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ORIGINAL ARTICLE

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Translation, Cultural Adaptation, and Validation of the Arabic Version of the STRONGkids Nutrition Screening Tool in the Moroccan Pediatric Clinical Setting

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ABSTRACT

Background: Malnutrition among hospitalized children is associated with adverse clinical outcomes and prolonged length of stay. Systematic nutritional screening upon admission is a recognized standard of care.

Aims: This study aimed to validate the Arabic version of the STRONGkids nutritional risk assessment tool within a Moroccan pediatric population.

Methods: A single-center, observational longitudinal study was conducted at Moulay Ali Chrif Hospital, Errachidia City, Morocco between June 2019 and February 2020. The study enrolled 367 children under-five years of age (337 for the validity analysis and 30 for the reliability analysis). The STRONGkids tool was translated into Arabic and administered upon hospital admission. The weight-for-height index served as the gold standard for assessing acute malnutrition. Diagnostic accuracy was evaluated employing the area under the receiver operating characteristic curve (AUROC), sensitivity, specificity, and predictive values. Agreement with the gold standard was assessed via Cohen's Kappa coefficient.

Results: Interobserver reliability indicated substantial agreement (κ=0.67). The STRONGkids tool demonstrated substantial agreement with the weight-for-height z-score (κ=0.61) and body mass index z-score (κ=0.67). The tool exhibited high diagnostic accuracy for screening a weight-for-height z-score below -2 SD (AUROC=0.94), with a sensitivity of 92.68% and a specificity of 88.51%. For predicting a hospital stay of ≥ 7 days and weight loss > 2%, the accuracy measures were AUROC = 0.59 and AUROC = 0.87 respectively.

Conclusions: The Arabic adaptation of the STRONGkids instrument demonstrated robust concurrent validity and substantial interobserver reliability. While the tool exhibited limited predictive validity regarding the duration of hospitalization, it remains reliable metric for malnutrition risk screening among pediatric populations in Arabic-speaking countries.

Keywords: Nutritional risk screening; Children; Translation; Validation; STRONGkids Arabic version.

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1 INTRODUCTION

At the dawn of the third millennium, acute malnutrition remains a primary determinant of the global burden of disease, affecting upwards of 50 million children under five years of age (Black *et al.,* 2013). More notably, one-third of under-five years of all-cause-mortality in this demographic is attributable to primary or secondary malnutrition (Joosten & Hulst, 2011). Furthermore, the prevalence of severe malnutrition within pediatric inpatient facilities remains alarming high (Mărginean *et al.,* 2014). In Morocco, malnutrition persists as a major public health challenge and represents a frequent etiology for pediatric hospitalization (Barouaca *et al.*, 2021; Barouaca, 2023; Barouaca, 2024). Recent epidemiological data indicate that 2.9% of children are underweight and 2.6% suffer from acute malnutrition, while 15.1% exhibit stunting— findings that emphasize the persistence of suboptimal child nutrition (Ministère de la Santé du Maroc & Ligue des États Arabes, 2018).

Undernutrition is established as a significant factor negatively impacting clinical outcomes (Desai *et al.*, 2025) and prolonging hospital stay (Mehta *et al.*, 2013). Despite the gravity of this situation, hospital-associated malnutrition frequently remains undiagnosed and, consequently, untreated (Barker *et al.,* 2011). Early diagnosis, however, offers the opportunity to intervene at an early stage, enabling improved outcomes, and prevent further physiological deterioration. While a comprehensive nutritional assessment involves complex and resource-intensive procedures, nutritional

screening offers a streamlined process to rapidly identify patients at risk of malnutrition through validated instruments. In this context, leading international bodies, including the European Society for Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the European Society for Parenteral and Enteral Nutrition (ESPEN), now advocate for systematic nutritional screening upon admission for all hospitalized children (Agostoni *et al.*, 2005; Kondrup *et al.,* 2003).

Although numerous nutritional risk-screening tools have been proposed during for adult populations over the last two decades, a universally accepted gold standard for pediatric populations has yet to be established (Fachal *et al.*, 2025). A robust screening tool must not be only economic, rapid, and accessible to non-specialized healthcare personnel, but must maintain essential levels of sensitivity, specificity, and psychometric reliability (McLaren & Green, 1998). In 2007, the Dutch Society developed a specialized instrument for children and adolescents: the "Screening Tool for Risk on Nutritional status and Growth" (STRONGkids) (Hulst *et al.,* 2010).

Linguistic and cultural adaptation of such instruments is paramount for diagnostic accuracy; literal translation is often insufficient when cultural contexts and dietary practices diverge significantly from those of the original validation cohort (Geisinger 1994; Wild *et al.,* 2005). While the STRONGkids questionnaire was initially validated in Dutch clinical populations (Hulst *et al.,* 2010), it has since been implemented across diverse global settings (Huysentruyt *et al.*, 2013; Moeeni *et al.,* 2012; Salerno *et al.,* 2024; Spagnuolo *et al.,* 2013). To date, however, no study has validated the STRONGkids nutritional risk tool for use in Arabic-speaking hospitalized pediatric populations.

