Journal of Food and Nutrition Research, 2020, Vol. 8, No. 1, 15-20
Available online at http://pubs.sciepub.com/jfnr/8/1/2
Published by Science and Education Publishing
DOI:10.12691/jfnr-8-1-2

Undernourishment Risk in Hospitalized Children: Development of a Risk Assessment Tool

Ericka Montijo-Barrios[1,#], Martha Guevara-Cruz[2,#], Beatriz Adriana Pinzón-Navarro[1], Judith Ileana Gris-Calvo[1], Miriam G. Bautista-Silva[1], Monserrat Cazares-Mendez[1], Roberto Cervantes-Bustamante[1], Jaime A. Ramírez-Mayans[1], Isabel Medina-Vera[3,*]

[1]Servicio de Gastroenterología y Nutrición Pediátrica, Instituto Nacional de Pediatría, CDMX, México
[2]Departamento de Fisiología de la Nutrición, Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubiran, CDMX, México
[3]Departamento de Metodología de la Investigación, Instituto Nacional de Pediatría, CDMX, México
[#]These authors contributed equally to this work.
*Corresponding author: imedinav@pediatria.gob.mx

Received December 06, 2019; Revised December 24, 2019; Accepted January 08, 2020

Abstract **Aim:** To develop a new screening tool that can quickly assess the risk of undernourishment and evaluate its correlation with frequently used anthropometric indicators. **Methods:** A new, easy-to-access screening tool was developed for clinical practice with 5 items. A total of 650 children were evaluated, with an average age of 54 months. Their global nutritional status was assessed, as well as the proposed new screening tool. **Results**: We found that the presence of the item "The patient is in serious condition" was associated with longer days of hospital stay (18.8 ± 4.5, p=0.002), as was the presence of the item "There are factors that increase metabolic and energy demand (20%)" (14.4 ± 1.9, p=0.007). Similarly, we observed a greater risk with the presence of undernourishment [OR=2.8 (95% CI=2 – 3.9)] and the item "There is functional limitation for feeding" [OR=2.3 (95% CI=1.4 – 3.5)]. The score of the new tool differed between those who children who exhibited undernourishment versus those who did not [2.1 ± 1.08 vs 1.6 ± 0.99 (p=0.0001)]. **Conclusions:** The identification of at least 2 items of the new screening tool could help to detect undernourishment, especially in paediatric populations where, due to the large amount of admissions.

Keywords: *undernourishment, nutrition screening tool, paediatrics*

Cite This Article: Éricka Montijo-Barrios, Martha Guevara-Cruz, Beatriz Adriana Pinzón-Navarro, Judith Ileana Gris-Calvo, Miriam G. Bautista-Silva, Monserrat Cazares-Mendez, Roberto Cervantes-Bustamante, Jaime A. Ramírez-Mayans, and Isabel Medina-Vera, "Undernourishment Risk in Hospitalized Children: Development of a Risk Assessment Tool." *Journal of Food and Nutrition Research*, vol. 8, no. 1 (2020): 15-20. doi: 10.12691/jfnr-8-1-2.

1. Introduction

The evaluation of nutritional status is a key component in the management of hospitalized children. The presence of undernourishment affects the clinical evolution, increases length of hospital stay, and results in immunological suppression and therefore a greater risk of infection, combined with a greater use of antibiotics, decreased functional capacity, delayed healing [1,2], and increased morbi-mortality [3]. In addition, a chronic state of undernourishment could affect the growth and development of the child. Undernourishment related to disease in children can be attributed to the loss of nutrients, a substantial increase in basal metabolism, a decrease in nutrient intake, or an altered utilization of nutrients [4].

