Review of Contemporary Philosophy
ISSN: 1841-5261, e-ISSN: 2471-089X
Vol 23 (1), 2024
Pp 1575 - 1587

Nutrition Status and Pediatrics with Cancers: An Updated Review

[1]Afnan Lafy alshammary , [1]Fawziah Mazi Alshurayhi , [1]Ebtsam rdin alshammri , [1] Amal Turqi Alharbi,[2]Waad mohammad alshammari , [3] Munirah gaman alanaze , [4] Amirah Ayed Mahareb Alshammari,[5] Alhanouf ali alenezi , [6] Samia Sewilem alrsheedi

[1] Ksa , Ministry of Health ,Maternity and Children Hospital-Hail

[2]. Ksa , Ministry of Health, King Khalid Hospital in Hail

[3] Ksa , Ministry of Health ksa , ministry of health , Hail

[4]Ksa , Ministry of Health , Hail Health Cluster, Manifa Al-Qa'id Primary Health Care Center.

[5] Ksa , Ministry of Health ,Al-Montazah Western Health Center

[6] Ksa , Ministry of Health ,Sharaf Hospital

Abstract:

Background: Undernutrition and overnutrition are prevalent conditions among children with cancer, impacting their nutritional status (NS). The factors contributing to these issues include the malignancy itself, the toxicity of cancer therapies, and increased metabolic demands. Undernutrition is particularly concerning due to its association with worsened outcomes, including higher infection rates, reduced treatment efficacy, and poorer survival rates. Despite its significance, nutritional status in pediatric oncology is often overlooked.

Aim:
The aim of this review is to provide an updated examination of nutritional status in pediatric cancer patients, focusing on the pathogenesis of malnutrition, its impact on treatment outcomes, and the importance of proper nutritional management during cancer treatment.

Methods: This review synthesizes existing research on the nutritional challenges faced by children with cancer, including the interplay of disease, treatment side effects, and altered metabolism. Nutritional assessment methods, including anthropometric measurements, biochemical tests, and clinical evaluations, are also discussed. The review further explores the role of the microbiome in cancer treatment outcomes and emphasizes the need for regular and comprehensive nutritional monitoring throughout the treatment and survivorship phases.

Results: The review highlights that undernutrition in pediatric cancer patients arises from various factors, including the tumor's metabolic demands, the inflammatory response, and the side effects of therapies such as chemotherapy, radiation, and surgery. Additionally, altered gut microbiome dynamics contribute to malnutrition. The prevalence of undernutrition varies widely, with studies showing it affects a significant proportion of children undergoing cancer treatment. The review also discusses the need for more precise and standardized nutritional assessments to improve patient care.

Conclusion: Nutritional status is a critical determinant of treatment success and long-term health outcomes in pediatric cancer patients. This review advocates for the inclusion of nutritional monitoring as an essential component of pediatric cancer care, recommending more frequent evaluations for at-risk children. Addressing undernutrition and overnutrition can improve survival rates, treatment tolerance, and the overall quality of life for children undergoing cancer treatment.

Keywords: Undernutrition, Pediatric Cancer, Nutritional Status, Chemotherapy, Radiation Therapy, Gut Microbiome, Cancer Treatment, Childhood Survivorship.

Received:15 March 2024 **Revised:** 24 May 2024 **Accepted:**14 June 2024

Introduction:

Undernutrition is a condition characterized by insufficient nutritional status (NS) [1], arising from an imbalance between the energy and nutrients available and the body's needs. The World Health Organization (WHO) defines undernutrition in children not only as undernutrition but also as overnutrition [2]. Under nutrition is commonly categorized into two forms: acute undernutrition (or wasting), which is defined by the WHO as weight-for-height (WFH) < −2 standard deviations (SD), and chronic undernutrition (or stunting), defined as height-for-age (HFA) < −2 SD. In children, age must be considered when identifying overweight and obesity. For those aged 5 to 19 years, overweight is characterized by a BMI-for-age > +1 SD, while obesity is defined as BMI-for-age > +2 SD. For children under 5 years, overweight is indicated by a WFH > +2 SD, and obesity is marked by a WFH > +3 SD [3,4]. Advances in supportive care, particularly in pain management, emesis control, and infection prevention and treatment, have significantly improved survival rates, now exceeding 80% in high-income countries, and have enhanced the quality of life for children undergoing cancer treatment [5,6]. Children with cancer are at heightened risk of nutritional deficits due to the cancer itself, the toxicity of therapies, and increased physiological demands. However, the significance of nutrition in pediatric cancer care is often underestimated. The prevalence of undernutrition among children and adolescents undergoing cancer treatment ranges from 0% to 70%, while the prevalence of overnutrition varies between 25% and 75% [7]. These variations in incidence data are likely influenced by numerous confounding factors, such as the absence of a standardized definition for undernutrition, the diversity of diseases and stages, the intensity and duration of therapy, and the small sample sizes in many studies [8]. Research typically focuses on hematological conditions and undernutrition during cancer treatment, with overnutrition frequently being overlooked.

Nutritional status during cancer treatment impacts several clinical outcomes, including overall survival (OS) and quality of life (QoL). NS significantly affects the risk of morbidity and mortality both during and after cancer treatment, influencing the long-term health of survivors [9,10]. Undernutrition has been identified as a critical risk factor for infection development, with its presence elevating the risk of infections and affecting survival rates [11]. Additionally, hyperglycemia, a complication arising from cancer therapies, has been linked to a higher risk of infections and poorer survival outcomes in pediatric cancer patients [12,13,14]. Long-term health outcomes may also be affected by late treatment-related effects, such as endocrinopathies, reduced bone mass, metabolic syndrome, cardiovascular disease, obesity, and hypertension [15]. Given that children are in critical growth and developmental stages, nutritional deficiencies during this period can disrupt proper growth, puberty, and development, as well as impede the establishment of balanced body composition [10].

The gut microbiome (GM) has garnered significant attention in recent years due to its role in the onset and progression of various diseases. In oncology, the microbiome is increasingly recognized for its involvement in oncological pathophysiology. Chemotherapy-induced gastrointestinal (GI) toxicity alters normal bacterial flora, leading to dysbiosis, which contributes to the undernutrition observed in these patients [16]. Certain foods, such as ready-to-use therapeutic foods (RUTFs), and probiotics like Bifidobacterium, have shown potential in modulating the microbiome, restoring eubiosis, ensuring adequate nutrition, and even influencing the effectiveness of cancer treatment [14,17]. Given the complexities discussed above, nutritional monitoring should become an integral component of the care pathway for children with cancer. However, there is currently no standardized approach or consistent guidelines for nutritional care in this population. This review focuses on the alterations in nutritional status observed in children undergoing cancer treatment, specifically examining the pathogenesis of undernutrition, its impact on treatment tolerance and response, its effects on the immune system, and its association with infection risk.