Cultural adaptation transcends lexical equivalence, necessitating systematic modifications to reflect the specific cultural beliefs, dietary practices, and health-related behaviors of the target population, thereby preserving the psychometric properties of the original tool in the new cultural context (Guillemin *et al.*, 1993). The Arab world encompasses distinct cultural, socio-religious frameworks that fundamentally influence pediatric feeding practices and perceptions of child health. These contextual factors, including traditional dietary customs, religiously-influenced feeding practices, and culturally-specific interpretations of child health and nutrition, necessitate rigorous cultural adaptation of the STRONGkids questionnaire to ensure its conceptual equivalence, content validity, and clinical utility in Arabic-speaking pediatric populations. Morocco presents distinct nutritional characteristics with persistent undernutrition coexisting with emerging trends in overweight and obesity (Barouaca & Rguibi 2012), alongside traditional dietary practices that may influence nutritional risk assessment differently than in the European populations. Ensuring that screening tools are culturally sensitive and linguistically appropriate for Arabic-speaking populations, particularly within the Moroccan healthcare context, is essential for accurately assessing the risk of malnutrition in hospitalized children. Thus, the present study aimed to translate, culturally adapt, and validate the STRONGkids instrument within a representative sample of the Moroccan pediatric population by evaluating its concurrent validity, predictive validity and interobserver reliability.

2 Patients and Methods

2.1 Setting

The present study was conducted at the Moulay Ali Chrif Hospital in Errachidia, a tertiary-level healthcare facility serving the Drâa-Tafilalt region of southeastern Morocco. As one of the twelve administrative regions of the kingdom, Drâa-Tafilalt encompasses approximately 88,836 km² and is characterized by an arid to semi-arid climate and a predominantly rural population. The region faces significant healthcare challenges, including geographical barriers to medical access, socioeconomic constraints, and higher-than-average rates of malnutrition. According to the National Survey on Population and Family Health (Ministère de la Santé du Maroc & Ligue des États Arabes, 2018), the prevalence of acute malnutrition among children under five years of age in this region is 2.5%, highlighting a significant nutritional vulnerability.

Moulay Ali Chrif Hospital serves as the primary regional referral center for pediatric care, providing comprehensive emergency, general, and specialized medical services. As a tertiary facility, it admits patients referred from various primary and secondary healthcare centers, resulting in a study population that reflects diverse socioeconomic backgrounds, geographical origins, and clinical presentations representative of the regional disease burden.

2.2 Sample Size Justification

Sample size calculations were performed employing the online calculator described by Arifin (2017). For the primary analysis, which assessed the level of agreement between two measurement methods, the required number of participants was estimated based on Cohen's Kappa (κ). We tested the null hypothesis H_0: $\varkappa_0$ = 0.40 (minimum acceptable agreement) against the alternative hypothesis H_1: $\varkappa_1$ = 0.99 (expected near-perfect agreement). Assuming a significance level (α) of 0.05 and a statistical power ($1 - \beta$) of 0.95, the computation incorporated the regional prevalence of acute malnutrition (2.5%) as category prevalence significantly influences κ variance. Under these parameters, the minimum required

sample size was determined to be 333 subjects, which was adjusted to 337 to mitigate potential data attrition.

For the reproducibility component, a smaller cohort was utilized in accordance with the recommendations of Johanson and Brooks (2010). Following Huysentruyt *et al.*, (2013), the sample size was calculated to test the null hypothesis H_0: κ = 0.00 (no agreement beyond chance) against the alternative H_1: κ = 0.61 (moderate agreement expected). The null value κ_0 = 0.00 represents the conventional baseline assumption of no agreement beyond chance, frequently utilized in reliability studies. A two-sided significance level of α = 0.05 and a statistical power of 90% ($1 - \beta = 0.90$) were used. Considering the identical regional prevalence of acute malnutrition (2.5%), a minimum of 30 children were required for reassessment to achieve ensure statistical precision.

2.3 Inclusion and Exclusion Criteria

Children aged 1 – 60 months were eligible for inclusion provided they had a minimum hospital stay of 48 hours—to facilitate adequate time for nutritional assessment and outcome evaluation—and their parents or legal guardians provided written informed consent. To minimize confounding variables associated with prematurity, eligibility was restricted to children born at term (gestational age ≥ 37 weeks) with a birth weight ≥ 2500 g. Exclusion criteria included the presence of generalized edema; transfer to another intensive care or other departments, mortality prior to discharge, and readmission during the study period.

2.4 Study Design and Nutrition Assessment

This single-center, observational longitudinal study was conducted from June 2, 2019, to February 29, 2020. A total of 367 children were consecutively enrolled upon admission, with 337 allocated to the validity study and 30 to the reproducibility study. The cohort exhibited a range of clinical conditions: acute respiratory tract infections (including bronchopneumonia, bronchiolitis, and asthma exacerbations) were most prevalent, followed by acute gastroenteritis with dehydration, and various systemic infectious diseases, such as sepsis and urinary tract infections.

Within 48 hours of admission, structured face-to-face interviews were conducted with parents to collect information about their child's gender, age, parental education level, medical history from medical records and length of hospital stay was recorded at discharge. Anthropometric measurements including head circumference (HC), mid-upper arm circumference (MUAC), weight, and height/length were obtained using standardized WHO techniques (WHO, 2008). These data were converted to gender-specific z-scores employing WHO Child Growth Standards (birth to 60 months) through WHO Anthro software version 3.2.2. Children were classified as acutely malnourished if their weight-for-height z-score (z-WFH) or body mass index-for-age z-score (z-BMI) was < -2SD, while those with weight-for-age z-score (z-WFA) < -2SD were classified as underweight (De Onis, 2015). The STRONGkids tool was applied to all participants within 24 hours of admission.