Hospitalized children are at risk of undernourishment during their stay; however, changes in anthropometry are a good indicator for their diagnosis, and these indicators are well standardized. These include Z scores weight/age, weight/height, height/age and body mass index (BMI) for age [5]. Another indicator that is important to determine the risk of undernourishment is the mid-upper arm circumference (MUAC), for which only a tape measure with millimetre marks is necessary. This indicator is a useful tool in hospitalized children whose weight and/or height/length cannot be taken, or those who have ascites or oedema [6]. However, in some hospitals, these anthropometric measurements are not carried out in common practice due to lack of health personnel, or increase in the number of hospital admissions involving a complicated practice.

The assessment of nutritional status is considered the best way to achieve accurate identification of undernourishment in hospitalized paediatric patients; it requires a series of anthropometric, biochemical, clinical, and dietetic assessments that together make it possible to establish the presence and severity of the clinical picture through the assessment by a professional in the field of nutrition [7]. As the identification of undernourishment is not an easy task, requiring trained personnel and the availability of certain resources that represent an investment of time and money, it is necessary to have a method that is simple, low cost, and with which one can evaluate all patients upon admission to hospitalization services. This can be achieved through the application of nutritional risk screening tools, whose main purpose is to predict the probability of a better or worse outcome due to nutritional factors, in addition to estimating whether a nutritional intervention could affect that probability [8].

The European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) has called for the detection of nutritional risk in hospitalized children [9], and although there are various risk assessment tools for undernourishment, none of these tools are universal. Thus, the objective of this study was to develop a new screening tool that quickly assesses the risk of undernourishment and to evaluate its correlation with the frequently used anthropometric indicators, as well as the prediction features of clinical outcomes, such as hospital stay, in hospitalized children.

2. Materials and Methods

2.1. Subjects

This was a longitudinal, prospective study conducted at the National Institute of Pediatrics in Mexico City. Children (n=650) admitted to a tertiary paediatric hospital from January 2018 to July 2018 were recruited. All patients admitted to hospital were included, except for those in critical units (intensive care), with an age of >31 days and <18 years; patients were excluded if they had severe renal or hepatic disease, presence of oedema, or admission <48 hours. Corrected gestational age was used for newborns with <37 weeks of gestation. The demographic data collected included age, gender, admission diagnosis, anthropometric measurements at admission and discharge of the patient, as well as days of in-hospital stay. The study was carried out following the ethical principles for medical research in humans of the Declaration of Helsinki.

2.2. New Tool of Risk Undernourishment

The undernourishment risk assessment characteristics were selected and developed based on current literature review [4,10-16] and the clinical practice of the experts in our hospital. A new risk assessment tool was created (Table 1). The time required to perform the new risk tool was 5 ± 2 minutes.

Table 1. New tool of risk malnutrition

Risk assessment characteristics	Present	Absent
1.The patient in in serious condition		
2. There are factors that contraindicate food for more than 24 hours		
3. There are factors that increase the metabolic and energy demand (>20% of the basal energy expenditure)		
4. There is a functional limitation for feeding oneself		
5. The patient presents with a high-risk disease		

The first item "The patient is in serious condition" refers to a condition of seriousness, such as any patient with intubated mechanical ventilation, and/or administration of inotropic drugs, and/or any type of sepsis. Item three "There are factors that increase metabolic and energy demand in more than 20% of basal energy expenditure", such as surgery, trauma, sepsis, and fever, and item five, "The patient presents a high-risk disease", were taken into account for underlying diseases with risk of malnutrition or related to major surgery **(Supplementary Table 1).**