Pathogenesis of Malnutrition in Pediatric Cancer

Undernutrition in children diagnosed with cancer arises from a complex interplay of factors, including the malignancy itself, the inflammatory response elicited by the host, the adverse effects of cancer therapies, and heightened metabolic demands. These factors disrupt normal dietary intake, physical activity, and the distribution of lean to fat body mass, leading to an imbalance in energy homeostasis [7]. Cancer-induced inflammation is characterized by the release of proinflammatory cytokines such as TNF-α, IL-1, IL-6, and IFN-γ. These cytokines accelerate the mobilization and oxidation of energy substrates, promote lipolysis, and induce the breakdown of body proteins. Additionally, cytokines may directly influence the central nervous system (CNS), affecting appetite regulation and elevating energy expenditure [18,19]. Each form of cancer therapy, including surgery, radiation therapy (RT), and chemotherapy (CHT), is associated with specific side effects that contribute to nutritional deficits. The combination of these therapeutic interventions, which is common in most cancer treatment protocols, may reduce appetite, impair oral intake, and induce nausea and vomiting [17]. These side effects can lead to fluid losses, electrolyte imbalances, and deficiencies in essential proteins, as well as macro- and micronutrients [16]. Cytotoxic therapies, such as CHT and RT, can also induce mucositis, which affects the mucosal lining of the oral cavity and gastrointestinal (GI) tract. Oral mucositis lesions are frequently painful, making oral intake and hygiene challenging, thus increasing the risk of both local and systemic infections [7,20,21].

Chemotherapy agents, particularly those used in the treatment of leukemia, have been shown to induce oxidative stress in vitro [22]. However, the relationship between oxidative stress and nutritional status remains under investigation. Oxidative stress, which can contribute to disease progression and DNA damage under normal circumstances, may also enhance the efficacy of certain chemotherapy regimens in pediatric leukemia and lymphoma patients. The impact of dietary compounds on oxidative stress levels during chemotherapy offers insights into how nutrition may influence treatment outcomes. A study by Raber et al. examined the link between nutritional status and oxidative stress in pediatric cancer patients undergoing chemotherapy for leukemia and lymphoma, tracking their nutritional intake and oxidative stress over a six-month period. The findings indicated that oxidative stress levels increased over time and were correlated with protein consumption, both animal and plant-based [22]. There remains significant debate regarding whether the metabolic rate of children with cancer differs from that of age- and sex-matched healthy controls. Broeder et al. observed that the basal metabolic rate (BMR) of children with solid tumors increased at diagnosis, decreased during treatment, and normalized post-treatment. This suggests that the tumor itself functions as an active metabolic tissue, raising basal energy demands [23]. In contrast, other studies have found no significant differences in the BMR between cancer patients and healthy controls, with no consistent evidence of elevated energy expenditure. These studies suggest that while cancer patients experience alterations in energy metabolism, they are not in a hypermetabolic state, challenging the notion that energy expenditure is universally increased in pediatric cancer patients [25,26].

Skeletal muscle depletion is a prominent feature in pediatric cancer patients, stemming from an imbalance in protein synthesis and degradation, as well as an increase in myocyte apoptosis [7,8]. Rapid loss of lean body mass can significantly impact muscle strength, immune function, wound healing, and overall morbidity in these patients [7,8]. In some cases, this depletion of lean mass is accompanied by an increase in body fat, particularly following prolonged glucocorticoid (GCS) therapy. GCS can promote central fat accumulation, decrease insulin sensitivity in adipocytes, and impair growth hormone (GH) responses, further exacerbating the metabolic disruption in these children [7,8,19]. Children with cancer have higher energy requirements than adults due to their ongoing growth and development [15]. Failure to meet these increased energy demands may hinder linear growth, which can be further impaired by endocrine complications resulting from both the disease and its treatments. Growth hormone deficiency (GHD), the most common pituitary disorder in pediatric cancer patients, is particularly prevalent after craniospinal radiation therapy for brain tumors or total body irradiation for bone marrow transplantation, leading to growth failure [27]. Additionally, cranial irradiation may contribute to obesity and metabolic syndrome through damage to the hypothalamic-pituitary axis. This damage disrupts the mechanisms regulating

hunger and satiety, increasing the risk of obesity during and after cancer treatment, especially in patients with brain tumors [19,28].

Methods for Analyzing Nutritional Status in Children with Cancer

Assessing nutritional status (NS) at the time of diagnosis and throughout treatment, as well as during survivorship, is crucial. Delaying the initial assessment may lead to distorted results due to the influence of treatment procedures and therapies [17]. The primary objective is to maintain adequate NS and promote optimal development [16]. Nutritional assessment should encompass the patient's NS, gastrointestinal function, treatment intensity, and any current or anticipated treatment-related side effects. A consensus statement by Fabozzi et al. outlined a schedule for nutritional evaluations during pediatric cancer treatment [29]. Children receiving intensive treatment or those at a high risk for malnutrition should undergo evaluations at intervals of no more than 3 to 4 weeks. For those undergoing less intensive treatment, evaluations should occur every 3 months, with assessments every 6 to 12 months during the maintenance phase. Children admitted to intensive care units (ICU) require more frequent reassessments. It is also essential to continue nutritional evaluations throughout survivorship to detect any changes and identify those who require advanced nutritional support [30]. Viani et al. proposed a nutritional assessment plan for childhood cancer survivors [31]. Children without nutritional risks should be evaluated every 6 months during the first year and annually thereafter. Children at risk due to factors like poor eating habits, sedentary lifestyles, or elevated lipid levels should be assessed quarterly during the first year, semi-annually until the fifth year, and annually thereafter. Severely undernourished children should undergo monthly assessments until their NS stabilizes. Obese children require evaluations every 3 months [29,31].

The A-B-C-D method is a standardized approach recommended for screening NS in pediatric cancer patients [29,32], which includes anthropometric measures (A), biochemical exams (B), clinical evaluations (C), and dietary intake (D) [32]. Traditional anthropometric measurements, such as BMI, are often inadequate for assessing NS in children with cancer, as they do not account for fluid imbalances or variations in body composition, especially in the presence of conditions like edema or abdominal tumor masses [7,16]. BMI fails to distinguish between fat and lean mass, which is critical, as cancer patients may experience selective loss of lean mass despite maintaining stable body weight [10]. Arm anthropometry offers more sensitive indicators of NS. Measurements such as triceps skinfold thickness (TSFT), which reflects fat mass, and middle-upper arm circumference (MUAC), which assesses lean body mass, are more accurate [8]. For children under 3 years of age, head circumference is also essential for assessing neurodevelopmental outcomes, although it may be impacted in patients with brain tumors [16]. The assessment of lean body mass, representing the body's metabolically active component, is crucial for accurate NS evaluation. Tools like bioelectrical impedance (BIA) can rapidly estimate body composition, distinguishing fat from lean tissue without radiation exposure [8], though accuracy may be compromised in patients with fluctuating hydration statuses or chronic illnesses. Dual-energy X-ray absorptiometry (DXA) is another technique that differentiates lean and fat tissue through pediatric-specific equations but cannot distinguish between visceral and subcutaneous fat [8,33]. Advances in imaging, including CT and MRI, allow for more precise differentiation between visceral and subcutaneous fat and for assessing skeletal muscle mass [33].

