuis Brussel, Vrije Universiteit Brussel (VUB), Laarbeeklaan 101, 1090 Brussels, Belgium (e-mail: Koen.Huysentruyt@uzbrussel.be).

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The awareness of undernutrition in hospitalized children has increased in the last 2 decades (1). Depending on regional differences and definitions, a prevalence ranging from 2.5% to 13% has been reported for acute undernutrition in developed countries (2–9). In developing countries, the prevalence of undernutrition is much higher and mainly because of primary undernutrition. Risk factors in these countries are mainly linked with food insecurity and poverty (10), whereas disease-related undernutrition is the leading cause in developed countries (1).

It is the pediatricians' responsibility to accurately and timely detect undernutrition. A thorough anthropometric assessment is however time-consuming and is not always interpreted correctly, whereas the reproducibility of clinical judgment alone in the assessment of the nutritional status is unreliable (11). Furthermore, the nutritional status on admission does not always correlate with the actual “nutritional risk,” that is, the risk of subsequent disease-related nutritional deterioration (9,12). Therefore, international organizations such as the American Society for Parenteral and Enteral Nutrition (ASPEN) and the European Society of Pediatric

Gastroenterology, Hepatology, and Nutrition have recommended nutritional screening (13,14).

Guidelines for the development of nutritional screening tools stated that they should consider the present condition, stability, and expected progression of the condition and the influence of the disease process on the nutritional status; the screening result should also be linked with a specific course of action (15). Different pediatric nutritional screening tools have been developed (12,16–18). The absence of a golden standard to define undernutrition, however, and more important, to define nutritional risk in pediatric patients has led to different approaches in validating those screening tools (19). Consequently, a consensus regarding which screening tool to use for hospitalized children has not been reached. The aim of this review was to summarize the evidence on the validity of presently existing nutritional screening tools for the assessment of nutritional risk in hospitalized children in developed countries.

## METHODS

### Search Strategy

MEDLINE, EMBASE, and Cochrane Central databases were searched for original research studies on nutritional screening tools in hospitalized children, using a structured and comprehensive search strategy. The search was last updated on January 17, 2014; no language or time restrictions were applied in the search. Because nutritional screening and assessment are often used interchangeably in literature (20), we included both the terms in our search strategy, which is presented in supplementary file 1 (<http://links.lww.com/MPG/A467>). One author (K.H.) also hand searched the references from included articles and narrative reviews (19,21) to identify additional publications. Finally, a panel of international experts in the field was contacted with the question whether they were aware of any other existing articles.

### Study Selection

The results from the search strategy in each database were loaded into the reference software (Endnote X5; Thomson-Reuters, New York, NY). Duplicates were eliminated, and all author and journal names were removed to minimize bias in the selection process. Only reports on original research about nutritional screening tools in hospitalized children were deemed eligible for inclusion. Studies were considered for inclusion if the study population contained hospitalized children in a developed country (as defined by the International Statistical Institute (ISI), based on the country's gross national income (22)), nutritional risk was assessed through some kind of nutritional risk scoring system, and a comparison of this scoring system was made with a reference standard for assessing nutritional risk. Articles were excluded if they met  $\geq 1$  of the following exclusion criteria: the report was only available in abstract form; the report was not original research (eg, review article, case report, position paper); the study was only on overnutrition and did not include undernutrition.

In a first phase, 1 author (K.H.) excluded studies that clearly did not meet the inclusion criteria based on reading the title alone. In a second phase, 2 authors (K.H. and T.D.) evaluated the abstracts of the remaining articles independently and were blinded for author and journal names. Disagreements were resolved by consensus. Finally, all remaining full-text articles were judged independently by 2 authors (K.H. and J.D.S.) on eligibility for inclusion. To overcome the confusion about the differentiation between nutritional screening and nutritional assessment (20), we relied on ASPEN's definitions of both the topics. They defined nutritional

screening as "a process to identify an individual who is malnourished or who is at risk for malnutrition to determine if a detailed nutritional assessment is indicated," as their definition of nutritional assessment focused on categories of data needed for full identification of nutritional problems (23). Therefore, every tool or questionnaire that required an extensive clinical examination, additional blood parameters, or any other additional investigation was considered to be a tool or questionnaire about nutritional assessment and thus was excluded from this review. Next, in the phase of detailed assessment of the articles, articles could be excluded if the reference standard that was used to validate the nutritional screening tool was not considered a direct assessment of nutritional risk. Although the association between the length of hospital stay and the nutritional status of children is well known (4,8,24), we did not consider the duration of hospital stay as a direct assessment of nutritional risk because it can be influenced by many other factors, and a causative relation has not been shown.