2.3. Assessment of Nutritional Status

The overall nutritional status of the participants was evaluated through the anthropometric measures weight-for-age, weight for height/length, height for height, and BMI for age, and the average circumference of the arm was measured. The weight was recorded to the 0.1 kg, and the height/length was recorded to the 0.1 cm using a fiberglass tape with a precision of 1 mm and a thickness of 0.7 cm. All anthropometric measurements were carried out by standardized personnel and calibrated equipment. Nutritional status was determined by Z scores, the standard deviation scores based on the child growth reference standards of the World Health Organization (WHO) (<2 years) and the Centers for Disease Control and Prevention (CDC) (<2 years). For weight, a TANITA brand digital scale with precision 100 g was. The patient was weighed barefoot with a light smock, standing in the centre of the platform, and the measurement was recorded in kilograms (kg). The height was measured on a portable SECA brand stadiometer with sensitivity 0.1 cm using the following technique: the child, without shoes or socks, stood upright so that heels, buttocks and head were in contact with the vertical surface; the heels remained together and the shoulders were relaxed to avoid the lordosis that occurs when the shoulders are placed backwards. The head was kept on the Frankfort plane, and the reading was made and recorded in centimetres cm [17].

To measure the MUAC, an inextensible MABIS fibreglass tape of no thicker than 5 mm was used, marked accurately to 0.1 cm. The child flexed the left arm and formed a 90-degree angle close to the body; the prominence of the shoulder acromion and the elbow olecranon were found, and the distance between the two points was measured, marking the midpoint. Then, the child extended the arm, and the midpoint was surrounded with the tape measure, taking care that the tape did not exert pressure, and then read, with the data recorded in centimetres (cm) [18].

2.4. Statistical Analysis

The results were analysed as the means ± standard deviations for data with normal distribution, and median and interquartile range (25-75) for data that did not present a normal distribution. Student's t-test was used for independent samples to identify the differences in hospital stay between the presence and absence of each item of the new tool and to compare the scores of the new tool between the presence or absence of undernourishment strata. Logistic regression was used to evaluate the odds ratio (OR) of each item with the presence of undernourishment. The ANOVA with Bonferroni post hoc test was used to compare the scores of the new tool between strata of the nutritional state. Criterion validity was determined with the characteristics of sensitivity, specificity, positive and negative likelihood ratio, and post-test probabilities, and corresponding correct classification percentages of the evaluated instrument with respect to the reference standard were used. The data were analysed with the IBM SPSS Statistics programme version 25.0.

3. Results

3.1. Patient Characteristics

The study population consisted of 650 patients in a tertiary paediatric hospital; 299 were females (46%), and the average age was 54 months (18-113). The median of the Z scores of the anthropometrics at admission were as follows: -1.08 (-2.5, -0.04) for weight-for-age, -0.66 (-1.7, 0.31) for weight for height, -1.03 (-2.2, -0.01)) for height for age, -0.59 (-1.71, 0.5) for BMI for age, and -1.21 (-2.46, -0.22) for MUAC. The median length of hospital stay was 7 days (3-15) for the entire population. The prevalence of undernourishment by Z score of weight-for-age was 53.2%, of which 20.3% was mild undernourishment, 13.4% was moderate undernourishment, and 19.5% was severe undernourishment.

3.2. Undernourishment Risk Factors and Characteristics

According to the risk characteristics of undernourishment in the proposed new tool, we found that the presence of the item "The patient is in serious condition" was associated with longer days of hospital stay (18.8 ± 4.5, p=0.002), as were the presence of the item "There are factors that increase the metabolic and energy demand (20%)" (14.4 ± 1.9, p=0.007) and "The patient presents a high-risk disease" (13.4 ± 1.2, p=0.05). A difference in the days of hospitalization with the remaining items was not seen. The risk of each of the items for undernourishment measured by the weight/age Z score was also calculated, and there was a risk for undernourishment with the item "There are factors that increase the metabolic and energy demand (20%)" OR=2.8 (95% CI= 2-3.9) and the item "There is functional limitation for feeding" OR=2.3 (95% CI= 1.4 - 3.5) (Table 2).