Muscle health and function are compromised in both pediatric cancer patients and survivors, with effects such as loss of mass and strength attributed to chemotherapy (CHT) and radiation therapy (RT) during critical stages of development. Hand-held dynamometry (HHD) offers an efficient, quantifiable measure of strength [34]. Laboratory tests should supplement anthropometric and body composition data. These tests include liver and renal function assessments, lipid and glucose panels, and serum protein concentrations such as albumin, pre-albumin, retinol-binding protein (RBP), and transferrin [35]. These proteins are influenced by factors like fever, inflammation, liver and renal dysfunction, and cancer treatments. Albumin, with its long half-life, is better suited for identifying chronic undernutrition [35], though it may be affected by conditions like protein-losing enteropathy or liver toxicity due to therapy. Pre-albumin, with a shorter half-life, is more responsive to acute changes in NS and provides an indication of

the effectiveness of nutritional interventions [36]. RBP, with an even shorter half-life, is useful for evaluating short-term changes in nutritional status, though it is more difficult to measure than pre-albumin [37,38]. Both proteins may be influenced by vitamin A deficiency. Transferrin, a predictor of mortality in children with protein-energy undernutrition, increases during infections or iron deficiency [35]. A comprehensive nutritional analysis also involves assessing the intake of micronutrients such as B vitamins, vitamin D, calcium, and zinc, as deficiencies in these can exacerbate therapy-related toxicity and increase morbidity [7].

Clinical evaluation remains essential for detecting signs of undernutrition. Indicators such as subcutaneous fat loss, muscle wasting, skin and hair changes, weight fluctuations, edema, mucous membrane dryness, and signs of vitamin and mineral deficiencies must be evaluated in undernourished children [31]. Additionally, the side effects of cancer treatment that affect oral intake, such as vomiting, loss of appetite, diarrhea, constipation, and mucositis, should be carefully monitored [31]. A thorough nutritional history, taken at the initial assessment and re-evaluated regularly, is essential to identify factors affecting dietary intake, including food aversions, allergies, and changes in physical activity or family behaviors [30,36]. A food diary documenting all intake for 3 to 7 days is a useful tool in this process [30,36]. This evaluation should be conducted by skilled professionals, such as dietitians or clinical nutritionists with expertise in pediatric oncology. Various nutritional screening tools, such as Strong Kids and the Patient-Generated Subjective Global Assessment (PG-SGA), have been developed to assess nutritional risk in children. Strong Kids is a straightforward tool based on subjective clinical assessment, disease risk, nutritional intake, and weight changes [18], though it does not differentiate based on tumor type or treatment stage [29,39]. The PG-SGA is a sensitive, non-invasive tool that can be used at the bedside to identify malnutrition and triage patients for nutritional support [40]. It collects data on weight loss, nutritional symptoms, changes in dietary intake, and physical evaluation, as well as the presence of ascites and edema. Developing a disease-specific nutrition score that considers disease type and treatment intensity would be beneficial. It is essential to integrate various assessments, including anthropometric measurements, laboratory data, body composition analysis, caloric intake assessment, and energy expenditure, to comprehensively define the NS of pediatric cancer patients.

Prevalence of Undernutrition Across Various Pediatric Cancer Types

The available literature on the prevalence of both undernutrition and overnutrition in pediatric cancer patients reveals significant variability. This variation is influenced by several factors, including tumor type (its location, stage, and biological behavior), the nature of the treatment administered, the age of the patients, and the methods and threshold values used for assessing nutritional status (NS) [1,16]. Generally, undernutrition is prevalent at the time of diagnosis and tends to worsen during the course of treatment, influenced by both the cancer itself and the effects of chemotherapy. In contrast, overnutrition becomes more prevalent towards the end of treatment, although it can also be observed at the initiation of therapy, particularly in patients with brain tumors or those receiving high doses of steroids [1,16]. Studies have reported lower rates of undernutrition in patients with acute lymphoblastic leukemia (ALL), lymphoma, and non-metastatic localized tumors, as well as in patients who are in remission and undergoing maintenance chemotherapy [41,42]. Specifically, the prevalence of undernutrition in leukemia patients is reported to be 5-10% at diagnosis, decreasing to around 5% during treatment. In contrast, patients with neuroblastoma exhibit a much higher rate of undernutrition, with 50% of patients being undernourished at diagnosis and 20-50% continuing to experience undernutrition during treatment. The prevalence in other malignant tumors ranges from 30% at diagnosis to 30% during treatment. Estimating the prevalence of undernutrition in patients with solid tumors is particularly difficult due to the scarcity of relevant studies, and even fewer studies focus on brain tumors [41].

Two retrospective studies have specifically investigated leukemia patients [43,44]. The first study found that 7.6% of male and 6.7% of female patients were undernourished at diagnosis, with 2.6% of males and 3.2% of females being overnourished in the cohort of ALL patients [43]. This study emphasized the importance of conducting early nutritional screenings to swiftly identify and address undernutrition,

suggesting the use of body mass index (BMI) calculations. The second study reported a 10.9% prevalence of underweight and 14.9% prevalence of overweight in acute myeloid leukemia (AML) patients [44]. AML patients with a BMI below the 11th percentile were found to have a lower chance of survival compared to children with normal weight, likely due to their diminished ability to combat infections [44]. As mentioned earlier, data on solid and brain tumors is limited. One study observed that the prevalence of undernutrition at diagnosis in patients with solid tumors was 50%, which decreased to 33% after two cycles of chemotherapy and further to 20% after the tumor was excised. Children with solid tumors are at particularly high metabolic risk [44]. Additionally, research indicates that pediatric patients diagnosed with neurological tumors have a 31% rate of undernutrition at diagnosis [45]. In children diagnosed with medulloblastoma, the undernutrition rate can be even higher due to recurrent episodes of nausea and vomiting [46]. Interestingly, patients with brain tumors exhibit the highest rate of overnutrition at diagnosis compared to other tumor types, with overnutrition and obesity rates of 42.6% and 40.4%, respectively [1].

Consequences of Undernutrition in Pediatric Cancer Patients

Undernutrition during cancer treatment can significantly impair the tolerance to chemotherapy (CHT), overall survival (OS), event-free survival (EFS), susceptibility to infections, and quality of life (QoL) in pediatric patients [7]. The adverse effects of undernutrition on QoL are both direct and indirect. It may contribute to a reduction in bone mineral density (BMD) and increase the risk of chronic conditions such as cardiovascular diseases, diabetes, and metabolic syndrome. Moreover, undernutrition heightens the vulnerability to infections and can alter the pharmacokinetics of chemotherapeutic agents, thereby increasing drug toxicity. These factors may lead to delays in treatment, poorer survival outcomes, increased risk of relapse, and diminished event-free survival [7,15,16].

