



Nutritional risk in pediatrics by StrongKids: a systematic review

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Abstract

Background/objective The nutritional risk in hospitalized children and adolescents is a frequent and under-diagnosed reality. There is still no consensus regarding the best nutritional screening method in pediatrics, with StrongKids being one of the existing proposals. A systematic review was performed to evaluate the scientific evidence about StrongKids, with emphasis on the world frequency of nutritional risk, associations of interest in health, validation and reproducibility studies.

Methods Databases Pubmed, Lilacs, Scielo, ScienceDirect, Web of Science, Scopus and Cochrane Library were searched, using keyword “StrongKids,” without limit on the year of publication, in English, Spanish, and Portuguese.

Results From 125 papers initially identified, 22 original were included in analysis. The sample size ranged from 43 to 2874, with a maximum of 44 hospitals. The frequency of nutritional risk (medium or high) ranged from 35.7 to 100%. The nutritional risk was mainly associated with acute and/or chronic malnutrition already installed, lower anthropometric indexes and longer length of hospital stay. The method presented satisfactory inter-rater and intra-rater agreements and was validated in the three studies performed with this proposal.

Conclusions The prevalence of nutritional risk in hospitalized children and adolescents is high. StrongKids is a valid, easy-to-use, and reproducible method, with significant associations of interest in health.

Introduction

Hospital malnutrition is a frequent and under-diagnosed reality worldwide [1]. Especially in pediatric patients, it is associated with impairment of growth, increased susceptibility to infections, longer length of hospital stay, increased hospital costs, and higher mortality [2, 3].

Nutritional screening consists of a practical, low-cost method that, applied at the bedside, is capable of preemptively identifying patients at nutritional risk who would benefit from early intervention, even before anthropometric deficits are identified by objective measures [4]. In adults and elderly, nutritional screening is well established, with

validated and internationally recommended methods for different clinical contexts. With regard to risk screening in children and adolescents, however, there is still no consensus and the available tools are still little used [5].

Currently, there are six nutritional screening methods available for hospitalized children and adolescents [5]: (1) Nutrition Risk Score (NRS) [6]; (2) Pediatric Nutritional Risk Score (PNRS) [7]; (3) Screening Tool for the Assessment of Malnutrition in Pediatrics (STAMP) [8]; (4) Subjective Global Nutritional Assessment (SGNA) [2]; (5) Paediatric Yorkhill Malnutrition Score (PYMS) [9]; and (6) Screening Tool Risk on Nutritional Status and Growth (StrongKids) [10].

StrongKids was developed by Hulst et al. [10] in a multicenter study in the Netherlands involving 44 hospitals and 424 children and adolescents (from 1 month to 18 years). The method evaluates important aspects that exert nutritional impact: the presence of high risk disease or major surgery planned; subjective loss of muscle or fat; decreased food intake; presence of diarrhea, nausea, vomiting and pain; weight loss or poor weight increase. Each item is assigned a score that, added, informs the presence of nutritional risk: 0 points: low risk (LR); 1–3 points: medium risk (MR); 4–5 points: high risk (HR). According to each category, the intervention and nutritional monitoring guidelines are

