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Nutritional Care Guide for Pediatric Cancer

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Washington, D.C., 2022

PAHO Pan American Health Organization World Health Organization Americas

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ISBN: 978-92-75-12619-6 (PDF)
ISBN: 978-92-75-12620-2 (Print version)

Suggested citation: Pan American Health Organization. Nutritional Care Guide for Pediatric Cancer. Washington, D.C.: PAHO; 2023. Available from: https://doi.org/10.37774/9789275126196.

Cataloguing-in-Publication (CIP) data: Available at http://iris.paho.org.

NMH/NV/2023

CONTENTS

ACKNOWLEDGMENTS

This edition of the Nutritional Care Guide for Pediatric Cancer was written by Erika Damasco, a nutritionist with a master's degree and doctorate in medical and health sciences with a focus on clinical epidemiology, in collaboration with the team from the International Initiative on Pediatrics and Nutrition (IIPAN). The author was also in charge of systematizing the edits made to the document.

We wish to express our gratitude to the members of the Nutrition Working Committee of the Global Initiative for Childhood Cancer of the Pan American Health Organization (PAHO) and to other collaborators, who, from June 2021 until the date of this publication, contributed their expertise to the revision of this manual: Ana Alava, Reynaldo Andree, Aliz Borja, Dayan Bravo Rodríguez, Verónica Cáceres Achá, María de los Ángeles Carrillo Bravo, Laura Cazalla, María Estela Coleoni, Laura Escobar, Milagros Escobedo, Paulina Gallardo Jaramillo, Adriana Garófolo, Natalia Lucía González, Trinidad González, Edith Grynszpancholc, Loyda Violeta López Rugel, Sandra Luna-Fineman, Bianca Manzoli, Carina Mougel, Leslie Muller, Eliana Muñoz Benavides, Juliana Nabarrete, María Paulina Onfray, Karina Quintero, Viviana Reyna, Karina Ribeiro, Catherine Sanon, Tamara Sepúlveda González, Karina Viani, Wanelia Vieira Afonso, Verónica Zambrano, and Stephany Zelaya Sagastizado.

We also want to extend our thanks for revision of the document to Leendert Nederveen, advisor, Food, Nutrition and Physical Activity in Schools, PAHO; Elena Ladas, Director of IIPAN, Sid and Helaine Lerner Associate Professor for Global Integrative Medicine, Co-Director of the Center for Comprehensive Wellness, and Associate Research Director, Pediatric Obesity Program at Columbia University Irving Medical Center, New York; and Ronald Barr, Associate Director of the International Initiative for Pediatrics and Nutrition and Professor Emeritus, Pediatrics, Faculty of Health Sciences, McMaster University.

Sara Benítez, Soad Fuentes-Alabí, Silvana Luciani, Mauricio Maza, and Liliana Vásquez, from PAHO, were responsible for editing and final revision.

This guide was prepared by PAHO within the framework of the Global Initiative for Childhood Cancer. The views expressed by the authors do not necessarily reflect the official views of the United States Agency for International Development (USAID) or the Government of the United States of America.

INTRODUCTION

Every year, almost 280 000 children and adolescents are diagnosed with some type of cancer worldwide; however, in low- and middle-income countries, health professionals face significant challenges in providing optimal delivery of cancer therapy, and must also address comorbidities that are endemic to each region. The type of cancer and socioeconomic background are important determinants of prognosis, but research in recent decades has shown that the two extremes of malnutrition increase the risk of treatment-related complications and abandonment of treatment, which negatively impacts the prognosis and survival of children and adolescents with cancer (1-5).

In Latin American countries, the two extremes of malnutrition in children and adolescents (0-18 years) diagnosed with some type of cancer are found in a high proportion at the time of the diagnosis. In Mexico, the prevalence of undernutrition and obesity is close to 12% and 24%, respectively. In Central America, the prevalence of undernutrition increases to moderate levels (18%) and there are severe levels of obesity (45%), while the prevalence of undernutrition in South America remains between 6% and 25%, and between 4% and 35% for obesity, depending on the region (6).

Given the above, children and adolescents with cancer in Latin America constitute a vulnerable population that would benefit from receiving regular nutritional assessment and adequate nutritional intervention. Likewise, the Nutritional Care Guide for Paediatric Cancer aims to help reduce the impact on morbidity and mortality from childhood cancer associated with nutritional changes by training health professionals within the framework of the World Health Organization (WHO) Global Initiative for Childhood Cancer.

Chapter 1.
Nutricional risk screening

Cancer patients experience changes caused by the tumor itself and by the treatment. It is common for hospitalized children to develop undernutrition, and the risk increases with constant hospitalizations, as in children and adolescents with cancer. Key risk factors include adverse effects of medical treatment, changes in caloric or protein intake, low-nutritional diets, increased energy expenditure, the disease itself, and medical complications (7, 8).

It is also important to recognize the risk of obesity or being overweight in these patients. Several studies report the onset of obesity during the early phases of treatment, especially in patients diagnosed with acute lymphoblastic leukemia (ALL), due to the type of drugs used. It may appear later in patients with hypothalamic damage, which may be secondary due to radiation, surgery, or the tumor itself. The presence of obesity considerably increases the appearance of other components of metabolic syndrome (hypertension, hyperglycemia, insulin resistance, and dyslipidemia) and, consequently, the patient's cardiometabolic risk (9–11).

Understanding the effects of treatment and the disease itself on patients allows for greater awareness of possible complications and timely action (see Table 1).

Table 1: *Diagnosis and treatment of the risk of malnutrition*

Chronic acute undernutrition	Overweight or obesity and adiposity
Diagnosis	
- Advanced (III or IV) solid tumors during initial treatment, or in relapse; especially: neuroblastoma, Wilms tumor, rhabdomyosarcoma, and Ewing's sarcoma - Relapsed and high- or medium-risk leukemias - Non-lymphoid leukemias - Head and neck tumors - Diencephalic tumors - Histiocytosis with visceral involvement Bone marrow post-transplantation: - Graft-versus-host disease (GVHD);	Central nervous system tumors: - Craniopharyngioma - Medulloblastoma - Astrocytoma By type of treatment: - Acute lymphoblastic leukemia - Ependymoma - Nasopharyngeal carcinoma - Sarcoma - Lymphoma - Disseminated testicular cancer
Treatment	
- Tumors requiring radiation therapy or surgery that affect the digestive system at any level - Chemotherapy at frequent intense intervals (≤3 weeks) in the absence of corticosteroids - Intracranial tumors with multiple treatments. - Bone marrow transplant	- Extensive brain surgery - High-dose craniospinal radiation therapy - Whole-body or abdominal radiation therapy - Long-term therapy with high-dose corticosteroids or other medications that increase body fat stores

Demographics	
The risk of developing chronic undernutrition will depend on the age-based growth rate. The most vulnerable groups are: - Children under 2 years of age - Children in puberty	The risk of developing these conditions will depend not only on the age of diagnosis and treatment, but on other characteristics such as sex and ethnicity. For: CNS tumors: - Female - High BMI at diagnosis Acute lymphoblastic leukemia (ALL): - Male - Hispanic - Diagnosed before age 10

Sources: Abbassi V. Growth and normal puberty. Pediatrics. 1998;102(2 Pt 3):507-511.
Co-Reyes E, Li R, Huh W, Chandra J. Malnutrition and obesity in pediatric oncology patients: Causes, consequences, and interventions. Pediatr Blood Cancer. 2012;59(7):1160-7.
Hernández Rodríguez M, Pedrón Giner G. Soporte Nutricional en el Paciente Oncológico. Consideraciones especiales en el paciente pediátrico. Madrid: Pediatric Department, Hospital Niño Jesús; 2010.
Viani K, Trehan A, Manzoli B, Schoeman J. Assessment of nutritional status in children with cancer: A narrative review. Pediatr Blood Cancer. 2020;67(3):e28211.
Vilela MI, Viana MB. Longitudinal growth and risk factors for growth deficiency in children treated for acute lymphoblastic leukemia. Pediatr Blood Cancer. 2007;48(1):86-92.

• *Nutrition screening tools*

In low- and middle-income countries, hospitals are often overwhelmed and resources are limited, making it difficult to conduct a detailed nutritional assessment of each patient. However, it is essential to detect patients at risk or with nutritional alterations already present, for the sake of prevention or to carry out timely treatment. Under these conditions, nutritional screening is a useful and practical tool, since it is a fast, simple method capable of identifying, upon admission, those patients who require early nutritional intervention because they already have nutritional impacts or because they are at risk due to their symptoms, their current status, or treatment.

Risk and nutritional status are constantly changing, requiring repeated screening and comprehensive and detailed nutritional assessments at different times (see Chapter 4).

● ***Table 2:*** *Screening tools available for the pediatric population*

Screening tools	Population	Assessment points	Advantages [a]	Desadvantages
Pediatric Nutritional Risk Scale (PNRS) [b]	Children from 1 to 18 years old	- Food intake - Difficulty retaining food - Ability to feed themselves - Pain - Medical condition	Does not require weighing the patient; contains a table to determine risk based on medical condition and integrates pain.	Does not take into account weight changes.
Screening Tool for the Assessment of Malnutrition in Pediatrics (STAMP) [c]	Children from 2 to 17 years old	- Clinical diagnosis - Food intake - Anthropometry (growth curves)	Short and easy to use.	Requires percentiles for use in growth curves.
Pediatric Yorkhill Malnutrition Score (PYMS) [d]	Children from 1 to 16 years old	- BMI/age - Weight (changes over time) - Food intake - Medical condition	Short and easy to use.	Requires BMI/age percentiles and has low sensitivity.
Screening Tool for Risk on Nutritional Status and Growth (STRONGkids) [e]	Children from 1 to 16 years old	- Subjective assessment - Weight (changes over time) - Food intake - Medical condition	It does not require weighing the patient, has been validated, is available in several languages, and is one of the most complete.	Lack of training in detecting undernutrition can alter the outcome.

Pediatric Nutrition Screening Tool (PNST)[f]	Children from 1 to 18 years old (age not specified)	- Weight (changes over time) - Food intake - Evidence of undernutrition	Short and easy to use.	Only determines the presence or absence of risk, without risk levels.
Subjective Global Nutritional Assessment (NAMS) [g]	Children from 1 month to 17.9 years old	- Weight (changes over time) - Gastrointestinal symptoms - Food intake - Functional ability - Physical examination - Medical condition - Parental height	The most complete of all.	Requires a lot of time to complete (as a screening tool).
Nutrition Evaluation Screening Tool (NEST) [h]	18 years old (age not specified)	- Food intake - Medical condition - Anthropometry (growth curves)	Short and easy to use.	Requires percentiles for use in growth curves.
Nutrition Screening Tool for Childhood Cancer (SCAN) [i]	Children from 1 month to 17.9 years old	- Type of cancer - Type of treatment - Gastrointestinal symptoms - Food intake - Weight loss - Signs of undernutrition	Specifically designed for pediatric cancer patients.	Without knowledge of the risk diagnoses, scoring may be incorrect.
St. Jude Children's Research Hospital [j]	Children from 1 month to 17.9 years old	- Ideal weight - Weight loss - Albumin - Treatment outcomes - Intake - Changes in growth curves - Nutritional risk by diagnosis	Specifically designed for pediatric cancer patients.	Requires albumin values to complete the score.

BMI: Body Mass Index

Sources: Adapted from Hartman C, Shamir R, Hecht C, Koletzko B. Malnutrition screening tools for hospitalized children. Curr Opin Clin Nutr Metab Care. 2012;15(3):303-9.

a. Carter LE, Shoyele G, Southon S, Farmer A, Persad R, Mazurak VC, BrunetWood MK. Screening for pediatric malnutrition at hospital admission: Which screening tool is best? Nutr Clin Pract. 2020;35(5):951-8.
b. Sermet-Gaudelus I, Poisson-Salomon AS, Colomb V, Brusset MC, Mosser F, Berrier F, Ricour C. Simple Pediatric Nutritional Risk Score to identify children at risk of malnutrition. Am J Clin Nutr. 2000;72(1):64-70.
c. 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(4):311-8.
d. 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(5):751-6.
e. Ortíz-Gutiérrez S, Pérez-Cruz E, Lara-Pompa NE, Serralde-Zúñiga AE, Fewtrell M, Peralta-Pedrero ML, et al. Validation and adaptation of the spanish version of the STRONGkids Nutrition Screening Tool. Nutr Clin Pract. 2019;34(4):589-96.
f. White M, Lawson K, Ramsey R, Dennis N, Hutchinson Z, Soh XY, et al. Simple Nutrition Screening Tool for pediatric inpatients. JPEN J Parenter Enteral Nutr. 2016;40(3):392-8.
g. Secker DJ, Jeejeebhoy KN. Subjective Global Nutritional Assessment for children. Am J Clin Nutr. 2007;85(4):1083-9.
h. Dokal K, Asmar N, Shergill-Bonner R, Mutalib M. Nutrition Evaluation Screening Tool: An easy to use screening tool for hospitalised children. Pediatr Gastroenterol Hepatol Nutr. 2021;24(1):90-9.
i. Murphy AJ, White M, Viani K, Mosby TT. Evaluation of the nutrition screening tool for childhood cancer (SCAN). Clin Nutr. 2016;35(1):219-24.
j. Elliott L, Molseed LL, Davis-McCallum P (eds). The clinical guide to oncology nutrition. 2ª ed. Chicago: Academy of Nutrition and Dietetics; 2006.

• *Main components of nutritional risk assessment*

Changes in weight: The weight variation percentage should be assessed along with the time in which it occurs. Avoid taking 10% as a cut-off point to establish the risk. A slight weight loss in a short period of time can be clinically significant; on the other hand, it is probable that greater weight loss over a lengthy period is not likely to confer a high risk of further undernutrition. Whether or not weight loss continues should be reviewed to make better decisions. Likewise, the percentage of weight gain and metabolic risk should be assessed along with the increase in body fat. The following should be considered:

1. Changes in dietary intake: changes in the amount a child currently eats compared to how much he or she regularly eats; changes in the type of diet (for example, switching from a solid diet to liquids or purees) and how long these changes have been happening.

2. Gastrointestinal symptoms may cause:
    a. Difficulty ingesting or retaining food or nutrients: nausea, vomiting, diarrhea, high expenditure because of fistulas. Where possible, it is very useful to know the number of episodes, consistency, and characteristics.
    b. Difficulty eating: dry mouth, problems chewing or swallowing, dyspnea, etc.
    c. Causes of pain when chewing or swallowing: mucositis.
3. Note: The longer these symptoms last, the greater the risk of weight loss.
4. Fitness: Loss of muscle mass, immobility, being bedridden, and limited physical activity can lead to loss of strength and functional capacity.
5. Disease and medical-stress metabolic complications: disease or complications (infectious, surgical, etc.) impact energy expenditure and metabolic stress, and may increase nutritional requirements or be the cause of decreased intake. Therefore, these factors must be considered to avoid deterioration in the child's nutritional status.
6. Other factors that may cause loss of appetite:
    a. Pain
    b. Medications
    c. Mood
    d. Diet (for example, little variation, different, tasteless)

Available screening tools assess some or all of the points, but there is no gold standard. It is almost impossible to judge the inferiority or superiority of one tool over the other since each can be useful in different populations, such as a hospital or community setting, in healthy children, or in those with a chronic disease. The SCAN tool is the only one validated specifically for pediatric cancer patients, although so far, the STRONGkids tool has proven to be the most useful for hospitalized patients. However, there is a lack of evidence related to cancer patients to strengthen its recommendation as the best tool for this group.

Chapter 2.
Nutritional assessment

Nutritional assessments evaluate growth and development and should be performed throughout the care process to identify growth problems in a timely manner (12-16). This includes anthropometric, biochemical, clinical, and dietary indicators. Below are the parameters to be considered, how they should be evaluated, and their interpretation.

• *Anthropometric assessment*

The anthropometric measurements used are weight, height (length for children under 2 years), and mid-arm circumference (MAC). The values are compared with tables or cut-off points for age and sex, where appropriate, to identify the presence of stunting, underweight or wasting, or overweight or obesity. Growth measures that cross Z-score lines indicate a possible risk. Children who grow and develop normally will be at or between –1 and 1 of the Z-score of a given indicator. The direction of the curve in consecutive measurements also indicates the development of the child and adolescent.

Basic parameters for anthropometric evaluation (12,17-20)

The basic parameters for anthropometric assessment are weight-for-age (W/A), height-for-age (H/A), and weight-for-height (W/H) or body mass index-for-age (BMI/A). The points marked on the growth curve of boys and girls should be compared with the Z-score lines to determine nutritional status. As already mentioned, deviations from the direction of the curve in successive measurements are very important, along with clinical assessment, to determine if there is a growth problem.