### Assessment of Study Quality and Risk of Bias

Methodological quality and risk of bias of included studies were assessed independently by 2 authors (K.H. and F.C.) using the Cochrane version of the QUADAS (Quality Assessment of Diagnostic Accuracy Studies) tool for diagnostic test accuracy (25). In the QUADAS tool, a number of methodological items are evaluated regarding the selection of study patients, the application of the index test (nutritional screening tool), the choice and application of the reference standard, and the timing of both the tests, to assess both the risk of bias and the possible concerns about applicability. Results of the QUADAS tool are expressed as a high, unclear, or low risk of bias and a high, unclear, or low level of applicability concern (25).

### Data Extraction and Handling

Two authors (K.H. and Y.V.) independently extracted data from the included articles based on a predesigned data extraction form on the following variables: name of the screening tool; scoring system of the screening tool; population size; age of the population; disease of the study population; any outcome measure regarding the detection of acute and chronic malnutrition; any outcome measure regarding the detection of  $>2\%$  weight loss during hospitalization; any outcome measure regarding the detection of the risk of nutrition interventions during hospital stay; any outcome measure regarding the detection of the risk of disease-related complications. Discrepancies were resolved by consensus. When data were missing or unclear in the published article, authors were contacted for additional information.

### Statistical Analysis

Estimates of sensitivity and specificity with their 95% confidence intervals (CIs) were calculated for each screening method using RevMan version 5.2 (Copenhagen, Denmark). In order to estimate the overall performance of nutritional screening tools to correctly identify children who are at nutritional risk, a meta-analysis was performed combining those studies that validated screening tools in a general, nondisease-specific population, thereby comparing the low versus moderate and the moderate versus high-risk screening categories. If multiple screening tools were studied on the same study population, only 1 screening tool was included in the meta-analysis to prevent artificial increase of the population size. Based on the assumption that clinical heterogeneity between studies, that is, differences in study population, nutritional screening tool, and/or reference test, would exist, a

random effects model was used. A summary relative risk of being truly at nutritional risk and its 95% CI was calculated. Heterogeneity was considered to be statistically significant if the test for homogeneity yielded a  $P$  value  $<0.1$ . The proportion of heterogeneity that is because of true differences between studies is expressed as  $I^2$ . An  $I^2$  of  $>50\%$  means that a considerable proportion of the observed variation between study results is because of true heterogeneity instead of random variation. The meta-analysis was performed using Comprehensive Meta-Analysis version 2.2 (Biostat, Englewood, NJ).

## RESULTS

### Search Results

Our search strategy yielded 15,967 records: 2209 articles from the Cochrane Central database, 9458 articles from EMBASE, and 4300 articles from MEDLINE. Hand searching of the reference lists and expert contacts yielded 1 extra article each (26,27). The flow diagram of the study selection process is shown in Figure 1. In total, 54 full-text reports were assessed, of which 36 were excluded: 3 did not contain any (separate) data on children (28–30); 18 were conference abstracts (31–47); 1 article was a report on the translation of a screening tool (48); 1 article was a study protocol (49); 2 studies were performed in developing countries according to the ISI classification (50,51); 9 articles were about methods of nutritional assessment instead of nutritional screening (13,52–59); 1 study contained duplicate data (60); 1 article was a report assessing the effect of nutritional screening on the acquisition of anthropometric measurements (61). Finally, 18 studies were included describing  $\geq 1$  of the following screening tools: Reilly Nutrition Risk Score (NRS) (2,62–64), the Pediatric Nutritional Risk Score (PNRS) by Sermet-Gaudelus et al (12,26,65,66), McCarthy Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP) (16,18,26,66–70), the Paediatric Yorkhill Malnutrition Score (PYMS) developed by Gerasimidis et al (16,26,69–71), and the Screening Tool for Risk on Nutritional Status and Growth (STRONG<sub>kids</sub>) by Hulst et al (17,26,27,68,69,72). The studies that were included in the qualitative synthesis are listed with their validation methods in supplementary file 2 (<http://links.lww.com/MPG/A468>).