Impact of Nutrition on Drug Pharmacokinetics

Poor nutritional status has been linked to an elevated risk of treatment-related toxicity [8]. Decreased body weight and alterations in body composition can influence the pharmacokinetics of chemotherapy by affecting the volume of distribution, absorption, metabolism, and elimination of drugs, resulting in reduced tolerance to treatment. Protein-caloric undernutrition can also disrupt the renal and hepatic metabolism of certain chemotherapeutic drugs, leading to enhanced adverse effects such as severe myelosuppression and febrile neutropenia (FN) [7,15]. In obese patients, alterations in body composition and organ function may result in altered serum protein binding, metabolism, and clearance of chemotherapy agents. For hydrophilic drugs, excess fat mass is not available for distribution, reducing the total volume of distribution, while lipophilic drugs experience an increased volume of distribution [15,16]. Furthermore, adiposity has been implicated in the production of tumor growth factors, such as insulin-like growth factor 1 (IGF-1), which contribute to resistance against the cytotoxic effects of chemotherapy by protecting tumor cells [10]. The combined effect of increased therapy toxicity and heightened infection risk, due to immune incompetence, may lead to delays or cessation of treatment, contributing to an elevated risk of relapse and poorer survival outcomes [10].

Impact of Nutrition on Survival Rates

Children with acute lymphoblastic leukemia (ALL) or acute myeloid leukemia (AML) and higher body mass index (BMI) at diagnosis tend to have poorer survival outcomes [47]. A higher BMI (above the 85th percentile) at diagnosis is associated with poorer event-free survival (EFS) in ALL patients, along with significantly increased mortality and, although not statistically significant, a greater risk of relapse [47]. Furthermore, ALL patients who are obese at the onset of therapy have a significantly higher risk of persistent minimal residual disease (MRD) in the bone marrow [48]. The influence of weight on EFS extends beyond diagnosis; maintaining a higher weight during treatment continues to negatively affect the risk of recurrence and death [49]. Obese or underweight patients with ALL who maintain their altered nutritional status for more than half of the pre-maintenance treatment period face double the risk of relapse or death compared to those who maintain normal weight or achieve normal weight during therapy [49]. In these groups, EFS is notably inferior, with hazard ratios of 1.43 and 2.30, respectively (global $p < 0.001$) [49].

Normalizing weight during treatment mitigates this risk, bringing it in line with patients who have never been obese or underweight, suggesting that nutritional interventions could potentially improve outcomes in cancer treatment [47,50]. Children with AML and higher BMI also demonstrate poorer EFS, OS, and increased treatment-related mortality. Overweight children with AML frequently experience abdominal pain, hypertension, and pulmonary and coagulation complications [44,47]. A recent systematic review by Joffe et al. examined the impact of BMI on survival and treatment toxicity in a diverse cohort of pediatric patients with solid tumors, including those derived from renal, bone, liver, eye, muscle, vascular, germ cell, and neural crest tissues. The review found that abnormal BMI was associated with worse OS in Ewing sarcoma, osteosarcoma, and showed a trend toward poorer OS in rhabdomyosarcoma. In osteosarcoma, high BMI was associated with increased nephrotoxicity and postoperative complications [51].

Undernutrition is linked to worse survival outcomes in both hematological and solid tumors. Loeffen et al. demonstrated that survival was significantly worse at diagnosis or 3 months post-diagnosis for patients who were undernourished compared to those who were well-nourished or over-nourished at diagnosis [52]. Notably, undernutrition at 3 months after diagnosis is potentially preventable through regular nutritional monitoring and early intervention, which could improve survival rates [52]. In leukemia patients, particularly in low- and middle-income countries, undernutrition is a significant negative prognostic factor. Barr et al. found that undernutrition was associated with a higher number of therapy dropouts and lower 2-year EFS [53]. Additionally, undernourished children with leukemia had substantially poorer 5-year disease-free survival compared to their well-nourished counterparts, highlighting the importance of early identification and intervention for undernutrition in these patients to improve long-term survival [53]. In patients with advanced neuroblastoma, Wilms tumor, and Ewing sarcoma, the prevalence of undernutrition is notably high (averaging 34%) [33]. Weight loss at diagnosis is a risk factor for the development of suboptimal nutritional status during cancer treatment, which, in turn, impacts morbidity and mortality outcomes [1]. Patients who are undernourished during the early stages of treatment face worse OS, regardless of the prognosis at diagnosis. The prevalence of undernutrition in solid tumor patients remains high from diagnosis through the completion of therapy [54]. The first 3 months of treatment are particularly critical, with undernutrition at diagnosis strongly correlating with an increased risk of relapse, death, or progression to palliative care, making these patients 14 times more likely to experience one of these outcomes [55].

Undernutrition and Infections:

In pediatric cancer patients, infections are a prevalent cause of morbidity and mortality [30]. The pathogenesis of infections in this population is multifactorial, with the risk influenced by disease-associated factors, treatment-related factors, and patient-specific factors. Disease-associated factors, such as bone marrow suppression resulting from hematologic malignancies, heighten infection susceptibility. Treatment-related factors, such as chemotherapy-induced neutropenia, further exacerbate this risk. Patient-related factors, including age, comorbidities, and nutritional status (NS), also play a critical role, with NS being a key determinant of infection risk. Undernutrition increases the likelihood of severe infectious complications, as the catabolic state and nutrient depletion characteristic of cancer heighten the risk of sepsis in pediatric patients [7]. Undernutrition impairs immune function, heightening vulnerability to infections and febrile neutropenia (FN) in pediatric cancer patients. This effect is mediated by hormonal changes and a compromised cytokine response [18,53]. Nutritional deficiencies adversely affect immune cells, including B and T lymphocytes, polymorphonuclear cells (PMNs), mononuclear phagocytes, as well as the function of the complement system and cytokine regulation [30]. A low baseline BMI and significant weight loss during cancer treatment are significant prognostic indicators for both bacterial and fungal infections, as well as reduced survival rates [11]. A study by Loeffen et al. demonstrated that children who lost more than 5% of their body weight within the first three months of diagnosis exhibited an increased incidence of FN episodes with bacteremia within the first year [52]. These findings suggest that rapid weight loss can increase susceptibility to bacterial infections, whereas weight loss occurring between 3–6 months and 6–12 months post-diagnosis did not significantly affect FN occurrence [52]. Similarly, a retrospective study by Triarico et al. affirmed that weight loss ≥5% within the first 3–6 months after

diagnosis strongly correlated with an increased frequency of ≥3 hospitalizations for FN. The study concluded that malnutrition at diagnosis is an independent risk factor for FN hospitalization [18]. These findings underscore the importance of identifying patients at risk of malnutrition to mitigate potential infection complications [18,52].