● ***Table 3:*** *Interpretation of parameters for weight, height, and body mass index*

Z-score (standard deviation [SD])	Weight/height (W/H) or body mass index/age (BMI/A)	Height/age (H/A)	Height/age (H/A)
Age	**< 5 years (W/H) > 5 years (BMI/A)**	**< 2 years (length) > 2 years (height)**	**< 1 year**
Below –3 SD	Severe undernutrition or wasting	Severe short stature [b]	Severe low weight
Below –2 SD	Severe undernutrition or wasting	Short stature [b]	Low weight
Below –1 SD	Low weight	Normal height	Appropriate weight
0 (median)	Appropriate weight	Normal height	Appropriate weight
Above 1 SD	Risk of being overweight [a]	Normal height	[d]
Above 2 SD	Overweight	Normal height	[d]
Above 3 SD	Obesity	[c]	[d]

Notes: For children diagnosed with Down syndrome, the use of specific growth charts is suggested: https://www.centroucdown.uc.cl/#documentos_descargables.

[a] A score above 1 indicates a possible risk. A trend towards the Z-2 score line indicates a definite risk

[b] It is possible for a child with stunting, short stature, or severely short stature to become overweight.

[c] A child in this range is very tall. A tall stature is rarely a problem unless it is an extreme case that indicates the presence of endocrine disorders, such as a growth hormone-producing tumor. If an endocrine disorder is suspected, the child in this range should be referred for medical evaluation (for example, if parents of normal height have a child who is excessively tall for their age).

[d] A child whose weight-for-age falls in this range may have a growth problem, but this can be best assessed by considering weight-for-length/height or BMI-for-age.

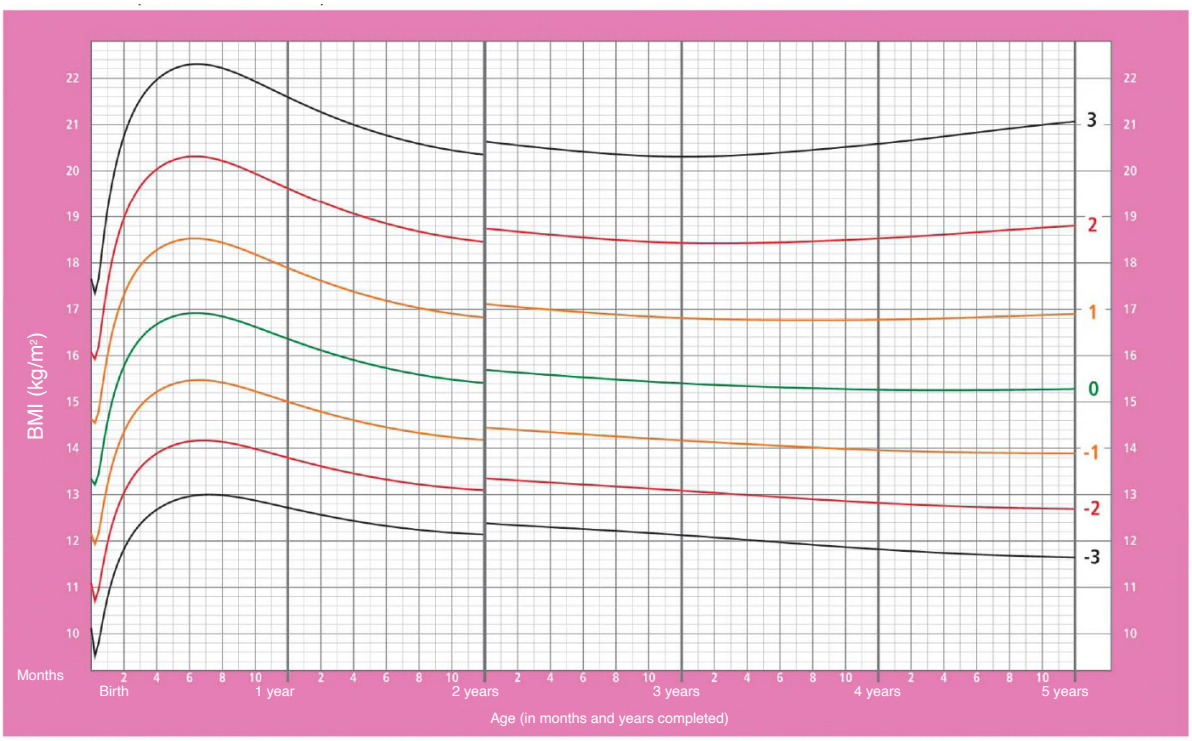
Source: World Health Organization. WHO Anthro for personal computers, version 3.2.2, 2011: Software for assessing growth and development of the world's children. Geneva: WHO, 2010. Available at: Anthro: https://www.who.int/tools/child-growth-standards/software (used only for children 0–5 years); AnthroPlus: https://www.who.int/toolkits/growth-reference-data-for-5to19-years/application-tools

Below is a series of figures containing the curves for the parameters, listed by age and sex. Panels A and B in Figure 1 reflect the body mass index by age in girls and boys, respectively, from birth to 5 years, while panels A and B in Figure 2 show the same index for girls and boys aged 5 to 10 years.

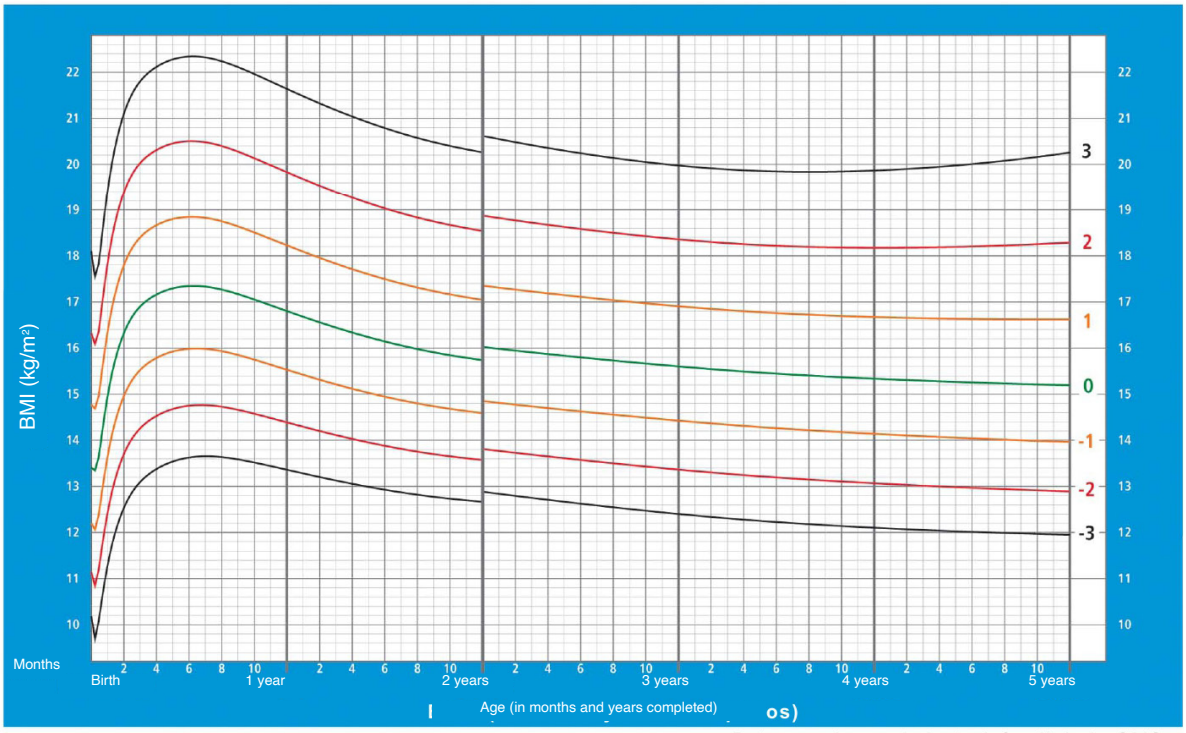
Panels A and B of Figure 3 show the proportions corresponding to length or height (height) by age in girls and boys, respectively, from birth to 5 years. Figure 4 presents that data for girls and boys between 5 to 19 years of age.

- ***Figure 1:*** *Body mass index by age, birth to age 5*

A. Girls (Z-score)



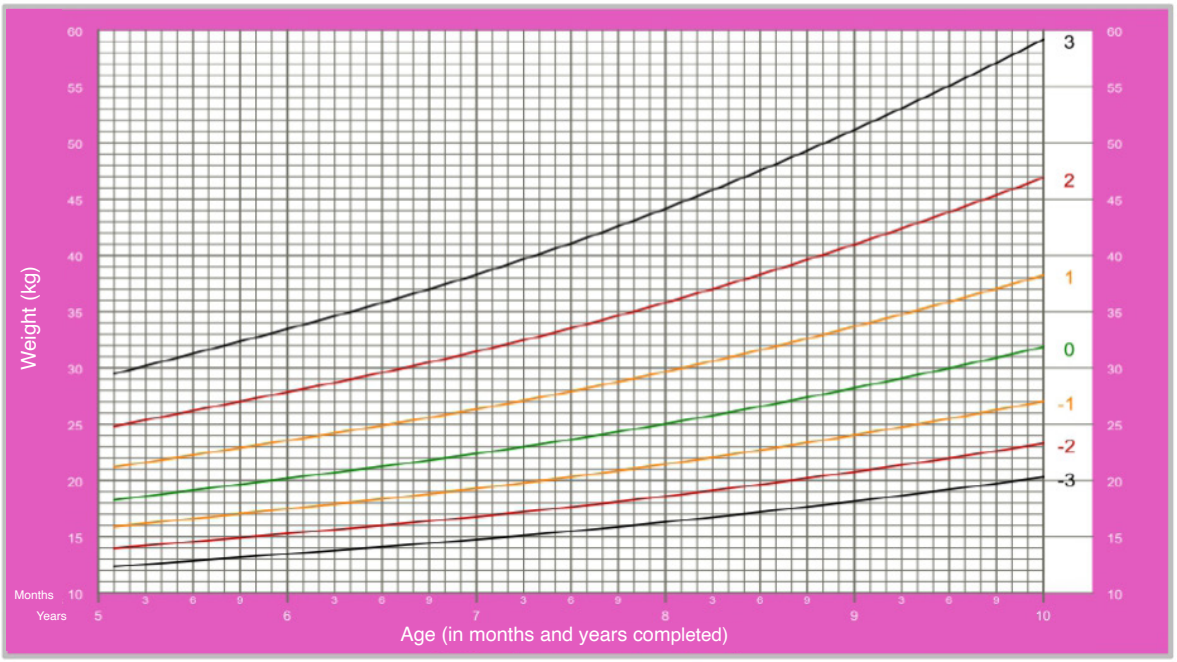
B. Boys (Z-score)



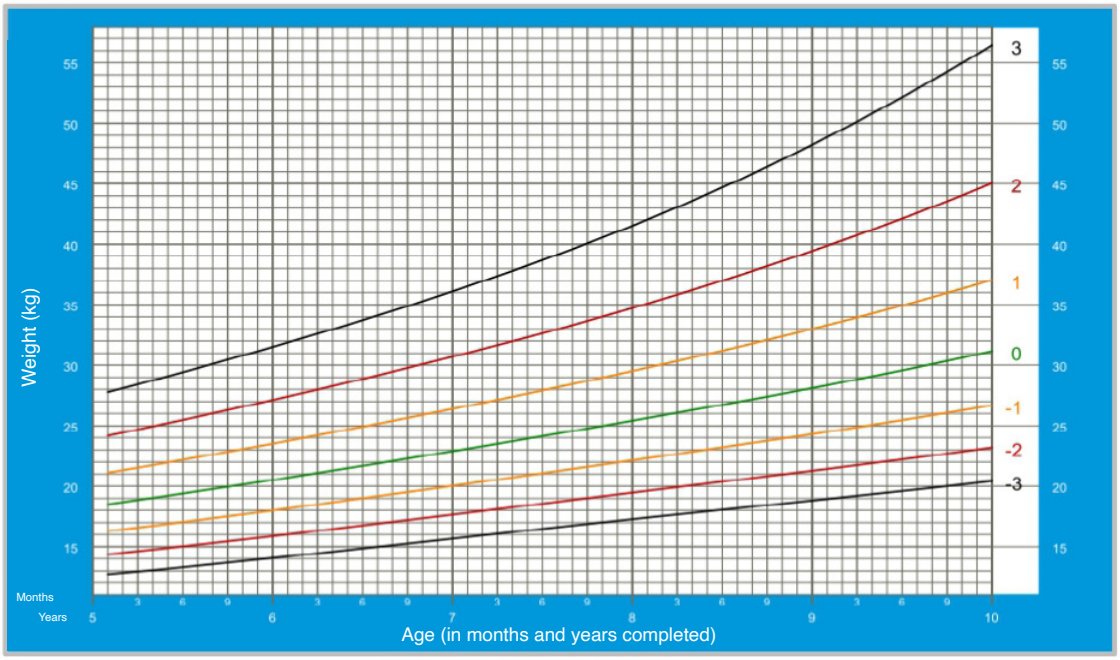
Source: World Health Organization. Child growth standards [Internet]. Geneva: WHO; 2022 [cited 31 August 2022]. Available at: https://www.who.int/tools/child-growth-standards/standards

Figure 2: *Body mass index by age, 5 to 10 years*

A. Girls (Z-score)



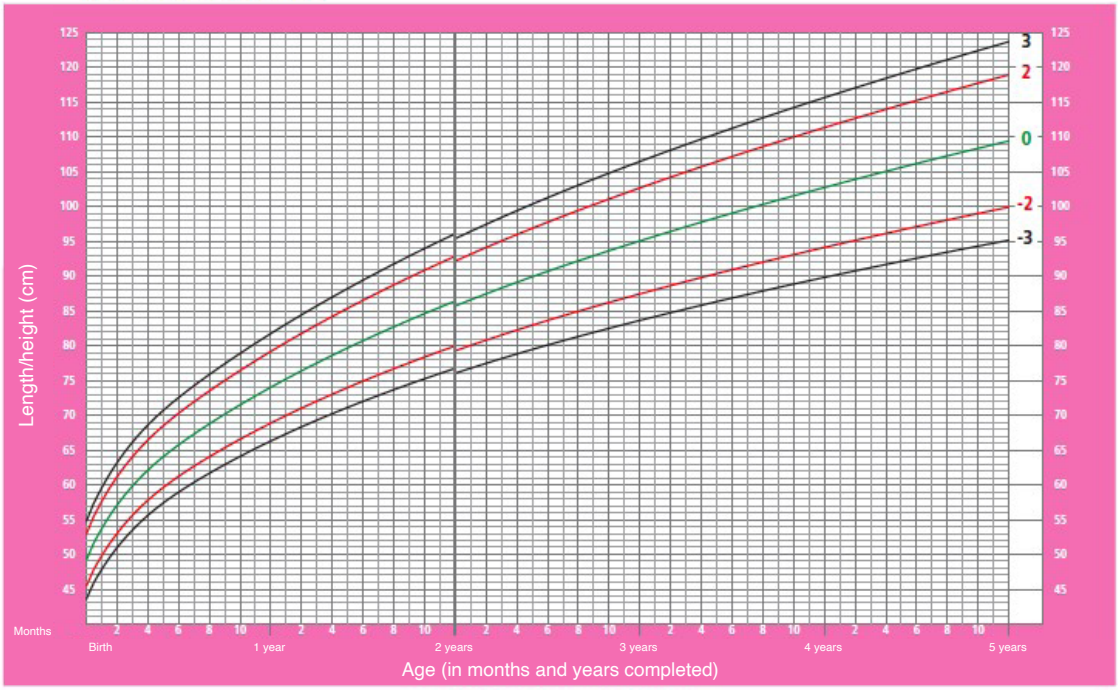
B. Boys (Z-score)