### Risk of Bias and Quality Assessment

A total of 7 studies were excluded for further quality assessment (2,26,27,62–64,66) because they did not provide a validation of the screening tool for predicting the nutritional risk and thus did not meet the review question. Of these reports, 5 used the NRS to assess nutritional risk in their study populations (2,62–64). These articles were not designed to validate the NRS, but instead as observational studies describing the nutritional risk in their populations. The study by Sikorová et al (66) also describes the nutritional risk in a Czech population, as assessed by the PNRS and STAMP screening tool, without comparison with a reference standard. One Italian study compared the STRONG<sub>kids</sub> with weight for height and height for age  $z$  scores on admission, in 11 secondary and 1 tertiary centers (27). Wiskin et al (26) compared the weight for age  $z$  score of inpatients and outpatients suffering from an inflammatory bowel disease with 4 screening tools.

The results of the risk of bias assessment of the remaining 11 studies are summarized in supplementary file 3 (<http://links.lww.com/MPG/A469>). There was a marked variation between studies in the reference tests that were used to validate the studied screening tool. They included weight loss during hospitalization/treatment (12,17,72), the clinical decision for referral to a dietician (69), a full dietetic assessment (16,18,67), and the clinical decision to institute

a nutritional intervention (68,72). Because it is unknown to what extent the choice of the reference standard affects the results of the included studies, the risk of bias was considered to be unclear. Bias in patient selection was of concern in 2 reports, which used a nonconsecutive patient recruitment (16,71). One of these was the study by Gerasimidis et al (71), which was designed to test the performance of the PYMS in clinical practice. Because of the design of this study, in which only children with a PYMS score  $\geq 2$  were referred for dietetic assessment, a calculation of sensitivity and specificity from these data was not possible. This led us to exclude this article from the quantitative analysis. Two studies focused on children with specific diseases (65,70), leading to applicability concerns of the patient selection, and were therefore not included in the quantitative analysis. No major applicability concerns were present in any of the other studies.

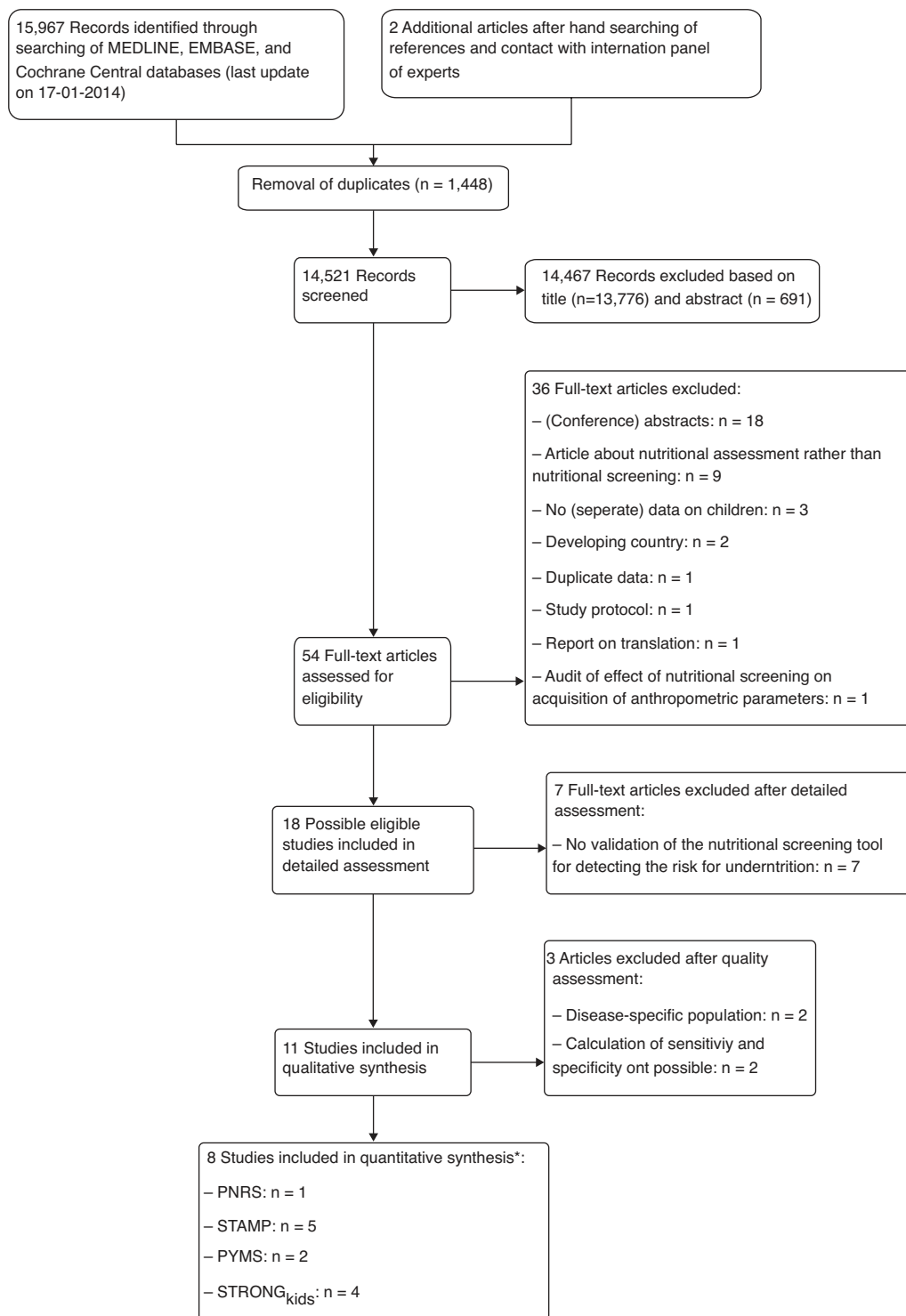
### Capability of Pediatric Nutritional Screening Tools to Assess Nutritional Risk

