



Assessment of Malnutrition Risk in Canadian Pediatric Hospitals: A Multicenter Prospective Cohort Study

Véronique Bélanger, RD, MSc^{1,2,*}, Andrea McCarthy, RD, MSc^{1,2,*}, Valérie Marcil, RD, PhD^{1,2}, Valérie Marchand, MD³, Dana L. Boctor, MD⁴, Mohsin Rashid, MD, MEd⁵, Angela Noble, MD⁶, Vishal Avinashi, MPH, BSc, MD⁷, Bridget Davidson, MHSc⁸, Véronique Groleau, MD³, Schohraya Spahis, MSc^{1,2}, and Emile Levy, MD, PhD^{1,2}

Objective To assess the prevalence, causes, and consequences of malnutrition, as well as the evolution of nutritional status, in Canadian pediatric health care institutions.

Study design In this multicenter prospective cohort study, a total of 371 patients were recruited from pediatric hospitals in 5 Canadian provinces. Subjects were aged 1 month to 18 years; admitted to a medical, surgical, or oncology ward; and had a planned hospital stay of >48 hours. Data on demographics, medical condition, anthropometric measures, and dietary intake were collected. The Screening Tool Risk on Nutritional Status and Growth (STRONG_{kids}) and Subjective Global Nutritional Assessment (SGNA) were applied at admission. Malnutrition was defined as a weight-for-age, height-for-age, body mass index-for-age, or weight-for-length/height z score <-2 SD.

Results Among 307 subjects (median age, 5.3 years; median length of stay, 5 days), 19.5% were malnourished on admission. Both STRONG_{kids} and SGNA classifications were associated with baseline nutritional status. Mean weight-for-age z score was lower at discharge compared with admission (-0.14 vs -0.09; $P < .01$), and nearly one-half of all patients lost weight during their hospital stay. Only one-half of the children who were malnourished or screened as high risk of malnutrition were visited by a dietitian during their stay. The percentage of patients who lost weight during hospitalization was significantly greater in the group not visited by a dietitian (76.5 vs 23.5%; $P < .01$).

Conclusion Nutritional status deterioration and malnutrition are common in hospitalized Canadian children. Screening tools, anthropometric measurements, and dietitian consultation should be used to establish adequate nutritional support. (*J Pediatr* 2019;205:160-7).

The burden of acute and chronic malnutrition seen in low-resource settings is largely attributed to an interplay among food security, poverty, and illness.¹⁻³ In adult hospitals, at least one-third of admitted patients are malnourished,⁴ which is associated with higher costs, morbidity, and mortality.³⁻⁷ Malnutrition in hospitalized patients is multifactorial, including inadequate nutrient consumption, elevated nutrient requirements, and increased losses.^{3,8} If malnutrition is not identified and addressed, continued deterioration in nutritional status may adversely impact recovery and increase complications, length of stay, and the risk of readmission⁹ while impairing growth and development and increasing morbidity and mortality.^{10,11}

Pediatric malnutrition in hospitals has been reported in many countries, with prevalence rates of 24.1% of children in Germany,¹² 18.7% in Brazil,¹³ 11% in France,¹⁴ 9.9% in New Zealand,¹⁵ 8.2% in Spain,¹⁶ and 31.8% in Turkey.^{17,18} Multicenter studies found a 2%-3.7% rate of malnutrition in newly admitted patients in the US¹⁹ and a 7% prevalence in European countries.²⁰ The reported prevalences in Asia, Africa, and South America range from 13.4% to 54%.^{13,17,21-27} The wide variability in the prevalence of pediatric malnutrition among studies may relate to differences in the type of institution, the tools used for nutritional screening, and the criteria used to define malnutrition.

Because malnutrition may go undetected, its true overall prevalence in hospitalized children remains uncertain.²⁸ In particular, in Canada, only a few studies pertaining to nutritional status of hospitalized children have been conducted to date. Parsons et al reported low anthropometric measures in 20% of their patients.²⁹

BMI	Body mass index
BMIZ	Body mass index-for-age z score
HAZ	Length/height-for-age z score
HC	Head circumference
MUAC	Mid-upper arm circumference
SGNA	Subjective Global Nutritional Assessment
STRONG _{kids}	Screening Tool Risk on Nutritional Status and Growth for Kids
TSFT	Triceps skinfold thickness
UMA	Upper-arm muscle area
WAZ	Weight-for-age z score
WHZ	Weight-for-length/height z score

From the ¹Research Centre, CHU Sainte-Justine; ²Department of Nutrition Université de Montréal; ³Department of Pediatrics, Université de Montréal, Montreal, Quebec; ⁴University of Calgary and Alberta Children's Hospital, University of Calgary, Calgary, Alberta; ⁵Dalhousie University and IWK Health Center, Halifax, Nova Scotia; ⁶Kingston General Hospital Research Institute, Kingston, Ontario; ⁷Division of Gastroenterology, Hepatology, and Nutrition, British Columbia Children's Hospital, Vancouver, British Columbia; and ⁸Canadian Nutrition Society, Ottawa, Ontario, Canada

Funded by Abbott Nutrition, Canada. The funder had no role in study design, data collection and analysis, decision to publish or preparation of the manuscript. The authors declare no conflicts of interest.

*Contributed equally.

0022-3476/\$ - see front matter. © 2018 Elsevier Inc. All rights reserved.

<https://doi.org/10.1016/j.jpeds.2018.09.045>

In a study conducted in a pediatric ward in the Province of Quebec, 13.3% of children were found to be acutely and/or chronically malnourished and 79.8% displayed a moderate to severe risk of malnutrition.³⁰ In a large tertiary center in Toronto, the overall prevalence of malnutrition was found to be 39.6%.²²

A number of tools have been developed to assess nutritional risk and malnutrition.³¹⁻³⁵ The Screening Tool Risk on Nutritional Status and Growth for Kids (STRONG_{kids}) scores the vulnerability of pediatric patients to malnutrition based on high-risk disease, assessment of the patients, nutritional intake and losses, recent weight loss, or poor gain.³² The tool has been validated³⁶ and endorsed by the Dutch government for use in pediatric patients.³² This instrument does not include any measurements and provides a quick, inexpensive, and reliable means of identifying patients in need of a nutritional consultation.³⁷ The Subjective Global Nutritional Assessment (SGNA) relies on clinical judgment to assess a patient's nutritional status by gathering information on weight history, current height and weight, parental heights, dietary intake, frequency and duration of gastrointestinal symptoms, and current functional capacity.³³ Adapted from the adult version, this tool addresses the many facets of malnutrition and must be completed by a trained individual, such as a dietitian or nurse.^{33,38}

To assess the prevalence of malnutrition in Canadian pediatric hospitals, we conducted a prospective multicenter study involving tertiary centers in 5 provinces in eastern, central, and western Canada. The goals were to assess the prevalence of malnutrition at admission and discharge, evaluate the usefulness of the STRONG_{kids} and SGNA tools, and identify factors associated with malnutrition and the impact of nutrition on length of stay.

Methods

This multicenter prospective cohort study was conducted in 5 Canadian pediatric tertiary university hospitals: Sainte-Justine University Hospital Center in Montreal, Alberta Children's Hospital in Calgary, IWK Health Centre in Halifax, British Columbia Children's Hospital in Vancouver, and Kingston General Hospital in Kingston, Ontario. Recruitment occurred from September 2012 to August 2016. Screening for nutritional risk and assessment of nutritional status were performed. Informed consent was obtained on admission. Participants were followed throughout their hospital stay until discharge to monitor changes in nutritional status and clinical outcomes. The study was coordinated by the Canadian Nutrition Society and approved by the Ethics Review Boards of the 5 participating institutions. To ensure interrater and interinstitution reproducibility and reliability, all site coordinators in charge of data collection received training on questionnaires, forms, and anthropometric measurements.

Eligibility and Recruitment

Children aged 1 month to 18 years who were admitted to either a medical or a surgical ward and had planned hospital stay >48

hours were eligible. Exclusion criteria included admission to pediatric or neonatal intensive care unit, palliative care or psychiatry, conditions leading to anasarca (ie, severe liver, renal, or cardiac failure), documented eating disorders, rehospitalization during the study, and prematurity (for infants who had not reached 1 month corrected age).

A sample size of 330 participants was established with a confidence level of 95% and a margin error of 5% to determine the prevalence of moderate to severe malnutrition of 25%, with an estimated dropout rate of 10%.