To evaluate the score of the new tool, we used the weight-for-age Z score as a reference and compared by strata of nutritional status, finding a higher average score of the new tool in severe undernourishment (2.5 ± 1), followed by moderate undernourishment (2 ± 0.9), and mild undernourishment (1.9 ± 1.1) a lower score in normal strata (1.7 ± 1) and overweight/obese children (1.3 ± 0.8) Interestingly, when stratifying by undernourishment, we found a higher tool score in those who presented undernourishment (2.1 ± 1.08) compared to those who did not present undernourishment (1.6 ± 0.99) (p=0.0001) (Figure 1). When analysing the risk undernourishment in paediatric patients who had 2 or more risk factors of the new tool (n=403), they had a 2.7 higher probability of undernourishment according to the weight-for-age Z score (95% CI, 1.9-3.7, p<0.0001). According to the previous results, the score of the new tool was categorized as follows: low risk, 0-1 items (n=247, 38%); moderate risk, 2 items (n=212, 32.6%); and high risk, >2 items (n=191, 29.4%).

We evaluated the concurrent validity with the anthropometric parameters, considering the categorization of the new tool as those that had ≥2 characteristics of risk assessment of undernourishment, observing that greater sensitivity was obtained when comparing it with weight/height and then BMI for age (Table 3). To evaluate the validity of predictive criteria, we compared the days of hospital stay stratified by those who had 2 or more undernourishment risk factors.

Table 2. Association between risk characteristics and days of hospital stay

	Hospital stay (days)			OR (95% CI)*	
Risk assessment characteristics	**Present**	**Absent**	**p**		**p**
1. The patient is in serious condition	18.8 ± 4.5	10.8 ± 0.6	0.002	2.1(1.4 - 3.1)	0.001
2. There are factors that contraindicate food for more than 24 hours	11.6 ± 2.8	12.8 ± 1.02	0.629	1 (0.7 - 1.5)	0.685
3. There are factors that increase the metabolic and energy demand (20%)	14.4 ± 1.9	10.7 ± 0.7	0.007	2.8 (2 - 3.9)	0.001
4. There is a functional limitation for feeding oneself	12.9 ± 1.2	12.4 ± 1.2	0.852	2.3 (1.4 - 3.5)	0.001
5. The patient presents with a high-risk disease	13.4 ± 1.2	8.41± 0.77	0.05	1.5 (1 -2.3)	0.035

*Odds Ratio (OR) for undernourishment, CI: confidence Interval.

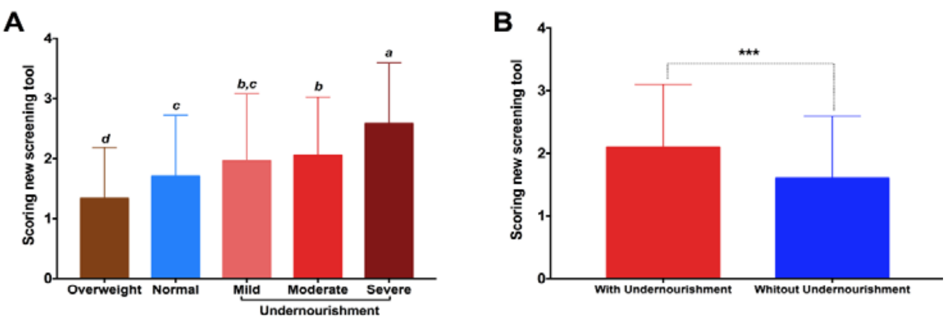

Figure 1. Scoring of the new tool. **(A)** Score of the new tool stratified by nutritional status. **(B)** Score of the new tool comparing those who presented undernourishment vs those who did not present undernourishment by the weight-for-age indicator. a > b > c > d. ***p < 0.001

Table 3. Concurrent validity for ≥2 characteristics of risk assessment for malnutrition

Indicators for Detecting Malnutrition	Weight/Age	Weight/Height	Height/Age	BMI for age	MUAC
Area under the curve (95% CI)	0.645 (0.603-0.688)	0.656 (0.597-0.715)	0.590 (0.546-0.634)	0.658 (0.615-0.7)	0.637 (0.594-0.68)
Sensitivity	0.72	0.76	0.71	0.74	0.72
Specificity	0.503	0.41	0.43	0.47	0.504
Likelihood ratio for positive test	1.47	1.31	1.27	1.41	1.45
Likelihood ratio for negative test	0.54	0.50	0.65	0.54	0.55
Correct classification (%)	62.3	67	60.8	64.3	62.6

BMI: Body mass index; MUAC: Mid-Upper Arm Circumference; CI: confidence Interval.