2.5 Cross-cultural Adaptation of the STRONGkids Tool

The STRONGkids tool, originally developed by Hulst *et al.* (2010), comprises four components:

- *Underlying Clinical Conditions (2 points):* Assesses conditions associated with high nutritional risk (e.g., malignancy, chronic cardiac/renal disease, major surgery).
- *Subjective Clinical Assessment (1 point):* Evaluates clinical signs of altered nutritional status, such as reduced muscle mass, subcutaneous fat mass, or hollow facial appearance.
- *Acute Nutritional Risk (1 point)*: Identifies gastrointestinal symptoms (diarrhea ≥ 5 episodes/day or vomiting > 3 episodes/day) or recent disruptions in nutritional intake, such as reduced food consumption, prior nutritional interventions, or pain-related limitations that impair the ability to consume an adequately nutritious diet. The presence of any single factor is sufficient to assign 1 point, reflecting the tool's sensitivity to short-term conditions that may compromise nutritional status.
- *Weight Trajectory (1 point):* Assesses recent weight trajectory, specifically evaluating weight decline or deterioration in weight-to-height ratio among infants under one year of age over the preceding weeks to months.

The translation and cross-cultural adaptation into Arabic followed the guidelines established by Wild *et al.*, (2005), through four systematic phases:

- *Initial Translation:* Parallel translations from English to Arabic were conducted by two independent translators: a linguist (English professor) and a subject-matter expert (PhD in Nutrition).
- *Synthesis:* A third independent moderator facilitated a structured comparison of the two initial translations, resolving discrepancies and ensuring conceptual equivalence.
- *Back-Translation:* The reconciled Arabic version underwent back-translation into English by two independent linguists blinded to the original text. A review panel, comprising a nutrition researcher, an English language specialist, and the original translators, conducted a comprehensive analysis of the back-translations. The panel evaluated semantic equivalence, idiomatic expressions, and conceptual consistency.
- *Expert Committee Review Phase:* A final committee evaluated the linguistic, cultural, and technical integrity of the tool, approving the final Arabic version for clinical use.

2.6 STRONGkids Validation

Procedural Implementation

The translated STRONGkids tool was administered in accordance with the protocols established by Hulst *et al.* (2010). A single registered nurse conducted assessments for the validity cohort, while two nurses performed independent evaluations for the interobserver reliability study. All questionnaires were reviewed at the point of data collection to ensure complete data capture. The tool generates a composite score (0 – 5) to stratify patients into three risk categories: high-risk (HR, score 4 – 5), moderate-risk (MR, score 1 – 3), and low-risk (LR, score 0) (Hulst *et al.*, 2010). For the purpose of validation analysis, scores were dichotomized following the methodology of Huysentruyt *et al.* (2013): children with scores ≥ 1 were classified as "nutritionally at risk," while those with a score of 0 were deemed "nutritionally not at risk."

Predictive Validity

Due to the paucity of standardized thresholds for length of hospital stay (LOS), study-specific criteria were established to assess predictive validity. Prolonged hospitalization was defined by the median LOS (≥ 7 days), while significant nutritional deterioration was indicated by a relative weight loss > 2% of admission body weight, calculated according to the methodology of Sermet-Gaudelus *et al.* (2000).

Predictive performance was evaluated employing the Area Under the Receiver Operating Characteristic Curve (AUROC) to determine the tool's ability to predict both extended LOS and significant weight loss. Correlation analyses and multiple regression models examined relationships between STRONGkids scores and these clinical outcomes. Additionally, diagnostic metrics—including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV)—were computed for both the LOS ≥ 7 days and weight loss > 2% thresholds.

Concurrent Validity

Concurrent validity was evaluated against established anthropometric indicators. Concurrent validity assesses a tool's correlation with a universal measure (the gold standard) utilized to assess what is being measured (Blacker & Endicott, 2000). While no universally accepted gold standard exists for nutritional risk screening in hospitalized children (Joosten & Hulst, 2011), anthropometric measurements based on WHO standards are widely used as reference criteria for assessing malnutrition status. Therefore, WHO z-scores for weight-for-height (z-WFH) and body mass index-for-age (z-BMI) at cut-off points of < -2SD were utilized as reference standards for acute malnutrition, following approaches adopted in previous validation studies (Hulst *et al.*, 2010; Huysentruyt *et al.*, 2013; Moeeni *et al.*, 2012; Qiao *et al.*, 2019; Santos *et al.*, 2020; Spagnuolo *et al.*, 2013). The agreement between STRONGkids and anthropometric indices (z-WFH, z-WFA, and z-BMI) was assessed using Cohen's Kappa coefficient (κ). Concurrent validity was further evaluated through correlation analysis and multiple regression between STRONGkids scores and these anthropometric indices. The diagnostic accuracy of STRONGkids in identifying acute malnutrition (z-WFH< -2SD, z-BMI < -2SD) and underweight (z-WFA<-2SD) was determined using area under the receiver operating characteristic curve (AUROC), sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

Interobserver reliability

To ensure the reproducibility of the translated tool, interobserver reliability was assessed between two nurses. Prior to the study, both examiners participated in a standardized training program—consisting of a 4-hour theoretical lecture and a 2-hour practical workshop—led by a pediatric nutritionist. The tool was independently administered to 30 hospitalized children within 24 hours of admission in a blinded fashion. A minimum 2-hour interval was maintained between assessments to prevent recall bias. To ensure the integrity of the blinding, nurses were prohibited from discussing their findings, and patient records were anonymized via coding.