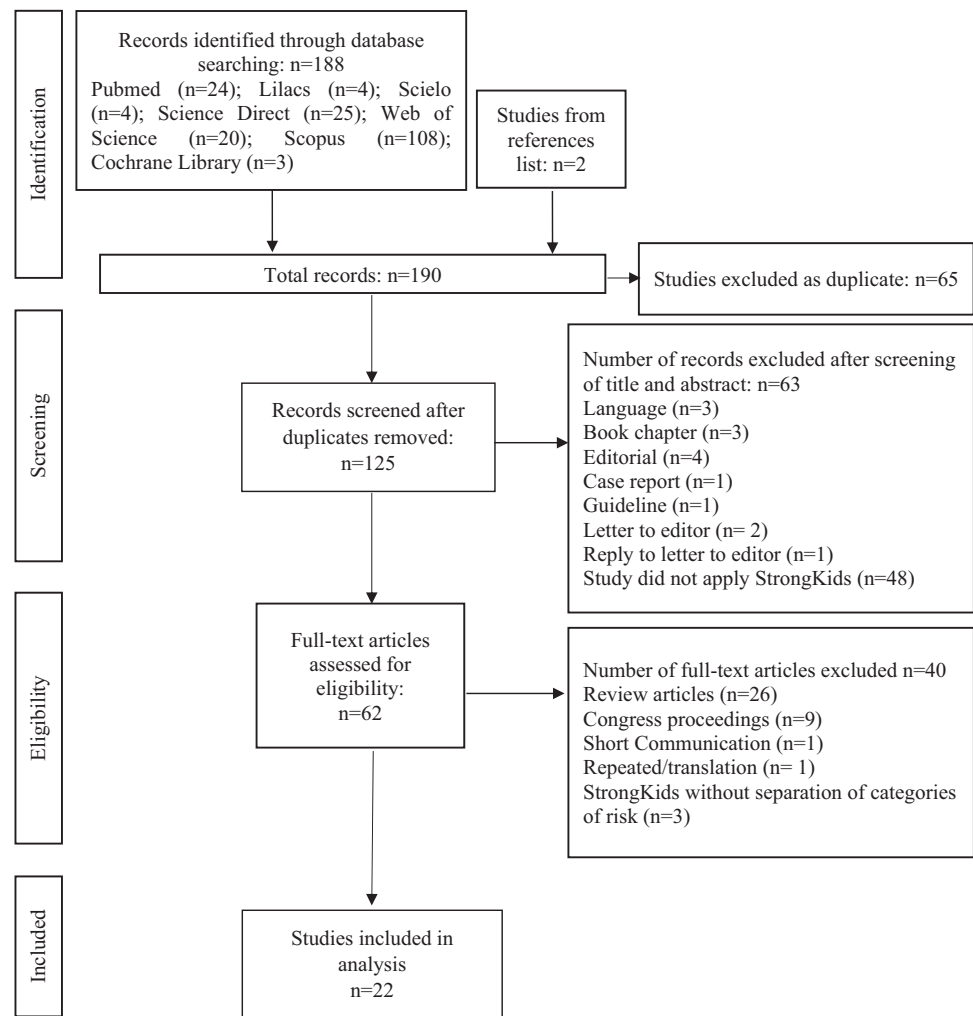
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Fig. 1 Flow chart of the literature search and study selection procedures, according to PRISMA recommendation



presented. The StrongKids questionnaire and the recommendations for intervention and follow-up are presented online in a supplementary table (Supplementary Table 1).

In a recent systematic review of the clinical performance and accuracy of different nutritional screening tools in pediatrics, StrongKids was considered a method of good clinical performance [11]. In another comparative study on the methodological aspects of the existing proposals, it was concluded that StrongKids seems to be the most practical, easy and reliable method to assess nutritional risk in this group [5]. It suggests its superiority among existing proposals, although there is still no method considered ideal for this purpose [5, 11, 12].

To choose a method of nutritional screening, it is necessary to evaluate its potentialities, mainly related issues associated with outcomes of interest in health, reproducibility and validity [4]. Furthermore, it is important to know the real magnitude of the problem, to justify actions of prevention, control, and monitoring. In this context, this systematic review aims to evaluate the available scientific evidence on StrongKids as a method of nutritional

screening, with the following specific purposes: (1) to know the prevalence of nutritional risk in children and adolescents evaluated by Strongkids; (2) to verify the association of nutritional risk assessed by this method with variables of interest in health; and (3) to evaluate the evidence of its validity and reproducibility.

Methods

The review was based on the recommendations of Preferred Reporting Items for Systematic Reviews (PRISMA) at all stages of design, implementation, and reporting [13].