Hyperglycemia and Infections:

Hyperglycemia is a recognized complication of the treatments used in pediatric cancer, particularly from glucocorticoids (GCS) and asparaginase, which are frequently implicated in its onset [12,13,14]. The prevalence of hyperglycemia during cancer treatment ranges from 10% to 20%, with the highest incidence observed in the treatment of acute lymphoblastic leukemia (ALL) [12]. Hyperglycemia has been associated with an increased susceptibility to infections and poorer survival outcomes in pediatric cancer patients [12,13,14]. While it remains unclear whether hyperglycemia serves solely as a clinical marker for infection or directly contributes to the infection risk, numerous studies suggest that acute hyperglycemia impairs innate immune function, thereby compromising the ability to combat infections [13]. Currently, no standardized guidelines exist for monitoring hyperglycemia during pediatric cancer therapy, either generally or for specific disease groups. There is no consensus on the frequency, type of measurements, or intervention protocols. However, it is recommended that pediatric patients receiving cancer treatment be monitored through serial blood glucose assessments, particularly those over the age of 10 or those with additional risk factors such as Down syndrome, central nervous system (CNS) involvement, obesity, or planned therapies involving glycemic-altering agents such as GCS and asparaginase [12].

Impact on Psychological Well-being, Quality of Life (QoL), and Long-term Consequences of Malnutrition:

Malnutrition can significantly affect the psychological well-being and overall QoL of children with cancer [1]. It specifically impacts emotional and cognitive functions, social interactions, and physical health. Cancer-related fatigue is a prominent issue among pediatric cancer patients, often extending beyond the completion of treatment [56]. This condition is characterized by persistent tiredness, low energy, and difficulty performing everyday tasks. Poor sleep quality and reduced physical performance are frequently associated with cancer-related fatigue, which can contribute to depression and impair cognitive function. Addressing fatigue through non-pharmacological interventions, such as exercise, massage, music therapy, and health education, may improve QoL. Beetroot juice supplementation is one such intervention being explored for its potential to alleviate fatigue and exercise intolerance. While beetroot has shown promise in athletes and certain patient populations, its effectiveness in children with cancer requires further investigation to assess both its safety and potential efficacy in combination with standard cancer treatments [56]. The long-term effects of cancer therapies and subsequent undernutrition represent a significant concern for pediatric cancer survivors. Metabolic disorders, including dyslipidemia, overweight/obesity, and metabolic syndrome, are prevalent in these survivors and present ongoing health challenges for healthcare providers [57,58]. Dyslipidemia and related conditions, such as high blood pressure, type 2 diabetes, metabolic syndrome, fatty liver disease, and orthopedic issues, may be exacerbated by thyroid dysfunction. Hypothyroidism, which may be either primary or secondary following radiation therapy, is the most common thyroid disorder in survivors. Studies have highlighted the increased risk of dyslipidemia and atherosclerosis in pediatric cancer survivors. In a study by Barg et al., lipid disorders, overweight/obesity, and thyroid dysfunction were examined in survivors who had completed their last cancer treatment at least one year prior, with some participants having survived for over five years. The results indicated that lipid abnormalities, including elevated cholesterol and triglycerides, were common among these patients [58].

Cardiovascular and Metabolic Health in Survivors:

Cardiovascular disease is a leading cause of non-malignant morbidity and mortality in pediatric cancer survivors [60-61]. Cancer treatments, particularly anthracycline-based chemotherapy and chest radiation can predispose survivors to early cardiovascular disease. In addition to these treatment-related

risks, modifiable factors such as hypertension, obesity, diabetes mellitus, smoking, and dyslipidemia contribute to cardiovascular risk in this population. Strategies to mitigate these risks should be prioritized to reduce the incidence of cardiovascular disease among survivors. A reduction in sodium intake, particularly for survivors with hypertension, could help lower blood pressure and potentially decrease cardiovascular events and mortality [60]. Early intervention in obesity prevention is crucial for pediatric cancer survivors. Zhang et al. proposed a 12-week remote program aimed at reducing obesity in pediatric survivors of ALL aged 3–11 years. The intervention, delivered through web-based sessions and phone calls with a lifestyle coach, did not show significant improvements in physical activity or weight status, but parents reported a decrease in the "pressure to eat" feeding practice. Further research is necessary to evaluate the long-term effectiveness of such interventions in pediatric cancer survivors [61].

Bone Health and Osteopenia:

Inadequate intake of bone-related nutrients, such as vitamin D and calcium, which often accompanies undernutrition, increases the risk of osteopenia late effect of oncological treatment [7]. Several factors contribute to alterations in bone metabolism in pediatric cancer patients, including direct effects of cancer (e.g., leukemia) on the skeleton, the toxic impact of chemotherapy and radiation on bones, treatment-induced endocrine deficits (e.g., growth hormone deficiency, hypogonadism), reduced physical activity, and altered muscle strength [7]. The use of glucocorticoids and nephrotoxic agents can induce hypercalciuria, further increasing the risk of osteopenia and fractures. Osteopenia is particularly prevalent among patients with ALL, CNS tumors, and those undergoing hematopoietic stem cell transplantation (HSCT). Recognizing and treating hormonal imbalances that affect bone metabolism, along with addressing vitamin D deficiencies and promoting physical activity, is essential for managing bone health in these patients.

Conclusion:

Pediatric cancer patients are highly vulnerable to both undernutrition and overnutrition, which significantly impact their treatment outcomes, immune function, and overall survival. The pathogenesis of malnutrition in these patients is complex, involving factors such as the cancer itself, the inflammatory response induced by the disease, the adverse effects of treatments like chemotherapy (CHT) and radiation therapy (RT), and increased metabolic demands. The interplay of these factors disrupts normal nutritional intake and energy balance, leading to nutritional deficits that may affect treatment tolerance and efficacy. Undernutrition during cancer treatment has been associated with worsened clinical outcomes, including increased morbidity, delayed recovery, and higher mortality rates. In contrast, overnutrition, often overlooked, can also be detrimental, especially in patients who experience treatment-related metabolic disturbances, such as obesity and metabolic syndrome. Malnutrition has been identified as a key risk factor for infection, which further compromises the health of these patients. Furthermore, nutritional deficiencies can impair growth, development, and immune responses, with long-term effects on the overall health of pediatric cancer survivors. The importance of regular and accurate nutritional assessments in pediatric oncology cannot be overstated. Monitoring nutritional status (NS) should begin at diagnosis and continue throughout treatment, with reassessments during survivorship. Several methods are available for evaluating NS, including anthropometric measurements, biochemical exams, and dietary intake assessments. Standardized guidelines for nutritional monitoring, particularly in high-risk patients undergoing intensive treatment, are essential for ensuring adequate nutritional support and preventing the detrimental effects of malnutrition. The gut microbiome plays a critical role in both the onset and progression of malnutrition in pediatric cancer patients. Cancer therapies, especially chemotherapy, can disrupt the gut flora, leading to dysbiosis and further exacerbating nutritional deficits. Probiotics and targeted nutritional interventions, such as ready-to-use therapeutic foods (RUTFs), have shown promise in modulating the microbiome and supporting adequate nutrition during cancer treatment. In conclusion, optimizing nutritional care for pediatric cancer patients requires a comprehensive, personalized approach that accounts for the unique challenges posed by cancer and its treatments. Ensuring adequate nutrition

through early detection and continuous monitoring is critical for improving treatment outcomes, minimizing complications, and enhancing the quality of life for children battling cancer.