We observed that the average number of hospitalization days for those who had 2 or more factors was 13.9 ± 1.6; for those with less than 1 factor, it was 10.2 ± 0.7 (p=0.043) (Figure 2).

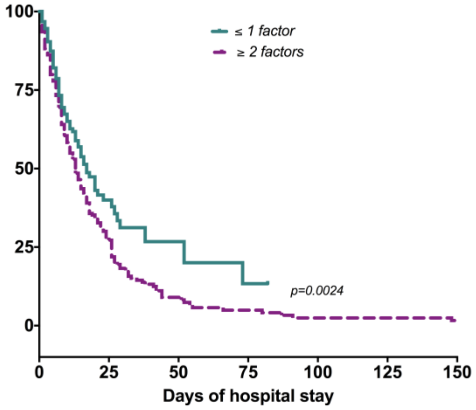

Figure 2. Longer hospital stays with ≥ 2 factors of the new tool. Comparison of days of hospital stay for those who had ≤ 1 factor vs ≥ 2 factors of the new tool

4. Discussion

The present study showed that the prevalence of acute undernourishment at the time of hospital admission was 53.2%, of which 19.5% of children were diagnosed with severe acute undernourishment; this coincides with studies that indicate that acute undernourishment in hospitals ranges from 20 to 53% in developed countries, and up to 60% in those developing countries [19]. A possible explanation for this finding could be due to the low food availability, which has been worsening in recent years; it has been observed that a good diet is not guaranteed in these countries, as 70% of calories available for human consumption are supplied in cereals, visible fats, and sugars [20].

On the other hand, in underdeveloped countries whose hospitals have a high demand for children but few health personnel, these children are not diagnosed in time after hospital admission. To diagnose the nutritional status of patients, we must remember that there is no ideal indicator and that no isolated parameter has a determining value at the time of the nutritional assessment; therefore, a test must be comprehensive, considering the combined clinical state. Hence, the nutritional assessment should be considered as the first link in the treatment, as its main objective is to identify undernourishment so that children can benefit from rapid and adequate treatment and thus avoid prolonged hospital complications and future consequences on growth and development.

We developed a new, rapid, and simple screening tool to determine the risk of undernourishment in children hospitalized in hospitals in underdeveloped countries with insufficient health personnel and high hospital demands. The tool was made based on the risk characteristics that we believe impact the paediatric inpatient and that have been associated with an increased risk of intrahospital undernourishment. With 5 items, which were analysed separately, 1 of the items was significantly associated with the days of hospital stay compared to those without positive item responses: the first item, "There are factors that increase metabolic and energy demands more than 20%". This item is relatively logical because the postoperative patient has increased metabolic demands up to 120% of their energy expenditure; children with trauma increase from 135 to 170%, patients with sepsis, depending on the type and degree, increase from 150 to 170%, and if the patient has a fever, they would increase their energy expenditure 13% more for each degree above normal temperature [21]. In addition, this item was associated with 2.8-fold greater probability of acute undernourishment compared to those who did not have this increase in energy demand. Therefore, it is necessary for these patients to undergo strict nutritional monitoring from admission and increase their energy intake based on their energy expenditure in an individualized way. This will be supported by just asking this question, thus avoiding longer days of inpatient stay and, by consequence, higher costs.

Another item of the nutritional tool that was associated with longer days of in-hospital stay was "The patient has a high-risk disease"; this is due to the increase in energy expenditure secondary to the patient’s basic pathology since admission and during intrahospital stay [22,23].