The sensitivity and specificity of each screening tool for predicting nutritional risk in mixed pediatric populations are presented in Figure 2. A direct comparison of the screening tools per reference standard was not possible because the number of studies was too low to perform separate meta-analyses. A visual analysis of the different plots suggests however that the same screening tool reproduces similar results in different populations. Clearly, sensitivity and specificity differ greatly when different cutoff values are applied. Moeeni et al found a higher specificity for dietetic referrals in the high-risk category of the STRONG<sub>kids</sub> compared with the PYMS and the STAMP, and a lower sensitivity in the low-risk category of the PYMS compared with the STAMP and the STRONG<sub>kids</sub>.<sup>69</sup>

A random effects model was used to calculate a summary relative risk of being truly at nutritional risk. The forest plot is presented in supplementary file 4 (<http://links.lww.com/MPG/A470>) and shows the estimated risk ratio per combination of reference test, nutritional screening tool, and study with the 95% CI. The risk ratios could not be calculated for the study by Gerasimidis et al (16), validating the PYMS, because the authors used 3 categories in their reference standard. In total, 1629 children were included in our model. Using this random effects model, the summary effect estimate revealed that the “true nutritional risk” is significantly lower in the low- versus moderate-risk group (risk ratio [RR] 0.349, 95% CI 0.156–0.780) and in the moderate- versus high-risk group (RR 0.292, 95% CI 0.194–0.441). For both the models, there was a statistically significant heterogeneity ( $P$  values for homogeneity 0.022 and 0.023, respectively), and a large proportion of the observed variation was because of true differences between the studies ( $I^2 = 59.5\%$  and  $59.0\%$ , respectively). In the study by Hulst et al, the “true nutritional risk” appeared, in contrast to what would be expected, to be 4-fold higher in the moderate-risk group as compared with the high-risk group (RR 4.29). There was a very wide 95% CI, however, with this estimate (0.269 up to 68.499). To test the robustness of our meta-analysis with respect to individual study results, we performed a post hoc sensitivity analysis in which we repeated the random effects model each time with 1 different study removed (supplementary file 5, <http://links.lww.com/MPG/A471>). This demonstrated that no single study had a sole impact on the meta-analysis result.