References:

1. Diakatou, V.; Vassilakou, T. Nutritional Status of Pediatric Cancer Patients at Diagnosis and Correlations with Treatment, Clinical Outcome and the Long-Term Growth and Health of Survivors. *Children* **2020**, *7*, 218.
2. WHO. Double Burder of Malnutrition. Available online: **www.who.int/nutrition/double-burden-malnutriotion/en/** (2022).
3. WHO. Malnutrition in Children. Available online: **https://www.who.int/data/nutrition/nlis/info/malnutrition-in-children/** (2022).
4. WHO. BMI-for-Age (5–19 Years). Available online: **https://www.who.int/tools/growth-reference-data-for-5to19-years/indicators/bmi-for-age/** (2022).
5. Henry, M.; Sung, L. Supportive care in pediatric oncology: Oncologic emergencies and management of fever and neutropenia. *Pediatr. Clin.* **2015**, *62*, 27–46.
6. Albano, E.A.; Odom, L.F. Supportive care in pediatric oncology. *Curr. Opin. Pediatr.* **1993**, *5*, 131–137.
7. Joffe, L.; Ladas, E.J. Nutrition during childhood cancer treatment: Current understanding and a path for future research. *Lancet Child Adolesc. Health* **2020**, *4*, 465–475.
8. Sala, A.; Pencharz, P.; Barr, R.D. Children, cancer, and nutrition—A dynamic triangle in review. *Cancer* **2004**, *100*, 677–687.
9. Viani, K.; Barr, R.D.; Odone Filho, V.; Ladas, E.J. Nutritional status at diagnosis among children with cancer referred to a nutritional service in Brazil. *Hematol. Transfus. Cell Ther.* **2021**, *43*, 389–395.
10. Barr, R.D.; Stevens, M.C. The influence of nutrition on clinical outcomes in children with cancer. *Pediatr. Blood Cancer* **2020**, *67*, e28117.
11. Hansen, B.A.; Wendelbo, Ø.; Bruserud, Ø.; Hemsing, A.L.; Mosevoll, K.A.; Reikvam, H. Febrile Neutropenia in Acute Leukemia. Epidemiology, Etiology, Pathophysiology and Treatment. *Mediterr. J. Hematol. Infect. Dis.* **2020**, *12*, 1.
12. Grimes, A.; Mohamed, A.; Sopfe, J.; Hill, R.; Lynch, J. Hyperglycemia during childhood cancer therapy: Incidence, implications, and impact on outcomes. *JNCI Monogr.* **2019**, *2019*, 132–138.
13. Dare, J.M.; Moppett, J.P.; Shield, J.P.; Hunt, L.P.; Stevens, M.C. The impact of hyperglycemia on risk of infection and early death during induction therapy for acute lymphoblastic leukemia (ALL). *Pediatr. Blood Cancer* **2013**, *60*, E157–E159.
14. McCormick, M.C.; Sharp, E.; Kalpatthi, R.; Zullo, J.; Gurtunca, N.; Zhang, J.; Krafty, R.; Raman, S. Hyperglycemia requiring insulin during acute lymphoblastic leukemia induction chemotherapy is associated with increased adverse outcomes and healthcare costs. *Pediatr. Blood Cancer* **2020**, *67*, e28475.
15. Tripodi, S.I.; Bergami, E.; Panigari, A.; Caissutti, V.; Brovia, C.; De Cicco, M.; Cereda, E.; Caccialanza, R.; Zecca, M. The role of nutrition in children with cancer. *Tumori J.* **2022**, 03008916221084740.
16. Bauer, J.; Jürgens, H.; Frühwald, M.C. Important aspects of nutrition in children with cancer. *Adv. Nutr.* **2011**, *2*, 67–77.
17. Santarpia, L.; Contaldo, F.; Pasanisi, F. Nutritional screening and early treatment of malnutrition in cancer patients. *J. Cachexia Sarcopenia Muscle* **2011**, *2*, 27–35
18. Triarico, S.; Rinninella, E.; Cintoni, M.; Capozza, M.A.; Mastrangelo, S.; Mele, M.C.; Ruggiero, A. Impact of malnutrition on survival and infections among pediatric patients with cancer: A retrospective study. *Eur. Rev. Med. Pharmacol. Sci.* **2019**, *23*, 1165–1175.

19. 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*, 1160–1167.

20. Lalla, R.V.; Sonis, S.T.; Peterson, D.E. Management of oral mucositis in patients who have cancer. *Dent. Clin. N. Am.* **2008**, *52*, 61–77.

21. Kuiken, N.S.; Rings, E.H.; van den Heuvel-Eibrink, M.M.; Van De Wetering, M.D.; Tissing, W.J. Feeding strategies in pediatric cancer patients with gastrointestinal mucositis: A multicenter prospective observational study and international survey. *Support. Care Cancer* **2017**, *25*, 3075–3083.

22. Raber, M.; Wu, J.; Donnella, H.; Knouse, P.; Pise, M.; Munsell, M.; Liu, D.; Chandra, J. Cellular oxidative stress in pediatric leukemia and lymphoma patients undergoing treatment is associated with protein consumption. *Nutrients* **2019**, *12*, 75.

23. Den Broeder, E.; Oeseburg, B.; Lippens, R.J.J.; Van Staveren, W.A.; Sengers, R.C.A.; van't Hof, M.A.; Tolboom, J.J.M. Basal metabolic rate in children with a solid tumour. *Eur. J. Clin. Nutr.* **2001**, *55*, 673–681.

24. Schmid, I.; Schmitt, M.; Streiter, M.; Meilbeck, R.; Haas, R.J.; Stachel, D.K. Effects of soluble TNF receptor II (sTNF-RII), IL-1 receptor antagonist (IL-1 ra), tumor load and hypermetabolism on malnutrition in children with acute leukemia. *Eur. J. Med. Res.* **2005**, *10*, 457.

25. Bond, S.A.; Han, A.M.; Wootton, S.A.; Kohler, J.A. Energy intake and basal metabolic rate during maintenance chemotherapy. *Arch. Dis. Child.* **1992**, *67*, 229–232.

26. Knox, L.S.; Crosby, L.O.; Feurer, I.D.; Buzby, G.P.; Miller, C.L.; Mullen, J.L. Energy expenditure in malnourished cancer patients. *Ann. Surg.* **1983**, *197*, 152.