Clinical Data Collection

Data collected at admission included demographics, medical information, and anthropometric measurements (height, weight, head circumference [HC], mid-upper arm circumference [MUAC], and triceps skinfold thickness [TSFT]). For children born prematurely (<37 weeks of gestation), corrected gestational age was used until 2 years of age. Diagnoses were classified according to 11 categories,³⁹ and the severity of the condition was classified as mild (grade 1), moderate (grade 2), or severe (grade 3).³¹ Nutritional status and dietary assessment and consultation with a dietitian were provided during the hospital stay. To avoid changes in standard clinical practice, discussions about the study with the clinical team were decidedly limited. Data were collected from medical charts and from direct interviews with the patients and family members using standardized forms.

Anthropometric Measurements

Children were weighed on a calibrated electronic scale wearing minimal clothing. Height was measured using a stadiometer with the child barefoot in children aged ≥3 years, and using an infantometer with the child supine in those aged <3 years. Arm span was used to estimate height in older children (aged >3 years) who were unable to stand or who had scoliosis, contractures, or additional conditions that prevented proper positioning. HC was measured in children aged <2 years. Weight was assessed every other day, and height and HC were recorded at admission and monthly thereafter when applicable. MUAC was measured, and TSFT was assessed using a Harpenden caliper. Arm measurements were obtained in children aged >1 year. Upper-arm muscle area (UMA) was derived from MUAC and TSFT ($UMA [cm^2] = [MUAC - (\pi TSFT)]^2 / 4\pi$). Arm evaluations were completed at admission and then weekly thereafter.

Evaluation of Nutritional Status

Nutritional status was determined as standard deviation (SD) from growth norms for reference age groups using the 2014 World Health Organization Growth Charts adapted for Canada. Weight-for-age z score (WAZ), length/height-for-age z score (HAZ), and weight-for-length/height z score (WHZ) were evaluated for patients from birth to age 2 years. For children aged >2 years, WAZ, HAZ, and BMI-for-age z score (BMIZ) were used to assess growth. Based on the international World Health Organization Global Database on Child Growth and Malnutrition criteria, participants with at least 1 growth

measure (ie, WAZ, HAZ, WHZ, or BMIZ) <-2 SD at admission or discharge were considered malnourished. Moderate malnutrition was defined as a z score <-2 ; severe malnutrition, as a z score <-3 . Variations in weight and WAZ were considered indicators of changes in nutritional status during the hospital stay. Deterioration of nutritional status was defined as weight loss of $\geq 5\%$ compared with admission weight for children aged 2-18 years or a decreased growth, defined as $<75\%$ of normal weight gain velocity for children aged <2 years during the hospital stay.⁴⁰

Screening Tools for Nutritional Risk and Status

Within 24-48 hours of admission, eligible patients were administered the STRONG_{kids} and the SGNA to evaluate their nutritional risk and nutritional status, respectively. With the STRONG_{kids}, each question is allocated 1 or 2 points adding up to a total maximum score of 5 points. Patients were classified as “low risk” (score of 0), “medium risk” (score of 1-3), or “high risk” (score of 4-5).³² With the SGNA, patients are classified by subjective global rating as “well nourished,” “moderately malnourished,” or “severely malnourished.”³³ Both tools are appropriate for this study, being previously validated in similar pediatric populations.^{32,33}

Dietary Assessment

Dietary intake was assessed with food diaries completed by parents. They were instructed to record consumption of all foods and beverages on a 6-point scale (none, $<25\%$, 25% , 50% , 75% , and 100%) for 3 consecutive days during the first week of admission. After that, parents recorded food intake on 2 days each week until discharge. In infants who were bottle-fed or breast-fed and those on specialized enteral or parenteral nutrition, the site coordinator recorded the intake. The mean energy intake from food and enteral/parenteral nutrition (kcal/day) was calculated each day based on the food journals and/or nutritional support records. The mean percentage energy intake was calculated based on patients' energy needs, considering sex, age, severity of condition, diagnosis, and presence of obesity at admission (defined as BMIZ >3). For all patients, the level of activity was considered sedentary during the hospital stay.

Statistical Analyses

Patients' characteristics and medical conditions were analyzed with the Pearson χ^2 or Fisher exact test to compare the distribution of participants in each condition according to their nutritional status at admission. The prevalence of malnutrition on admission and on discharge were compared using the Pearson χ^2 test. Continuous variables (age, length of stay, change in WAZ from discharge to admission [Δ WAZ]) were analyzed between 2 or more categories with the Mann-Whitney or Kruskal-Wallis test, respectively. Wilcoxon test was used to compare anthropometric measurements (weight and BMI) and growth measures (z scores) between admission and discharge. Logistic regressions were used for estimation of ORs (both unadjusted and adjusted) and corresponding 95% CIs. Targeted variables were malnutrition status at admission, de-

terioration of nutritional status, longer length of hospital stay, and consultation with a dietitian. A series of simple logistic regression analyses were used to assess the association between each outcome and potential predictors, namely age, sex, and socioeconomic status. Based on the literature and our clinical experience, covariates were added to the adjusted analysis. Analyses were performed using SPSS version 24.0 (IBM, Armonk, New York). A *P* value $<.05$ was considered significant. Bonferroni correction was used for multiple analyses in the logistic regression model.

Results

A total of 371 participants were recruited, of whom 64 were excluded from the analyses because of missing anthropometric data. The remaining 307 patients composed the cohort for our analysis (Figure 1; available at www.jpeds.com). The main characteristics of the participants are summarized in Table I. Of the 60 patients (19.5%) who were malnourished at admission, 28 were classified as moderately malnourished and 32 were classified as severely malnourished based on z score criteria. The median length of stay was 5 days.

Table II (available at www.jpeds.com) shows no significant associations between baseline characteristics and nutritional status. In contrast, the STRONG_{kids} and SGNA assessments at admission were associated with participants' nutritional status. Significantly lower z score values were noted for all growth measures (WAZ, BMIZ/WHZ, and HAZ) at admission for patients classified as high risk (STRONG_{kids}) and as severely malnourished (SGNA) compared with patients in the other categories (Figure 2, A). In addition, being identified as at high risk for malnutrition according to the STRONG_{kids} and as malnourished (moderately or severely) with the SGNA was strongly associated with the nutritional status defined by anthropometric data (OR, 5.83; 95% CI, 1.54-22.12 and OR, 8.56; 95% CI, 3.94-18.61, respectively; *P* $<.001$) (Table II).

The use of growth parameters criteria did not identify an important change in malnutrition prevalence between admission and discharge (Table III; available at www.jpeds.com). A total of 149 patients (48.5%) lost weight during their hospital stay; 27 (18.1%) of these patients lost $>5\%$ of their admission weight. There was a decrease in mean WAZ at discharge compared with admission (-0.09 vs -0.14 ; *P* $<.01$). When analyses were stratified according to participants' nutritional status, a difference in WAZ was noted only in participants who were well nourished on admission (Figure 3; available at www.jpeds.com). Measures associated with negative Δ WAZ included having a medical condition classified as moderate and being identified as well nourished with the SGNA or at medium risk of malnutrition with the STRONG_{kids} (Table IV; available at www.jpeds.com). Other factors associated with negative Δ WAZ during hospital stay were no visit by a dietitian and an inadequate energy intake ($<50\%$ of requirement). Admission diagnoses were also associated with negative Δ WAZ; patients with gastrointestinal or hepatic conditions had greater