Database and search strategy

The bibliographic survey was carried out on March 2018, in the following databases: Publisher Medline (PubMed), Latin American and Caribbean Center on Health Sciences Information (Lilacs), Scientific Electronic Library Online (Scielo), ScienceDirect, Web of Science, Scopus e

Table 1 Main characteristics of studies, frequency of nutritional risk according to categories of StrongKids and associations of interest in health

Author (year)	Country	Study design	Sample size (%M)	Age	Place of study	LR	MR	HR	Associations
Vallandro et al. [27]	Brazil	Cross-sectional	477 (55.9)	6.2 y ^a	1 hospital	27.7	64.4	7.8	HR: ↓ adductor pollicis muscle thickness
Beser et al. [16]	Turkey	Prospective observational	1513 (56.4)	4.4 y ^b	37 hospitals	47	49.4	3.6	HR: ↑ proportion of underlying chronic disease, LOS ↑ from LR to HR.
Oliveira et al. [30]	Brazil	Cross-sectional	71 (50.7)	5 y 2 m ^b	1 hospital	31.0	63.4	5.6	Correlation between HR vs. severe malnutrition and LR vs. the well-nourished, but the agreement was weak.
Bang et al. [17]	Korea	Prospective cross-sectional	100 (52)	7.6 y ^b	1 regional burn centre	0	84	16	HR: ↑ LOS, ↑ weight loss, ↑ incidence of at least one fever event, and ↑ incurred hospital expenses
Song et al. [15]	China	Prospective	2874 (67)	8.4 y ^a	1 hospital	0	80	20	Children with liver disease: HR: ↑ % of malnutrition, ↑ % of nutritional support, ↑ LOS, ↑ hospital expenses, ↓ serum albumin and prealbumin.
Li et al. [18]	China	Retrospective	106 (56.6)	MR: 64.9 d ^a HR: 61.8 d ^a	1 hospital	0	46.2	53.8	Children with biliary atresia: HR compared to MR: ↑ LOS, ↑ postoperative hospitalization time, ↑ incidence of precocious cholangitis, ↓ hemoglobin, ↓ serum albumin.
Galera-Martínez et al. [19]	Spain	Prospective observational	223 (53.4)	5.6 y ^a	5 hospitals	E: 33.1 NE: 46.2	E: 57 NE: 47.1	E: 9.9 NE: 6.7	↑ score: ↑ LOS (HR compared to MR and LR). HR: ↑ % of malnutrition according to BMI.
Chourdakis et al. [20]	12 European countries ^c	Prospective	2089 (56)	4.7 y ^b	14 hospitals	43.8	46.3	9.9	HR: ↓ MUAC, ↓ TFSF, ↑ LOS, ↑ % of nutritional support administration, ↑ % of fever and ↑ % of use of antibiotics.
Joosten et al. [31]	The Netherlands	Prospective	642 (60)	9.8 y ^b	9 special schools for chronically ill children	59.3	38.5	2.2	HR: ↑ % of acute, chronic and overall malnutrition. HR/MR: more problems on usual activities (attending school, sport and leisure activities, play, do things with family or friends) and pain/discomfort. LR: Higher VAS ^d compared to MR/HR.
Campos et al. [21]	Brazil	Cross-sectional	317 (56.5)	76.1 m ^a	1 hospital	24.6	67.5	7.9	↑ score: ↑ LOS; HR: ↑ % of malnutrition according to BMI; LR: ↑ parents' education and better socioeconomic status in children; significant, though weak, agreement between SK and anthropometry.
Costa et al. [22]	Brazil	Prospective	181 (66.3)	8.8 y ^b	1 hospital	28.7	55.3	16	↑ risk: ↑ LOS; HR: n° of hospitalization days 2x higher than LR.
Cao et al. [1]	China	Prospective	1325 (64.8)	3.1 y ^b	1 hospital	47.6	43.3	9.1	HR: ↑ LOS, ↑ weight loss during hospitalization, ↑ % of infectious complications, ↑ hospital expenses, ↑ % of malnutrition; ↑ % HR risk in children under 3 years and in those with heart, respiratory and oncological diseases. HR/MR: ↓ WFA, ↓ HFA, ↓ WFH, ↓ MUAC, and ↓ BMI than LR.
Durakbaşa et al. [28]	Turkey	Cross-sectional	494 (75.8)	59 m ^b	1 pediatric surgery unit of a tertiary hospital	64.3	34.5	1.2	HR/MR: ↓ HFA than LR HR: ↑ % of acute and chronic malnutrition.
Mărginean et al. [23]	Romania	Prospective	271 (55.4)	5.2 y ^b	1 hospital	42.4	33.9	23.7	HR: ↓ BMI, ↓ TFSF and ↓ MUAC; ↑ score: ↑ LOS and ↓ age.
Moeeni et al. [32]	New Zealand	Cross-sectional	162 (47)	1.8 y ^b	1 hospital	P: 25.9 N: 33.3	P: 63 N: 56.2	P: 11.1 N: 10.5	SK identified 84 and 90% of the malnourished (according to anthropometry) when applied by