The inclusion and exclusion criteria were identical to those of the validation study. The time required to complete each assessment was recorded, starting from the initial review of patient information to the final risk categorization. All assessments were conducted during regular ward rounds to maintain consistency in the evaluation process.

2.7 Statistical Analysis

Statistical analyses were performed using MedCalc® software (version 3.2.2). Data integrity was maintained through a double-entry verification process. Continuous variables are expressed as mean ± standard deviation (SD), while categorical variables are presented as frequencies and percentages with 95% confidence intervals (95% CI). The normal distribution was assessed with Kolmogorov-Smirnov statistical test.

Differences in nutritional status between risk categories were evaluated using the Student's t-test for normally distributed data and the Mann-Whitney U-test for non-parametric comparisons (e.g., median LOS). Categorical variables were compared using the Chi-square test. Relationships between STRONGkids scores, anthropometric indices, and clinical outcomes were analyzed using Pearson's correlation, followed by multiple regression analysis to identify independent predictors. Model goodness-of-fit was assessed using the coefficient of determination R^2.

The difference was significant if p-value < 0.05 for the entire test. The receiver operating characteristic (ROC) curves were applied to evaluate diagnostic accuracy of the STORNGkids regarding the acute malnutrition status of the children. The interpretation of the AUROC results was performed according to Swets (1988) who divided the value of AUROC into zero contributions (AUROC = 0.5), not very informative (0.5 ≤ AUROC < 0.7), moderately informative (0.7 ≤ AUROC < 0.9), very informative (0.9 ≤ AUROC < 1) and perfect (AUROC = 1). For the Sens, Spec, PPV and NPV we have used the criteria of Neelemaat *et al.* (2011) as follows: (90 to 100%) "Excellent"; (80 to 90%) "Good"; (70 to 80%) "Fair"; (60 to 70%) "Insufficient"; and (50 to 60%) "Poor". Cohen's Weighted Kappa (κ) coefficient was employed to measure the consistency agreement between the anthropometric indices, the STRONGkids tool and also to evaluate the interobserver reliability between the two nurses. The interpretation of consistency was performed by the value of the Kappa coefficient (κ) that provides the strength of agreement as follows: poor agreement (< 0.00); slight agreement (0.00 – 0.20); fair agreement (0.21 – 0.40); moderate agreement (0.41 – 0.60); substantial agreement (0.61 – 0.80); and almost perfect agreement (0.81 – 1.00) Landis & Koch, (1977).

The selection of intervals is a critical methodological consideration in evaluating diagnostic test accuracy, as it directly influences result interpretation and the validity of reported performance metrics. For the STRONGkids tool, validity was classified according to the sensitivity and specificity criteria established by Van Bokhorst-de van der Schueren *et al.* (2014): "*Good validity*" if the sensitivity and specificity > 80%; "*Fair validity*" either sensitivity or specificity < 80%, provided both exceed 50%; and "*Poor validity*" if the sensitivity or specificity < 50%.

Internal consistency of the translated STRONGkids instrument was assessed through Cronbach's alpha coefficient (α), a measure of inter-item reliability within a scale. The translated version demonstrated acceptable internal consistency (α = 0.708), meeting the threshold for acceptable reliability as defined by Nunnally and Bernstein (1994).

2.8 Ethical Considerations and Consent

This study was conducted in accordance with the principles of the Declaration of Helsinki (World Medical Association, 1964). As the research involved only routine clinical observations without intervention or modification to standard treatment protocols, it was deemed exempt from formal institutional ethics committee approval. Patient anonymity was rigorously maintained. Parents were informed about the study's purpose and procedures in their native language (Arabic or Amazigh) and provided written informed consent.

3 Results

3.1 Demographic and Clinical Characteristics

The demographic and anthropometric characteristics of the study population (N = 337) reveal a cohort predominantly composed of infants (50.15%), followed by toddlers (25.52%) and young children (24.33%). The mean age was 16.59 ± 14.74 months, with a slight male predominance (53.12%) (Table 1).

Clinical presentations were primarily dominated by acute respiratory infections (n = 112, 33.23%), of which bronchopneumonia was the most prevalent subtype (18.69%), followed by bronchiolitis (10.09%) and asthma exacerbation (4.45%). Gastrointestinal pathologies, including acute gastroenteritis and dehydration, accounted for 99 cases (29.38%) of admission. Febrile and infectious diseases represented 21.96% (n = 74) of the sample, primarily represented by urinary tract infections (11.87%) and sepsis (10.09%). Neurological disorders and other miscellaneous

Table 1. Characteristics of the Studied Pediatric Population for the Validity Study

Characteristics	n (%)
Age (Mean, SD)	16.59 ± 14.74
Group age	
Infants [1 month – 1 year [	169 (50.15)
Toddlers [1 – 2 years [	86 (25.52)
Young children [2 – 5 years]	82(24.33)
Sex n (%)	
Male	179 (53.12)
Female	158 (46.88)
Anthropometric measures (Mean; SD)	
Weight (kg)	9.78 ± 3.30
Height or length (cm)	76.86 ± 13.70
Mid-Upper-Arm-Circumference (cm)	15.55 ± 2.24
Head Circumference (cm)	45.94 ± 3.91
Primary diagnostic categories, n (%)	
Acute respiratory infections	112 (33.23)
Bronchopneumonia	63 (18.69)
Bronchiolitis	34 (10.09)
Asthma exacerbation	15 (4.45)
Acute gastroenteritis and dehydration	99 (29.38)
Febrile illness/infectious diseases	74 (21.96)
Urinary tract infection	40 (11.87)
Sepsis	34 (10.09)
Neurological disorders	19 (5.64)
Other conditions	33 (9.79)
Clinical outcomes	
WL > 2% during hospitalization, n (%)	55 (16.32)
Mean weight change, % (SD)	−0.84 ± 2.76
In-hospital mortality, n (%)	0 (0.00)
STRONGkids n (%)	
Low	265 (79.63)
Moderate	55 (16.32)
High	17 (5.04)

Note: SD, Standard deviation, WL: Weight loss

medical conditions accounted for 5.64%, and 9.79% of the cohort, respectively.