Table I. Characteristics of participants at admission

Characteristics	All (n = 307)	Well-nourished (n = 247)	Malnourished (n = 60)	P value
Male sex, n (%)	157 (51.1)	126 (51.0)	31 (51.7)	1.00
Age, y, median (IQR)	5.3 (1.3-10.8)	5.4 (1.5-10.8)	4.9 (0.5-11.8)	.56
Age category, n (%)				
13-18 y	60 (19.5)	51 (20.6)	9 (15.0)	
6-12 y	95 (30.9)	76 (30.8)	19 (31.7)	
2-5 y	71 (23.1)	61 (24.7)	10 (16.7)	
<2 y	81 (26.4)	59 (23.9)	22 (36.7)	.16
Ethnicity, n (%)				
White	232 (75.6)	185 (74.9)	47 (78.3)	
South Asian*	10 (3.3)	6 (2.4)	4 (6.7)	
East Asian†	13 (4.2)	12 (4.9)	1 (1.7)	
African	12 (3.9)	10 (4.0)	2 (3.3)	
Pacific island	3 (1.0)	2 (0.8)	1 (1.7)	
Caribbean	4 (1.3)	4 (1.6)	0	
South/Central American	13 (4.2)	12 (4.9)	1 (1.7)	
Indigenous	9 (2.9)	7 (2.8)	2 (3.3)	
Arabic	11 (3.6)	9 (3.6)	2 (3.3)	.59
Parental education level, n (%)	258	210	48	
Elementary school	3 (1.2)	3 (1.4)	0	
High school	48 (18.6)	35 (16.7)	13 (27.1)	
University/college	207 (80.2)	172 (81.9)	35 (72.9)	.23
Parental employment, n (%)	291	235	56	
1 parent	99 (34.0)	78 (33.2)	21 (37.5)	
Both parents	155 (53.3)	131 (55.7)	24 (42.9)	
Both unemployed	37 (12.7)	26 (11.1)	11 (19.6)	.12
Living arrangement, n (%)	305	246	59	
Lives with both parents	256 (83.9)	209 (85.0)	47 (79.7)	
Lives with 1 parent or shared custody	48 (15.7)	36 (14.6)	12 (20.3)	
Residential care	1 (0.3)	1 (0.4)	0	.45
Admission ward, n (%)	301	242	59	
Medical	198 (65.8)	157 (64.9)	41 (69.5)	
Surgical	54 (17.9)	47 (19.4)	7 (11.9)	
Oncology	49 (16.3)	38 (15.7)	11 (18.6)	.38
Severity of condition, n (%)	299	244	55	
Mild	96 (32.1)	82 (33.6)	14 (25.5)	
Moderate	133 (44.5)	108 (44.3)	25 (45.5)	
Severe	70 (23.4)	54 (22.1)	16 (29.1)	.42
Underlying medical condition‡, n (%)				
Yes	173 (56.4)	133 (53.8)	40 (66.7)	.08
Admission diagnosis, n (%)				
Cardiovascular	8 (2.6)	7 (2.8)	1 (1.7)	
Gastrointestinal/hepatic	58 (18.9)	47 (19.0)	11 (18.3)	
Genitourinary	8 (2.6)	6 (2.4)	2 (3.3)	
Respiratory	57 (18.6)	48 (19.4)	9 (15.0)	
Musculoskeletal	25 (8.1)	22 (8.9)	3 (5.0)	
Neurological	21 (6.8)	17 (6.8)	4 (6.7)	
Autoimmune disease	2 (0.7)	1 (0.4)	1 (1.7)	
Metabolic disorder	5 (1.6)	3 (1.2)	2 (3.3)	
Trauma (including burns)	3 (1.0)	3 (1.2)	0	
Infectious	39 (12.7)	31 (12.6)	5 (8.3)	
Renal	16 (5.2)	10 (4.0)	6 (10.0)	
Hematology/oncology	40 (13.0)	38 (15.3)	5 (8.3)	
Developmental	9 (2.9)	5 (2.0)	4 (6.7)	
Other	16 (5.2)	9 (3.6)	7 (11.7)	.09
WAZ, SD, median (IQR), all	-0.1 (-0.9 to 0.8)	0.2 (-0.5 to 0.9)	-2.1 (-3.3 to -0.7)	<.001
HAZ, SD, median (IQR), all	-0.2 (-1.3 to 0.6)	0.0 (-0.8 to 0.8)	-2.5 (-3.5 to -1.9)	<.001
WHZ, SD, median (IQR), ≤2 y	0.2 (-0.8 to 0.9);n = 83	0.2 (-0.2 to 0.9);n = 61	-2.0 (-3.1 to 0.7);n = 22	.001
BMIZ, SD, median (IQR), >2 y	0.2 (-0.9 to 1.1);n = 224	0.3 (-0.6 to 1.2);n = 186	-0.8 (-2.3 to 1.1);n = 38	.001
SGNA, n (%)	304	244	60	
Well nourished	192 (63.2)	175 (71.7)	17 (28.3)	
Moderately malnourished	95 (31.3)	66 (26.9)	29 (48.3)	
Severely malnourished	17 (5.6)	3 (1.2)	14 (23.3)	<.001
STRONG _{kids} score, n (%)	305	245	60	
Low risk	40 (13.1)	35 (14.3)	5 (8.3)	
Medium risk	184 (60.3)	159 (64.9)	25 (41.7)	
High risk	81 (26.6)	51 (20.8)	30 (50.0)	<.001
Length of stay, d, median (IQR)	5 (3-7)	5 (3-7)	5 (4-10)	.05

Nutritional status was determined at admission using SD for at least 1 growth norm (WAZ, HAZ, BMIZ, or WHZ) for reference age groups: well-nourished, ≥ 2 SD; malnourished, < -2 SD. Data were analyzed using the Pearson χ^2 , Fisher exact, or Mann-Whitney U test (age, length of stay, WAZ, HAZ, BMIZ, WHZ). A P value $< .05$ was considered statistically significant.

*Pakistani, Indian.

†Vietnamese, Chinese, Korean, Japanese.

‡Preexisting chronic medical condition.

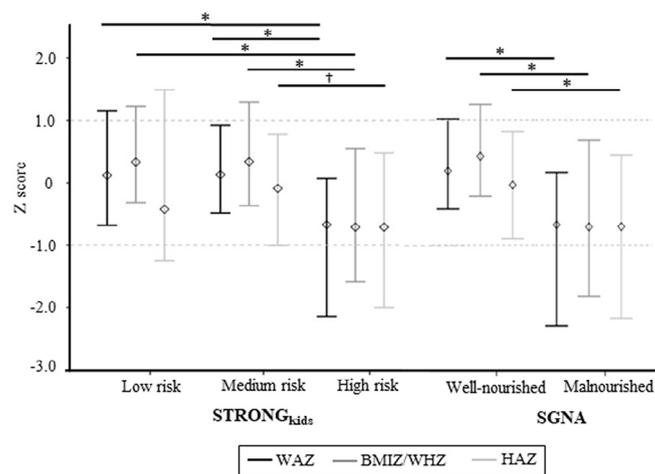


Figure 2. Growth measures according to screening tools. Patients were classified at admission according to the STRONG_{kids} (n = 304) and SGNA (n = 305) tools. Growth measures (WAZ, BMIZ/WHZ, HAZ) at admission were evaluated in each category. Data are shown as the median (◇) and interquartile range (25th and 75th percentiles). †*P* < .05 and **P* < .01 using Mann-Whitney test.

declines in WAZ compared with those with other conditions (Table IV).

Seventy-eight patients (25.4%) experienced deteriorating nutritional status during their hospital stay. Patients admitted with a hematology or oncology diagnosis were less likely than those with a gastrointestinal or hepatic to experience nutritional deterioration (OR, 0.22; 95% CI, 0.07-0.73). In the adjusted model, the factors that remained significant were patient diagnosis, WAZ, and HAZ at admission. Age category, especially infants under 2 years, was also strongly associated with deterioration of nutritional status (Table V). After excluding infants from analysis, association with age category was lost but no other significant differences were found (Table VI; available at www.jpeds.com). Patients identified as at high risk of malnutrition (STRONG_{kids}) and assessed as malnourished (SGNA) had a longer length of stay compared with low-risk and well-nourished patients (5 vs 4 days; *P* < .05). However, using logistic regression, no factor was associated with prolonged length of stay (>5 days) (Table VII; available at www.jpeds.com).

A total of 94 participants (30.6%) had at least 1 consultation with a dietitian during their hospital stay. A higher proportion of malnourished patients were visited compared with well-nourished participants (50.0% vs 25.9%; *P* < .01) (Figure 4, A; available at www.jpeds.com). Although significantly more children were malnourished or identified as at risk of malnutrition, only one-half of them (50% of malnourished and 46.9% of high risk) were visited by a dietitian. Factors associated with dietitian consultation are listed in Table VIII. Nutritional status, SGNA, and STRONG_{kids} scores were positively associated with a dietitian consultation. Longer hospital stay and presence of a chronic condition were also associated with a dietitian consult. Patients admitted in the surgical ward were less likely than those

in medical or oncology ward to be seen by a dietitian (OR, 0.33; 95% CI, 0.15-0.72; *P* = .006). The percentage of patients who experienced weight loss was significantly greater in the group without a dietitian visit (76.5% vs 23.5%, *P* < .01) (Figure 4, B; available at www.jpeds.com), and the proportion of patients with negative ΔWAZ between admission and discharge was lower in children who had a dietitian consult compared with those who did not (26.1% vs 73.9%) (Figure 4, B).