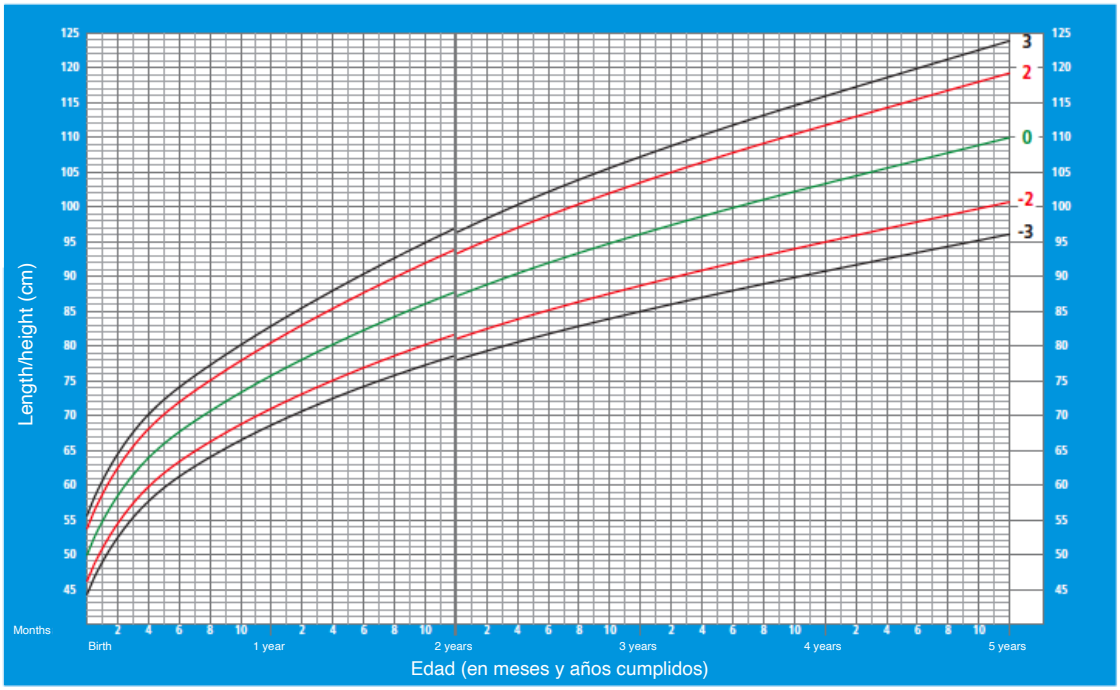
Source: World Health Organization. Child growth standards [Internet]. Geneva: WHO; 2022 [cited 31 August 2022]. Available at: https://www.who.int/tools/child-growth-standards/standards

Figure 3: *Length or height by age, birth to age 5*

A. Girls (Z-score)



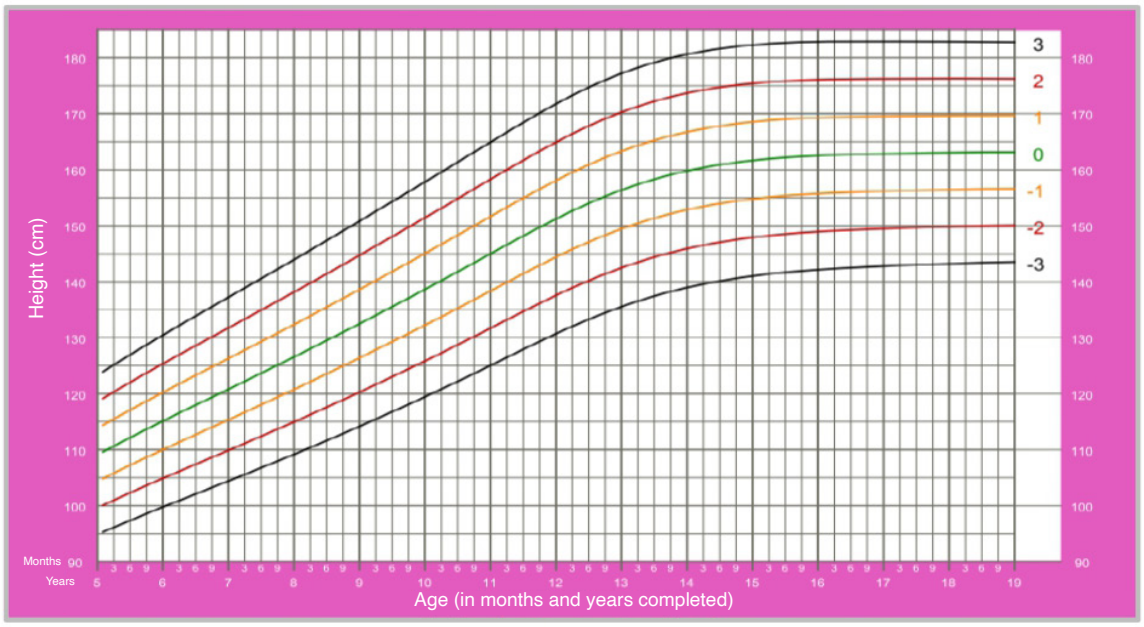
B. Boys (Z-score)



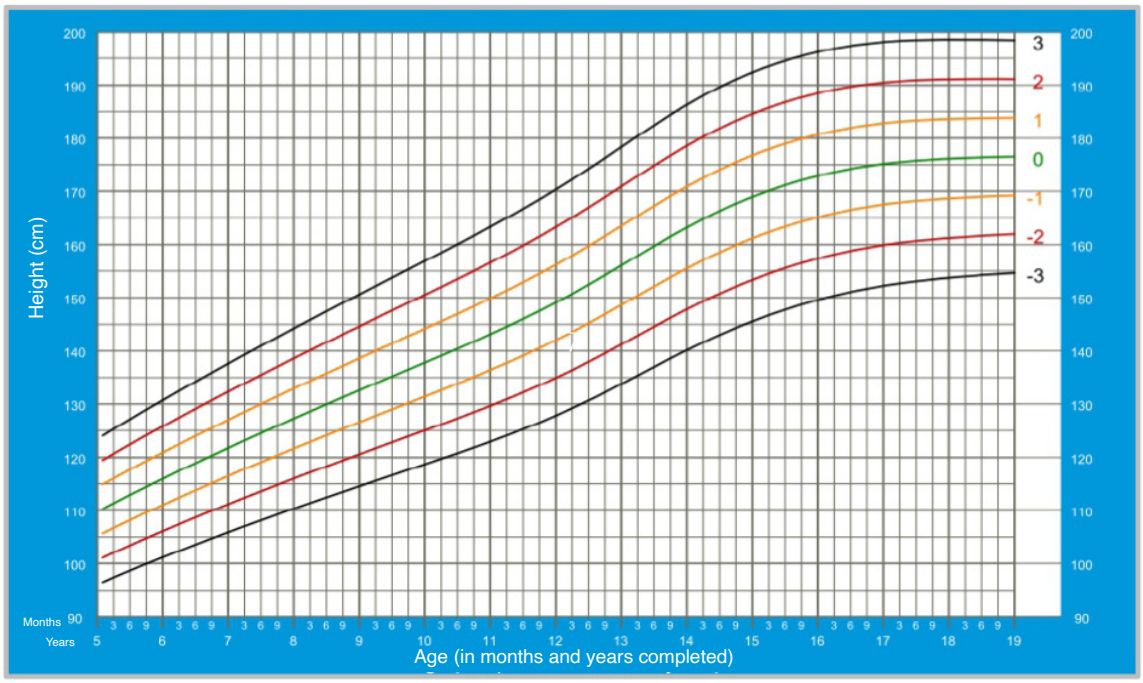
Source: World Health Organization. Child growth standards [Internet]. Geneva: WHO; 2022 [cited 31 August 2022]. Available at: https://www.who.int/tools/child-growth-standards/standards

Figure 4: *Height by age, 5 to 19 years*

A. Girls (Z-score)



B. Boys (Z-score)



Source: World Health Organization. Child growth standards [Internet]. Geneva: WHO; 2022 [cited 31 August 2022]. Available at: https://www.who.int/tools/child-growth-standards/standards

Ideal body weight percentage

The interpretation of ideal weight in pediatric patients is based on the following formula:
[Current weight(kg)/Ideal weight(kg)] *100.

Table 4: *Interpretation of the ideal weight percentage*

Percentage	Interpretation
>120	Obesity
110-19	Overweight
90-109	Eutrophic
80-89	Low weight or risk
70-79	Moderate undernutrition
< 69,9	Severe undernutrition

Note: It is possible to work with one of the two parameters (weight/height or BMI/height and ideal weight percentage) since both use growth curves as a reference. This parameter may be used for any age.

Amputation-adjusted weight (19)

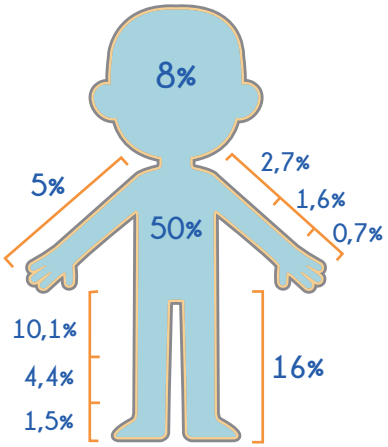
For amputee children and adolescents, weight should be adjusted using the following formula:

(Current weight (kg) * % amputation) /100 + Current weight (kg)
= Amputation-adjusted weight (kg)

Example:

1. [Current weight 45 kg * 16% amputation] / 100 = 7.2 kg ("missing" weight)
2. "Missing" weight (7.2 kg) + Current weight (45 kg) = 52.2 kg (amputation-adjusted weight)

- ***Figure 5:*** *Body proportions*



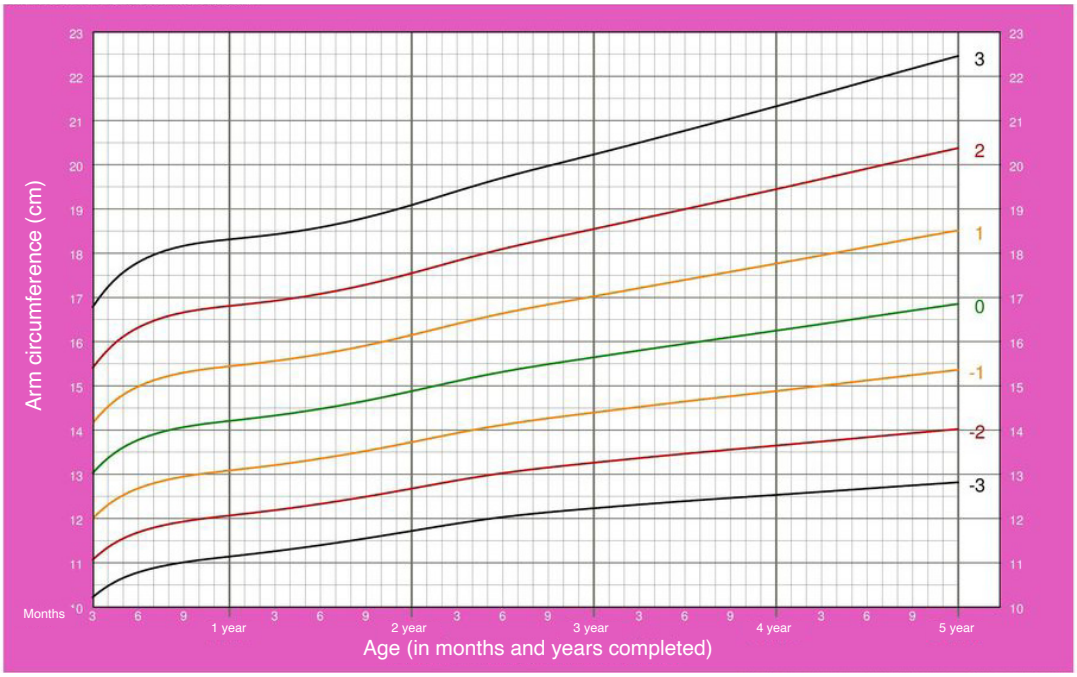
Source: Ladas E et al. Nutritional Assessment: A Training Manual for Pediatric Oncology. International Initiative for Pediatrics and Nutrition 2022. New York: Columbia University Medical Center; [Unpublished manuscript].

Mid upper arm circumference (MUAC)

Arm anthropometry is recommended to assess nutritional status, particularly in patients whose weight may be affected by edema in the lower extremities, ascites, steroids, or the weight of the tumor mass itself. This measure is correlated with BMI in children and adults and has shown greater sensitivity to changes in muscle mass than BMI. It can be used as an independent anthropometric assessment tool to determine undernutrition in children aged 6 to 59 months to WHO standards, while in older children the Mramba reference is used. When serial weight and height Z-scores are not available, serial measurements of mid-upper arm circumference or mid-arm circumference (MUAC) can be used to monitor changes in body composition, using the child as his or her own control. The measures of MUAC by age are found in Figures 6 and 7, whose panels A and B correspond to girls and boys, respectively. Table 5 gives an interpretation of these measures.

- ***Figure 6:*** *Mid upper arm circumference, from 3 months to 5 years*

A. Girls (Z-score)



B. Boys (Z-score)

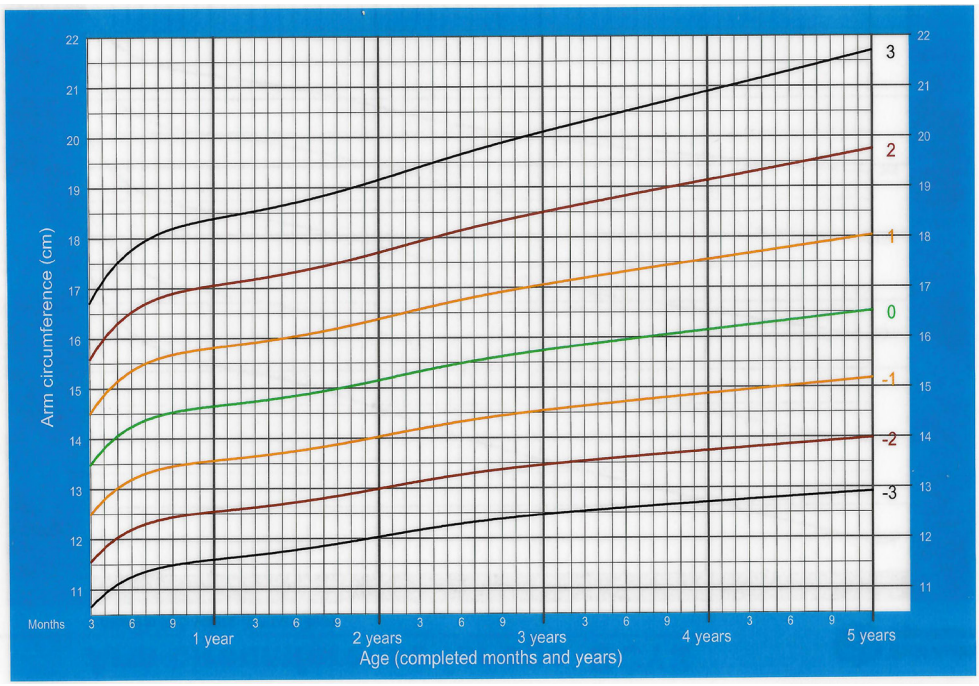
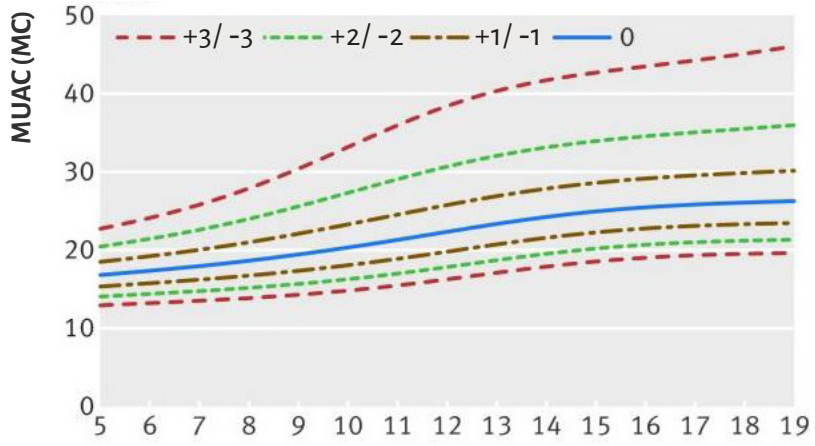
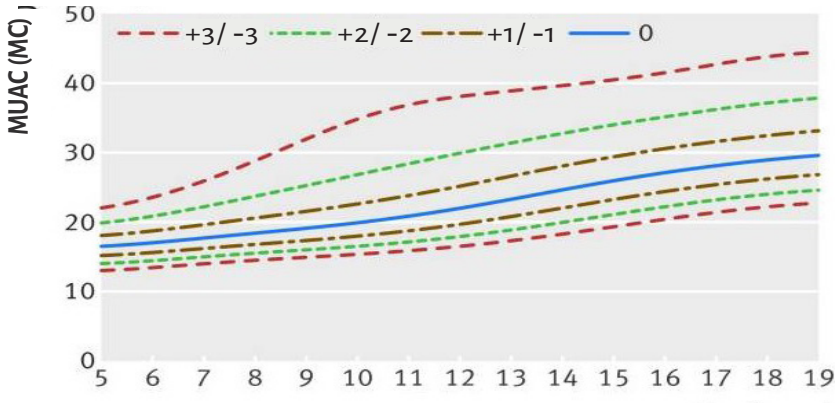