Regarding clinical outcomes, 55 children (16.32%) experienced clinically weight loss (≥ 2% of admission body weight), with an overall mean weight fluctuation of –0.84 ± 2.76%. No in-hospital mortality was recorded. Nutritional risk stratification via the STRONGkids tool classified the majority of children as low risk (79.63%), while 16.32% and 5.04% were identified as being at moderate and high nutritional risk, respectively.

3.2 Concurrent and Predictive Validity

Agreement between the STRONGkids risk categories and objective anthropometric indices was quantified through Cohen's Kappa (κ) coefficient (Table 2). The tool demonstrated substantial agreement with indices of acute malnutrition, specifically *z*-BMI (κ = 0.67; 95% CI: 0.572 – 0.768), followed by z-WFH (κ = 0.61; 95% CI: 0.512 – 0.708), both indicating substantial agreement. In contrast, agreement with *z*-WFA was slight agreement (κ = 0.11; 95% CI: 0.032 – 0.188).

Table 2. Agreement between STRONGkids, and Anthropometric Indices in Children with Malnutrition

Nutritional indices	Value Cohen's Kappa concordance	
	Kappa at 95% C.I	Standard error
z-WFH	0.61 (0.512 – 0.708	0.05
z-WFA	0.11 (0.032 – 0.188	0.04
z-BMI	0.67 (0.572 – 0.768	0.05

C.I, Confidence Interval at 95%; **z-BMI**; z-score body mass index-for-age; **z-WFA**, z-score weight-for-age; **z-WFH**, z-score weight-for-height

The diagnostic accuracy of STRONGkids is summarized in Table 3. For concurrent validity, the tool exhibited excellent diagnostic performance in identifying acute malnutrition, yielding better sensitivities and specificities of 92.68% and 88.51% for *z*-WFH, and 89.8% and 90.24% for *z*-BMI. The corresponding high AUROC values were 0.94 (95% CI: 0.910 – 0.963) and 0.92 (95% CI: 0.890 – 0.950), respectively. Performance for z-WFA, remained moderate (AUROC: 0.64).

In terms of predictive validity, STRONGkids demonstrated robust capacity to predict significant in-hospital weight loss (> 2%), with a sensitivity of 83.64%, specificity of 90.78%, and an AUROC of 0.87 (95% CI: 0.840 – 0.912). However, its utility in predicting prolonged LOS ≥ 7 days, was limited, characterized by low sensitivity (30.46%) and a moderate AUROC of 0.59 (95% CI: 0.538 – 0.646).

3.3 Correlation and Multivariate Analysis

Bivariate analysis revealed significant inverse correlations between STRONGkids scores and both *z*-WFH (r = –0.670, $p < 0.001$) and *z*-BMI (r = –0.651, $p < 0.001$), whereas *z*-WFA exhibited a weaker association (r = –0.314, $p < 0.001$). Strong positive correlations were identified between risk scores and both LOS (r = 0.480, $p < 0.001$) and relative weight loss (r = 0.591, $p < 0.001$).

Multiple regression analysis (Table 4) revealed that STRONGkids scores were significant predictors of z-WFH (β = –0.360, SE=0.116, t = –3.092, $p = 0.002$), length of hospital stays (β = 0.046, SE = 0.014, t = 3.26, $p = 0.001$), and weight loss (β = 1.112, SE = 0.148, t = 7.504, $p < 0.001$). However, the associations with z-WFA ($p = 0.131$) and z-BMI ($p = 0.809$) were not statistically significant in the multivariate model. The regression coefficients suggest that weight loss has the largest effect size (β = 1.112, SE = 0.148), while z-BMI shows minimal impact (β = 0.028, SE = 0.116) on the outcome measure.

3.4 Anthropometric Indices and Data Outcomes According to Risk Categories

A comparative analysis of anthropometric indices and clinical outcomes between nutritional risk categories revealed significant differences (Table 5). Children classified as nutritionally at risk by STRONGkids (moderate-high risk) exhibited significantly lower z-scores for all anthropometric indices compared to those who are not at risk (*z*-WFH: - 2.21 ± 0.75 vs 0.52 ± 1.31; *z*-WFA: - 0.79 ± 0.97 vs 0.12 ± 1.10; *z*-BMI: - 2.31 ± 0.70 vs 0.40 ± 1.36; all $p < 0.001$).