Table 1 (continued)

Author (year)	Country	Study design	Sample size (%M)	Age	Place of study	LR	MR	HR	Associations
Moeeni et al. [24]	New Zealand	Cross-sectional	162 (51.2)	5.1 y ^b	1 hospital	37	59	4	nurses and paediatrician respectively; SK identified 25/29 children who were considered at risk of malnutrition by a nutritionist. HR: median LOS 2.24x greater than LR; HR: ↓BMI ↓WFH; HR/MR: ↑LOS four of six patients classified as HR lost weight during hospitalization.
Spagnuolo et al. [29]	Italy	Prospective observational	144 (52)	6.5y ^a	12 hospitals	32	53	15	HR: ↓HFA, ↓BMI; ↑ score: ↓HFA, ↓BMI; HR: ↑ % in <5y and ↑ % in children with gastrointestinal diseases.
Huysentruyt et al. [25]	Belgium	Prospective	R: 29 V: 368 (53.5)	R: 1.5 y ^b V: 2.2 y ^b	R: 1 hospital V: 4 hospitals	V: 47.3	V: 45.1	V: 7.6	↑ score: ↓WFH, ↑ LOS; HR/MR: ↑ % of acute malnutrition and need for nutritional intervention during hospitalization.
Moeeni et al. [26]	Iran	Cross-sectional	119 (53)	3.6 y ^b	1 hospital	41.2	55.4	3.4	HR: ↑ LOS; ↑ score: ↓WFH, ↓HFA; 50% of HR patients lost weight during hospitalization.
Wiskin et al. [33]	United Kingdom	Prospective observational	46 (54.3)	14.6 y ^b	1 pediatric gastroenterology service	0	58.7	41.3	Children with inflammatory bowel disease: SK identified all children who had moderate or severe malnutrition according to anthropometry, ↑ score: ↓ WFH, ↓ HFA, ↓ BMI, ↓ age.
Ling et al. [12]	United Kingdom	Prospective cross-sectional	43 (%M NA)	6 y 4 m ^a	1 hospital	24	49	27	↑ score: ↓ WFH; HR/MR: ↓ WFH, ↑ % of acute malnutrition and ↑ LOS.
Hulst et al. [10]	The Netherlands	Prospective observational	424 (63)	3.5 y ^b	44 hospitals	38	54	8	

% frequency, ↑ increase, ↓ reduction, %M % male, LR low risk, MR medium risk, HR high risk, y years, m months, d days, E experts (registered dietitians or physicians specialized in paediatric nutrition working in the Paediatric Nutrition Unit), NE non-experts (nonspecialized in nutrition nurses or paediatric residents who have never worked in a Paediatric Nutrition Unit), LOS length of hospital stay, BMI body mass index, MUAC midupper arm-circumference, TSF tricipital skinfold, HFA height-for-age, WFH weight-for-height, WFA weight-for-age, P paediatrician, N nursing staff, R reproducibility study, V validation study, NA frequency by category not available