Figure 7: *Mid upper arm circumference, 5 to 19 years*

A. Girls



B. Boys

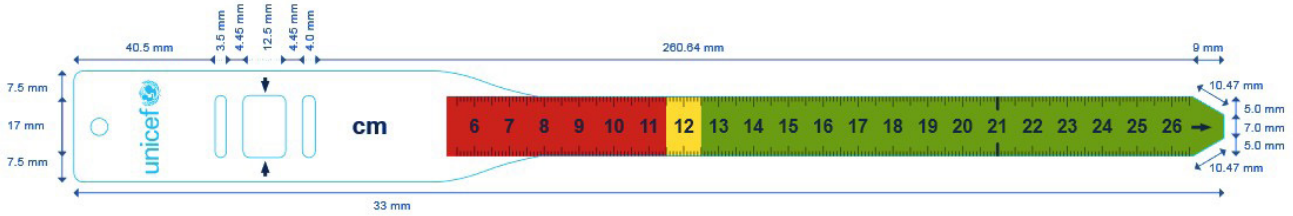


- ***Table 5:*** *Interpretation of the mid upper arm circumference measurement*

Z-score (standard deviation [SD])	Interpretation
Below –3 SD	Severe malnutrition
Below –2 SD	Moderate undernutrition
Below –1 SD	Risk of undernutrition
Between –0.99 and 0.99	Adequate mid-arm circumference
Above 1 SD	Risk of being overweight or overweight
Above 2 SD	Being overweight or obese
Above 3 SD	Obesity

Source: World Health Organization. Arm circumference-for-age [Internet]. Geneva: WHO; 2022 [cited 31 August 2022]. Available at: https://www.who.int/tools/child-growth-standards/standards/arm-circumference-for-age

WHO and the United Nations Children's Fund (UNICEF) issued a joint statement on child growth standards and the identification of severe acute undernutrition in children aged 6 months to 5 years. To reflect this, a new standardized MUAC tape was made available:



Source: Government of the Dominican Republic, National Health Service, United States Agency for International Development, United Nations Children's Fund. Guía informativa para personal de salud y promotores comunitarios: Diagnóstico y tratamiento de la desnutrición aguda en el primer nivel de atención y en la comunidad. Santo Domingo: UNICEF; [Undated] Available at:. https://www.unicef.org/dominicanrepublic/media/3926/file/Gu%C3%ADa%20informativa%20para%20personal%20de%20salud%20y%20promotores%20comunitarios%20-%20Documento.pdf

- ***Table 6:*** *Measurement of mid upper arm circumference for children aged 3 months to 5 years, according to the United Nations Children's Fund*

Code	Measurement	Interpretation
Red	0 a 11,5cm	Severe acute undernutrition
Yellow	11,5 a 12,5cm	Acute undernutrition
Green	12,5 a 26,5 cm	Adequate mid-arm circumference

To quickly identify acute undernutrition in children and adolescents, the cut-off points listed in Table 7 can be used.

Table 7: *Recommended cut-off points for the use of mid upper arm circumference to identify acute undernutrition in children*

Age	Mid upper arm circumference	Interpretation
6 a 59 months	<11.5 cm (Z score of –3)	Severe undernutrition
	> 0 =11.5 cm (Z-score of –2)	Moderate undernutrition
	> 0 =12,5 cm	No undernutrition
5 a 9 years	<13,0 cm	Severe undernutrition
	> 0 =13 - 14,5 cm	Moderate undernutrition
	> 0 =14,5 cm	No undernutrition
10 a 15 years	<16 cm	Severe undernutrition
	> 0 =16,0 – 18,5 cm	Moderate undernutrition
	> 0 =18,5 cm	No undernutrition

The use of the cut-off points presented in Table 8 is recommended to identify overweight in children over 5 years of age, taking into account that these points may vary according to the region or population.

Table 8: *Recommended cut-off points for overweight in children over 5 years old*

Age group	Overweight
5 a 9 years - Male - Female	MUAC > 18,4cm MUAC> 18,3cm
10 a 14 years - Male - Female	MUAC > 22,2cm MUAC > 22,5cm
15 a 19 years - Male - Female	MUAC > 27,5cm MUAC > 27,9cm

Cut-off points may vary by region or population.

• *Biochemical assessment*

Biochemical values may be used to support a patient's nutritional status assessment. However, their analysis should take into account that they may be altered due to patients' inflammation status and medical treatment, and they may not reflect their nutritional status. These values can be used effectively in conjunction with a dietary assessment to assess recent consumption and diet adherence: they have the advantage of confirming any deficiencies in nutrient intake before certain clinical or anthropometric indicators are altered. Availability and cost vary between institutions, and some can be very expensive. This is why they should be used as required with assessment and monitoring (12,26,27).

Table 9: *Biochemical parameters commonly used in cancer patients for practical use in nutritional assessment*

Indicator and range	Clinical interpretation	Comments
Glucose < 12 months: 40-90 mg/dL < 2 years: 60-100 mg/dL > 2 years: 70-100 mg/dL	Hyperglycemia due to pancreatic neoplasms, hyperthyroidism, steroid therapy, adrenocortical dysfunction, high consumption of refined and simple carbohydrates, and constant food consumption (without giving time to decrease in the postprandial period). Hypoglycemia due to exogenous or endogenous insulin, prolonged fasting, and liver disease.	Monitor patients on high doses of steroids and those receiving nutritional support, especially total parenteral feeding.

Albumin 8 days–1 year: 1.9–4.9 g/dL 1–3 years: 3.4–5.2 g/dL 4–19 years: 3.5–5.6 g/dL (14–21 days half-life)	Increases in dehydration or volume changes. Decreases in inflammation, malabsorptive syndrome, undernutrition, infection, trauma, edema, ascites, liver and kidney dysfunction, burns.	Proper hydration, good hygiene, keep the rectal area clean and dry Clear liquid diet, if needed, or use nutritional support
Prealbumin 1 to 5 years: 14-30 mg/dL 6 to 9 years: 15-33 mg/dL 10 to 13 years: 22-36 mg/dL 14 to 19 years: 22-45 mg/dL (2-3 days half-life)	Increases in kidney dysfunction, dehydration, and steroid therapy. Decreases in inflammation, liver disease, and edema.	-
C-Reactive Protein (CRP) Boys and girls: < 0.8 mg/dL	Helps determine whether serum proteins are diminished due to an inflammatory process or by a reduced substrate associated with undernutrition.	Suitable for monitoring nutritional support because it has a short half-life.
Creatinine	Increases in renal failure and varies based on sex, race, and muscle mass. Decreases with the loss of muscle mass.	Low levels can indicate reduced muscle mass.
Blood Urea Nitrogen (BUN) 2–20 ml/dL	Increases with the intake of a high-protein diet, the use of steroids, dehydration, burns, and renal insufficiency or failure.	-
Nitrogen balance	Used to assess protein intake. A negative balance means that there is more loss than intake. Urine should be collected over 24 hours. Useful for assessing protein intake in nutritional support.	-
Platelets Thrombocytopenia Grade 1: <150 000 to 75 000/mm3 Grade 2: 50 000 to 75 000/mm3 Grade 3: 25 000 to 50 000/mm3 Grade 4: <25 000/mm3	The risk of bleeding complications increases with the severity of thrombocytopenia. In invasive procedures, local guidelines should be considered in order to proceed, but if there is no local cut-off value for bleeding risk, a high risk of bleeding is considered below 30,000/mm3. Thrombocytopenia can be considered a contraindication to placing a feeding tube; it depends on the risk of bleeding complications.	Thrombocytopenia is common among cancer patients as a result of chemotherapy.
Neutrophils Neutropenia Grade 1: <Below normal level at 1500/mm3 Grade 2: 1000 to 1500/mm3 Grade 3: 500 to 1 000/mm3 Grade 4: <500/mm3 (severe neutropenia)	The severity of neutropenia is related to the risk of infection, including foodborne infections.	-
Triglycerides 0 to 9 years: < 75 mg/dL 9 to 19 years: < 90 mg/dL	May be increased by corticosteroids and in L-Asparaginase and non-dietary toxicity.	-

Sources: Bharadwaj S, Ginoya S, Tandon P, Gohel TD, Guirguis J, Vallabh H, et al. Malnutrition: Laboratory markers vs nutritional assessment. Gastroenterol Rep (Oxf). 2016;4(4):272-80.
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• *Clinical assessment*

Clinical assessment is based on physical examination of the patient and helps to find signs and symptoms that could be related to nutritional alterations. Clinical signs are objective manifestations of both deficiencies and excesses in nutritional intake (see Table 10). In children and adolescents with cancer, the side effects of treatment should be taken into account, as these commonly affect their general condition, as well as their nutrient consumption and absorption (see Table 11).

● ***Table 10:*** *Signs observed during physical examination and nutritional deficiencies*

	Sign	Possible deficiency
Skin	- Petechiae - Purpura - Pigmentation - Edema - Pallor - Seborrheic dermatitis - Unhealed wounds	- Vitamins A and C - Vitamins C and K - Niacin - Protein and Vitamin B1 - Folic acid, iron, biotin, Vitamins B12 and B6 - Vitamin B6, biotin, zinc, and essential fatty acids - Vitamin C, protein and zinc
Nails	- Pallor and whitish coloration - Spoon nails or with transverse lines, excessive dryness, dark nails, wedged nails	- Iron - Protein and Vitamin B12
Head/hair	- Hair is dull, opaque, presence of bands, depigmentation, scarcity, alopecia, scales	- Iron - Protein and Vitamin B12
Eyes	- Conjunctival pallor - Night-vision impairment - Photophobia	- Vitamin B12, folic acid, iron - Vitamin A - Zinc
Oral cavity	- Glossitis - Gingivitis - Fissures, stomatitis - Cheilosis - Pale tongue - Atrophied papillae	- Vitamins B1, B6 and B12, niacin, iron, folic acid - Vitamin C - Vitamin B2, iron, protein - Niacin, vitamins B2 and B6, proteins - Iron, Vitamin B12 - Vitamin B2, niacin, iron
Nervous system	- Mental confusion - Depression, lethargy - Weakness, paralysis in legs - Peripheral neuropathy - Ataxia - Hyporreflexia - Muscle cramps - Fatigue	- Vitamins B1, B2 and B12, water - Biotin, folic acid, Vitamin C - Vitamins B1, B6 and B12, pantothenic acid - Vitamins B1, B6 and B12 - Vitamin B12 - Vitamin B1 - Vitamin B6, calcium and magnesium - Energy, biotin, magnesium, iron

When detecting any important symptoms or signs of nutritional status, it is necessary to know the possible causes. For example, if diarrhea is present, the causes may be medications, radiation or surgery, laxatives, or a diet that is very high in fiber. Hypertriglyceridemia may be due to diet, medications, family history, or an associated pathology, such as hypothyroidism (5, 12, 26).

Table 11: *Signs or symptoms observed during physical exam and possible causes*

Sign or symptom	Possible causes
Loss of muscle mass or fat	Protein and energy deficit, prostration, or little physical activity or mobility
Fat mass gain	Corticosteroids, overfeeding
Weight loss not linked to water changes	Energy and protein deficit
Presence of edema in ankles, sacrum, or face	Protein deficit
Diarrhea	Infection, prolonged use of antibiotics, chemotherapeutic agents (cisplatin, cyclophosphamide, methotrexate, irinotecan, among others), or chemotherapy in very high doses; radiation to the abdominal area, bowel resection, intestinal malabsorption, or inflammation
Constipation	Chemotherapeutic agents, dehydration, low fiber intake, intestinal obstruction, spinal cord compression, pain medications (mainly opioids), low activity or mobility, poor adaptation to defecating in places outside the home
Mucositis and stomatitis	Chemotherapeutic agents (anthracyclines, methotrexate) or chemotherapy in very high doses; radiation in the head and neck or abdominal area
Problems chewing or swallowing	Mucositis, head or neck tumor, diet with a consistency inadequate for the needs of the child, pain when swallowing or chewing, gum disease, etc
Nausea and vomiting	Chemotherapeutic agents, predisposition or psychological conditions, intestinal obstruction, alterations of the central nervous system.
Intestinal obstruction or perforation	Invasion due to tumor mass causing blockage or perforation (common in Burkitt lymphoma, Wilms tumor, and neuroblastoma); severe intestinal inflammation
Gastrointestinal bleeding	Intestinal infection, enterocolitis, ulcers, primary intestinal tumors, graft-versus-host disease (GVHD), complications of thrombocytopenia, and coagulation defects
Neutropenic colitis	Often preceded by chemotherapy-induced intestinal mucositis; prolonged neutropenia; bacterial translocation
Pancreatitis	Chemotherapeutic agents (L-asparaginase, cytarabine), hematopoietic cell transplantation, hypertriglyceridemia >500mg/dL, prolonged use of total parenteral feeding
Decreased appetite/anorexia	Treatment side effects; pain; psychological conditions, such as fear of food (due to the side effects already mentioned), pickiness, or apathy

• *Dietary assessment*

Dietary assessment provides information about food and nutrient intake; eating habits and patterns; intake of supplements, and possible problems related to food. The disadvantages of the tools used include variations in portion estimates; underestimating or overestimating consumption; depending on the memory of the patient or a family member, in which case the subject may lie about their consumption, for example, if they feel judged or evaluated. Estimates on the adequacy of protein or carbohydrate intake, household food security, and food availability should be routinely determined for all children, especially when an increased risk of malnutrition has been identified (26, 27, 28, 29).

Dietary history

This method assesses general aspects such as food preferences and aversions, allergies and intolerances, established religious or cultural customs, special diets that have been made, nutritional restrictions, etc. It is useful for individualizing dietary recommendations and ensuring better adherence. This method is qualitative:

1. Has the child had to follow dietary recommendations before?
2. Does the child have any food allergies or intolerances?
3. Does the child have any dietary restrictions due to religion or another cause?
4. How long was the child exclusively breastfed? Or exclusively formula-fed?
5. At what age did the child begin complementary feeding?
6. At what age did the child start with the family diet?
7. How long does it take for the child to eat?
8. How much of the serving does the child consume?

Usual diet

This method provides an overview of consumption habits. It assesses aspects of the daily diet, such as the number of meals, where they are prepared, commonly consumed foods at each meal time, dietary changes on the weekends, and weekly consumption of the different food groups. It is useful for building menus and recommending relevant substitutions. This method is qualitative:

1. How many meals does the child eat during the day?
2. Does the child skip any meals?
3. Does the child have set times for each meal?
4. Who prepares their food?
5. Does the child usually eat in front of some kind of screen?
6. Does the child eat accompanied or not?
7. How many times a week does the child eat fruits and vegetables?
8. How many times a week does the child eat meat, fish, or poultry?
9. How many times a week does the child eat legumes?
10. How many times a week does the child eat milk, yogurt, or cheese?
11. How many times a week does the child consume bread, pasta, or flour tortillas?
12. How many times a week does the child drink sugary beverages?
13. How many times a week does the child engage in physical activity?
14. Approximately how many hours does the child sleep per day?
15. What medications does the child take, in addition to cancer treatment?
16. Does the child consume any type of nutritional supplement such as vitamins, growth formulas, fiber, etc.?
    a. How much and how many times per day?
    b. Who recommended it and for what purpose?

24-hour recall

This instrument assesses the patient's current consumption and consists of recording all the foods and beverages consumed during the 24 hours prior to the interview (see tables 12 and 13). If applied on two or more occasions, it may represent habitual consumption. It is useful for estimating energy, proteins, carbohydrates, and lipids consumed. This method is quantitative:

Table 12: *Example of 24-hour recall*

Food or preparation	Amount	Time	Location
Banana smoothie: - Milk - Banana - Oatmeal	1 glass whole milk 1 Banana 2 tablespoons	Breakfast 8:00am	Hospital
Sandwich: - White loaf bread - Ham - Cheese - Mayonnaise - Lettuce	2 slices 2 thin slices 1 thin slice 1 teaspoon 1 leaf	Lunch 11:00am	Home
Oreo cookies	4 cookies	11:00am	Home
Continue with the list of foods consumed for 24 hours			School

Note: 24-hour recall can be as simple or detailed as necessary depending on the information needed, as well as the time available to analyze the information obtained. The parents can be given a paper and asked to write down everything the child eats in a day or two; so there will be time to record it upon arrival at the hospital.