Table 3. Concurrent and predictive validity of the STRONGkids

STRONGkids validity assessment	Sens % (95% C.I)	Spec % (95% C.I)	PPV (%)	NPV (%)	AUROC % (95% C.I)
Concurrent validity					
z-WFH<-2SD	92.68 (80.1 – 9 8.4)	88.51 (84.3 – 91.9)	52.8	98.9	0.94 (0.910 – 0.963)
z-WFA <-2SD	50.0 (24.7 – 75.3)	80.06 (75.3 – 84.3)	11.1	97.0	0.64 (0.58 – 0.69)
z-BMI <-2SD	89.8 (77.8 – 96.6)	90.24 (86.2 – 93.4)	61.1	98.1	0.92 (0.890 – 0.950)
Predictive validity					
LOS ≥ 7 days (median)	30.46 (23.7 – 37.9)	88.34 (82.4 – 92.8)	73.6	54.3	0.59 (0.538 – 0.646)
Weight loss >2%	83.64 (71.2 – 92.2)	90.78 (86.8 – 93.9)	63.9	96.6	0.87 (0.840 – 0.912)

Sens, sensitivity**; Spec,** specificity**; PPV,** positive predictive value**; NPV,** negative predictive value**; C.I,** confidence interval**; AUROC,** the area under the receiver operating characteristics curve**; LOS,** Length of hospital stays**.**

Table 4. Correlation and Multiple Regressions between the STRONGkids Scores and Anthropometric Indices

Characteristics	Correlations		Multiple regressions			
	r	*p* [a]	β	SE	t	*p* [b]
z-WFH < -2SD	-0.670	< 0.001	-0.360	0.116	-3.092	0.002
z-WFA < -2SD	-0.314	< 0.001	-0.068	0.0475	1.513	0.131
z-BMI < -2SD	-0.651	< 0.001	0.028	0.116	-0.241	0.809
LOS days (median)	0.480	< 0.001	0.046	0.014	3.26	0.001
Weight Loss	0.591	< 0.001	1.112	0.148	7.504	< 0.001

a, *p*-value for correlation; **b**, *p*-value for multiple regressions; **r**, Coefficient of correlation; **β**, Regression coefficient; **SE**, Standard Error; **t-value**, ratio of the regression coefficient to its standard error

Table 5. Differences between Malnutrition Risk Categories and Both Anthropometric indices and outcome data

Parameters	STRONGkids Nutritionally not at risk (Low risk) (n=265)	STRONGkids Nutritionally at risk (Moderate – High risk) (n=72)	*p-value*
z-WFH	0.52 ± 1.31	-2.21 ± 0.75	**< 0.001** [a]
z-WFA	0.12 ± 1.10	-0.79 ± 0.97	**< 0.001** [a]
z-BMI	0.40 ± 1.36	-2.31 ± 0.70	**< 0.001** [a]
Median LOS Days (95%.CI)	6 (6 to 7)	9 (8 to 10)	**< 0.001** [b]
LOS ≥ 7days n (%)	121(45.66)	53(73.61)	**0.012** [c]
Weight loss >2% n (%)	9(3.39)	46(63.88)	**0.003** [c]

All anthropometric indices were expressed as mean ± SD; a, *p*-values were determined by Student-T test for the anthropometric indices (continuous variable normally distributed); b, *p*-value was determined by Mann-Whitney U-test; c, *p*-values were determined with the use of the Che-2 test; Difference was significant if $p < 0.05$.

Clinical outcomes also differed significantly between risk groups. The median length of hospital stay was longer in the at-risk group (9 days, 95% CI: 8 – 10) compared to the low-risk group (6 days, 95% CI: 6 – 7; $p < 0.001$). Furthermore, children at nutritional risk demonstrated higher rates of prolonged hospitalization (LOS ≥ 7 days: 73.61% vs 45.66%, $p = 0.012$) and were more likely to experience significant weight loss during hospitalization (> 2%: 63.88% vs 3.39%, $p = 0.003$).

3.5 Interobserver Reliability

A subset of 30 children was evaluated for observer reliability between two nurses (Table 6). The sample comprised 56.66% males and 43.33% females, with a mean age of 16.18 ± 17.73 months. Anthropometric measurements showed mean values for weight (8.02 ± 3.67 kg), length/height (71.85 ± 15.32 cm), MUAC (12.85 ± 3.22 cm), and head circumference (42.96 ± 4.64 cm). The mean z-scores were -0.98 ± 2.33 for WFH, -1.36 ± 1.98 for WFA, and -1.11 ± 2.19 for BMI.

Risk categorization using STRONGkids showed some variation between nurses. Nurse 1 classified 46.66% as low risk, 30.00% as moderate risk, and 23.33% as high risk, while Nurse 2 classified 56.66%, 16.66%, and 30.00%, respectively. The mean time spent completing the STRONGkids assessment was similar between nurses (5:13 ± 2.22 vs 4:86 ± 1.99 minutes). The interobserver reliability coefficient was 0.67, indicating substantial agreement between the two nurses.

Table 6. Baseline Characteristics and Screening Malnutrition Risk in the Studied Population (n=30) for Observer Reliability

Characteristics	n (%)	
Age (Mean ± SD)	16.18 ± 17.73	
Sex		
Male	17 (56.66)	
Female	13 (43.33)	
Anthropometric measures (Mean ± SD)		
Weight (Kg)	8.02 ± 3.67	
Height or length (Cm)	71.85 ± 15.32	
MUAC (Cm)	12.85 ± 3.22	
HC (Cm)	42.96 ± 4.64	
Z-WFH	-0.98 ± 2.33	
Z-WFA	-1.36 ± 1.98	
Z-BMI	-1.11 ± 2.19	
STRONGkids n (%)	Nurse 1	Nurse 2
Low	14(46.66%)	17(56.66%)
Moderate	9(30.00%)	5(16.66%)
High	7(23.33%)	9(30.00%)
TSFS (Mean ± SD)	5:13 ± 2.22	4:86 ± 1.99
Interobserver reliability	0.67	

Note: TSFS: Time spent in filling STRONGkids

4 Discussion

The present study offers a novel contribution to the field of pediatric nutrition by translating and validating the STRONGkids tool for an Arabic-speaking, hospitalized Moroccan pediatric population. Our validation framework

examined three critical psychometric dimensions: concurrent validity, predictive validity, and interobserver reliability. The instrument classified the cohort (N = 337) into three distinct risk categories: low risk (78.63%), moderate risk (16.32%), and high risk (5.04%).