Energy intake was calculated for 256 patients during their hospital stay. Among them, 83 patients (27.0%) had an energy intake <50% of the estimated requirement but with no associated deterioration in nutritional status (Table V) or prolonged length of stay (Table VII). A higher proportion of malnourished patients than well-nourished patients achieved ≥50% of their energy requirement (81.3% vs 64.9%; *P* < .05).

Discussion

Nutritional health is important for the overall well-being of all hospitalized children. However, barriers exist that preclude appropriate diagnosis of malnutrition due to the lack of uniformly applied assessment protocols and limited clinical nutrition education among health care providers. We found that on admission, 19.5% of patients (n = 60) were malnourished based on at least 1 growth measure <-2 SD. This is slightly different from the 13% prevalence of malnutrition reported from a general pediatric unit in Sherbrooke, Quebec based on a combination of low BMI and HAZ.³⁰ Our results are similar to those from another Canadian study at a large tertiary care pediatric hospital (The Hospital for Sick Children in Toronto, Ontario), in which 13.4% of patients were identified as chronically malnourished (HAZ <-2 SD), compared with 14.0% in our study.²² In a large European study, including several countries, the prevalence of malnutrition was 13.4%, with 7% defined as underweight (BMIZ <-2 SD) and 7.9% as stunted (HAZ <-2 SD).²⁰

In our study, the 2 screening tools used to assess nutritional risk and status led to similar results, with both tools able to differentiate patients according to nutritional status. This is in line with the purpose of the SGNA and in agreement with previously reported data.^{38,41} Both tools were associated with length of hospital stay, also as observed in other studies.^{15,23,41,42} The inclusion of patients' medical history might explain why the STRONG_{kids} and SGNA classifications are more accurate in predicting length of stay compared with nutritional status evaluation based on growth norms. A Brazilian study of 181 hospitalized children found similar results for length of stay when using STRONG_{kids} compared with anthropometric indicators.⁴³

Interestingly, growth outcomes during hospital stay (as measured by ΔWAZ) were worse in patients assessed as at medium risk of malnutrition compared with those at high or low risk. In fact, patients screened as at high risk had a better nutritional evolution than others, an observation reported elsewhere.^{15,32} It is known that patients admitted to the hospital with moderate or severe malnutrition sometimes

Table V. Factors associated with deteriorating nutritional status during hospital stay

Factors	OR (95% CI), crude analysis	P value	OR (95% CI), adjusted analysis*	P value
Sex		.11		
Female	Reference			
Male	1.53 (0.91-2.57)			
Age category		<.001		
Adolescents (13-18 y)	Reference			
Children (6-12 y)	1.29 (0.42-3.99)			
Preschoolers (2-5 y)	1.80 (0.58-5.60)			
Infants (<2 y)	20.82 (7.48-57.95)			
Ethnicity		.99		.55
White	Reference		Reference	
Other†	0.995 (0.55-1.81)		1.30 (0.55-3.12)	
Parental education level		.28		
University/college	Reference			
High school or less	0.66 (0.31-1.40)			
Parental employment		.035		.12
Both parents	Reference		Reference	
1 parent	0.46 (0.24-0.86)		0.41 (0.17-0.97)	
Out of work	1.14 (0.53-2.46)		0.93 (0.30-2.89)	
Underlying medical condition‡		.29		.67
No	Reference		Reference	
Yes	1.33 (0.79-2.25)		0.85 (0.41-1.78)	
Diagnosis at admission		.02		.032
Gastrointestinal/hepatic	Reference		Reference	
Respiratory	1.21 (0.55-2.67)		0.32 (0.09-1.15)	
Infectious	1.29 (0.53-3.15)		0.52 (0.14-1.93)	
Hematology/oncology	0.22 (0.07-0.73)		0.10 (0.02-0.59)	
Developmental§	0.52 (0.21-1.27)		0.13 (0.03-0.51)	
Other¶	0.52 (0.25-1.31)		0.36 (0.12-1.15)	
Admission ward		.10		.89
Medical and Oncology	Reference		Reference	
Surgical	0.53 (0.24-1.14)		1.08 (0.37-3.14)	
SGNA		.12		.18
Well nourished	Reference		Reference	
Malnourished (moderate-severe)	0.64 (0.37-1.21)		0.59 (0.27-1.28)	
STRONG _{kids} score		.53		.53
Low risk	Reference		Reference	
Medium risk	1.53 (0.66-3.55)		1.24 (0.35-4.40)	
High risk	1.23 (0.48-3.11)		0.75 (0.18-3.15)	
WAZ at admission, per SD unit	1.12 (0.95-1.33)	.18	1.40 (1.09-1.80)	.009
BMIZ/WHZ at admission, per SD unit	1.09 (0.92-1.29)	.33	1.07 (0.98-1.16)	.067
HAZ at admission, per SD unit	1.13 (0.97-1.32)	.12	1.39 (1.09-1.76)	.008
Length of stay, per day	1.01 (0.96-1.07)	.64		
Registered dietitian consultation (≥1)		.75		.15
No	Reference		Reference	
Yes	1.09 (0.63-1.90)		0.51 (0.21-1.28)	
Energy intake (% of requirement)**		.71		.32
≥50%	Reference		Reference	
<50%	0.89 (0.48-1.65)		1.54 (0.66-3.59)	

Deterioration of nutritional status was characterized by weight loss ≥5% compared with admission weight for children aged 2-18 years or by decreased growth, defined as <75% of weight gain velocity norms for infants (<2 years) during the hospital stay. The Bonferroni correction threshold is $P < .003$ for crude analysis and $P < .004$ for adjusted analysis.

*Model included center of care, sex, age category, parental education level, and length of stay.

†Other included south Asian, east Asian, African, Pacific Island, Caribbean, South/Central American, Native, and Arabic.

‡Preexisting chronic medical condition.

§Developmental included neurologic condition.

¶Other diagnoses included cardiovascular, genitourinary, autoimmune disease, renal, metabolic, and musculoskeletal disorders and trauma.

**Daily dietary intake was expressed as percentage of requirement calculated according to age, sex, and medical condition.

can remain unchanged, improve, or worsen during hospitalization.^{15,20,28,31} Nonetheless, early screening and nutritional therapy should be implemented to improve nutritional status and prevent complications during admission in both moderately and severely malnourished children.

In our study, 30.6% of participants were seen by a dietitian during their hospital stay. Despite this relatively low rate, a dietitian's involvement was associated with a lower decline in mean WAZ over the course of admission. A dietitian was involved in the care of 50% of the malnourished children, com-

pared with 25.9% of the well-nourished children. The low rate of dietitian visits for well-nourished patients is of concern and demonstrates the need to improve nutritional assessment and therapy among inpatients generally.

This study has several limitations. The need for different clinical investigators to collect data could influence some variables despite training, the criteria for seeking a dietitian consultation might have varied, and differences in discharge policies may have affected length of stay data. Deterioration of nutritional status and particularly changes in growth are

Table VIII. Factors related to consultation with dietitian during hospital stay

Factors	OR (95% CI), crude analysis	P value	OR (95% CI), adjusted analysis*	P value
Sex		.31		
Female	Reference			
Male	0.78 (0.48-1.27)			
Age category		.20		
Adolescents (13-18 y)	Reference			
Children (6-12 y)	1.31 (0.62-2.75)			
Preschoolers (2-5 y)	1.38 (0.63-3.03)			
Infants (<2 y)	2.15 (1.02-4.52)			
Underlying medical condition†		.046		
No	Reference			
Yes	1.67 (1.01-2.75)			
Diagnosis at admission		.48		.36
Gastrointestinal/hepatic	Reference		Reference	
Respiratory	1.20 (0.55-2.62)		0.66 (0.25-1.71)	
Infectious	0.50 (0.18-1.36)		0.31 (0.09-1.04)	
Hematology/oncology	0.69 (0.28-1.67)		0.81 (0.27-2.41)	
Developmental‡	0.74 (0.32-1.709)		1.03 (0.38-2.81)	
Others§	1.05 (0.49-2.23)		1.12 (0.44-2.86)	
Admission ward		.006		.018
Medical and Oncology	Reference		Reference	
Surgical	0.33 (0.15-0.72)		0.28 (0.095-0.80)	
SGNA		<.001		.001
Well nourished	Reference		Reference	
Malnourished (moderate-severe)	2.71 (1.64-4.48)		2.81 (1.52-5.18)	
STRONG _{kids} score		<.001		.001
Low risk	Reference		Reference	
Medium risk	3.55 (1.20-10.46)		3.14 (0.86-11.53)	
High risk	7.95 (2.59-24.41)		9.77 (2.46-38.86)	
Nutritional status at admission¶		<.001		.03
Well nourished	Reference		Reference	
Malnourished	2.86 (1.60-5.11)		2.20 (1.09-4.43)	
Length of stay, per day	1.22 (1.14-1.31)	<.001		

The Bonferroni correction threshold is $P < .006$ for the crude analysis and $P < .01$ for the adjusted analysis.