## DISCUSSION

This is the first systematic review evaluating the accuracy of nutritional screening tools for predicting nutritional risk in hospitalized children in the developed world. We identified 4 pediatric

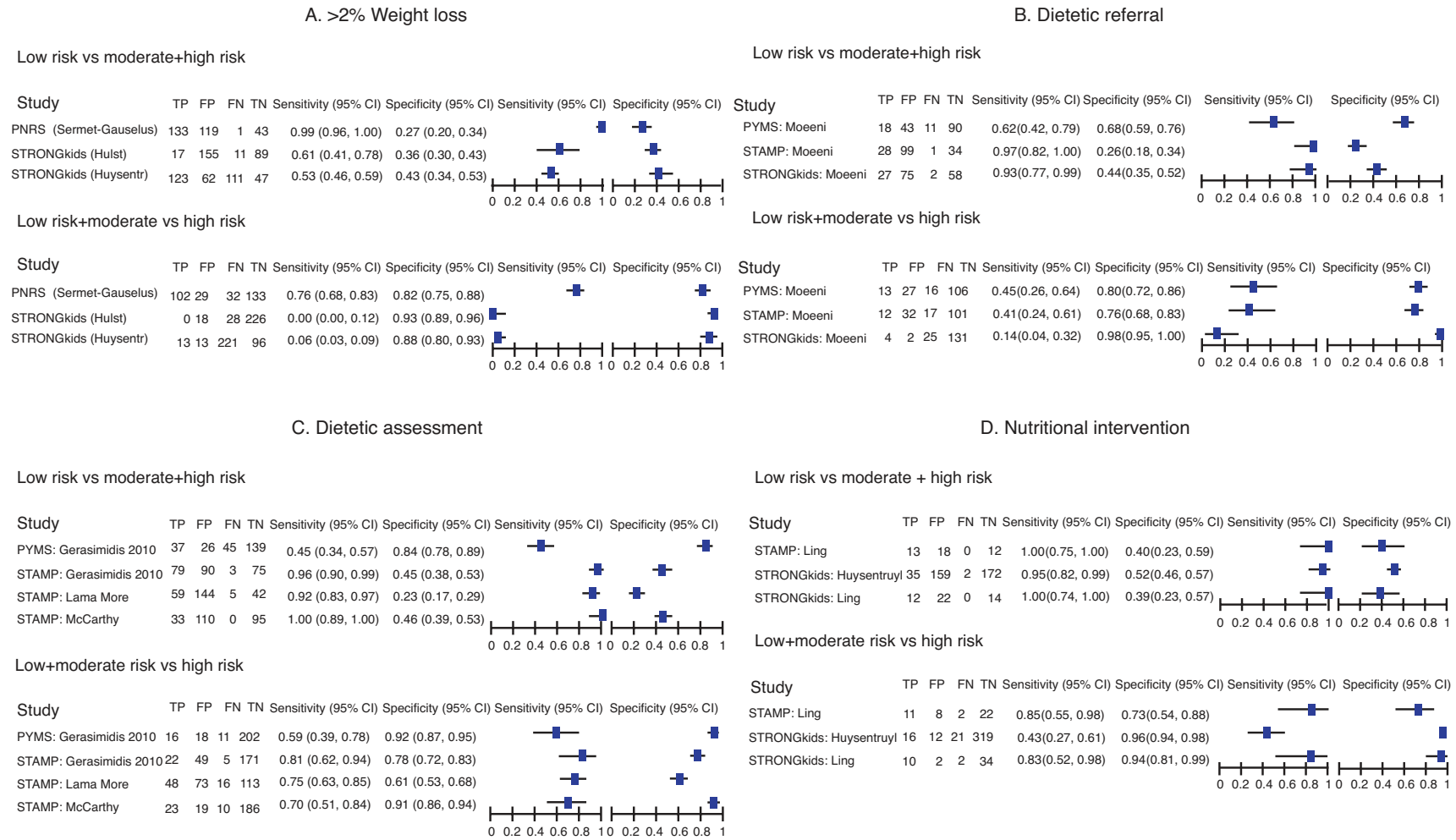


**FIGURE 1.** Study flow diagram. PNRS = Pediatric Nutritional Risk Score; PYMS = Paediatric Yorkhill Malnutrition Score; STAMP = Screening Tool for the Assessment of Malnutrition in Paediatrics; STRONG<sub>kids</sub> = Screening Tool for Risk on Nutritional Status and Growth.

nutritional screening tools (PNRS, STAMP, PYMS, and STRONG<sub>kids</sub>) of which the predictive accuracy has been studied. A schematic overview of these screening tools is provided in supplementary file 6 (<http://links.lww.com/MPG/A472>). Presently, there is insufficient evidence to support the use of the NRS to assess nutritional risk in children, which is a score derived from the Nutritional Risk Index (73)

by Reilly et al (30). Different studies have investigated its concurrent validity (2,62–64), but none have investigated its predictive validity so far.