Table 13: *Multi-step method*

Step	Objective
Quick list of foods and beverages	Make a list of beverages and foods consumed by the patient in the last 24 hours
Forgotten food and beverages	Get a list of beverages and foods that were forgotten on the first list. Focus on different food categories and groups and give examples.
Time and occasion	Collect information on the approximate time each intake took place (breakfast, brunch, lunch, dinner, other).
Details	Get details about the method of preparation, the amount consumed, the place where each meal was made, the extra ingredients (add them to the first list when relevant), the brands, etc.
End	Read the list; it is still a good time to remember any forgotten food, even when the portion has been small. Greater detail can be added at this stage.

Fuente: Department of Health and Human Services, National Center for Health Statistics. National Health and Nutrition Examination Survey. USDA Five-Step Multiple-Pass Method. CDC [Internet]. 2021 [cited 18 September 2021]. Available at: http://www.cdc.gov/nchs/nhanes/

Frequency of food consumption

This method is intended to establish the consumption of different food groups in the past, enabling awareness of the patient's eating patterns. Generally, a questionnaire is used and tools have already been validated in different countries. It is useful for detecting possible deficiencies due to low consumption, in conjunction with biochemical and clinical evaluation. This method is qualitative:

Food diary / log

This method consists of asking the patient to make a list of the foods consumed for a certain time (normally three to seven days). It is useful to associate the symptoms (mainly gastrointestinal) with the consumption of certain foods or preparations; For example, linking fruit and whole grain bread consumption to increased stools with lower consistency. This is a qualitative method (see Table 14).

- ***Table 14:*** *Food diary outline*

Foods of the day	Daytime problem
For example, noodle soup	For example, constipation

- ***Table 15:*** *Sample nutritional assessment form*

Name:		Record:	
Date of birth:	Age:	Sex:	Religion:
Diagnosis:			
Date of diagnosis:	Nutritional assessment date: Follow-up visit		
Anthropometry: Z-score			
Height (cm): Weight (kg): MAC (mc) BMI (kg/m^2) Weight loss/gain: kg in weeks/months		BMI/age Ideal weight percentage: Height/age: MAC: ICT:	
Nutritional risk factors:			
High-risk malignancy Nausea or vomiting Diarrhea Constipation Poor appetite/early satiety/anorexia Problems chewing or swallowing Mucositis Dysgeusia Gastrointestinal problems (obstruction, malabsorption, parasites, fistula, etc.) Specify: Other (specify):		Loss of muscle mass and/or fat (specify): Fat mass gain (specify): *Acanthosis nigricans* (specify site): Food insecurity Low dietary diversity Suspected nutrient deficiency (specify):	
Dietary assessment:			
Oral Catheter/ostomy Parenteral	Dietary intake Kcal(g): Prot(g):	Solid diet Complete liquids Clear liquids	Food allergies Intolerances to: Aversions to:
Nutritional supplements (formulas, vitamins, etc.): Dosage/day:			
Comments about the diet:			
Nutritional diagnosis(es):			

Nutrition plan:
Energy (kcal): Protein (g): Type of diet: Administration (oral, enteral by tube or ostomy, central or peripheral parenteral route):
Objective:
Nutrition education (portion control, calorie increase, dietary measures for a low bacterial load, food handling, etc.):

Chapter 3.
Nutritional intervention

Nutritional intervention is the nutritional care plan implemented so that the patient is able to cope as well as possible with medical cancer treatment and, at the same time, maintain appropriate growth. Each child needs his or her own nutritional care plan because diagnosis, treatment modality and even demographics have been shown to influence the risk of malnutrition.

• *Nutritional requirements (30, 31)*

The equations used to calculate energy expenditure are inaccurate; indirect calorimetry is the reference method for measuring energy requirements, but this method is not available in most hospitals. There is no evidence to date of increased energy expenditure or changes in nutrient metabolism in children with cancer, compared with apparently healthy children. Direct calorimetry is used to easily calculate energy and protein requirements for different age groups (see its application for children aged 0 to 2 years in Tables 16 and 17). The calculation may also include the level of physical activity in children from the age of 3 (see Tables 18 and 19). To calculate the level of physical activity and the daily protein requirement, see Tables 20 and 21, respectively. There are several formulas for calculating requirements according to age, sex, weight, and other variables, but there is still no golden rule.

● ***Table 16:*** *Estimated energy requirement for boys aged 0 to 2*

Age (months)	Reference weight (kg)	Energy expenditure (kcal/d)	Energy deposition (kcal/d)	Total energy expenditure (kcal/d)
1	4,4	292	180	472
2	5,3	372	195	567
3	6,0	434	138	572
4	6,7	496	52	548
5	7,3	550	46	596
6	7,9	603	42	645
7	8,4	648	20	668
8	8,9	692	18	710
9	9,3	728	18	746
10	9,7	763	30	793
11	10,0	790	27	817
12	10,3	817	27	844
15	11,1	888	20	908
18	11,7	941	20	961
21	12,2	986	20	1006
24	12,7	1030	20	1050
27	13,1	1066	20	1086
30	13,5	1101	20	1121
33	13,9	1137	20	1157
35	14,2	1166	20	1184

Source: Food and Agriculture Organization of the United Nations. Human energy requirements: report of a joint FAO/WHO/UNU Expert Consultation. Food and Nutrition Technical Report Series 1. Rome, FAO. 2001. Available at : https://www.fao.org/3/y5686e/y5686e.pdf.

Table 17: *Estimated energy requirement for girls aged 0 to 2*

Age (months)	Reference weight (kg)	Energy expenditure (kcal/d)	Energy deposition (kcal/d)	Total energy expenditure (kcal/d)
1	4,2	274	164	438
2	4,9	336	164	500
3	5,5	389	132	521
4	6,1	443	65	508
5	6.7	496	57	553
6	7,2	541	52	593
7	7,7	585	23	608
8	8,1	621	22	643
9	8,5	656	18	678
10	8,9	692	25	717
11	9,2	719	23	742
12	9,5	745	23	768
15	10,3	817	20	837
18	11,0	879	20	899
21	11,6	932	20	952
24	12,1	977	20	997
27	12,5	1013	20	1033
30	13,0	1057	20	1077
33	13,4	1093	20	1113
35	13,7	1119	20	1139

Table 18: *Estimated energy requirement for boys aged 3 to 18 based on physical activity*

Age (years)	Reference weight (kg)	Reference height (m)	Sedentary (kcal/d)	Not very active (kcal/d)	Active (kcal/d)	Very active (kcal/d)
3	14,3	0,95	1162	1324	1485	1683
4	16,2	1,02	1215	1390	1566	1783
5	18,4	1,09	1275	1466	1658	1894
6	20,7	1,15	1328	1535	1742	1977
7	23.1	1,22	1393	1617	1840	2115
8	25,6	1,28	1453	1692	1931	2225
9	28,6	1,34	1530	1787	2043	2359
10	31,9	1,39	1601	1875	2149	2486
11	35,9	1,44	1691	1985	2279	2640
12	40,5	1,49	1798	2113	2428	2817
13	45,6	1,56	1935	2276	2618	3038
14	51,0	1,64	2090	2459	2829	3283
15	56,3	1,70	2223	2618	3013	3499
16	60,9	1,74	2320	2736	3152	3663
17	64,6	1,75	2366	2796	3226	3754
18	67,2	1,76	2383	2823	3263	3804

Table 19: *Estimated energy requirement for girls aged 3 to 18 based on physical activity*

Age (years)	Reference weight (kg)	Reference height (m)	Sedentary (kcal/d)	Not very active (kcal/d)	Active (kcal/d)	Very active (kcal/d)
3	13,9	0,94	1080	1243	1395	1649
4	15,8	1,01	1133	1310	1475	1750
5	17,9	1,08	1189	1379	1557	1854
6	20,2	1,15	1247	1451	1642	1961
7	22,8	1,21	1298	1515	1719	2058
8	25,6	1,28	1360	1593	1810	2173
9	29,0	1,33	1415	1660	1890	2273
10	32,9	1,38	1470	1729	1972	2376
11	37,2	1,44	1538	1813	2071	2500
12	41,6	1,51	1617	1909	2183	2640
13	45,8	1,57	1684	1992	2281	2762
14	49,4	1,60	1718	2036	2334	2831
15	52,0	1,62	1731	2057	2392	2870
16	53,9	1,63	1729	2059	2368	2883
17	55,1	1,63	1710	2042	2353	2871
18	56,2	1,63	1690	2024	2336	2858

Source: Food and Agriculture Organization of the United Nations. Human energy requirements: report of a joint FAO/WHO/UNU Expert Consultation. Food and Nutrition Technical Report Series 1. Rome, FAO. 2001. Available at: https://www.fao.org/3/y5686e/y5686e.pdf.

Table 20: *Calculation of physical activity level*

	Sedentary (PAL 1.0–1.39)	Not very active (PAL 1.4–1.59)	Active (PAL 1.6–1.89)	Very active (PAL 1.9–2.5)
	Typical activities of daily living (e.g., household chores, walking to catch the bus)	Typical activities of daily living PLUS 30–60 minutes daily of moderate activity (e.g., walking at 5-7 km/h)	Typical activities of daily living PLUS at least 60 minutes of moderate daily activity	Typical activities of daily living PLUS at least 60 minutes daily of moderate activity PLUS an additional 60 minutes of vigorous activity or 120 minutes of moderate activity
Boys aged 3 to 18 years	1,00	1,13	1,26	1,42
Girls aged 3 to 18 years	1,00	1,16	1,31	1,56

Source: Health Canada. Physical Activity Coefflcients (PA values) for use in EER equations. Canadá: Minister of Public Works and Goverment Services; 2008.

Table 21: *Daily protein requirement*

Age	Recommendation
1 – 3 years	1,05 g/kg/d o 13 g/d
4 – 8 years	0,95 g/kg/d o 19 g/d
9 – 13 years	0,95 g/kg/d o 34 g/d
14 – 18 years - Boys - Girls	0,85 g/kg/d o 52 g/d 0,85 g/kg/d o 46 g/d

• *Oral nutritional intervention (29, 32-36)*

Oral nutritional intervention is intended to improve energy and nutrient intake, as well as any stage of the food digestion process (chewing, absorption, etc.). Its objective is to adapt the diet based on the symptoms, treatment, and general needs of each patient.

On this point, it should be noted that the Latin American population that is affected by moderate or severe food insecurity and poverty keeps increasing. When designing the nutritional intervention, it should be tailored to the individual so that the procedure may be successful. When in doubt, it is worth requesting answers to these two statements: 1) "In the last 12 months, we have worried about whether our food would run out before we had money to buy more;" 2) "In the last 12 months, the food we bought just didn't last and we didn't have money to buy more." Possible answers are: often, sometimes, or never. Food insecurity can be determined from a single affirmative answer (37). Table 22 provides some considerations on issues with different dietary regimens in children with cancer.

Table 22: *Nutritional considerations based on the type of diet*

Type of diet	Description	Indications
Normal	No modification in preparation or "normal" consistency	Patients whose diet does not require modifications

Clear liquids	Provides fluids, electrolytes, and energy in an easily digestible form and provides minimal intestinal waste. Liquids should have a maximum osmolarity of 250–300 mOsm/L, so those exceeding this figure should be diluted. It is highly restrictive and provides few calories. Note: The concentration of simple and refined carbohydrates in the food used may cause osmotic diarrhea.	Immediate postoperative period Preparation for radiological studies of the gastrointestinal tract Colon surgery Acute diarrhea of short duration It should not be used for more than 48 hours; if continued use is required, enteral or parenteral elemental support should be used.
Complete liquids	Based on liquid or liquefied foods that do not require chewing Depending on the foods chosen, can provide the fluids, energy, proteins, lipids, and carbohydrates necessary to meet the patient's requirements	Transition between clear liquids and solid diet Head and neck surgery Any condition presenting with dysphagia to solid foods In subjects on mixed feeding (parenteral and oral)
Porridge or puree	Based on general foods that have the consistency of puree. The energetic and nutritional composition may or may not meet the patient's requirements.	Patients with chewing problems Head or neck surgery that does not require chopped or porridge diets Any condition presenting with dysphagia to normal consistency or "hard" foods
Smooth	Provides complete nutrition with soft-consistency food The nutritional contribution is equal to that of a normal diet.	Patients with chewing problems Head or neck surgery that does not require chopped or porridge diets Any condition presenting with dysphagia to normal consistency or "hard" foods
Soft	Low in fats and irritants (oils or fats, seasonings, spices)	Transition between low-consistency diet and normal diet In inflammatory processes of the gastrointestinal tract (gastritis, ulcer, colitis, etc.) Lipid intolerance or when low pancreatic stimulation is required.
Low carbohydrates (diabetes)	A modified carbohydrate diet, using a smaller percentage of carbohydrates compared to a normal diet. Does not usually exceed 50% in terms of carbohydrate intake Limits simple sugars and eliminates refined sugars Maintains complex carbohydrate intake	Periods of hyperglycemia or patients in whose cases these symptoms are expected to occur Patients with hypoglycemia or patients in whose case this is expected (curve control) Overweight and obese patients
Low bacterial load	A diet with no or few infectious agents	Immunosuppressed patients
Neutropenic diet [a]	Evidence shows that establishing a neutropenic diet, which is highly restrictive, can affect a patient's nutritional status. Also, in terms of developing infections, there is no evidence of the benefit of providing completely sterile preparations. Use of this diet should be eliminated; instead, follow indications for diets with a low bacterial load under the supervision of a professional nutritionist. It is also essential to evaluate the social, educational, and health context of each particular case and family.	

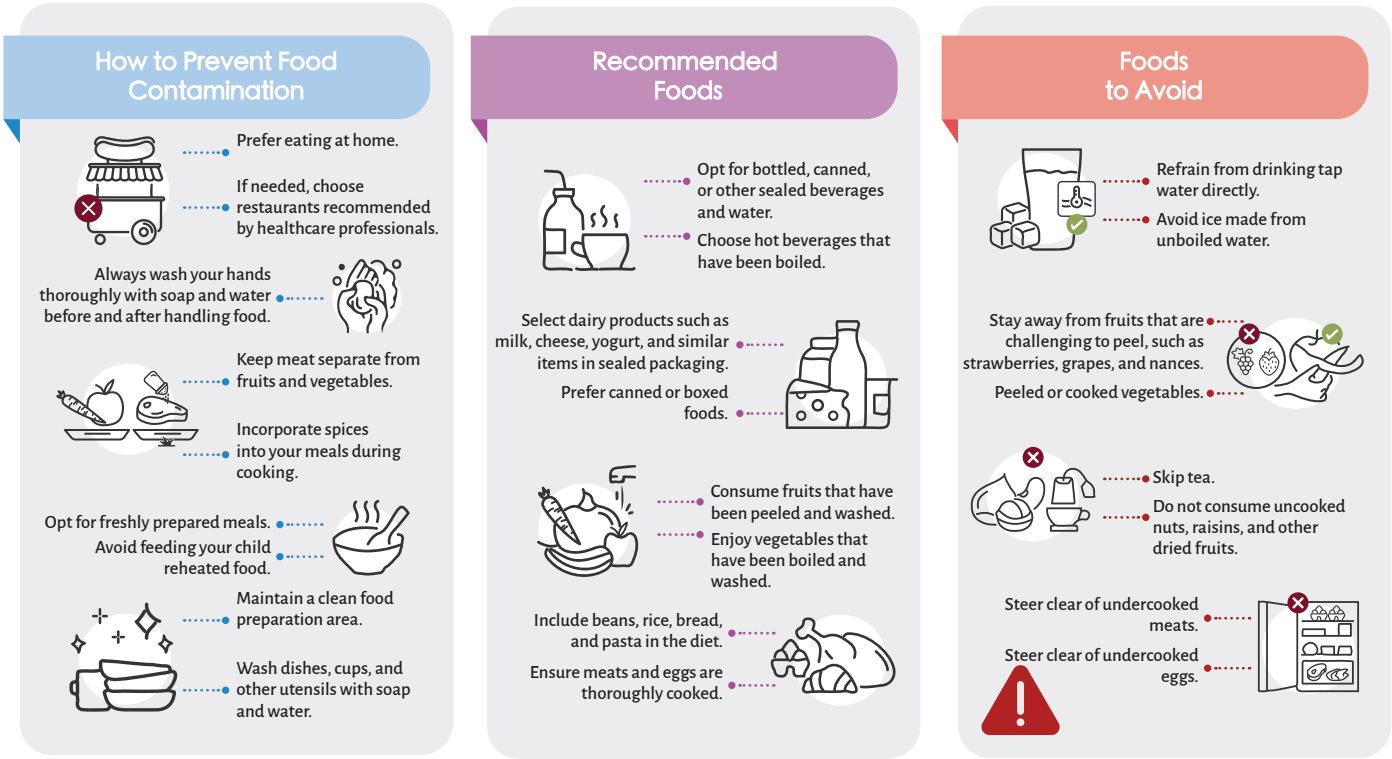
Sources: [a] Moody KM, Baker RA, Santizo RO, Olmez I, Spies JM, Buthmann A et al. A randomized trial of the effectiveness of the neutropenic diet versus food safety guidelines on infection rate in pediatric oncology patients. Pediatr Blood Cancer. 2018;65(1).
Taggart C, Neumann N, Alonso PB, Lane A, Pate A, Stegman A et al. Comparing a neutropenic diet to a food safety-based diet in pediatric patients undergoing hematopoietic stem cell transplantation. Biol Blood Marrow Transplant. 2019;25(7):1382-6.
Van Dalen EC, Mank A, Leclercq E, Mulder RL, Davies M, Kersten M, Van de Wetering MD. Low bacterial diet versus control diet to prevent infection in cancer patients treated with chemotherapy causing episodes of neutropenia. Cochrane Database Syst Rev. 2016;4(4):CD006247.