*Model included center of care, sex, age category, underlying medical condition, and length of stay.

†Preexisting chronic medical condition.

‡Developmental included neurologic condition.

§Other diagnostics included cardiovascular, genitourinary, autoimmune, renal, metabolic, and musculoskeletal disorder and trauma.

¶Nutritional status was determined at admission using SD for at least 1 growth norm (WAZ, HAZ, BMIZ or WHZ) for reference age groups: well-nourished, ≥ 2 SD; malnourished, < -2 SD.

difficult to assess during a short hospital stay. WAZ appears to be a good measure for evaluating the impact of hospitalization on nutritional status given its sensitivity, but no cutoff value has been proposed to estimate a clinically significant deterioration of nutritional status. Importantly, hydration status should be considered as well. The strengths of the study include its multicenter nature and design. The use of several screening tools allowed the capture of multiple variables for nutritional status assessment.

In conclusion, considering the complexity of malnutrition, multiple actions could be incorporated into clinical practice to better detect at-risk or malnourished children. This study confirms the usefulness of simple screening tools and the benefit of dietitian consultation for improving the nutritional outcomes of hospitalized children. ■

We acknowledge the contributions of Dr Claude Roy for his leadership and devotion to this work and others. We thank the study coordinators and dietitians of the participating institutions. We also thank The Canadian Malnutrition Task Force, a standing committee of the Canadian Nutrition Society, that provided advice and recommendations through its Director, Bridget Davidson who was also part of the research/facilitation team. We are grateful to the Canadian Nutrition Society and

the Canadian Society of Nutrition Management, which supported the dissemination of this work.

Submitted for publication May 16, 2018; last revision received Aug 16, 2018; accepted Sep 14, 2018

Reprint requests: Emile Levy, MD, PhD, GI-Nutrition Unit, Research Centre, CHU Sainte-Justine, 3175 Sainte-Catherine Rd, Montreal, QC, Canada H3T 1C5. E-mail: emile.levy@recherche-ste-justine.qc.ca

References

1. Mehta NM, Corkins MR, Lyman B, Malone A, Goday PS, Carney LN, et al. Defining pediatric malnutrition: a paradigm shift toward etiology-related definitions. *JPEN J Parenter Enteral Nutr* 2013;37:460-81.
2. Naber TH, Schermer T, de Bree A, Nusteling K, Eggink L, Kruimel JW, et al. Prevalence of malnutrition in nonsurgical hospitalized patients and its association with disease complications. *Am J Clin Nutr* 1997;66:1232-9.
3. Norman K, Pichard C, Lochs H, Pirlich M. Prognostic impact of disease-related malnutrition. *Clin Nutr* 2008;27:5-15.
4. Tappenden KA, Quatrara B, Parkhurst ML, Malone AM, Fanjiang G, Ziegler TR. Critical role of nutrition in improving quality of care: an interdisciplinary call to action to address adult hospital malnutrition. *J Acad Nutr Diet* 2013;113:1219-37.

5. Barker LA, Gout BS, Crowe TC. Hospital malnutrition: prevalence, identification and impact on patients and the healthcare system. *Int J Environ Res Public Health* 2011;8:514-27.
6. Lim SL, Ong KC, Chan YH, Loke WC, Ferguson M, Daniels L. Malnutrition and its impact on cost of hospitalization, length of stay, readmission and 3-year mortality. *Clin Nutr* 2012;31:345-50.
7. Curtis LJ, Bernier P, Jeejeebhoy K, Allard J, Duerksen D, Gramlich L, et al. Costs of hospital malnutrition. *Clin Nutr* 2017;36:1391-6.
8. Hise ME, Halterman K, Gajewski BJ, Parkhurst M, Moncure M, Brown JC. Feeding practices of severely ill intensive care unit patients: an evaluation of energy sources and clinical outcomes. *J Am Diet Assoc* 2007;107:458-65.
9. Somanchi M, Tao X, Mullin GE. The facilitated early enteral and dietary management effectiveness trial in hospitalized patients with malnutrition. *JPEN J Parenter Enteral Nutr* 2011;35:209-16.
10. Pollack MM, Ruttimann UE, Wiley JS. Nutritional depletions in critically ill children: associations with physiologic instability and increased quantity of care. *JPEN J Parenter Enteral Nutr* 1985;9:309-13.
11. Soeters PB, Reijnen PL, van Bokhorst-de van der Schueren MA, Schols JM, Halfens RJ, Meijers JM, et al. A rational approach to nutritional assessment. *Clin Nutr* 2008;27:706-16.
12. Pawellek I, Dokoupil K, Koletzko B. Prevalence of malnutrition in pediatric hospital patients. *Clin Nutr* 2008;27:72-6.
13. Rocha GA, Rocha EJ, Martins CV. The effects of hospitalization on the nutritional status of children. *J Pediatr (Rio J)* 2006;82:70-4.
14. Gerbaud-Morlaes L, Frison E, Babre F, De Luca A, Didier A, Borde M, et al. Frequency and risk factors for malnutrition in children undergoing general anaesthesia in a French university hospital: a cross-sectional observational study. *Eur J Anaesthesiol* 2017;34:544-9.
15. Moeeni V, Walls T, Day AS. Nutritional status and nutrition risk screening in hospitalized children in New Zealand. *Acta Paediatr* 2013;102:e419-23.
16. Durá-Travé T, San Martín-García I, Gallinas-Victoriano F, Vaquero Iñigo I, González-Benavides A. Prevalence of malnutrition in hospitalised children: retrospective study in a Spanish tertiary-level hospital. *JRSM Open* 2016;7:2054270416643889.
17. Doğan Y, Erkan T, Yalvaç S, Altay S, Cokuğraş FC, Aydin A, et al. Nutritional status of patients hospitalized in pediatric clinic. *Turk J Gastroenterol* 2005;16:212-6.
18. Oztürk Y, Büyükgözbiz B, Arslan N, Ellidokuz H. Effects of hospital stay on nutritional anthropometric data in Turkish children. *J Trop Pediatr* 2003;49:189-90.
19. Carvalho-Salemi J, Salemi JL, Wong-Vega MR, Spooner KK, Juarez MD, Beer SS, et al. Malnutrition among hospitalized children in the United States: changing prevalence, clinical correlates, and practice patterns between 2002 and 2011. *J Acad Nutr Diet* 2018;118:40-51.e7.
20. Hecht C, Weber M, Grote V, Daskalou E, Dell'Era L, Flynn D, et al. Disease associated malnutrition correlates with length of hospital stay in children. *Clin Nutr* 2015;34:53-9.
21. Joosten KF, Hulst JM. Prevalence of malnutrition in pediatric hospital patients. *Curr Opin Pediatr* 2008;20:590-6.
22. Baxter JA, Al-Madhaki FI, Zlotkin SH. Prevalence of malnutrition at the time of admission among patients admitted to a Canadian tertiary-care paediatric hospital. *Paediatr Child Health* 2014;19:413-7.
23. Moeeni V, Walls T, Day AS. Assessment of nutritional status and nutritional risk in hospitalized Iranian children. *Acta Paediatr* 2012;101:e446-51.
24. Yellanthoor RB, Shah VKB. Prevalence of malnutrition among under-five year old children with acute lower respiratory tract infection hospitalized at Udipi District Hospital. *Archiv Pediatr Infect Dis* 2014;2:203-6.
25. Brink J, Pettifor JM, Lala SG. The prevalence of malnutrition in children admitted to a general paediatric ward at the Chris Hani Baragwanath Academic Hospital: a cross-sectional survey. *South Afr J Child Health* 2014;8:112-6.
26. Debnath DJ, Parulekar CV. Profile of under-five malnourished children admitted in a tertiary care teaching hospital in Pune, India. *Int J Prev Med* 2014;5:882-6.
27. Keerthiwansa J, Gajealan S, Sivaraja S, Subashini K. Malnutrition and anaemia among hospitalised children in Vavuniya. *Ceylon Med J* 2014;59:141-3.
28. Huysentruyt K, Alliet P, Muyschont L, Devreker T, Bontems P, Vandenas Y. Hospital-related undernutrition in children: still an often unrecognized and undertreated problem. *Acta Paediatr* 2013;102:e460-6.
29. Parsons HG, Francoeur TE, Howland P, Spengler RF, Pencharz PB. The nutritional status of hospitalized children. *Am J Clin Nutr* 1980;33:1140-6.
30. Groleau V, Thibault M, Doyon M, Brochu EE, Roy CC, Babakissa C. Malnutrition in hospitalized children: prevalence, impact, and management. *Can J Diet Pract Res* 2014;75:29-34.
31. Sermet-Gaudelus I, Poisson-Salomon AS, Colomb V, Brusset MC, Mosser F, Berrier F, et al. Simple pediatric nutritional risk score to identify children at risk of malnutrition. *Am J Clin Nutr* 2000;72:64-70.
32. Hulst JM, Zwart H, Hop WC, Joosten KF. Dutch national survey to test the STRONGkids nutritional risk screening tool in hospitalized children. *Clin Nutr* 2010;29:106-11.
33. Secker DJ, Jeejeebhoy KN. Subjective Global Nutritional Assessment for children. *Am J Clin Nutr* 2007;85:1083-9.
34. McCarthy H, Dixon M, Crabtree I, Eaton-Evans MJ, McNulty H. The development and evaluation of the Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP©) for use by healthcare staff. *J Hum Nutr Diet* 2012;25:311-8.
35. Gerasimidis K, Keane O, Macleod I, Flynn DM, Wright CM. A four-stage evaluation of the Paediatric Yorkhill Malnutrition Score in a tertiary paediatric hospital and a district general hospital. *Br J Nutr* 2010;104:751-6.
36. Ling RE, Hedges V, Sullivan PB. Nutritional risk in hospitalised children: an assessment of two instruments. *Eur J Clin Nutr Metab* 2011;6:e153-7.
37. Charney P. Nutrition screening vs nutrition assessment: how do they differ? *Nutr Clin Pract* 2008;23:366-72.
38. Secker DJ, Jeejeebhoy KN. How to perform Subjective Global Nutritional assessment in children. *J Acad Nutr Diet* 2012;112:424-31.e6.
39. Allard JP, Keller H, Jeejeebhoy KN, Laporte M, Duerksen DR, Gramlich L, et al. Malnutrition at hospital admission—contributors and effect on length of stay: a prospective cohort study from the Canadian Malnutrition Task Force. *JPEN J Parenter Enteral Nutr* 2016;40:487-97.
40. Becker P, Carney LN, Corkins MR, Monczka J, Smith E, Smith SE, et al. Consensus statement of the Academy of Nutrition and Dietetics/American Society for Parenteral and Enteral Nutrition: indicators recommended for the identification and documentation of pediatric malnutrition (undernutrition). *Nutr Clin Pract* 2015;30:147-61.
41. Carniel MP, Santetti D, Andrade JS, Favero BP, Moschen T, Campos PA, et al. Validation of a subjective global assessment questionnaire. *J Pediatr (Rio J)* 2015;91:596-602.
42. Chourdakis M, Hecht C, Gerasimidis K, Joosten KF, Karagiozoglou-Lampoudi T, Koetse HA, et al. Malnutrition risk in hospitalized children: use of 3 screening tools in a large European population. *Am J Clin Nutr* 2016;103:1301-10.
43. Márquez Costa MV, Alberici Pastore C. Nutritional screening tool versus anthropometric assessment in hospitalized children: which method is better associated to clinical outcomes? *Arch Latinoam Nutr* 2015;65:12-20 (in Spanish).