A formal comparison of the 4 screening tools with respect to their predictive accuracy was not possible because of a marked variation in the reference standards that were used in the studies.



**FIGURE 2.** Sensitivities and specificities of the nutritional screening tools per reference standard, using different cutoff values. CI = confidence interval; FN = false-negative; FP = false-positive; PNRS = Pediatric Nutritional Risk Score; PYMS = Paediatric Yorkhill Malnutrition Score; STAMP = Screening Tool for the Assessment of Malnutrition in Paediatrics; STRONG<sub>kids</sub> = Screening Tool for Risk on Nutritional Status and Growth; TN = true-negative; TP = true-positive.



This variation reflects a present lack of consensus about the optimal way of assessing nutritional risk in children. Only 3 studies assessed >1 screening tools on the same population (16,68,69). Gerasimidis et al (16) preferred the PYMS over the STAMP because it produced fewer false-positive results in the high-risk screening group when compared with a full dietetic assessment. Using the clinical decision to institute a nutritional intervention as a reference standard, Ling et al (68) favored the STRONG<sub>kids</sub> over the STAMP, also because of the lower number of false positives in the high-risk screening group, while both the screening tools did not misclassify any child in the low-risk screening group. Moeeni et al (69) preferred the STRONG<sub>kids</sub> over the STAMP and the PYMS, mainly because of its ability to identify all children with a weight for height, height for age, or BMI  $z$  score  $< -2$  as moderate or high risk, which was not considered a true validation of nutritional risk in our review. So, present evidence does not support the selection of 1 specific screening tool as the most accurate one for clinical practice. This means that pediatricians will rely on other criteria when selecting their preferred screening tool, such as interrater reliability, ease of use, and time required to complete the tool. In their original study, Gerasimidis et al (16) reported a moderate agreement between nurses and dietitians for the PYMS ( $\kappa = 0.46$ , 95% CI 0.27–0.64). The STRONG<sub>kids</sub> had a slightly better interrater agreement between nurses and pediatricians ( $\kappa = 0.61$ , 95% CI 0.39–0.81) in a small pilot group (72). Recently, a Spanish study of 223 children confirmed the substantial interrater agreement between experts and nonexperts for the STRONG<sub>kids</sub> ( $\kappa = 0.72$ , 95% CI 0.63–0.80) and reported on similar results for the STAMP ( $\kappa = 0.74$ , 95% CI 0.67–0.81) (74). Moeeni et al (69) reported an almost perfect agreement between 2 assessors in a small group of 15 children for the PYMS, STAMP, and STRONG<sub>kids</sub> ( $\kappa = 0.89$ –0.93). No data on interrater agreements for the PNRS have been reported (74). Data on the ease of use and speed of administration have been summarized elsewhere (21). Moeeni et al (75) reported that the STRONG<sub>kids</sub> was easier to apply in their study, as this tool does not include the patient's weight and height. Gerasimidis et al (76) reported a suspected learning effect for the application of the PYMS because significantly more nurses who did not attend a training session took >5 minutes to complete the tool than those who did (29% vs 9%, respectively,  $P = 0.036$ ).

There has been some debate among experts on what the most appropriate cutoff point of those screening tests is to determine whether a child is nutritionally at risk. Some have considered only children screened at high risk to be truly at nutritional risk (18,67,71), whereas others combined the moderate- and high-risk categories (69,72). We have shown that the choice of the cutoff point will have great influence on the screening tools' performance, and that neither cutoff point provides a favorable balance between

sensitivity and specificity. Our meta-analysis also suggests that linking each outcome category of the screening test to a separate course of action might be the preferable mode of action (15). These results, however, should be interpreted cautiously. On one hand, there was substantial and statistically significant heterogeneity between studies, with 3 of the 7 included studies not showing significant differences between different screening categories. This was probably because of the wide variation between studies in the use of reference standards and screening tools under evaluation. On the other hand, the pooled risk ratios are robust and do not seem to be dominated by a single study result. Last, because the study on the PNRS has been performed >1 decade before the other studies included in the meta-analysis, one could argue that it has no longer a place in our meta-analysis because the study population might no longer be compared with the present population. Because our sensitivity analysis showed that leaving this study out of the meta-analysis (supplementary file 5, <http://links.lww.com/MPG/A471>), however, did not change the outcome of the meta-analysis and because of the fact that some French speaking centers still use this screening tool in clinical practice, we believe that the study still has its relevance. Furthermore, research is needed to investigate whether the presently existing predefined actions (an overview is provided in Table 1) should be treated with different strategies.