The immune system is often affected by cancer treatment and the risk of infections increases exponentially. This is why it is important to administer a diet with a low bacterial load, which minimizes the entry of pathogenic organisms through food via the gastrointestinal tract. This allows prepared foods to be offered safely, without restrictions in terms of variety (see Table 23). Some guidance for parents and caregivers of children with cancer is described in Figure 8.

● ***Table 23:*** *Diet with low bacterial load*

Food groups	Not allowed	Allowed
Food of animal origin	Raw or precooked: - Egg (raw, poached, raw meringue). - Chicken - Red meats (beef, pork, cold meats, sausages, etc.) - Processed meats and sausages (Viennese, cured sausage, etc.). - Fish (fresh tuna, in water or oil, salmon, etc.) - Seafood (shrimp, octopus, surimi) - Raw tofu - Vegetable or animal lard Preparations to avoid: beef that is smoked, tartare, medium raw, medium, or pickled	Well cooked: - Egg - Chicken - Red meats (beef, pork, etc.) - Fish (fillets, etc.) - Seafood (shrimp, octopus, etc.) - Cooked tofu (minimum 5 minutes) Preparations to choose from: cooked, baked, steamed, roasted (>80 °C)
Milk products	Raw, unpasteurized or non-refrigerated: - Milk, all types of dairy with probiotics, including yogurt - Mature cheeses, with molds, with blue veins (blue cheese, brie, camembert, feta, gorgonzola, Roquefort, stilton, queso fresco, panela, and from farms). - Raw cream or fermented buttermilk Preparations to avoid: raw or unpasteurized, fermented, containing raw fruit or vegetables	Pasteurized (industrially and subjected to some heat processing: - Lactose-free milk - Yogurt - Cheese (in tubes, cream, cured, parmesan, manchego) - Pasteurized cream or fermented milk (commercial) Preparations to choose from: cooked, baked, steamed, roasted (>80 °C)
Fruit and vegetables	Raw, with thin skin or cannot be peeled, unwashed or not disinfected (grape, loquat, plum, peach, etc.; cabbage, unpackaged or pre-prepared lettuce, alfalfa sprouts, etc.). Raw, with uneven surface that prevents thorough washing (strawberries) Fresh salad dressings found in the refrigerated section of the supermarket (pebre, chimichurri, pesto, among others) Preparations to avoid: raw fruit or vegetable juices, unroasted nuts or nuts straight from the shell (e.g., walnut, pistachio, etc.).	Cooked: any fruit Raw: with thick skin or well peeled, thoroughly washed, and without bruises Example: banana, orange, well-peeled apple Preparations to choose from: industrialized vegetable juices (canned or Tetra Pak), canned vegetables and fruits
Cereals, tubers and legumes	Raw cereals and grains, unpackaged bread Unrefrigerated pastry with creamy filling Cereals with probiotics	Cereals and cooked grains
Water and beverages	Tap water extracted directly from lakes, rivers, streams or springs, wells, and waterwheels Commercial ice Raw commercial fruit and vegetable juices that have not been disinfected or pasteurized Tea, kombucha, and other herbs or infusions Water or energy drinks with added electrolytes, caffeine, etc., should be prescribed by the doctor or nutritionist.	Boiled water, commercially bottled water, and authorized herbal water in individual packages (chamomile and diluted Matico) Fruit and vegetable juices that have been previously disinfected as directed and prepared with boiled water Ice made at home with boiled water
Dried fruit or seeds	None are allowed, due to their excessive handling and the presence of fungi	None, unless included during cooking
Other foods or preparations	Salad dressings containing raw or unpasteurized eggs (Thousand Island, mayonnaise, etc.). Foods with short expiration dates (such as desserts, milks, and juices) and packaged in plastic bags Meringue and Chantilly cream Homemade jams or honey Confectionery not made at home, soft-serve ice cream	All types of preserves and canned foods, preferably those low in sodium and sugar

Figure 8: *Nutritional Guidance for Parents and Caregivers of Children with Cancer*



Source: Mosby TT, Romeo AL, Linares AL, Chalinor JM, Day SW, Caniza M. Testing efficacy of teaching food safety and identifying variables that effect learning in a low-literacy population. J Cancer Educ. 2015 Mar; 30(1):100-7. doi: 10.1007/s13187-014-0666-2. PMID:24781933

• *Oral nutritional support (5, 29, 38-53)*

For patients with inadequate intake, several oral nutritional support strategies can be used, such as increasing food density, providing snacks during the day, and providing nutritious beverages. These strategies can be used alone or in combination with other methods, such as oral nutritional supplements and enteral or parenteral feeding.

It has been shown that increasing the energy density of meals can raise caloric intake up to 30%, and nutritional counseling promotes weight gain. If a patient has poor appetite, suffers from eating problems, or has recently lost weight, it is important that the food and beverages consumed contain as much energy and protein as possible.

Oral nutritional supplements are sterile liquids, semi-solids or powders that provide macronutrients and micronutrients. They are widely used in cases when patients cannot meet their nutritional requirements through oral diet alone. They contain macronutrients and micronutrients in different concentrations. Therefore, not all supplements are "complete," i.e., they cannot be used as a single food source. The individual diet assessment will take into account the nutritional requirements and taste and texture preferences to provide tailor-made recipes. A range of flavors should be offered to avoid flavor fatigue, and supplement use should end when dietary intake meets nutritional requirements, weight has increased to the stated target, or supplements are no longer required.

Evidence shows that establishing a neutropenic diet, which is highly restrictive, can affect a patient's nutritional status. Also, there is no evidence of the benefit of completely sterile preparations in the development of infections. Their use should be eliminated; instead, follow

indications for diets with a low bacterial load. Another practice that should be eliminated is the restriction of gluten or dairy in patients with immunosuppression, since there is no evidence of any benefit and, as with sterile diets, this practice restricts food choices.

Table 24: *Characteristics of foods and products suitable for oral nutritional support*

Type of food	Description
Smoothies	Volume varies between 125–220 ml; the energy density ranges from 1–2.4 kcal/ml. Also available with added fiber.
Juices with or without pulp	Volume varies between 200–220 ml, with an energy density of 1.25–1.5 kcal/ml. Fat-free.
Powdered milk	Volume varies between 125–350 ml; ideally, whole milk should be used to provide an energy density of 1.5–2.5 kcal/ml.
Soups	Volume varies between 200–330 ml; the calories can be increased in calories or diluted with water or milk, as needed, to provide an energy density of 1–1.5 kcal/ml.
Thickeners (useful in dysphagia)	Thickened liquid presentations (stage 1 and 2) and soft puddings (stage 3), with an energy density of ~1.4-2.5 kcal/ml. Powdered thickeners can be used in any liquid and modified as needed.
High-protein formulas	Various presentations, most commonly sold as a smoothie and contains 11–20 g of protein in volumes between 30–250 ml.
Low-volume formulas (shots)	Lipid- and protein-based products that are taken in small amounts, usually 30–40 ml, as a dose to be given 3–4 times a day.
Oils and fats	Volume varies between 5–50 ml; useful for adding lipids and calories to smoothies, soups, etc.

Table 25: *Types of oral or enteral nutritional supplements*

Supplements	Description	Indications
Polymeric formulas	Milk-based, with intact macronutrients; may or may not contain fiber. Most commercially available sources provide 1–2 kcal/ml.	First choice for any patient without allergies to soy protein or cow's milk.
Partially hydrolyzed formulas	Milk-based formulas; 100% partially hydrolyzed protein concentrate (short peptides) to facilitate digestion	Malabsorption, intolerance Food allergy or allergy to proteins of beef origin
Hydrolyzed protein	Free peptides and amino acids Often contain medium-chain triglycerides, which favors their intestinal absorption	IgE-modulated allergy to soy protein and cow's milk
Soy-based formulas	Contain soy protein isolate	Cow's milk protein allergy Vegetarianism
Multivitamins	May contain vitamins (water-soluble, fat-soluble) and trace elements	Low intake of food or supplements for an extended period Severe undernutrition Supplements nutrient supply when the requirement is not met
Modular	Contain one or two macronutrients Not a complete, stand-alone formula	Modifies macronutrient intake of foods or formulas

Artisanal formulas	Compound food formulations; the latter are liquefied and prepared based on patient needs	Home or enteral nutritional support These formulas can also be used orally.
Glutamine	Essential amino acid, a precursor of glutathione, which regulates intracellular redox reactions, and is essential during stress metabolism It has been used in patients with mucositis, although evidence is still lacking for pediatric cancer patients.	Commonly used as a powder dissolved in water Varied dose; on average, it is 2 g/m2 (twice a day) The schedule should be adjusted as needed. It can be administered orally or through a feeding tube.
Polyunsaturated omega-3 fatty acids	Fish oil supplements are rich in oils from cod, krill, salmon, and other species high in long-chain polyunsaturated fatty acids. Docosahexaenoic acid and eicosapentaenoic acid have been used to control weight loss in adults with cancer, but evidence is still lacking for pediatric cancer patients.	The dose in clinical studies is 2–3 g per day.
Prebiotics	Plant fibers that stimulate the growth of healthy bacteria in the gut.	Safe to use The dose depends on the type of prebiotic used.
Probiotics	Live micro-organisms which, administered in proper quantities benefit the health of the host	Although there are no known safety concerns with the use of most probiotic bacteria in healthy people, they should be used with caution in patients with grade 2 or higher neutropenia, who are immunosuppressed or critically ill, due to theoretical concerns about the development of bacteremia. If they are required, they should be administered with caution, under individualized criteria, and after considering the pros and cons carefully with the health team.

Note: Commercial formulas are lactose- or gluten-free, although the restriction of these two components is only necessary in very particular cases.

Special considerations for cancer patients

General indications

- Nutritional intervention is recommended to increase oral intake in cancer patients who are able to eat but are undernourished or at risk. This includes providing dietary advice, treating the symptoms and disorders that affect food intake (nutritional impact symptoms), and offering oral nutritional supplements.
- Patients should not use therapeutic diets to treat cancer.
- Protein intake should exceed 1 g/kg/day.
- Cancer patients who lose weight and experience insulin resistance should increase the ratio of energy to lipids while decreasing carbohydrates. This will increase the energy density of the diet and reduce the glycemic load.
- Vitamins and minerals should be supplied in amounts approximately equal to the recommended daily allowance. The use of micronutrients in high doses is discouraged in the absence of specific deficiencies.
- Supplementing with omega-3 fatty acids may help stabilize weight in cancer patients on oral diets who experience progressive, unintentional weight loss.
- Maintaining or increasing physical activity in cancer patients is recommended for improving or preserving muscle mass, physical function, and metabolic patterns.
- There is insufficient consistent clinical data to recommend cannabinoids to improve taste disorders or anorexia in cancer patients.
- There is insufficient consistent clinical data to recommend currently approved androgenic steroids for increasing muscle mass.
- There is insufficient consistent clinical data to recommend supplementing with branched-chain or other amino acids, or metabolites, to improve fat-free mass.
- There is insufficient consistent clinical data to recommend the use of non-steroidal anti-inflammatory drugs to improve body weight in cancer patients who lose weight.

- Individualized resistance exercises, in addition to aerobic exercise, are recommended for maintaining strength and muscle mass.
- Corticosteroids may be used to increase appetite in patients with cancer-induced anorexia who have advanced disease for a restricted period (1 to 3 weeks). However, the side effects (e.g., muscle atrophy, insulin resistance, infections) should be considered.
- It is suggested to consider the use of progestins to increase the appetite of patients with cancer-induced anorexia who have advanced disease, but possible serious side effects (e.g., thromboembolism) should not be neglected.
- If oral food intake has been significantly reduced over a prolonged period, nutrition (oral, enteral, or parenteral) should be increased slowly over several days and extra precautions taken to prevent refeeding syndrome.
- Enteral nutrition is advised when deciding to feed a patient if oral nutrition remains inadequate despite nutritional interventions (oral counseling and supplementation). Parenteral nutrition should be used if the former is insufficient or not feasible.
- Dysphagia should be detected and treated.

Radiation therapy

- Nutritional support therapy should not be used routinely in patients undergoing irradiation of the head and neck, abdomen, or pelvis.
- During radiation therapy, especially of the head and neck, chest, and gastrointestinal tract, ensure adequate nutritional intake through individualized nutritional counseling or the use of oral nutritional supplements. This will prevent nutritional deterioration, maintain intake, and prevent interruptions to the therapy.
- There are insufficient consistent clinical data to recommend glutamine to prevent radiation-induced enteritis or diarrhea, stomatitis, esophagitis, or skin toxicity.
- There are insufficient consistent clinical data to recommend probiotics to reduce radiation-induced diarrhea.

Surgery

- Perioperative nutritional support therapy may be beneficial in patients with moderate or severe undernutrition if given for 7–14 days prior to surgery.
- Surgical oncology patients with undernutrition or those at risk should have access specialized nutritional support before, during their hospital stay, and after discharge.
- The use of oral or enteral immunonutrition is recommended for patients with cancer in the upper gastrointestinal tract who undergo a surgical resection in a traditional perioperative care setting.

Chemotherapy

- During chemotherapy, it is necessary to ensure adequate nutritional intake and maintain physical activity.
- In patients undergoing chemotherapy (curative), if oral food intake is inadequate despite oral nutritional advice and supplementation, supplementary enteral nutrition may be required. If it is not sufficient or possible, parenteral nutrition may be used.
- There are insufficient consistent clinical data to recommend glutamine supplements during conventional or targeted cytotoxic therapy.

Table 26: *Drug and nutrient interactions*

Drug	Side effects	Food interaction
Busulfan	Nausea, vomiting, loss of appetite, constipation, mucositis, dry mouth	Consume two hours before or after eating.
Carboplatin	Nausea, vomiting, divarrhea, loss of appetite	There are no specific foods that should be excluded from the diet.