^aMean

^bMedian

^cCroatia, Denmark, England, France, Germany, Greece, Israel, Italy, Netherlands, Poland, Romania, Scotland

^dVAS: visual analogue scale score, which represents the child's health in the past week, resulting in a score between 0 and 100, with a higher score representing a better health status

Table 2 StrongKids reproducibility studies

Author (year)	Methodology	Intra-rater agreement	Inter-rater agreement	Conclusions
Bang et al. [17]	SK applied by two pediatric trainees	NE	$k = 0.61^*$ (95% CI: 0.40–0.78)	Good agreement in classification between two different observers
Galera-Martínez et al. [19]	SK applied within 24 h of admission by one expert (dietitians or physicians specialized in pediatric nutrition) and one non-expert (nonspecialized in nutrition nurses or pediatric residents)	NE	$k = 0.72^{**}$ (95% CI: 0.63–0.80) 94.78% agreement	Substantial agreement between expert and non-expert staff. SK is reliable and reproducible, independent of the expertise of the examiner.
Moeeni et al. [32]	SK applied during the first day of admission by one of the 24 nursing staff and by a pediatrician.	NE	$k = 0.65$	SK provided a quick and reliable assessment of nutritional risk, with substantial agreement between the nursing and pediatrician assessments.
Huysentruyt et al. [25]	SK applied by two different nurses on the day of admission and the following day	$k = 0.66^*$ sum of risk points: $k = 0.60^*$	$k = 0.61^*$ sum of risk points: $k = 0.48^*$	SK is an easy-to-use and rapid screening tool, with substantial intra-rater and inter-rater reproducibility.

SK StrongKids, NE not evaluated in the study, CI confidence interval, k kappa index

* $p < 0.01$; ** $p < 0.001$

Cochrane Library. Hand searches were also performed of the references in the studies selected in order to identify non-localized papers in the databases, which were submitted to the same analysis protocol.

As a keyword, we have chosen to use the name method, “StrongKids,” since the term is used in its original form, regardless of the language of publication. The search was conducted in all fields of articles, including articles in English, Spanish, and Portuguese, without restriction as to the publication year.

Eligibility criteria and selection of studies

This review includes original articles that apply StrongKids as a tool for nutritional screening in children and/or adolescents. We excluded studies that did not present the frequency of risk estimates according to the categories of the method, as well as review studies, congress publications, theses, and dissertations.

The selection of the studies was carried out in two phases by two independent reviewers (Santos, CA and Ribeiro, AQ), including title/abstract analysis and full text reading. A third reviewer (Rosa, COB) resolved the disagreements. The steps included: identification of the articles in the databases, deletion of the duplicate files, initial selection by title and abstract reading, and complete analysis of the manuscripts that met the eligibility criteria. Articles duplicated in different databases were identified using the EndNote® program.

Systematization of results

The extraction and systematization of the results were carried out using Microsoft Excel® document. The results were organized following the specific purposes: (1) to know the prevalence of nutritional risk in children and adolescents evaluated by StrongKids; (2) to verify the association of nutritional risk assessed by this method with variables of interest in health; and (3) to evaluate the evidence of its validity and reproducibility.

In the analysis of the reproducibility studies we used the recommendation of Landis and Koch [14] to evaluate concordance: kappa from 0 to 0.19 = poor agreement; 0.20 to 0.39 = fair agreement; 0.40 to 0.59 = moderate agreement; 0.60 to 0.79 = substantial agreement; and 0.81 to 1.00 = almost perfect agreement.