Regarding concurrent validity, the analysis revealed substantial agreement between STRONGkids and anthropometric indices for both z-WFH (κ=0.61) and z-BMI (κ=0.67), with fair agreement observed for z-WFA. These findings align with previous validation studies conducted in diverse international settings (Huysentruyt *et al.*, 2013; Ortíz-Gutiérrez *et al.,* 2019). Although Mărginean *et al.* (2014) suggested that incorporating serum protein levels may enhance diagnostic accuracy, such biochemical markers would inevitably compromise the tool's primary utility as a rapid, non-invasive bedside screening instrument.

In identifying acute malnutrition (z-WFH < -2SD), the Arabic version of STRONGkids demonstrated excellent sensitivity (92.68%) and high specificity (88.51%). This sensitivity aligns with the findings of Wonoputri *et al.* (2014) and Sermet-Gaudelus *et al.* (2000), although our specificity significantly exceeds several recent studies (Maciel *et al.,* 2020; Ortíz-Gutiérrez *et al.,* 2019; Qiao *et al.,* 2019) and remains slightly below the 93.0% reported by Beser *et al.* (2018) in infants aged 1 – 5 months. The tool demonstrated interesting validity with both sensitivity and specificity exceeding 80%. The high negative predictive value (NPV) of 98.9% suggests that children identified as low risk are correctly classified with a high degree of certainty, which is essential for a screening tool to avoid missing cases of malnutrition. While the positive predictive value (PPV) was more modest (52.8%), this is consistent with the established literature; Wonoputri *et al.* (2014), who reported 100% NPV and 57.14% PPV, Huysentruyt *et al.* (2013), who observed identical NPV (94.8%) but lower PPV (11.9%). and Cao *et al.* (2014), who noticed comparable PPV (49.8%) but lower NPV (67.2%).

It should be reminded that the high NPV (97.0 – 98.9%) indicates that children screened as low risk are correctly classified with high probability (98.9%), while the moderate PPV suggests that children identified as at-risk have a 52.8% probability of actual malnutrition. Despite the modest PPV, the tool's overall performance supports its validity for clinical investigation.

The discriminative capacity of STRONGkids, as quantified by AUROC analysis, proved highly informative (0.9 ≤ AUROC < 1). The tool effectively distinguished nutritional risk for both z-WFH (0.94) and z-BMI (0.92). Furthermore, significant differences across risk categories were observed for all anthropometric indices and clinical outcomes (LOS ≥ 7 days and WL > 2%).

Children scoring 0 (low-risk group) exhibited significant difference regarding the nutritional status considering anthropometric indices compared to those scoring ≥ 1 (moderate and high-risk groups). This finding confirms the tool's ability to appropriately stratify children according to z-scores deviations, as corroborated by Beser *et al.,* 2018 and Hulst *et al.,* 2010). The significant inverse correlation between STRONGkids scores and anthropometric indices aligns with findings by Mărginean *et al.* (2014), further supporting the tool's validity in assessing nutritional risk.

Regarding length of hospital stay (LOS) prediction, STRONGkids demonstrated low sensitivity (30.46%) for identifying patients with LOS ≥ 7 days, considerably lower than the 62.6%, as reported by Huysentruyt *et al.* (2013) in their study employing a 4-day threshold. Despite this limited sensitivity, our analysis revealed high specificity (88.34%), adequate PPV (73.6%), and moderate NPV (54.3%), indicating reliable identification of patients not at risk for extended hospitalization. These results contrast with Qiao *et al.* (2019), who reported high sensitivity (89.2%) but poor specificity (18.6%) for LOS > 5 days.

The tool indicated significant positive correlations with both LOS and weight loss, consistent with previous research (Chourdakis *et al.,* 2016; Qiao *et al.,* 2019). Patients classified as nutritionally at-risk demonstrated significantly longer hospital stays, with a higher proportion experiencing LOS ≥ 7 days compared to the not-at-risk group. Overall, these findings indicate that while STRONGkids exhibits strong concurrent validity, its predictive validity for extended hospital stays (≥ 7 days) is limited.

For weight loss prediction (> 2% of admission weight), STRONGkids demonstrated excellent sensitivity (83.64%) and specificity (90.78%), with fair PPV (63.9%) and excellent NPV (96.6%). These results exceed those reported by da Cruz Gouveia *et al.* (2018), who found lower values (sensitivity 55.8%, PPV 50.3%, specificity 38.8%). While multiple regression analysis showed that STRONGkids could significantly predict both length of stay and weight loss during hospitalization, its discriminative ability was only moderate for extended hospitalization (AUROC = 0.59 for LOS ≥ 7 days). Thus, the tool demonstrates limited predictive validity for extended hospitalization but good predictive validity for significant weight loss (> 2%).