Another important item was whether "There is functional limitation when eating", which makes the patient 2.3 times more likely to be acutely malnourished compared to those who did not have feeding limitations on admission. This is very important because if this limitation was diagnosed from the time of admission, personalized early treatment and nutritional support could be given according to the limited food intake of this patient, which could improve the child's condition and recovery.

On the other hand, when evaluating the new tool in a comprehensive way, the 5 risk factors together were associated with severe and moderate acute undernourishment. When establishing the cut-off point for our tool, presenting 2 or more risk factors was associated with 2.7 times greater probability of having acute undernourishment regardless of the item. When evaluating the validity of our tool, we observed a correct classification greater than 60% in all anthropometric indicators. We accept the limitation of this tool by integrating the 5 items together, as their concurrent validity was moderate. Nevertheless, the tool's predictive criterion validity when comparing days of hospital stay was significant. We believe that performing this tool on admission could reduce hospital stay days and thus reduce hospitalization cost, which consequently could help create a nutritional support service in the hospital to screen and diagnose nutritional status in time, as well as the early treatment of a malnourished patient.

This study also shows that in hospitals where height and weight are not easy to measure, the MUAC can be used, as in childhood there are few changes, and it is an indirect indicator of body mass [24]. In this sense and with the intention of providing data through a simple and effective technique that allows early identification of the presence of undernourishment, in our work the MUAC is a reliable anthropometric marker of predictive value for acute undernourishment, at admission and during hospitalization, as it is not markedly affected by hydration states [25].

Studies have shown that even for minimally trained health workers, the reliability of arm circumference measurements is at least as good, or better, than other anthropometric measurements. In addition, their reliability and simplicity have a higher sensitivity to predict the risk of death and can offer important advantages in terms of costs [26].

The MUAC indicator presented good sensitivity and specificity. Additionally, the MUAC indicator showed better positive predictive value than negative predictive value in all groups studied. According to the levels of undernourishment observed, it is recommended to include the MUAC to detect nutritional risk at hospital admission and establish early nutritional diagnosis in order to provide the child with adequate, balanced, and timely nutritional support to avoid complications and reduce the risk of dying.

One limitation of the study is that it was more focused on a preschool population and that the concurrent validity of the new tool was moderate. It is necessary to carry out further research and adapt this pilot tool with positive predictive items, thus improving its validity.

5. Conclusions

Our study provides a good framework to identify the risk characteristics of undernourishment in children. We identify elements that can be of great relevance to optimize the nutritional status of patients in paediatric hospitals with high demand and a low number of health personnel. The identification of risk factors (severity of the condition of the patient, factors that contraindicate food, factors that increase metabolic demand, functional limitation when eating, and having a high-risk disease) beyond anthropometry could define undernourishment, and this risk assessment of hospital undernourishment could allow acute care to be prioritized in a paediatric hospital.

The identification of at least two or more undernourishment risk factors that we evaluated in the present study could help to provide an idea of the state of nutrition, especially in paediatric populations where, due to the large amount of admissions, it is necessary to distinguish patients with risk of undernourishment and where it is difficult to obtain anthropometric measures for the entire population that enters the hospital.

Acknowledgements

We appreciate the technical assistance of the 2017 - 2018 Bachelor in Nutrition interns.

References

[1] Joosten KF., Zwart H., Hop WC., Hulst JM. National malnutrition screening days in hospitalised children in The Netherlands. Arch Dis Child. 2010; 95: 141-145.

[2] 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: 514-527.

[3] Cao J., Peng L., Li R., Chen Y., LiX, Mo B., Li X. Nutritional risk screening and its clinical significance in hospitalized children. Clin Nutr 33:432-436, 2014.

[4] Mehta NM., Corkins MR., Lyman B., Malone A., Goday PS., Carney LN., et al. American Society for Parenteral and Enteral Nutrition Board of Directors. Defining pediatric malnutrition: a paradigm shift toward etiology-related definitions. JPEN J Parenter Enteral Nutr. 2013; 37: 460-481.