Results

Initial screening identified 190 titles. After removing duplicate files, 125 papers were analyzed. From these, 63 were excluded by reading the title and abstract, totaling 62

Table 3 StrongKids validation studies

Author (year)	Methodology	Results	Conclusions
Marginean et al. [23]	Analysis of agreement between SK and WHO classification of malnutrition ^a .	$k = 0.61^*$ By incorporating the total serum protein level (if < 6 mg/dL increases risk to next category): $k = 0.71^*$	A modified SK, incorporating total serum protein levels, could be useful to identify hospitalized children at risk of malnutrition.
Huysentruyt et al. [25]	(1) Concurrent validity: SK's ability to predict malnutrition at hospital admission.	SK and acute malnutrition ^b : sens: 71.9%, spec: 49.1%; NPV: 94.8%; PPV: 11.9% ↑ score SK ↓ WFH: $\rho = -0.23^{**}$ Association between the presence of risk (MR or HR) and acute malnutrition: OR: 2.47 (95% IC: 1.11–5.49 ^{***}) Mean WFH in LR > MR > HR ^{**} SK and chronic malnutrition ^c : sens: 69%; spec: 48.9%; NPV: 94.8%; PPV: 10.4%	SK correlates well with current nutritional status and is a predictor of LOS and the need for nutritional intervention. The study authenticates SK as an easy-to-use screening tool for hospitalized children.
	(2) Predictive validity: SK's ability to predict outcomes: weight loss during hospitalization, LOS and the need for supplementary feeding.	SK and weight loss > 2% during hospitalization: sens: 52.65%; spec: 43.1%; NPV: 29.7%; PPV: 66.5% LOS ≥ 4 days: sens: 62.6%; spec: 53.9%; NPV: 72%; PPV: 43.3% ↑ score SK ↑ LOS ($\rho = 0.25^{**}$) Need for supplementary feeding ^d : sens: 94.6%; spec: 52%; NPV: 98.9%; PPV: 18% Association between the presence of risk (MR or HR) and LOS ≥ 4 days (OR: 1.96; 95% IC: 1.25–3.07 ^{**}) and need for supplementary feeding (OR: 18.93; 95% CI: 4.48–80.00 ^{**})	
Ling et al. [12]	(1) Correlation of SK score with anthropometry (WFH, BMI, and HFA). (2) Evaluation of need for nutritional intervention in each risk category	(1) Correlation of SK score with anthropometry (WFH, SK and WFH (for those with height < 120 cm): $\rho = 0.63^{**}$ SK and BMI (for those with height > 120 cm): $\rho = 0.40^{***}$ SK and HFA: $\rho = 0.54^{**}$ Nutritional intervention was required in 83% HR, 9% MR and 0% LR	StrongKids was identified as superior tool ^e and correlated to all anthropometric measures.

SK StrongKids, WHO World Health Organization, k kappa index, WFH weight-for-height, BMI body mass index, HFA height-for-age, ρ Spearman's correlation coefficient, ρ sensitivity, ρ specificity, NPV negative predictive value, PPV positive predictive value, LR low risk, MR medium risk, HR high risk, OR odds ratio, CI confidence interval, LOS length of hospital stay

^a Standard deviation (SD) < -2 for WFH and HFA was considered to indicate acute or chronic malnutrition, respectively

^bWFH < -2 SD

^cHFA < -2 SD

^dEnteral nutrition, oral supplements or not well specified intervention

^eCompared to STAMP

* $p = 0.001$; ** $p < 0.01$; *** $p < 0.05$

remaining. After full reading for evaluation of the pre-established eligibility criteria, 22 original articles were included in this review. Details of the selection process are shown in Fig. 1.

The main characteristics of the studies, the prevalence of nutritional risk according to the categories of StrongKids and the associations identified is presented in Table 1. The articles were published as of 2010, year in which the method was described. The majority of studies were conducted in Europe (50%, $n=11$), the age ranged from 1 month to 17.7 years, and 21/22 studies included children and adolescents of both sexes (in one study, this data were not available). The studies were predominantly performed in hospitals (91%; $n=20$).

The risk frequency by StrongKids presented great variability for LR (0–64.3%), MR (33.9–84%), and HR (1.2–53.8%). The sample size ranged from 43 [12] to 2874 [15] children and adolescents, with a maximum of 44 hospitals evaluated [10].