27. Vatner, R.E.; Niemierko, A.; Misra, M.; Weyman, E.A.; Goebel, C.P.; Ebb, D.H.; Jones, R.M.; Huang, M.S.; Mahajan, A.; Grosshans, D.R. Endocrine deficiency as a function of radiation dose to the hypothalamus and pituitary in pediatric and young adult patients with brain tumors. *J. Clin. Oncol.* **2018**, *36*, 2854.

28. Ross, J.A.; Oeffinger, K.C.; Davies, S.M.; Mertens, A.C.; Langer, E.K.; Kiffmeyer, W.R.; Sklar, C.A.; Stovall, M.; Yasui, Y.; Robison, L.L. Genetic variation in the leptin receptor gene and obesity in survivors of childhood acute lymphoblastic leukemia: A report from the Childhood Cancer Survivor Study. *J. Clin. Oncol.* **2004**, *22*, 3558–3562.

29. Fabozzi, F.; Trovato, C.M.; Diamanti, A.; Mastronuzzi, A.; Zecca, M.; Tripodi, S.I.; Masetti, R.; Leardini, D.; Muratore, E.; Barat, V. Management of Nutritional Needs in Pediatric Oncology: A Consensus Statement. *Cancers* **2022**, *14*, 3378.

30. Pizzo, P.A.; Poplack, D.G. *Principles and Practice of Pediatric Oncology*; Lippincott Williams & Wilkins: Philadelphia, PA, USA, 2015.

31. Viani, K.; Trehan, A.; Manzoli, B.; Schoeman, J. Assessment of nutritional status in children with cancer: A narrative review. *Pediatr. Blood Cancer* **2020**, *67*, e28211.

32. Ladas, E.J.; Arora, B.; Howard, S.C.; Rogers, P.C.; Mosby, T.T.; Barr, R.D. A framework for adapted nutritional therapy for children with cancer in low-and middle-income countries: A report from the SIOP PODC Nutrition Working Group. *Pediatr. Blood Cancer* **2016**, *63*, 1339–1348.

33. Joffe, L.; Schadler, K.L.; Shen, W.; Ladas, E.J. Body composition in pediatric solid tumors: State of the science and future directions. *JNCI Monogr.* **2019**, *2019*, 144–148.

34. Goodenough, C.G.; Partin, R.E.; Ness, K.K. Skeletal muscle and childhood cancer: Where are we now and where we go from here. *Aging Cancer* **2021**, *2*, 13–35.

35. Pencharz, P.B. Assessment of protein nutritional status in children. *Pediatr. Blood Cancer* **2008**, *50*, 445–446.

36. Ladas, E.J.; Sacks, N.; Meacham, L.; Henry, D.; Enriquez, L.; Lowry, G.; Hawkes, R.; Dadd, G.; Rogers, P. A multidisciplinary review of nutrition considerations in the pediatric oncology population: A perspective from children's oncology group. *Nutr. Clin. Pract.* **2005**, *20*, 377–393.

37. Yaprak, D.S.; Yalçın, B.; Pınar, A.A.; Büyükpamukçu, M. Assessment of nutritional status in children with cancer: Significance of arm anthropometry and serum visceral proteins. *Pediatr. Blood Cancer* **2021**, *68*, e28752.

38. Keller, U. Nutritional laboratory markers in malnutrition. *J. Clin. Med.* **2019**, *8*, 775.

39. Huysentruyt, K.; Alliet, P.; Muyshont, L.; Rossignol, R.; Devreker, T.; Bontems, P.; Dejonckheere, J.; Vandenplas, Y.; De Schepper, J. The STRONGkids nutritional screening tool in hospitalized children: A validation study. *Nutrition* **2013**, *29*, 1356–1361.

40. de la Torre, M.J.V.; Stein, K.; Garibay, E.M.V.; Ichikawa, M.R.K.; Sanromán, R.T.; Salcedo-Flores, A.G.; Sánchez-Zubieta, F.A. Patient-Generated Subjective Global Assessment of nutritional status in pediatric patients with recent cancer diagnosis. *Nutr. Hosp.* **2017**, *34*, 1050–1058.

41. Aarnivala, H.; Pokka, T.; Soininen, R.; Möttönen, M.; Harila-Saari, A.; Niinimäki, R. Trends in age-and sex-adjusted body mass index and the prevalence of malnutrition in children with cancer over 42 months after diagnosis: A single-center cohort study. *Eur. J. Pediatr.* **2020**, *179*, 91–98.

42. Brinksma, A.; Huizinga, G.; Sulkers, E.; Kamps, W.; Roodbol, P.; Tissing, W. Malnutrition in childhood cancer patients: A review on its prevalence and possible causes. *Crit. Rev. Oncol./Hematol.* **2012**, *83*, 249–275.

43. Reilly, J.J.; Weir, J.; McColl, J.H.; Gibson, B.E. Prevalence of protein-energy malnutrition at diagnosis in children with acute lymphoblastic leukemia. *J. Pediatr. Gastroenterol. Nutr.* **1999**, *29*, 194–197.

44. Lange, B.J.; Gerbing, R.B.; Feusner, J.; Skolnik, J.; Sacks, N.; Smith, F.O.; Alonzo, T.A. Mortality in overweight and underweight children with acute myeloid leukemia. *JAMA* **2005**, *293*, 203–211.

45. Green, G.J.; Weitzman, S.S.; Pencharz, P.B. Resting energy expenditure in children newly diagnosed with stage IV neuroblastoma. *Pediatr. Res.* **2008**, *63*, 332–336.

46. Bakish, J.; Hargrave, D.; Tariq, N.; Laperriere, N.; Rutka, J.T.; Bouffet, E. Evaluation of dietetic intervention in children with medulloblastoma or supratentorial primitive neuroectodermal tumors. *Cancer Interdiscip. Int. J. Am. Cancer Soc.* **2003**, *98*, 1014–1020.

47. Orgel, E.; Genkinger, J.M.; Aggarwal, D.; Sung, L.; Nieder, M.; Ladas, E.J. Association of body mass index and survival in pediatric leukemia: A meta-analysis. *Am. J. Clin. Nutr.* **2016**, *103*, 808–817.

48. Orgel, E.; Mueske, N.M.; Sposto, R.; Gilsanz, V.; Freyer, D.R.; Mittelman, S.D. Limitations of body mass index to assess body composition due to sarcopenic obesity during leukemia therapy. *Leuk. Lymphoma* **2018**, *59*, 138–145.

49. Orgel, E.; Sposto, R.; Malvar, J.; Seibel, N.L.; Ladas, E.; Gaynon, P.S.; Freyer, D.R. Impact on survival and toxicity by duration of weight extremes during treatment for pediatric acute lymphoblastic leukemia: A report from the Children's Oncology Group. *J. Clin. Oncol.* **2014**, *32*, 1331.

50. Amankwah, E.K.; Saenz, A.M.; Hale, G.A.; Brown, P.A. Association between body mass index at diagnosis and pediatric leukemia mortality and relapse: A systematic review and meta-analysis. *Leuk. Lymphoma* **2016**, *57*, 1140–1148.