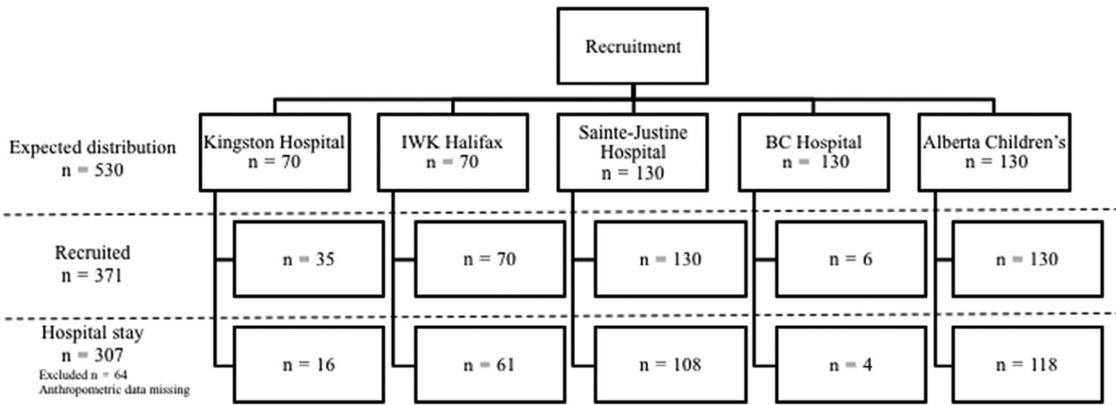


Figure 1. Chart of patient recruitment.

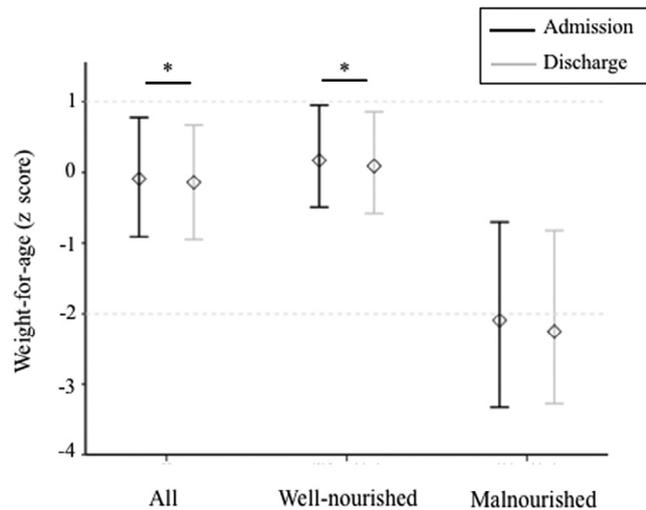


Figure 3. Weight-for-age at admission and discharge according to nutritional status at admission. Z scores for weight-for-age at admission and discharge was calculated for all participants (n = 307). Nutritional status was determined at admission using standard deviation (SD) from at least one growth norms (weight-for-age, height-for-age, body mass index-for-age, or weight-for-height) for reference age groups: well-nourished: ≥ 2 SD and malnourished: < 2 SD. Data are shown as the median (\diamond) and interquartile range (25th and 75th percentiles). Lines (—) represent distribution of normal growth. * $P < .01$ using Wilcoxon test.