From 22 studies that described the frequency of risk according by categories, 16 predominated MR and five LR. By grouping the categories in which the risk is already present (MR and HR), it ranged from 35.7 to 100%.

Regarding the associations found, we highlighted the relationship between the diagnosis or the risk score of the StrongKids with the longest length of hospital stay [1, 10, 15–26], with the reduction of anthropometric measures (objective indicators of nutritional status) [1, 10, 12, 20, 23–29] and with acute and/or chronic malnutrition already installed [1, 10, 15, 16, 19, 21, 23, 25, 28–33]. It was also demonstrated the association between the presence of risk and outcomes of interest in health, as: weight loss during hospitalization [1, 17, 24], higher frequency of administration of nutritional support [15, 20], fever [17, 20], infectious complications [1], use of antibiotics [20], and hospital costs [1, 15, 17]. In the only study carried out in a special school for children with chronic diseases [31], the nutritional risk evaluated by StrongKids was associated for the first time with the occurrence of difficulties in performing daily activities, the presence of pain/discomfort and with a worse health status.

Four reproducibility studies have been identified, presented in Table 2 [17, 19, 25, 32]. It can be observed that agreement on categorical classification was substantial [14], both in relation to the inter-rater—kappa variation from 0.61 [17, 25] to 0.72 [19]—as intra-rater agreement—kappa = 0.66 [25]. Only one article [25] evaluated the agreement in relation to the numerical score, identifying a substantial and moderate inter-rater (kappa = 0.60) and intra-rater agreement (kappa = 0.48), respectively. The studies included the comparison between the diagnosis performed by different examiners with the same training—nurses [25] or pediatric trainees [17]—as well as the

evaluation by professionals with different knowledge—pediatricians vs. nurses [19, 32], experts vs. non-experts [19]. The authors of the three studies concluded, in a consensual way, that StrongKids is a reproducible, viable, and reliable method for use in clinical practice, even when applied by different professionals and non-experts.

Few studies have validated StrongKids until now, as shown in Table 3. This analysis was performed by investigating the ability of the method to predict malnutrition or reduction of anthropometric measures (concurrent validity) [12, 23, 25] and/or the evaluation of its relation with outcomes of interest (predictive validity), as length of hospital stay [25], weight loss during hospitalization [25], and the need for nutritional intervention [12, 25]. The higher sensitivity of the StrongKids, to the detriment of the specificity, stands out both for the detection of children with malnutrition already installed and for the prediction of health outcomes. In general, the associations found were considered satisfactory for validation in the three studies performed for this purpose.

Two studies measured the time spending for completing the StrongKids. Huysentruyt et al. [25] found a median time of 3 min and Moeeni et al. [32] a range of 1 to 5 min. The tool was considered easy-to-use and no time-consuming.

From the studies analyzed, only three [16, 19, 32] presented the detailed calculation of the sample size, while the others used convenience sample. Regarding the blinding bias, in only three papers [17, 26, 28] it is clearly stated that the application of StrongKids and the anthropometric evaluation were performed by different examiners, independently. In others, it is not possible to conclude whether or not there was knowledge of the results of the anthropometric evaluation at the moment of interpretation of the nutritional risk, or vice versa.

Discussion

Based on this extensive literature review, this is the first systematic review that compiled the scientific evidence specifically related to StrongKids. From this study, the magnitude of the nutritional risk in pediatrics was confirmed, important associations were identified, and it was possible to obtain evidence of the reproducibility and validity of the method.

There was a high concentration of studies in European countries (11/22), and their use in developing or underdeveloped countries is still limited. Considering that, in general, undeveloped countries have poorer health and nutrition [34], there is an even more worrying panorama in these places. Besides the influence on the health and prognosis of patients, the impact of malnutrition on hospital costs is significant. Amaral et al. [35] analyzed the hospital

costs of patients at nutritional risk and identified that care costs were more than double when compared to risk-free patients, representing an average increase of 20% in hospital expenses. Guest et al. [36] also showed that the cost of patients more than doubled when there is malnutrition. The nutritional risk, as assessed by StrongKids, was also associated with increased hospital costs in the three studies that investigated this association [1, 15, 17]. The incorporation of nutritional screening routines, in addition to their low cost, represents a significant savings strategy when considering the financial impacts of unidentified nutritional risk and, consequently, of malnutrition.

