ARC Journal of Cancer Science
Volume 9, Issue 1, 2024, PP 8-15
ISSN (Online): 2455-6009
DOI: https://doi.org/10.20431/2455-6009.0901003
www.arcjournals.org

Nutritional Status of Pediatric Cancer Patients at Diagnosis and Correlations with Treatment

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Abstract

Background: *Nutritional status (NS) at diagnosis is crucial for pediatric cancer patients, significantly influencing treatment outcomes and prognosis. Malnutrition, prevalent in pediatric oncology, impacts disease progression, response to treatment, and survival. Factors like tumor burden and chemotherapy side effects exacerbate nutritional imbalances. Malnutrition's consequences include increased infection risks and treatment complications, emphasizing the need for early detection and nutritional interventions to improve survival and quality of life in pediatric cancer patients.*

Aim of the study: *This study aims to investigate the nutritional status of children diagnosed with cancer at the time of their diagnosis and correlations with treatment.*

Methods: *This retrospective cross-sectional study analyzed nutritional assessments from the NICRH database in Dhaka, Bangladesh, between 01 Feb 2022 and 30 Nov 2022. Data included weight, height, MUAC, date of birth, diagnosis, date of diagnosis, and date of death, with patients grouped by tumor type (hematological, solid, or CNS). Inclusion criteria were patients aged 3 months to 5 years with a recent cancer diagnosis and a nutritional assessment within seven days. Exclusion criteria included syndromic conditions, previous or relapsed cancer, and missing MUAC data. Nutritional status was evaluated using zBMI/A and MUAC percentiles. Statistical analysis employed SPSS, utilizing t-tests and Chi-Square tests.*

Result: *The study included 120 participants aged three months to 5 years, with 45% aged three months to 2 years and 55% aged 3 to 5 years. Gender distribution showed 54.17% males and 45.83% females. BMI analysis revealed 10.83% underweight, 73.33% normal weight, and 15.83% overweight. MUAC indicated 8.33% undernourished, 72.5% normal, 5% overweight, and 14.17% malnourished. Tumor types were 42% solid, 33.33% CNS, and 24.17% hematological, with ALL being the most common diagnosis at 51.67%. Chemotherapy was the predominant treatment, and survival duration increased slightly with weight: 3.5 years (underweight), 4.0 years (normal), and 4.2 years (overweight).*

Conclusion: *The study found that the nutritional status of pediatric cancer patients at diagnosis impacts treatment outcomes and survival rates. Chemotherapy was the most common treatment. Early and ongoing nutritional interventions are crucial for improving treatment tolerance and outcomes.*

Keywords: *Nutritional Status, Pediatric Cancer Patients, Diagnosis and Treatment*

1. INTRODUCTION

The nutritional status (NS) of pediatric cancer patients at diagnosis is a critical factor influencing their treatment outcomes and overall prognosis.

NS refers to the body's ability to maintain adequate nutrient levels necessary for essential physiological functions, which is often compromised in pediatric cancer patients due to the disease and its treatment. Malnutrition, whether in the form of under nutrition or over nutrition, is highly prevalent in pediatric oncology, significantly impacting disease progression, response to treatment, and long-term survival [1]. Various cancer-related factors, including tumor burden, organ involvement, and the side effects of chemotherapy or radiation