Regarding interobserver reliability, our study evaluated the tool's performance between two trained nurses in a subset of 30 children. Results indicated substantial agreement (κ = 0.67), exceeding the agreement (κ = 0.61) reported by Huysentruyt *et al.* (2013) in their study of 29 hospitalized Belgian children. This aligns with findings by Joosten *et al.* (2011) and Moeeni *et al.* (2014), who reported substantial agreement (κ = 0.65) between nurses and physicians. Recent

studies have reported even higher agreement when comparing nurses with dieticians (κ = 0.90) (Qiao *et al.,* 2019; Santos *et al.,* 2020) and among nutritionists (κ = 0.87).

Implementation time is crucial for nutritional screening tools, with Becker *et al.* (2020) suggesting completion within 10 minutes for practical utility. In our study, administration time averaged 5.13 and 4.86 minutes for the first and second nurses respectively, comparable to the 4.42 minutes reported by Ortíz-Gutiérrez *et al.* (2019). While these times exceed the two to three minutes reported in some studies (Huysentruyt *et al.,* 2013; Santos *et al.,* 2020; Spagnuolo *et al.,* 2013), they remain within acceptable limits for clinical implementation.

The feasibility of routine implementation warrants consideration, particularly in resource-limited settings where additional screening responsibilities may impact staff workload. However, evidence from various contexts suggests successful implementation is possible. Gerasimidis *et al.* (2011), studying a different tool (PYMS), found that nutritional screening did not significantly impact staff workload. Studies in developing countries have demonstrated STRONGkids' practicality, with Moeeni *et al.* (2012) reporting successful implementation in Iranian pediatric populations, and Moeeni *et al.* (2014) documenting efficient nurse administration in New Zealand without substantial workload increase.

To address time constraints, regular training and practice can enhance efficiency in tool administration. Following Teixeira and Viana's (2016) recommendation, additional validation studies in resource-limited settings are required to further evaluate STRONGkids' practicality and validity in diverse healthcare contexts.

While numerous validation studies have been conducted in developed nations, data from developing and transitional economies remain limited. Our study performs a unique contribution by validating STRONGkids in a Moroccan pediatric population under five years of age. Furthermore, this represents, to the best of our knowledge, the first validation of an Arabic version of STRONGkids in a representative sample, potentially enabling its implementation across Arabic-speaking nations. This validation is particularly timely in Morocco, where childhood nutrition and growth deficits have emerged as key health priorities for the Ministry of Health and Social Protection. The 2019 National Nutrition Program (Ministère de la Santé et de la Protection Sociale du Maroc, 2019) emphasizes early malnutrition detection in its first axis, mandating nutritional screening for all children accessing health facilities for either preventive or curative services. The program specifically prioritizes children under five years, recognizing their heightened vulnerability to malnutrition due to increased growth requirements.

Implementation of STRONGkids in Moroccan pediatric hospitals enables efficient resource allocation through risk stratification: High-risk patients receive priority intervention, Moderate-risk patients receive second-tier assistance and Low-risk patients receive routine monitoring. This hierarchical approach aligns with national health policy recommendations while optimizing resource utilization. The successful validation of this version provides a reliable screening instrument for pediatric malnutrition risk assessment across Arabic-speaking healthcare systems.

4.1 Limitations of the study

Several methodological constraints warrant consideration when interpreting the findings. First, the single-center design —conducted exclusively at Moulay Ali Chrif Hospital in Errachidia, Morocco—may limit the generalizability of results to other healthcare facilities or regions characterized by distinct patient demographics, nutritional profiles, or clinical practices. Multicenter validation is required to confirm the broader applicability of the Arabic STRONGkids tool across heterogeneous pediatric populations and diverse healthcare settings.

Second, the study's limited timeframe (June 2019-February 2020) may have introduced seasonal bias, potentially obscuring temporal variability in nutritional status and disease patterns. Longitudinal investigations spanning multiple seasonal cycles would provide more robust evidence regarding the tool's performance under varying epidemiological and environmental contexts.

Third, the validation protocol relied exclusively on anthropometric indices as the reference standard, consistent with prior validation studies (Hulst *et al.,* 2010; Huysentruyt *et al.,* 2013). The absence of biochemical assessments may have limited detection of subclinical malnutrition states or inflammation-mediated nutritional alterations not yet manifested in anthropometric changes.

Fourth, STRONGkids exhibited modest predictive validity for prolonged hospitalization (LOS ≥ 7 days). This suggests that incorporating additional clinical parameters or disease severity indicators could improve prognostic accuracy within Moroccan pediatric populations. Future research might explore the integration of complementary clinical variables or the development of population-specific risk stratification models.

Finally, the potential for selection bias should be acknowledged, as the study sample was composed of children drawn from the southeastern region of Morocco. While the sample was representative of this subgroup, findings may not be generalizable to the wider population of the region.

Despite these limitations, the study represents a substantive step toward adapting and validating a culturally appropriate nutritional screening instrument for Arabic-speaking pediatric populations, thereby addressing a notable gap in available assessment tools.

5 Conclusions

The Arabic version of the STRONGkids screening tool demonstrated strong concurrent validity and substantial interobserver reliability, although its predictive validity was poor. These findings support the use of this instrument as a valid and reliable screening tool for malnutrition risk assessment in Arabic-speaking populations, both in clinical practice and research settings.

Although the STRONGkids was originally developed in high-resource settings for administration by physician, this study suggests its potential adaptability for use in resource-limited healthcare settings. Further research is warranted to evaluate the tool's implementation feasibility and effectiveness in various healthcare contexts across developing nations, particularly in settings with limited resources.

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