Carmustine	Nausea, vomiting, sore throat, black and tarry stools, lack of energy, loss of appetite, vomiting blood	There are no specific foods that should be excluded from the diet.
Cisplatin	Nausea, vomiting, diarrhea, loss of ability to taste food, hiccups, dry mouth, dark urine, sweating, dry skin and other signs of dehydration, black and tarry stools, red blood in the stool, vomiting blood	There are no specific foods that should be excluded from the diet.
Corticosteroids (such as prednisone, prednisolone, dexamethasone, hydrocortisone)	Upset stomach, stomach irritation, vomiting, insomnia, increased appetite, and weight gain	There are no specific foods that should be excluded from the diet.
Cyclophosphamide	Nausea, vomiting, loss of appetite, weight loss, stomach pain, diarrhea, mouth sores	Take in the morning and drink plenty of fluids throughout the day to remove metabolites and protect the bladder; food can help reduce adverse gastrointestinal effects but should be consumed two hours apart. There are no specific foods that should be excluded from the diet.
Cytarabine (cytosine arabinoside or ara-C)	Fatigue, nausea, vomiting, constipation, stomach pain, muscle aches, insomnia, dehydration, loss of appetite	There are no specific foods that should be excluded from the diet.
Daunorubicin	Nausea, vomiting, mouth and throat sores, diarrhea, stomach pain, red urine	There are no specific foods that should be excluded from the diet.
Doxorubicin (adriamycin)	Nausea, vomiting, lack of appetite or increased thirst, mouth sores, weight changes, stomach (abdominal) pain, diarrhea	Simultaneous use of doxorubicin and grapefruit or grapefruit juice may result in increased exposure to doxorubicin.
Etoposide	Nausea, vomiting, low blood pressure, stomach pain, loss of appetite, weight loss, diarrhea, constipation, mouth and throat sores, liver toxicity, and unusual tiredness	Simultaneous use of etoposide and grapefruit or grapefruit juice may result in reduced levels of etoposide in the blood. Consume two hours before or after eating.
Idarubicin	Nausea, vomiting, stomach cramps, diarrhea, swelling and mouth sores, fever	There are no specific foods that should be excluded from the diet.
Imatinib	Nausea, vomiting, diarrhea	Simultaneous use of imatinib and grapefruit or grapefruit juice may alter levels of imatinib
L-asparaginase, PEG-L-asparaginase	Severe abdominal pain that begins in the stomach area but may spread to the back, excessive thirst or urination, dark, colored urine, nausea, vomiting, weight loss, tiredness, fever, headache	There are no specific foods that should be excluded from the diet.
Lomustine (CCNU)	Nausea, vomiting, loss of appetite, sores in the mouth and throat, unusual tiredness or weakness	Can be taken with or without food; however, taking it on an empty stomach before bed reduces nausea.
Melphalan	Nausea, vomiting, loss of appetite, mouth and throat sores	Should be taken on an empty stomach since food reduces its absorption.
Mercaptopurine	Nausea and vomiting	Foods such as coffee, tea, cocoa, and milk can decrease their bioavailability Avoid taking with these foods.

Methotrexate	Headache, swollen and tender gums; decreased appetite fever vomiting reduced urine output; swelling of the face, arms, hands, feet, ankles, or lower legs; difficulty breathing or swallowing.	Drink plenty of fluids in the morning and throughout the day to reduce the risk of kidney damage. Concomitant intake of alcohol may increase the risk of hepatotoxicity. Abstain from caffeinated beverages, including cola drinks, within 24 hours before and while taking methotrexate, and until the drug is completely eliminated. Cola drinks may increase serum methotrexate levels and increase the risk of toxicity. It is not advisable to consume acidic or acidified dairy foods.
Temozolomide	Nausea and vomiting, headache, tiredness, loss of appetite, diarrhea, weakness, fever	Taking it with food may reduce the rate and extent of medication absorbed by the body, and increase adverse effects; taking it before bedtime can reduce nausea.
Thiotepa	Nausea, vomiting, diarrhea, inflammation of the buccal mucosa; irritation of the stomach, throat, and intestine; inflammation of the colon; anorexia, decreased appetite, high blood sugar; back and abdominal pain; enlarged liver, impaired organ function, arterial hypertension; increased liver, kidney, and digestive enzymes; abnormal blood electrolytes; weight gain; fever, general weakness, chills; delayed weight and height gain; bladder dysfunction; underproduction of testosterone; insufficient thyroid hormone production; poor activity of the pituitary gland; constipation and upset stomach; obstruction of the intestine, and perforation of the stomach.	There are no specific foods that should be excluded from the diet.
Vincristine	Nausea, vomiting, diarrhea, constipation, fatigue (feeling tired), peripheral neuropathy (weakness, numbness, and pain, usually in the hands and feet), cramps, weight loss, changes in taste and appetite, mouth sores, anemia, sores on the lips or mouth	Simultaneous use of vincristine and grapefruit or grapefruit juice may result in increased plasma concentrations of vincristine.
6-thioguanine (6-TG)	Nausea, vomiting, diarrhea, inflammation of the mouth	There are no specific foods that should be excluded from the diet.
6-Mercaptopurine (6-MP)	Anemia, nausea, vomiting, fatigue	The medication may be better absorbed on an empty stomach; avoid dairy or calcium products within two hours of dosing; tablets can be crushed; proper handling precautions should be followed.

Source: Ladas E et al. Nutritional Assessment: A Training Manual for Pediatric Oncology. International Initiative for Pediatrics and Nutrition 2022. Nueva York: Columbia University Medical Center; [Unpublished manuscript].

Adverse effects are almost universal among cancer patients. They have a deleterious effect on nutritional status, especially adverse effects related to the gastrointestinal tract, although others, such as pain or depression, also have an indirect incidence. It is essential to manage these adverse effects successfully to improve patients' general status and quality of life (Table 27).

Table 27: *Management of adverse events*

Adverse effect	Possible causes	Recommendations
Nausea/vomiting	Most commonly caused by the following chemotherapeutic agents: Cytarabine, methotrexate, cisplatin, cyclophosphamide, doxorubicin, dactinomycin, and dacarbazine	Antiemetic therapy Cold foods and in small quantities; encourage slow eating; avoid strong odors Drink fluids between meals and not during the meal.
Diarrhea	Most commonly caused by actinomycin, adriamycin, and high doses of methotrexate Can result from mucositis, tumor infiltration into the gastrointestinal tract, malabsorption, infection from long-term use of antibiotics, alterations in the gut microbiome, and radiation therapy to the gastrointestinal tract	Proper hydration, good hygiene, keep the rectal area clean and dry Clear liquid diet, if needed, or use nutritional support
Constipation	Vincristine, intestinal obstruction, spinal cord compression, electrolyte imbalance, pain medications, sedentary lifestyle, low fiber in the diet, or little time spent on bowel movements	Increase fluids and fiber in the diet. Movement (exercise or a certain type of physical activity) Privacy to use the restroom
Altered taste	Vinciristine, dacarbazine, cisplatin, cyclophosphamide, and antibiotics are the most common causes.	Good oral hygiene, keep mouth moist, use strong flavors and serve hot/warm food; avoid sweet foods, and offer salty or slightly acidic foods. Use non-irritating dressings to help with swallowing. Introduce new flavors and new cooking methods.
Anorexia and low consumption	Result of organs or a tumor pressing on the stomach; difficulty breathing Altered taste, constipation, diarrhea, nausea or vomiting, pain, fatigue, metabolic disorders, depression, sadness, or fear	Nutritional counseling can help increase caloric intake with more energy- and protein-dense foods. Encourage the consumption of small and constant meals during the day; serve food on small plates. Use foods such as butter, cream, cheese, milk, skim milk powder, oils, cream, etc., to increase energy and protein content. Provide nutritional supplements or use nutritional support, and consider a multivitamin.
Mucositis / stomatitis	Actinomycin, Adriamycin, Daunomycin, Epirubicin, Bleomycin, Melphalan, and Methotrexate are the most common causes.	Ideally, this should be prevented with good oral hygiene and cryotherapy (ice cubes or sugar-free popsicles). The latter causes vasoconstriction and can prevent damage from chemotherapy. Optimal pain medication. Liquid, pureed, or soft diet. Use non-irritating dressings to help with swallowing. Avoid very irritating or seasoned foods. Avoid deep-fried foods. Use enteral or parenteral feeding when necessary.
Dysphagia	Constant use of probes, mucositis, radiation therapy to the head and neck, presence of a tumor mass	Provide the correct consistency for feeding. Thickeners can be used if necessary.

- ***Specialized nutritional support: enteral feeding (42, 46, 47, 48, 50, 54-57)***

Enteral feeding is necessary for patients who are unable to consume enough or any food by mouth, but whose gastrointestinal tract is functional.

Special considerations for cancer patients

General indications

- Start nutritional therapy if undernutrition already exists or if the patient is not expected to be able to eat for more than seven days.
- Start enteral nutrition if inadequate dietary intake is expected (< 60% of estimated energy expenditure over > 10 days). This type of nutrition should replace the difference between actual intake and calculated needs.
- In patients with weight loss caused by insufficient nutritional intake, provide enteral nutrition to improve or maintain nutritional status.
- Tube feeding can be administered transnasally or percutaneously.
- Enteral feeding through nasogastric or percutaneous tubes is recommended with severe radiation-induced mucositis or obstructive tumors of the head, neck, or chest.
- Standard polymeric formulas are recommended.
- Immune-enhancing enteral formulas, which contain mixtures of arginine, nucleic acids, and essential fatty acids, may be beneficial in malnourished patients undergoing major cancer operations.
- Tube feeding should be used if there is a head or neck cancer that obstructs or interferes with swallowing or if severe local mucositis is expected. Dysphagia should be detected and treated dysphagia, and patients should be encouraged and educated on how to maintain their swallowing function during enteral nutrition.
- No reliable data show any effect of enteral nutrition on tumor growth. Therefore, these theoretical considerations should not influence feeding decisions for cancer patients.

Complications

Presence of abdominal pain or bloating: may be caused by constipation, gas buildup, or gastrointestinal obstruction. Intestinal function should be checked; if necessary, adapt the feeding regimen, method, volume, speed, and concentration of food, as well as its temperature and fiber content. It is also important to consider other causes, such as air entering the feeding tube.

Chemotherapy

- Routine enteral nutrition during chemotherapy has no effect on tumor response to chemotherapy or on unwanted effects associated with chemotherapy; therefore, it is not considered helpful.

Radiation therapy

- Routine enteral nutrition is not recommended during radiation therapy.
- Because of radiation-induced oral and esophageal mucositis, a percutaneous gastrostomy may be preferred.

Surgery

- Perioperative patients at severe nutritional risk benefit from nutritional support given 10 to 14 days before major surgery, even if surgery must be delayed.
- It is preferable to administer preoperative enteral feeding prior to hospital admission.
- Preoperative enteral nutrition, preferably with immunomodulatory substrates (arginine, omega-3 fatty acids, nucleotides), should be used for five to seven days in all patients undergoing major abdominal surgery, regardless of nutritional status.

Diarrhea: can be caused by infections, medications, rapid infusion rate, migration of feeding tube from the stomach to the small intestine, and poor feeding tolerance. Before changing the feeding regimen, the cause of the problem should be investigated (new medications, long-term use of antibiotics, sorbitol content in food, infection-positive cultures, etc.), especially if the patient has already shown tolerance. However, a temporary change in diet or a break in eating may relieve symptoms. The supply of electrolytes and fluids should be maintained.

Constipation: usually caused by lack of fluid, lack of fiber, immobility, or medications. It is advisable to consider the bowel pattern before the constipation or any pre-existing disorder, as well as the medications and analgesics taken (especially opioids).

Reflux and vomiting: to reduce the risk of these complications, the patient should be fed

upright or at a minimum angle of 30°-45°. If the patient ingests boluses, the position should be 30°-60°.If they are given a continuous infusion, a comfortable sleeping position is important but a 180° angle should be avoided. If necessary, the volume, concentration, or infusion rate should be adjusted.

Oral discomfort or infections: Most patients on enteral feeds will have minimal or no oral intake, which can lead to problems such as dry mouth, oral infection, and general oral discomfort. Patients should be given the option of rinsing the mouth with water regularly throughout the day and they may use artificial saliva products (e.g., oral gels or sprays, etc.) or ice, in addition to the usual hygienic care.

- ***Specialized nutritional support: parenteral feeding (42-44, 55-61)***

Parenteral feeding can be used when it is not possible to provide enteral nutrition or when the route is insufficient, but enteral feeding should always be prioritized. Some patients treated with parenteral feeding may absorb some fluid and food by mouth; In these cases, parenteral feeding is a supplement to oral intake.

Parenteral feeding is indicated to provide pediatric nutrition under the following conditions:

- There is some degree of undernutrition or a high risk of undernutrition due to therapy, etc.
- When oral food intake covers < 60% of energy and protein needs, and there is a high risk of treatment-induced undernutrition, etc.
- If food digestion or absorption is impaired and the patient is expected to require nutritional therapy for at least seven days. In this case, parenteral feeding should be started as soon as possible and continued until the gastrointestinal tract is fully operational.

Special considerations for cancer patients

General considerations

- Energy expenditure is usually comparable to that of healthy subjects.
- There is no consensus on an ideal ratio of lipids to carbohydrates; the proportion of lipids can be above 35% of the total energy intake without problems
- Glucose should be the preferred parenteral carbohydrate.
- Micronutrients should be supplied in sufficient quantities, not less than the intravenous doses recommended for healthy people.
- Parenteral feeding is prescribed if oral and enteral food intake provides < 500 kcal per day and is expected to continue for more than five days, or three to five days in case of severe undernutrition, or if oral and enteral food intake reaches 60% of the estimated requirement and is expected to last 10 to 14 days in adult patients.
- Supplemental parenteral feeding is recommended if inadequate enteral or oral intake (< 60% of estimated energy expenditure) is expected to last more than ten days.
- The amount of parenteral feeding should complement oral or enteral nutrition and, when combined, should provide full nutritional requirements.
- Parenteral feeding should begin as soon as it is prescribed and increased to target doses over two to four days, as necessary.
- Most cancer patients who require parenteral feeding for a short time do not need a special formulation.
- Using a higher-than-usual lipid percentage (e.g., 50% non-protein energy) may be beneficial for those with apparent cachexia who need prolonged parenteral feeding.
- Special substrates like glutamine, arginine, taurine, branched-chain amino acids, or omega-3 fatty acids is not recommended because there are no convincing data to support their use.
- In cases of non-surgical therapy, routine use

of parenteral feeding during chemotherapy, radiotherapy, or combination therapy is not advised.
- Although parenteral feeding provides nutrients to the tumor, there is no evidence that this has harmful effects on the outcome. Therefore, this consideration should not influence the decision to use parenteral feeding for a cancer patient when it is clinically indicated.

Chemotherapy
- The indications for parenteral feeding during chemotherapy do not differ from general indications for malignant diseases. Routine parenteral feeding therapy is not indicated as an adjuvant to chemotherapy.

Radiation therapy
- Parenteral feeding should not be used as a general adjuvant to radiation therapy but it is indicated if sufficient enteral intake cannot be achieved.
- Parenteral feeding is recommended for patients with severe mucositis or severe radiation enteritis.

Surgery
- Perioperative parenteral feeding is advised in malnourished patients when the enteral route is not possible.

• *Special considerations for patients undergoing hematopoietic progenitor cell transplantation (38, 40, 43, 48, 62)*

All patients undergoing hematopoietic cell transplantation with myeloablative conditioning regimens are at nutritional risk and should have a nutritional assessment to identify when a formal nutritional assessment is required to develop a nutritional care plan.

General considerations
- Patients should receive dietary advice regarding foods that may carry risks of infection and safe handling of food during the period of neutropenia.
- There are insufficient consistent clinical data to recommend a low-bacterial diet for patients 30 days after allogeneic transplantation.
- There are insufficient clinical data to recommend glutamine to improve clinical outcomes in patients treated with high-dose chemotherapy and hematopoietic stem cell transplantation.
- If oral feeding is inadequate, enteral tube feeding is recommended instead of parenteral feeding unless severe mucositis, intractable vomiting, ileus, severe malabsorption, prolonged diarrhea, or symptomatic graft-versus-host gastrointestinal disease are present.
- If oral intake decreases, parenteral nutrition may be preferred to tube feeding in certain situations (there is an increased risk of bleeding and infections associated with enteral tube placement in immunocompromised and thrombocytopenic patients).
- In patients with cachexia, steroids or progestogens are recommended to improve appetite, modulate metabolic disorders, and prevent deterioration of quality of life (taking into account the side effects of such therapies).
- During intensive chemotherapy and after stem cell transplantation, it is recommended that patients maintain physical activity and ensure adequate nutritional intake. This may require enteral or parenteral feeding.

Enteral feeding
- The routine use of enteral nutrition is not recommended.
- Enteral feeding should be used in patients with a functional gastrointestinal tract when oral intake is inadequate to meet nutritional requirements.
- Enteral administration of glutamine or eicosapentaenoic acid is not recommended because conclusive data are not available.

Parenteral feeding
- Nutritional support therapy is appropriate for patients undergoing hematopoietic cell transplantation who are somewhat malnourished and who are expected to

be unable to adequately ingest or absorb nutrients for an extended period. If parenteral feeding is used, it should be discontinued as soon as toxicities have resolved after stem cell engraftment.

- No clear recommendation can be made on the timing of introducing parenteral feeding in transplant patients, but withdrawal should be considered when patients are able to tolerate approximately 50% coverage of their needs enterally.
- Pharmacological doses of parenteral glutamine may benefit patients undergoing hematopoietic cell transplantation.
- Parenteral feeding is required only in selected patients after autologous transplantation, whereas after an allogeneic transplant, parenteral feeding is normally required in most patients and for prolonged periods, due to the development of pronounced mucositis and gastrointestinal damage related to graft-versus-host disease.
- Particular attention should be paid to the increased risk of bleeding and infection associated with parenteral feeding.