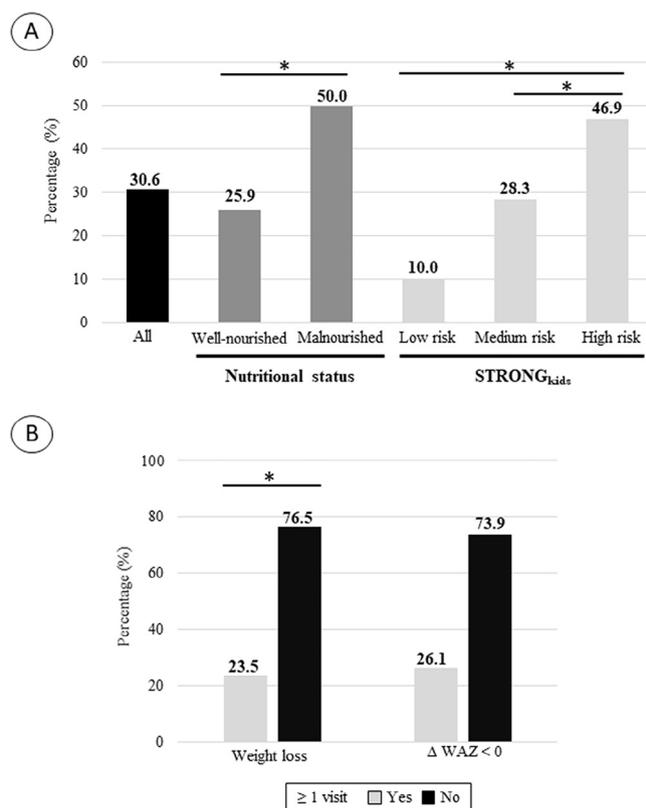


Figure 4. Visit by a dietitian during hospital stay. **A**, Data were divided according to participants' nutritional status at admission: well-nourished ($n = 247$) and malnourished ($n = 60$) and to malnutrition risk using the STRONG_{kids} tool: low risk ($n = 40$), medium risk ($n = 184$), high risk ($n = 81$). Nutritional status was determined at admission using standard deviation (SD) from at least one growth norms (WAZ, HAZ, BMIZ/WHZ) for reference age groups: well-nourished: ≥ -2 SD and malnourished: < -2 SD. **B**, Weight loss ($n = 149$) and Δ WAZ < 0 ($n = 161$) were compared in patients that were visited or not by a dietitian. Any weight loss between admission and discharge was considered. Δ WAZ: difference of weight-for-age z score during hospital stay (discharge—admission). $*P < .01$ using Chi-square test.

Table II. Factors related to malnutrition status at admission

Factors	OR (95% CI), crude analysis	P value	OR (95% CI), adjusted analysis*	P value
Sex		.93		
Female	Reference			
Male	1.03 (0.58-1.81)			
Age category		.17		
Adolescents (13-18 y)	Reference			
Children (6-12 y)	1.42 (0.59-3.38)			
Preschoolers (2-5 y)	0.93 (0.35-2.46)			
Infants (<2 y)	2.11 (0.89-5.00)			
Ethnicity		.58		.075
White	Reference		Reference	
Other	0.83 (0.42-1.63)		0.43 (0.17-1.09)	
Parental education level		.16		
University/college	Reference			
High school or less	1.68 (0.81-3.48)			
Parental employment		.12		.39
Both parents	Reference		Reference	
1 parent	1.47 (0.77-2.81)		1.49 (0.72-3.07)	
Out of work	2.31 (1.01-5.29)		1.78 (0.68-4.67)	
Underlying medical condition†		.07		
No	Reference			
Yes	1.71 (0.95-3.01)			
Diagnosis at admission		.30		.089
Gastrointestinal/hepatic	Reference		Reference	
Respiratory	0.96 (0.35-2.63)		0.46 (0.13-1.58)	
Infectious	1.03 (0.33-3.21)		0.41 (0.10-1.72)	
Hematology/oncology	0.66 (0.20-2.13)		0.44 (0.10-1.86)	
Developmental‡	2.03 (0.80-5.16)		1.66 (0.60-4.60)	
Other§	1.57 (0.63-3.90)		1.48 (0.56-3.89)	
Admission ward		.18		.50
Medical and Oncology	Reference		Reference	
Surgical	0.56 (0.24-1.31)		0.72 (0.28-1.86)	
SGNA		<.001		<.001
Well nourished	Reference		Reference	
Malnourished (moderate-severe)	6.42 (3.43-12.01)		8.56 (3.94-18.61)	
STRONG _{kids} score		<.001		<.001
Low risk	Reference		Reference	
Medium risk	1.10 (0.39-3.08)		1.46 (0.39-5.50)	
High risk	4.12 (1.46-11.65)		5.83 (1.54-22.12)	

Malnutrition status was defined as <-2 SD compared with growth standards for at least 1 measure (WAZ, HAZ, BMIZ or WHZ). The Bonferroni correction threshold was $P < .005$ for the crude analysis and $P < .008$ for the adjusted analysis.

*Model included sex, age category, underlying medical condition, and parental education level.

†Preexisting chronic medical condition.

‡Developmental included neurologic condition.

§Other diagnoses included cardiovascular, genitourinary, autoimmune, renal, metabolic, and musculoskeletal disorders and trauma.

Table III. Prevalence of malnutrition at admission and at hospital discharge

Status	Parameters	Admission, n (%)	Discharge, n (%)	P value
Anthropometric criteria (n = 307)				
Malnourished	WAZ or HAZ or BMIZ/WHZ	60 (19.5)	60 (19.5)	.54
Underweight	WAZ	32 (10.4)	33 (10.7)	.50
Stunting	HAZ	43 (14.0)	43 (14.0)	.55
Wasting	BMIZ/WHZ	28 (9.1)	24 (7.8)	.33
Arm anthropometric criteria (n = 50)				
Malnourished	MUAC or TSFT or UMA	5 (10.0)	8 (16.0)	.28
Reduced lean mass	MUAC	4 (8.0)	7 (14.0)	.26
Reduced fat mass	TSFT	1 (2.0)	1 (2.0)	.55
Reduced muscle mass	UMA	4 (8.2)	4 (8.2)	.64
SGNA (n = 304)				
Malnourished		112 (36.9)	N/D	N/D
Moderately malnourished		95 (31.3)	N/D	N/D
Severely malnourished		17 (5.6)	N/D	N/D

Malnutrition status was defined as <-2 SD comparing to growth standards for at least one of the measures. Prevalence of malnutrition at admission and discharge was compared using chi-square tests. A P value of <.05 was considered statistically significant.

Table IV. Associations between patient characteristics and WAZ

Characteristics	Number	Δ WAZ (z score), median (IQR)	P value
Sex			
Female	150	-0.02 (-0.14 to 0.08)	.21
Male	157	-0.02 (-0.21 to 0.07)	
Age category			
Adolescents (13-18 y)	60	-0.02 (-0.11 to 0.08)	.82
Children (6-12 y)	95	-0.01 (-0.13 to 0.08)	
Preschoolers (2-5 y)	71	-0.02 (-0.25 to 0.08)	
Infants (<2 y)	81	-0.04 (-0.26 to 0.12)	
Parental education level			
High school or less	51	0.00 (-0.12 to 0.12)	.38
University/college	207	-0.03 (-0.15 to 0.07)	
Parental employment			
1 parent	99	-0.03 (-0.18 to 0.07)	.08
Both parents	155	0.00 (-0.13 to 0.11)	
Out of work	37	-0.08 (-0.22 to 0.05)	
Underweight at admission*			
No	275	-0.03 (-0.16 to 0.07)	.002
Yes	32	0.08 (-0.07 to 0.28)	
Nutritional status at admission [†]			
Well nourished	247	-0.02 (-0.16 to 0.07)	.08
Malnourished	60	0.02 (-0.14 to 0.15)	
Admission ward			
Medical	198	-0.02 (-0.16 to 0.07)	.25
Surgical	54	-0.04 (-0.13 to 0.12)	
Oncology	49	0.01 (-0.14 to 0.13)	
Underlying medical conditions [‡]			
Yes	173	-0.02 (-0.14 to 0.11)	.81
No	134	-0.02 (-0.15 to 0.07)	
Diagnosis at admission			
Gastrointestinal/hepatic	54	-0.08 (-0.34 to 0.02)	.009
Respiratory	56	-0.04 (-0.21 to 0.06)	
Infectious	35	-0.04 (-0.26 to 0.04)	
Hematology/oncology	43	0.00 (-0.21 to 0.11)	
Developmental [§]	52	0.00 (-0.08 to 0.16)	
Other [¶]	67	0.00 (-0.14 to 0.10)	
Severity of medical condition			
Moderate	133	-0.06 (-0.21 to 0.06)	.03
Mild-severe	166	0.00 (-0.12 to 0.11)	
SGNA			
Well nourished	192	-0.04 (-0.20 to 0.06)	.023
Malnourished (moderate-severe)	112	0.01 (-0.13 to 0.13)	
STRONG _{kids} score			
Low risk	40	-0.01 (-0.06 to 0.12)	.019
Medium risk	184	-0.06 (-0.23 to 0.06)	
High risk	81	0.00 (-0.11 to 0.12)	
Registered dietitian consultation (≥ 1)			
No	213	-0.04 (-0.16 to 0.07)	.027
Yes	94	0.00 (-0.14 to 0.17)	
Energy intake (% of requirement)**			
$\geq 50\%$	176	0.00 (-0.12 to 0.12)	.004
<50%	83	-0.07 (-0.29 to 0.07)	

Δ WAZ was calculated as the difference in WAZ during the hospital stay (discharge vs admission) expressed as z score. Comparisons were made using the Mann-Whitney (2 categories) or Kruskal-Wallis (≥ 3 categories) test to evaluate the difference in Δ WAZ between groups. A P value $<.05$ was considered statistically significant.