therapy, exacerbate nutritional imbalances, highlighting the importance of assessing NS at diagnosis. The consequences of poor nutritional status include increased treatment-related toxicity, prolonged hospital stays, and lower survival rates, making nutrition an integral component of pediatric cancer care [2,3]. International studies have consistently documented the high prevalence of malnutrition among pediatric cancer patients, with significant variation across countries and income levels. In developing nations, malnutrition affects a significant portion of pediatric oncology patients, with prevalence rates ranging from 40% to 90% [4]. In contrast, high-income countries report lower malnutrition rates, between 0% and 30%, primarily due to better access to healthcare and nutritional support services [4]. These differences emphasize the global challenge of addressing malnutrition in pediatric oncology, particularly in low- and middle-income countries where healthcare resources may be limited. International guidelines, such as those from the International Society of Pediatric Oncology (SIOP), recommend using mid-upper arm circumference (MUAC) and other anthropometric measurements for nutritional assessment, as these methods are affordable, non-invasive, and effective in evaluating body composition without being influenced by tumor mass [5]. The burden of malnutrition is particularly high in Asian countries due to economic disparities, inadequate healthcare infrastructure, and limited access to specialized nutritional care. These challenges are exacerbated by cultural dietary practices and a lack of standardized nutritional assessment protocols, making it difficult to accurately identify and manage malnutrition in pediatric oncology populations. The consequences of nutritional disorders in these patients are profound, including increased risks of infection, prolonged neutropenia, and treatment-related complications, all of which can adversely affect treatment efficacy and overall survival [2,3]. Weight loss exceeding 5% within the first three months of treatment is associated with significantly poorer outcomes, including higher mortality rates [6]. In many regions, including Bangladesh, where limited research exists on pediatric oncology nutrition, addressing this issue is paramount. Malnutrition remains under-recognized and undertreated in these populations, leading to poorer clinical outcomes. The presence of tumors and organ enlargement in cancer patients can further complicate the assessment of nutritional status, often resulting in misclassification when using traditional anthropometric measures such as body mass index (BMI) alone. Early detection of nutritional status emphasizes that adequate nutrition can reduce treatment toxicity, lower infection rates, and improve overall survival and quality of life [5,7-11]. This study aims to investigate the nutritional status of children diagnosed with cancer at the time of their diagnosis and correlations with treatment.

2. Methodology & Materials

This retrospective cross-sectional study utilized a convenience sample drawn from all nutritional assessments recorded in the nutrition service database of the National Institute of Cancer Research & Hospital (NICRH) in Dhaka, Bangladesh, between 01 Feb 2022 and 30 Nov 2022. Ethical approval was obtained from the institutional ethics committee. Data collected included weight, height, mid-upper arm circumference (MUAC), date of birth, diagnosis, date of diagnosis, and date of death. Patients were categorized by their type of tumor diagnosis: hematological, solid, or central nervous system (CNS) tumors. Each patient received treatment tailored to their nutritional status, including chemotherapy, radiation, and surgery, and they were evaluated for survival rates over a five-year follow-up period.

Inclusion Criteria

- Patients aged three months to 5 years with a cancer diagnosis.
- Patients who underwent a nutritional assessment within seven days of diagnosis.

Exclusion Criteria

- Patients with Down syndrome or Turner syndrome.
- Patients with a previous cancer diagnosis or cancer relapse.
- Patients without a recorded MUAC in the nutritional assessment.

Anthropometric Measurements

- **Weight:** Measured on a digital scale. Infants under two years were weighed using infant scales, while children older than two years were weighed standing, with weight distributed evenly on both feet.
- **Length/Height:** For children up to 2 years old, length was measured using a pediatric anthropometer with a precision of 0.1 cm, with the child lying flat. For children older

than two years, height was measured using a wall stadiometer with a precision of 0.1 cm, with the child standing barefoot, back straight, and arms at the sides.

- **MUAC:** Measured using a flexible, inelastic graduated tape. The midpoint between the acromion and the olecranon was determined with the arm flexed at a 90° angle, and the circumference was measured with the arm extended along the body.

Nutritional Status Assessment

Nutritional status was assessed using:

- **Body Mass Index for Age z-score (zBMI/A):** Calculated using WHO growth curves and classified as follows [12]:
  - **Under nutrition: z-score <-2**
  - **Normal:** z-score ≥-2 and ≤ +2 for children 5 years and younger; z-score ≥ -2 and ≤ +1 for children older than 5 years
  - **Overweight:** z-score > +2 for children five years and younger; z-score > +1 for children older than five years

MUAC Percentiles:

- For children aged 3-60 months: WHO growth curve percentiles
- For children older than 60 months: Percentiles from Frisancho tables [13].
- Classified as:
  - **Under nutrition:** Percentile (P) < 5
  - **Normal:** 5 ≤ P < 95
  - **Overweight:** P ≥ 95

Delivery of Nutritional Care

All inpatients were screened for nutritional risk within 24 hours of admission and received a complete nutritional assessment within 72 hours, including weight, height, and MUAC measurements. Follow-up assessments were conducted every seven days. For outpatients, a complete nutritional assessment was performed at each consultation with a nutritionist. Nutritional interventions, including oral supplements and enteral or parenteral nutrition, were provided as deemed appropriate by the nutritionist.

Statistical Analysis

Descriptive statistics were used for demographic, clinical, and anthropometric data. Statistical analyses were conducted using SPSS for Windows. Group comparisons for continuous variables were performed using Student's t-test, while categorical variables were compared using the Chi-Square test.