• *Special Palliative Care Considerations (42-44, 59)*

It is recommended to offer and implement nutritional interventions in patients with advanced cancer only after considering, with the patient, the malignant disease prognosis and both the expected benefit in terms of quality of life and potential survival and the burden associated with nutritional care.

General considerations

- Prioritize enteral feeding when possible.
- Treatment should be based on comfort. Hydration and specialized nutritional support are unlikely to provide any benefit to most patients. However, in states of acute confusion, short and limited hydration is recommended to rule out dehydration as a precipitating cause.
- When the end of life is very near, most patients require only minimal amounts of food and a little water to reduce thirst and hunger.
- Small amounts of fluid can also help avoid dehydration-induced confusion.
- If food intake is insufficient, survival for patients in advanced stages of cancer may be compromised more by inadequate diet than by the underlying disease.
- Palliative use of specialized nutritional support therapy is rarely indicated for patients with end-stage cancer.
- Provide enteral feeding to minimize weight loss as long as the patient consents and has not begun the death phase.
- Long-term parenteral feeding should be initiated if intestinal absorption is severely impaired and if the following four criteria are met:
  1. Enteral feeding is insufficient to maintain nutritional status.
  2. Expected survival is greater than three or four months.
  3. Parenteral feeding is expected to stabilize or improve quality of life.
  4. The patient explicitly wishes to receive parenteral feeding.

- Dehydration-induced and agitated confusion can be controlled by parenteral infusion of saline solutions (or appropriate pediatric solutions, respectively).

Chapter 4.
Nutritional monitoring

Nutritional monitoring should be carried out based on the patient's diagnosis, at the start of and during treatment; the risk and nutritional status at the time of each assessment will determine how often the assessment will be repeated (see Tables 28 and 29).
Monitoring the nutritional status of the patient and the nutritional intervention is as relevant as the diagnosis itself or the nutritional intervention itself. The objectives of the follow-up are to: prevent nutritional deterioration, assess the improvement or depreciation of the patient's nutritional status, and determine the effectiveness of the nutritional treatment implemented. The follow-up should assess the patient's current stage of treatment, the resulting complications, the medications received, any changes in the patient's activity and general condition, and any symptoms that may interfere with eating, such as pain or stress.

The frequency of the follow-up and how parameters are measured will depend on the diagnosis and underlying clinical status of the patient; they will also be affected by the clinical environment and the availability of supplies for certain procedures.

• *Nutritional status (12, 18, 22, 63)*

An estimate of standard parameters and dietary intake is recommended as part of the follow-up of pediatric cancer patients (Tables 28 and 29).

● ***Table 28:*** *Parameters for nutritional monitoring*

Parameter	Measurement frequency
Weight	Weekly Daily if there is water imbalance
Height	According to age and growth rate: - < 3 months: 2.6 to 3.5 cm/month - 3–6 months: 1.6 to 2.5 cm/month - 6–12 months: 1.2 to 1.7 cm/month - 1–3 years: 0.7 to 1.1 cm/month - 4–6 years: 0.5 to 0.8 cm/month - 7–10 years: 0.4 to 0.6 cm/month
Mid-arm circumference (MAC)	Monthly
Waist	Monthly
Gastrointestinal symptoms	Daily initially; Then, reduce to twice a week. This makes it possible to assess the ability to continue using the gastrointestinal tract for food.
Glucose	Based on clinical indications. Greater monitoring is required for patients undergoing corticosteroid treatment.
Outpatients	Every one to three months The frequency depends on the condition found in the last assessment.

Note: In short hospital stays, a nutritional assessment should be performed at admission and (at least) before discharge, and then followed up in the outpatient setting. In prolonged hospital stays, serial assessments should be obtained.

Table 29: *Monitoring*

	Frequency	Commentary
Current intake (without enteral/parenteral feeding)	Hospital: two to three times a week Outpatient consultation: at each visit.	If a patient's intake covers < 70% of their nutritional needs, supplementary or enteral/parenteral feeding should be considered, as appropriate.
Current intake (with enteral/ parenteral feeding)	Hospital: daily Outpatient consultation: at each visit.	Compare intake with needs; where necessary, transition between nutritional support and oral intake.

- ***Nutritional support (45, 47, 48, 57, 58, 64-66)***

Patients with nutritional support should be monitored daily. Follow-up is vital to reduce the incidence of complications, decrease electrolyte and metabolic disturbances, and ensure that adequate nutrition is provided. The objectives, route, and risks/benefits should be reviewed regularly to ensure patient progress and ensure that nutrition remains adequate (see Tables 30 and 31).

Table 30: *Nutritional monitoring of enteral feeding*

	Frequency	Commentary
Oral intake	Daily	Compare intake with needs, initiate transition as needed
Liquid balance	Daily in critical patients Weekly with changes in indications	Assess the volume of fluid prescribed with the volume administered (including intravenous medications; food and oral fluids).
Vomiting	Daily	Monitor feeding tolerance
Weight or mid-arm circumference	Twice a week or more frequently if the fluid status requires it Monthly with home enteral nutrition	Assess changes in fluid status and body composition over time.
Bowel movement	Weekly or more regularly if there is pain	Monitor bowel function and tolerance to enteral feeding.
Waist	Every 2-3 days	Monitor bowel function and tolerance to enteral feeding.
Glucose	Daily when starting feeding until the caloric goal is reached, or twice a week as needed	Detect hypoglycemia or hyperglycemia Greater monitoring is required for patients undergoing corticosteroid treatment.
Liver function test (LFT)	Weekly or based on clinical indication	Detect overfeeding if the alteration is not due to medications or treatments.
Electrolytes	Daily when starting feeding until the caloric goal is reached, and then tailor to the needs of each patient	Patients at risk of refeeding syndrome should be monitored daily with electrolyte correction as needed.
Vitamin D	Every six months on prolonged nutritional support or if deficiency is suspected	Especially for patients on total parenteral feeding and for patients with prolonged hospitalizations.
Medications	Daily	Ensure that potential side effects as well as drug-nutrient interactions are identified and prevented.
General patient status	Daily	Ensure that feeding is tolerated and the enteral route remains adequate.

Note: The integrity and proper position of the catheter or ostomy should be checked regularly.

Table 31: *Nutritional monitoring of parenteral feeding*

Al establecer un nuevo paciente en alimentación parenteral, se recomienda seguimiento diario hasta que el paciente esté estable en términos de electrolitos, requerimientos y equilibrio de líquidos.

Variable	Commentary
Blood sugar monitoring	It should be done daily. It can be measured several times during the day based on the needs of the patient.
Electrolytes	They should be evaluated daily until stabilized; then, plan a follow-up based on the patient's needs. Patients at risk of refeeding syndrome should be monitored daily; ideally, every 8–12 hours. Electrolyte correction should be performed as needed.
Trace Elements	At baseline, check for prior evidence of undernutrition. In the long term, repeat every three months to detect deficiencies or high concentrations. Interpret the results with caution and monitor clinical symptoms.
Cholesterol and triglycerides	At first, they should be checked weekly. Once stable, monitoring can be reduced to three months.
Renal function	Monitor daily until stabilized; then, plan a follow-up based on the patient's needs.

Chapter 5.
Childhood cancer survivors

Overall childhood cancer survival rates have improved significantly in recent decades, along with increased rates of overweight, obesity, and cardiovascular disease in child survivors. In order to maintain good growth and development of children and adolescents, it is necessary to pay special attention to efforts that promote a healthy lifestyle (67).

- ***Dietary assessment***

Medical history

Coronary heart disease, stroke, and heart failure are among the leading causes of morbidity and mortality in childhood cancer survivors. This increased risk is caused by the combined effects of treatment and traditional cardiovascular risk factors (hypertension, diabetes, dyslipidemia, obesity). The American Heart Association and the Council on Cardiovascular Diseases of the Young have declared cancer treatments as risk factors for the development of cardiovascular disease (CVD) early in adult life.

- ***Radiation therapy:*** Has been associated with endocrine and cardiac conditions. Cranial irradiation receptors have a significantly higher percentage of fat mass and, along with abdominal irradiation receptors, insulin resistance and risk of type 2 diabetes mellitus. Growth hormone deficiency contributes to central obesity, insulin resistance, and dyslipidemia.
- ***Chemotherapy:*** Exposure to cytotoxic drugs is associated with an increased risk of cardiovascular disease among survivors two years from the start of treatment for any type of cancer. Anthracycline cardiotoxicity is one of the major risk factors for the development of cardiovascular disease.

The diseases that cause the highest risk include leukemias and brain tumors. At the end of treatment, the prevalence of obesity in acute lymphoblastic leukemia (ALL) can reach 70%, and components of metabolic syndrome and possible anthracycline cardiotoxicity may also be present (68–72). Obesity prevalence above 50% can be observed in brain tumor survivors; these patients also have a higher percentage of fat mass and higher chances of presenting with type 2 diabetes mellitus, dyslipidemia, hypertension, and metabolic syndrome (73–85).

Lifestyle (79, 80)

Exposure to treatment, alone or in combination, contributes to an elevated risk of obesity and CVD in childhood cancer survivors. The attributable fraction is less than 50% (9.3% for hypertension, 15.5% for dyslipidemia, 41.7% for diabetes, and 42.1% for obesity). This presents a great opportunity to reduce the burden of chronic disease through lifestyle interventions. And the best time to intervene is before the end of treatment (80).

- ***Dietary intake:*** Food consumption patterns in children with cancer are characterized by high-calorie foods, low dietary fiber, a diet with few variations, and making changes due to taste-related preferences.
- ***Physical activity:*** Sedentary lifestyle, fatigue, decreased physical performance, reduced muscle mass and strength, low mobility, and stress are observed.

- ***Other:*** While the child is in treatment, it is reasonable for parents to practice permissive parenting, which is often associated with unhealthy eating and sedentary behavior. After treatment, parents find it difficult to reverse this lifestyle, thus fostering an obesogenic environment. Genetic predisposition and alterations of the microbial environment can also be considered, among other factors.

Table 32: *Risk factors associated with comorbidities related to nutrition and lifestyle*

	Associated factor	Associated treatment
Overweight / obesity	Central nervous system tumors Craniopharyngioma, medulloblastoma, astrocytoma Acute lymphoblastic leukemia Hodgkin and non-Hodgkin lymphomas Osteosarcomas Neuroblastoma Wilms tumor Soft tissue sarcomas Growth hormone deficiency Treatment at an early age (< 5 years) Female sex African American Hispanic ethnicity	Extensive brain surgery High-dose craniospinal irradiation (> 20 Gy) Whole-body or abdominal radiation therapy Cytotoxic medicines Neurosurgery involving the hypothalamic-pituitary axis Use of antidepressants
Cardiovascular disease	Treatment at an early age (< 5 years) Female sex	Mediastinal irradiation (chest and spine) Long-term high-dose corticosteroid therapy Cumulative doses of anthracyclines > ^{500} mg/m^2
Changes in growth and development	Treatment at an early age (< 5 years)	Skull irradiation (> 18 Gy) Corticosteroids Whole-body irradiation
Bone disease	Hypothyroidism Hypogonadism Growth hormone deficiency	Corticosteroids Craniospinal irradiation Gonadal irradiation Whole-body irradiation
Dental abnormalities	Treatment at an early age (< 5 years)	Craniospinal irradiation Receiving chemotherapy before developing permanent dentition

Source: Adapted from Landier W, Armenian S, Bhatia S. Late effects of childhood cancer and its treatment. Pediatr Clin North Am. 2015;62(1):275–300.

• *Nutrition and lifestyle intervention (12, 67, 79-82)*

The treatment team should be multidisciplinary and include doctors, nurses, nutritionists, psychologists, and physical activity specialists. The risk factors that each child presents must be identified early for the intervention to be successful. This will facilitate positive behavioral change, the responsibility for which must be shared between the family and the survivor.

This responsibility is distributed as follows:

- In children under 5 years of age, parents bear complete responsibility for treatment.
- Between 5 and 9 years old: Some responsibility is given to minors, but parents must monitor them and are mainly responsible.
- Over 9 years old: The greatest responsibility falls on the child, with the help of parents. Adolescent children are 100% responsible for their treatment, but it is essential that they have the support of their parents.

Table 33: *Lifestyle interventions for managing overweight/obesity and cardiovascular risk*

	Child/Adolescent	Family, parents, and environment
Education	Instill healthy eating habits Manage excessive hunger Encourage learning self-control ***Implement gradual, but coherent changes***	Educate about the risk of obesity-related problems Educate about the risk of depression and low self-esteem ***Empower parents with effective parenting skills and practices, which are important in shaping children's eating and activity behaviors.***
Diet	A balanced and healthy diet should be planned, covering all food groups. Make use of preparations already used at home, but with healthy modifications. There should be no dietary restrictions, but energy balance should be achieved. Steps to be considered are: - Include a variety of foods from all food groups. - Establish meal schedules and respect them; three main meals and one or two light meals are recommended. - Consume between five to seven daily servings of fruits and vegetables to obtain phytochemicals, antioxidants, and fiber. - Limit refined carbohydrates, eat little or no added sugars, and eliminate the consumption of sugary drinks (juices, soft drinks, fruit beverages with sugar). - Limit high-fat foods. - Practice low consumption of saturated fats. - Choose low-fat dairy. - Choose foods rich in fiber. - Choose foods high in Vitamin D. - Choose lean meats, fish, and poultry. - Consumption of animal protein should be 1/3 or less and 2/3 of vegetable protein. - Avoid salt-cured, smoked, pickled foods, etc. Maintain these changes over the long term.	
Specific dietary interventions	Calcium and vitamin D supplements. With dyslipidemia, if LDL-cholesterol is above healthy levels: - Saturated fat should be < 10% of calories. - Limit trans fat intake to less than 1%. - Replace saturated fats and trans fats with unsaturated fats, especially polyunsaturated fats. - Ingest 10–25 g/day of soluble fiber and 2 g/day of plant sterols as therapeutic options. Following a ketogenic diet appears to be safe and feasible; however, more studies are needed on its effect on clinical outcomes, quality of life, and efficacy in the pediatric population.[a]	The family diet is extremely important for a successful transition, as children learn through observation and imitation. The family diet should meet nutritional recommendations.
Physical activity	Increase energy expenditure with a healthy and sustainable exercise plan: ideally 60 minutes a day of enjoyable physical activity and recreational, non-strenuous activities, at least five days a week. Avoid intense programs. Start slowly and increase gradually. Reduce sedentary activities and time spent in front of screens	It would be ideal to include the whole family and establish a simple routine that adapts to the family lifestyle.
Other	Active counseling against tobacco and alcohol use.	

Sources: [a] Martin-McGill KJ, Srikandarajah N, Marson AG, Tudur-Smith C, Jenkinson MD. The role of ketogenic diets in the therapeutic management of adult and paediatric gliomas: A systematic review. CNS Oncol. 2018;7(2):CNS17.
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Criteria for pediatric metabolic syndrome (84)

To detect metabolic syndrome, central obesity plus two of the following four symptoms must be observed: [1]

1. High triglyceride level: > 150 mg/dL.
2. Reduced HDL cholesterol: < 40 mg/dL in men and < 50 mg/dL in women.
3. High blood pressure: systolic blood pressure > 130 or diastolic blood pressure > 85 mm Hg (or 95th >percentile for age).
4. High fasting plasma glucose: > 100 mg/dL.

[1] The following criteria should be considered: family history of metabolic syndrome, diabetes mellitus, cardiovascular disease, hypertension, or obesity. Specialized definitions indicate that three or more of the above criteria must be met to determine the presence of metabolic syndrome (86–90).

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This manual has been developed within the framework of the World Health Organization's Global Initiative for Childhood Cancer, Cure All Americas, to help improve the situation of pediatric cancer patients, ensure that they enjoy quality of life, and provide them with comprehensive nutritional care throughout the course of the disease.

In the countries of Latin America and the Caribbean, there is a very high prevalence of malnutrition in children and adolescents at the time of their cancer diagnosis. In addition, malnutrition leads to a worse prognosis for patients and deteriorates their quality of life.

The target audience of this publication are multidisciplinary pediatric oncology care teams, which include medical, nutritional, and nursing staff, among other professionals. Based on the best evidence, this guide addresses nutrition screening, nutritional risk assessment, nutritional care plans, and initiatives to promote a healthy lifestyle for survivors of the disease.

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