[5] Corkins KG., Teague EE. Pediatric nutrition assessment. Nutr Clin Pract. 2017, 32: 40-51.

[6] Goossens S., Bekele Y., Yun O., Harczi G., Ouannes M., Shepherd S. Mid-upper arm circumference based nutrition programming: evidence for a new approach in regions with high burden of acute malnutrition. PLoS One. 2012; 7 (11):e49320.

[7] Corkins KG., Teague EE. Pediatric nutrition assessment: anthropometrics to zinc. Nutr Clin Pract. 2017; 32:40-51.

[8] Kondrup J., Allison SP., Elia M., Vellas B., Plauth M. ESPEN guidelines for nutrition screening 2002. Clin Nutr. 2003; 22: 415-421.

[9] Agostoni C., Axelson I., Colomb V., Goulet O., Koletzko B., Michaelsen KF., et al. ESPGHAN Committee on Nutrition, European Society for Paediatric Gastroenterology. The need for nutrition support teams in pediatric units: a commentary by the ESPGHAN committee on nutrition. J Pediatr Gastroenterol Nutr. 2005; 41:8-11.

[10] Wong Vega VM., Beer S., Juarez M., Srivaths PR. Malnutrition risk in hospitalized children: a descriptive study of malnutrition-related characteristics and development of a pilot pediatric risk-assessment tool. Nutr Clin Pract. 2019; 34 (3): 406-413.

[11] Wonoputri N., Djais JT., Rosalina I. Validity of nutritional screening tools for hospitalized children. J Nutr Metab. 2014; 143649.

[12] Durakbasa CU., Fettahoglu S., Bayar A., Mutus M., Okur H. The prevalence of malnutrition and effectiveness of STRONGkids tool in the identification of malnutrition risks among pediatric surgical patients. Balkan Med J. 2014; 31: 313-321.

[13] Marginean O., Pitea AM., Voidazan S., Marginean C. Prevalence and assessment of malnutrition risk among hospitalized children in Romania. J Health Popul Nutr. 2014; 32: 97-102.

[14] Velasco C., Garcia E., Rodriguez V., Frias L., Garriga R., Alvarez J, et al. Comparison of four nutritional screening tools to detect nutritional risk in hospitalized patients: a multicentre study. Eur J Clin Nutr. 2011; 65: 269-274.

[15] Hartman C., Shamir R., Hecht C., Koletzko B. Malnutrition screening tools for hospitalized children. Curr Opin Clin Nutr Metab Care. 2012; 15: 303-309.

[16] Huysentruyt K., Devreker T., Dejonckheere J., De Schepper J., Vandeplas Y., Cools F. Accuracy of nutritional screening tools in assessing the risk of undernutrition in hospitalized children. J Pediatr Gastroenterol Nutr. 2015; 61:159-166.

[17] Lohmann TG., Roche AF., Martorell R. Anthropometric Standardization Reference Manual. Champaign: Human Kinetics Books; 1988.

[18] Dairo MD., Fatokun ME., Kuti M. Reliability of the mid upper arm circumference for the assessment of wasting among children aged 12-59 months in urban ibadan, Nigeria. Int J Biomed Sci. 2012; 8:140-143.

[19] Carvalho-Salemi J., Salemi JL., Wong-Vega MR., Spooner KK., Juarez MD., Beer SS., Canada NL. 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.

[20] Lutter CK., Daelmans BM., de Onis M., Kothari Mt., Ruel MT., Arimond M., et al. Undernutrition, poor feeding practices, and low coverage of key nutrition interventions. Pediatrics. 2011; 128: e1418-1427.

[21] Wiskin AE., Davies JH., Wootton SA., Beattie RM. Energy expenditure, nutrition and growth. Arch Dis Child. 2011; 96: 567-572.