Nutritional risk has been evidenced to be a major problem, reaching significant frequencies in hospitalized children and adolescents. The prevalence found warned to the importance of incorporating routine protocols for nutritional screening at the time of hospital admission. Particularities regarding the characteristics of the samples may justify the great variability found for each category, but in general the situation is worrisome: from the 22 studies analyzed, 20 (91%) presented more than half of the children and adolescents already in nutritional risk.

The methodology to perform the validation of nutritional screening tools is not consensual in the literature, since there is no universally accepted “gold standard” for comparison. This evaluation involves, in practice, the analysis of questions, as reproducibility, applicability, and validity as to the prediction of malnutrition and other outcomes [5]. The higher sensitivity values, compared to the specificity, meet one of the desirable characteristics regarding the methods of screening: not leaving individuals at risk without identification, that is, providing a lower number of false negatives [37].

Regarding reproducibility studies, although StrongKids has been developed to be applied by physicians [10], the results demonstrate good agreement with the evaluation made by nurses and by the clinical staff not specialized in pediatric nutrition. This feature represents an important advantage of the method, since it allows its use by a greater number of professionals. In practice, in addition to nurses, StrongKids is also used by dietitians [5].

The applicability of StrongKids is described in the original study [10], in which the tool was completely filled in 98% of the sample. It contributes to this aspect not to need anthropometric measures, which, in hospital practice, may not be possible. Studies that use methods in which the evaluation of body measurements is necessary present loss rates of up to 17.6%, attributed mainly to the impossibility of measuring weight and length/height [8, 9].

For a screening instrument to be effective in practice, another important feature is the time of application. If an accurate screening instrument can be applied in less time,

resources may be allocated to higher priority nutritional assistance actions [38]. Because it does not require anthropometric measures, StrongKids has an additional advantage with regard to speed. In a comparative study carried out by Ling et al. [12] in the United Kingdom, the application of STAMP (which requires measure of weight and height) was about 10 min longer than StrongKids (15 vs. 5 min).

Although it was developed to be applied in hospitals, Joosten et al. [31] applied StrongKids in 642 children and adolescents in special schools for chronically ill children in the Netherlands. This survey suggests a possible extension of the use of StrongKids, which may, in the future, expand the research of associations of interest into specific groups.

The main methodological limitation of the studies was the lack of satisfactory information to determine if the interpretation of the nutritional screening was independent or if there was influence of knowledge of the results of the reference standard (anthropometric diagnosis). The non-existence/non-presentation of the calculation and the detailing of the sample selection also makes it difficult to infer the extent and representativeness of the samples. The results demonstrate that the number of studies that evaluated the reproducibility and validity of StrongKids is still low. Particularly regarding the validation articles, there is great variability in the techniques of analysis, which limits the comparison of the results.

With regard to limitations of this study, although the search process was intense and detailed, the restriction on the language of publication may have excluded some work of interest.

Conclusions

Screening for nutritional risk in pediatrics is a relatively recent practice when compared to adult care, but no less relevant. The results show that this is a frequent problem, even in developed countries, which is associated with important health outcomes and nutritional impairment already installed. StrongKids is a valid method with good reproducibility and predictive capacity, which can be easily incorporated in clinical practice for the identification of nutritional risk in children and adolescents.

Author contributions CAS had primary responsibility for the review protocol development, carried out the literature search, extracted the data, and wrote the manuscript. AQR: carried out the literature search, extracted the data, and wrote the manuscript. COBR: participated in the selection of articles and in the preparation of the manuscript. VEA: revised the data analysis and wrote the manuscript. SCCF: supervised the design and the execution of the review. All authors have read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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