*Underweight was defined as WAZ <-2 z scores at admission.

[†]Nutritional status was determined at admission using SD from at least 1 growth norm (WAZ, HAZ, BMIZ or WHZ) for reference age groups: well-nourished, ≥ -2 SD; malnourished, <-2 SD.

[‡]Preexisting chronic medical condition.

[§]Developmental diagnosis included neurologic conditions.

[¶]Other diagnoses included cardiovascular, genitourinary, autoimmune, renal, metabolic, and musculoskeletal disorders and trauma.

**Daily dietary intake expressed as percentage of requirement calculated according to age, sex, and medical condition.

Table VI. Factors associated with deteriorating nutritional status during hospital stay in patients aged >2 years

Factors	OR (95% CI), crude analysis	P value	OR (95% CI), adjusted analysis*	P value
Sex		.91		
Female	Reference			
Male	1.05 (0.46-2.42)			
Age category		.57		
Adolescents (13-18 y)	Reference			
Children (6-12 y)	1.29 (0.42-3.99)			
Preschoolers (2-5 y)	1.80 (0.58-5.60)			
Ethnicity		.74		.84
White	Reference		Reference	
Other†	1.17 (0.46-2.98)		0.88 (0.26-3.03)	
Parental education level		.24		
University/college	Reference			
High school or less	0.41 (0.09-1.83)			
Parental employment		.12		.15
Both parents	Reference		Reference	
1 parent	0.37 (0.12-1.15)		0.20 (0.04-1.01)	
Out of work	1.50 (0.49-4.56)		0.93 (0.21-4.04)	
Underlying medical condition‡		.56		.09
No	Reference		Reference	
Yes	0.78 (0.34-1.79)		0.39 (0.13-1.17)	
Diagnostic at admission		.02		.056
Gastrointestinal/hepatic	Reference		Reference	
Respiratory	0.23 (0.05-1.12)		0.19 (0.02-1.77)	
Infectious	1.13 (0.35-3.62)		1.06 (0.23-4.97)	
Hematology/oncology	0.28 (0.07-1.12)		0.08 (0.01-0.79)	
Developmental§	0.10 (0.01-0.85)		0.15 (0.02-1.44)	
Other¶	0.20 (0.05-0.80)		0.24 (0.05-1.11)	
Admission ward		.41		.47
Medical and Oncology	Reference		Reference	
Surgical	1.48 (0.58-3.81)		1.55 (0.47-5.06)	
SGNA		.47		.63
Well nourished	Reference		Reference	
Malnourished (moderate-severe)	0.72 (0.30-1.76)		0.77 (0.27-2.22)	
STRONG _{kids} score		.22		.39
Low-medium risk	Reference		Reference	
High risk	0.50 (0.16-1.52)		0.58 (0.17-2.02)	
WAZ at admission, per SD unit	1.42 (1.05-1.91)	.02	1.64 (1.06-2.54)	.03
BMI _Z /WHZ at admission, per SD unit	1.32 (0.999-1.75)	.051	1.46 (0.98-2.18)	.06
HAZ at admission, per SD unit	1.27 (0.99-1.64)	.065	1.48 (1.03-2.13)	.03
Length of stay, per day	1.07 (0.995-1.16)	.069		
Dietitian consultation (≥1)		.95		.19
No	Reference		Reference	
Yes	1.03 (0.41-2.61)		0.29 (0.05-1.85)	
Energy intake (% of requirement)**		.029		.12
≥50%	Reference		Reference	
<50%	2.64 (1.11-6.29)		2.30 (0.80-6.63)	

Deterioration of nutritional status was characterized by weight loss ≥5% compared with admission weight for children aged 2-18 years or by decreased growth, defined as <75% of weight gain velocity norms for infants (<2 years) during the hospital stay. The Bonferroni correction threshold is $P < .003$ for crude analysis and $P < .004$ for adjusted analysis.

*Model included center of care, sex, age category, parental education level, and length of stay.

†Other included south Asian, east Asian, African, Pacific Island, Caribbean, South/Central American, Native, and Arabic.

‡Preexisting chronic medical condition.

§Developmental included neurologic condition.

¶Other diagnoses included cardiovascular, genitourinary, autoimmune disease, renal, metabolic, and musculoskeletal disorders and trauma.

**Daily dietary intake was expressed as percentage of requirement calculated according to age, sex, and medical condition.

Table VII. Factors associated with longer length of hospital stay

Factors	OR (95% CI), crude analysis	P value	OR (95% CI), adjusted analysis*	P value
Sex		.26		
Female	Reference			
Male	0.77 (0.48-1.21)			
Age category		.073		
Adolescents (13-18 y)	Reference			
Children (6-12 y)	0.89 (0.46-1.71)			
Preschoolers (2-5 y)	0.42 (0.20-0.87)			
Infants (<2 y)	0.89 (0.46-1.71)			
Ethnicity		.77		.86
White	Reference		Reference	
Other	0.92 (0.54-1.58)		1.06 (0.56-2.03)	
Parental education level		.65		
University/college	Reference			
High school or less	1.16 (0.62-2.16)			
Parental employment		.53		.80
Both parents	Reference		Reference	
1 parent	0.87 (0.51-1.46)		0.80 (0.44-1.45)	
Out of work	1.35 (0.65-2.77)		1.12 (0.47-2.65)	
Nutritional status at admission [†]		.09		.24
Well nourished	Reference		Reference	
Malnourished	1.63 (0.92-2.88)		1.48 (0.77-2.83)	
Underlying medical condition [‡]		.35		
No	Reference			
Yes	1.25 (0.78-1.99)			
Diagnosis at admission		.39		.45
Gastrointestinal/hepatic	Reference		Reference	
Respiratory	1.35 (0.64-2.88)		1.17 (0.47-2.91)	
Infectious	1.23 (0.52-2.89)		1.68 (0.62-4.55)	
Hematology/oncology	0.70 (0.30-1.62)		0.86 (0.32-2.32)	
Developmental [§]	0.65 (0.29-1.44)		0.59 (0.23-1.48)	
Other [¶]	0.81 (0.39-1.70)		0.81 (0.36-1.85)	
Admission ward		.89		.54
Medical and Oncology	Reference		Reference	
Surgical	0.96 (0.52-1.76)		0.79 (0.37-1.67)	
SGNA		.048		.007
Well nourished	Reference		Reference	
Malnourished (moderate + severe)	1.62 (1.01-2.60)		2.18 (1.24-3.82)	
STRONG _{kids} score		.16		.012
Low risk	Reference		Reference	
Medium risk	1.66 (0.78-3.52)		3.08 (1.13-8.36)	
High risk	2.22 (0.98-5.04)		4.97 (1.72-14.40)	
Deterioration of nutritional status		.46		.30
No	Reference		Reference	
Yes	1.22 (0.72-2.06)		1.49 (0.70-3.17)	
Energy intake (% of requirement)**		.52		.79
≥50%	Reference		Reference	
<50%	0.84 (0.49-1.44)		1.09 (0.57-2.09)	

Longer length of hospital stay was defined as longer than the median (5 days). The Bonferroni correction threshold is $P < .004$ for the crude analysis and $P < .005$ for the adjusted analysis.

*Model included center of care, sex, age category, parental education level, and length of stay.

†Nutritional status was determined at admission using SD for at least 1 growth norm (WAZ, HAZ, BMIZ or WHZ) for reference age groups: well-nourished, ≥ -2 SD; malnourished, < -2 SD.

‡Preexisting chronic medical condition.

§Developmental included neurologic condition.

¶Other diagnoses included cardiovascular, genitourinary, autoimmune disease, renal, metabolic, and musculoskeletal disorders and trauma.

**Daily dietary intake was expressed as percentage of requirement calculated according to age, sex, and medical condition.