One of the major strengths of this review is that we are confident that all existing studies have been found and, hence, selection bias is minimal. Second, we focused on studies that validated their screening tool against a measure of nutritional risk instead of a measurement of actual nutritional status, such as weight and height. This gives a better idea of how those screening tools perform in predicting undernutrition that might occur in the future.

This study also has some limitations. First, the methodological quality of included studies is only moderate, resulting in a certain risk of bias. This was mainly because of the heterogeneity in the choice of the reference standard. As we know, any bias present in the original studies will also be present in the systematic review and the meta-analysis. Because of this heterogeneity, we decided not to perform a direct comparison of test performance between studies. In addition, we accounted for this expected heterogeneity in our meta-analysis by choosing the random effects model. Second, research for pediatric nutritional screening tools is frequently done in studies with small sample sizes, which mandates caution when extrapolating these results for large groups. After our quality assessment, however, only 1 study with a sample size of <100 children remained (68). Last, although we are confident that we provided a complete overview of the literature up to the date of our search, we are aware of 1 additional study that was published after our last search update (77). The authors developed a computer-based screening tool, the PeDiSMART. In their validation study in a

TABLE 1. Predefined actions linked to screening result

	Low risk	Moderate risk	High risk
NRS	N/A	N/A	N/A
PNRS	None	Weight surveillance, report intake, consider dietetic consult	Nutritional assessment, monitor intake, consider nutritional intervention
STAMP	Repeat screening after 1 wk	Monitor intake for 3 days	Dietetic consult
PYMS	Repeat screening after 1 wk	Repeat screening after 3 days	Dietetic consult
STRONG <sub>kids</sub>	Repeat screening after 1 wk	Check weight 2 times per week, consider dietetic consult	Dietetic consult, strongly consider nutritional intervention

N/A = no predefined action available; light gray: no immediate action; dark gray: intensified monitoring; brown: dietetic consult. NRS = Nutrition Risk Score; PNRS = Pediatric Nutritional Risk Score; STAMP = Screening Tool for the Assessment of Malnutrition in Paediatrics; PYMS = Paediatric Yorkhill Malnutrition Score; STRONG<sub>kids</sub> = Screening Tool for Risk on Nutritional Status and Growth.

population of 500 Greek hospitalized children, they used a combination of weight loss during hospitalization and the implementation of nutritional support as the reference standard. Logistic regression analyses showed that not only the PeDiSMART, but also the STRONG<sub>kids</sub>, STAMP, and PYMS screening tools could significantly predict weight loss/nutritional support during hospitalization, which strengthens our conclusions even further.

Although studies have shown that some nutritional screening tools are capable of detecting nutritional risk in children from developed countries who need to be hospitalized, we could not find any evidence that nutritional screening actually improves their (nutrition related) outcome. There are some studies investigating the association between nutritional risk scores and the length of hospital stay, in developed (2,17,69,72) and developing (50,51,75) countries. Up to date, there are no studies proving a causal relation between nutritional screening and a decreased length of hospital stay. We recently suggested that future research should focus on demonstrating improved outcome of a nutritional screening program in hospitals that includes both screening and an associated nutritional intervention. In our opinion, a very relevant parameter could be the time interval until complete recovery at home, such as the resumption of normal daily school and leisure activities (78).

In conclusion, this review identified 4 nutritional screening tools (STAMP, PYMS, PNRS, and STRONG<sub>kids</sub>) that are validated to assess nutritional risk in pediatric hospitals in the developed world. The “true nutritional risk” was higher in the high versus moderate and the moderate versus low screening category. This finding supports the recommendation that different actions should be linked with different screening results, although further research is needed to validate these results. The choice of the cutoff values for considering a child nutritionally at risk will greatly influence the sensitivity and specificity of screening tools. There is presently insufficient evidence to choose 1 nutritional screening tool over the other. Therefore, other criteria will determine a pediatrician’s choice of which screening tool to use in clinical practice in accordance with the available resources and dietetic staff.

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