[22] Wiskin AE., Wootton SA., Culliford DJ., Afzal NA., Jackson AA., Beattie RM. Impact of disease activity on resting energy expenditure in children with inflammatory bowel disease. Clin Nutr. 2009; 28:652-656.

[23] Shetty PS. Adaptation to low energy intakes: the responses and limits to low intakes in infants, children and adults. Eur J Clin Nutr. 1999; 53 Suppl 1:S14-S3.

[24] Chaput JP., Katzmarzyk PT., Barnes JD., Fogelholm M., Hu G., Kuriyan R., et al. ISCOLE Research Group. Mid-upper arm circumference as a screening tool for identifying children with obesity: a 12-country study. Pediatr Obes. 2017; 12: 439-445.

[25] Bejon P., Mohammed S., Mwangi I., Atkinson SH., Osier F., Peshu N., et al. Fraction of all hospital admissions and deaths attributable to malnutrition among children in rural Kenya. Am J Clin Nutr. 2008; 88: 1626-1631.

[26] Mwangome MK., Fegan G., Mbunya R., Prentice AM., Berkley JA. Reliability and accuracy of anthropometry performed by community health workers among infants under 6 months in rural Kenya. Trop Med Int Health. 2012; 17: 622-629.

Supplementary Table 1. List of disease related with risk of malnutrition or to major surgery

High risk diseases		
	Code	**Diseases**
Infectious	A: infectious and parasitic diseases	Intestinal infectious diseases, tuberculosis, viral hepatitis, human immunodeficiency virus disease, mycosis, infection by EBV, CMV infections, viral diarrhoea in immunosuppressed patients
Oncology	B: solid neoplasms	Tumours in the oral cavity or pharynx, hepatoblastoma, Kaposi sarcoma, Wilms' tumour
	C: haematopoietic neoplasms	Hodgkin Disease, lymphomas, leukaemia
	D: diseases of the blood	Nutritional anaemia, haemolytic anaemia, disseminated intravascular coagulation, Langerhans cell lymphohistiocytosis, haemophagocytic lymphohistiocytosis
	E: diseases that affect the immune system	Hypogammaglobulinemia, selective deficiency of immunoglobulins, severe combined immunodeficiency, Wiskott-Aldrich syndrome, DiGeorge syndrome, hyperIgE syndrome
Endocrinology	F: diseases of the endocrine system	Hyperthyroidism, thyrotoxicosis, diabetic ketoacidosis, panhypopituitarism
	G: metabolic disorders	Phenylketonuria, tyrosinemia, maple syrup disease
Neurology	H: organic mental disorders	Pick's disease, dementia due to Huntington's disease, schizophrenia, bipolar disorder, depressive disorder, anorexia nervosa, bulimia nervosa, mental retardation
	I: diseases of the central nervous system.	Meningitis, paraplegia, intracerebral abscess, multiple sclerosis, epilepsy, cerebral palsy, cerebral oedema
Cardiology	J: diseases of the circulatory system	Pericarditis, acute myocarditis, heart failure, cyanotic congenital cardiomyopathies
Pneumology	K: diseases of the respiratory system	Complicated pneumonia, cystic fibrosis, acute respiratory distress syndrome
Gastro	L: diseases of the digestive system	Esophagitis, achalasia, gastroesophageal reflux disease, Crohn's disease, ulcerative colitis, functional diarrhoea, liver failure, primary biliary cirrhosis, autoimmune hepatitis, portal hypertension, autoimmune hepatitis, cholangitis, acute pancreatitis, malabsorption syndrome, celiac disease
Neonatology	M: diseases in the neonatal period	Asphyxia, congenital pneumonia, meconium aspiration syndrome, congenital viral diseases, bacterial sepsis of the newborn, prematurity, necrotizing enterocolitis, intestinal perforation, congenital malformation of the oesophagus
Emergency	N: trauma	Severe cranioencephalic trauma, multiple contusions, 2nd-3rd degree burns.