51. Joffe, L.; Dwyer, S.; Bender, J.L.G.; Frazier, A.L.; Ladas, E.J. Nutritional status and clinical outcomes in pediatric patients with solid tumors: A systematic review of the literature. In *Seminars in Oncology*; Elsevier: Amsterdam, The Netherlands, 2019; pp. 48–56.

52. Loeffen, E.A.; Brinksma, A.; Miedema, K.G.; De Bock, G.H.; Tissing, W.J. Clinical implications of malnutrition in childhood cancer patients—Infections and mortality. *Support. Care Cancer* **2015**, *23*, 143–150.

53. Barr, R.D.; Gomez-Almaguer, D.; Jaime-Perez, J.C.; Ruiz-Argüelles, G.J. Importance of Nutrition in the Treatment of Leukemia in Children and Adolescents. *Arch. Med. Res.* **2016**, *47*, 585–592.

54. Iniesta, R.R.; Paciarotti, I.; Brougham, M.F.; McKenzie, J.M.; Wilson, D.C. Effects of pediatric cancer and its treatment on nutritional status: A systematic review. *Nutr. Rev.* **2015**, *73*, 276–295.

55. Iniesta, R.R.; Paciarotti, I.; Davidson, I.; McKenzie, J.M.; Brougham, M.F.; Wilson, D.C. Nutritional status of children and adolescents with cancer in Scotland: A prospective cohort study. *Clin. Nutr.* **2019**, *32*, 96–106.

56. Swartz, M.C.; Allen, K.; Deer, R.R.; Lyons, E.J.; Swartz, M.D.; Clifford, T. A narrative review on the potential of red beetroot as an adjuvant strategy to counter fatigue in children with cancer. *Nutrients* **2019**, *11*, 3003.

57. Brinksma, A.; Roodbol, P.F.; Sulkers, E.; Kamps, W.A.; de Bont, E.S.; Boot, A.M.; Burgerhof, J.G.; Tamminga, R.Y.; Tissing, W.J. Changes in nutritional status in childhood cancer patients: A prospective cohort study. *Clin. Nutr.* **2015**, *34*, 66–73.

58. Barg, E.; Połubok, J.; Hetman, M.; Gonera, A.; Jasielska, O.; Sęga-Pondel, D.; Galant, K.; Kazanowska, B. Metabolic Disturbances in Children Treated for Solid Tumors. *Nutrients* **2019**, *11*, 3062.

59. Bis, G.; Szlasa, W.; Sondaj, K.; Zendran, I.; Mielcarek-Siedziuk, M.; Barg, E. Lipid complications after hematopoietic stem cell transplantation (HSCT) in pediatric patients. *Nutrients* **2020**, *12*, 2500.

60. Belle, F.N.; Schindera, C.; Guessous, I.; Beck Popovic, M.; Ansari, M.; Kuehni, C.E.; Bochud, M. Sodium and potassium intakes and cardiovascular risk profiles in childhood cancer survivors: The sccss-nutrition study. *Nutrients* **2019**, *12*, 57.

61. Pedretti, L., Massa, S., Leardini, D., Muratore, E., Rahman, S., Pession, A., ... & Masetti, R. (2023). Role of nutrition in pediatric patients with cancer. *Nutrients*, *15*(3), 710.**الة التغذية وأطفال السرطان: مراجعة محدثة**

الملخص:

الخلفية :سوء التغذية سواء بالنقص أو بالزيادة من الحالات الشائعة بين الأطفال المصابين بالسرطان، مما يؤثر على حالتهم التغذوية .(NS) تشمل العوامل المساهمة في هذه المشكلات السرطان نفسه، سمية العلاجات الكيميائية، وزيادة المتطلبات الأيضية. يعتبر سوء التغذية بالنقص مصدر قلق خاص نظرًا لارتباطه بتدهور النتائج، بما في ذلك زيادة معدلات العدوى، تقليل فعالية العلاج، وتدهور معدلات البقاء على قيد الحياة. على الرغم من أهميته، غالبًا ما يتم تجاهل حالة التغذية في طب الأورام للأطفال.

الهدف :تهدف هذه المراجعة إلى تقديم فحص محدث لحالة التغذية في المرضى الأطفال المصابين بالسرطان، مع التركيز على تطور سوء التغذية، تأثيره على نتائج العلاج، وأهمية الإدارة التغذوية السليمة خلال العلاج من السرطان.

الطرق :تدمج هذه المراجعة البحوث الحالية المتعلقة بالتحديات التغذوية التي يواجهها الأطفال المصابون بالسرطان، بما في ذلك التفاعل بين المرض، الآثار الجانبية للعلاج، والتمثيل الغذائي المعدل. يتم أيضًا مناقشة طرق تقييم التغذية، بما في ذلك القياسات الأنثروبومترية، الاختبارات البيوكيميائية، والتقييمات السريرية. بالإضافة إلى ذلك، تستكشف المراجعة دور الميكروبيوم في نتائج علاج السرطان وتؤكد على الحاجة إلى المراقبة التغذوية المنتظمة والشاملة طوال مراحل العلاج والبقاء على قيد الحياة بعد العلاج.

النتائج :تسلط المراجعة الضوء على أن سوء التغذية بالنقص في الأطفال المصابين بالسرطان ينشأ من عوامل متعددة، بما في ذلك المتطلبات الأيضية للأورام، الاستجابة الالتهابية، وآثار العلاجات مثل العلاج الكيميائي، الإشعاعي، والجراحة. بالإضافة إلى ذلك، تساهم الديناميكيات المعدلة للميكروبيوم المعوي في سوء التغذية. تختلف انتشار سوء التغذية بشكل واسع، حيث أظهرت الدراسات أنه يؤثر على نسبة كبيرة من الأطفال الذين يتلقون العلاج من السرطان. كما تناقش المراجعة الحاجة إلى تقييمات غذائية أكثر دقة وموحدة لتحسين رعاية المرضى.

الاستنتاج :تعتبر حالة التغذية من العوامل الحاسمة في نجاح العلاج والنتائج الصحية طويلة الأمد للأطفال المصابين بالسرطان. تدعو هذه المراجعة إلى تضمين المراقبة التغذوية كجزء أساسي من رعاية سرطان الأطفال، مع التوصية بإجراء تقييمات أكثر تكرارًا للأطفال المعرضين للخطر. يمكن أن يؤدي معالجة سوء التغذية والنظام الغذائي الزائد إلى تحسين معدلات البقاء على قيد الحياة، تحمل العلاج، وجودة الحياة بشكل عام للأطفال الذين يتلقون العلاج من السرطان.

الكلمات المفتاحية :سوء التغذية، سرطان الأطفال، حالة التغذية، العلاج الكيميائي، العلاج الإشعاعي، الميكروبيوم المعوي، علاج السرطان، بقاء الأطفال بعد العلاج.