3. RESULT

The study sample consisted of 120 participants, with ages ranging from 3 months to 5 years. Of these, 45.00% (n=54) were between 3 months to 2 years old, while 55.00% (n=66) were between 3 to 5 years old. Regarding gender distribution, 54.17% (n=65) of the participants were male, and 45.83% (n=55) were female (Table 1). This data highlights a slightly higher representation of older children and a significant predominance of female participants in the sample. The anthropometric indicators show a diverse distribution among the subjects based on their Body Mass Index (BMI) and Mid-Upper Arm Circumference (MUAC). For BMI, 10.83% of the individuals are underweight, 73.33% have normal weight and 15.83% are overweight. In terms of MUAC, 8.33% of the subjects are undernourished, 72.50% fall within the normal range, 5.00% are overweight, and 14.17% are malnourished. The average zBMI/A for children aged 3 months to 2 years was -1.2 with a standard deviation (SD) of 0.32, and for children aged 3 to 5 years, it was 1.5 with a standard deviation of 0.8 (Table 2). More than 42% of the tumors were solid, 33.33% were classified as central nervous system (CNS) cases, and 24.17% were diagnosed as hematological tumors (Figure 1). Acute lymphoblastic leukemia (ALL) was the most common diagnosis, accounting for 51.67% of cases. Acute Myeloid Leukemia (AML) was diagnosed in 23.33% of cases, Neuroblastoma in 15%, and Medulloblastoma in 10% of cases (Figure 2). The table provides a breakdown of weight status among patients with different diagnoses, categorized as underweight, normal, and overweight. For all diagnoses combined (ALL), 38.46% of patients were underweight, 53.41% had normal weight, and 52.63% were overweight. Among patients with Acute Myeloid Leukemia (AML), 15.38% were underweight, 22.73% had normal weight, and 31.58% were overweight. For Neuroblastoma patients, 30.7% were underweight, 13.64% had a normal weight, and 10.53 % were overweight.

Lastly, among Medulloblastoma patients, 15.38% were underweight, 10.23% had normal weight, and 5.26% were overweight. Table 4 shows the association between nutritional status (underweight, normal, overweight) and treatment type, along with survival duration among pediatric cancer patients. For treatment, chemotherapy is the most common across all groups, with 46.15% of underweight, 50.00% of

normal, and 47.37% of overweight patients receiving it. Radiation treatment is used consistently across groups (~30%), while surgery is slightly less common, ranging from 19.32% (normal) to 23.08% (underweight). Regarding survival duration, the mean survival increases slightly with weight: 3.5 ± 1.2 years for underweight, 4.0 ± 1.5 years for normal, and 4.2 ± 1.3 years for overweight patients.

Table 1. *Age and gender distribution of the pediatric patients (N=120).*

Variables	Frequency (n)	Percentage (%)
Age in years		
3 months to 2 years	54	45
3 to 5 years	66	55
Gender		
Male	65	54.17
Female	55	45.83

Table 2. *Classification of the pediatric cancer patient nutritional status at diagnosis by different anthropometric indicators.*

Anthropometric indicator	Frequency (n)	Percentage (%)
BMI		
Underweight	13	10.83
Normal	88	73.33
Overweight	19	15.83
MUAC		
Undernutrition	10	8.33
Normal	87	72.5
Overweight	6	5
Malnutrition	17	14.17
zBMI/A		
3 months to 2 years (Mean±SD)	-1.2±0.32	
3 to 5 years (Mean±SD)	1.5±0.8	

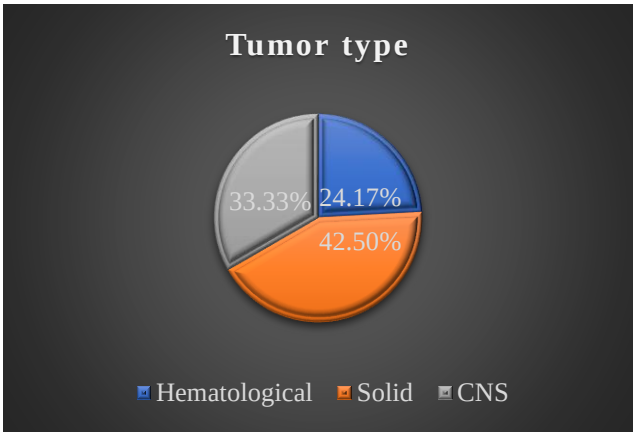

Figure 1. *Distribution of tumor type of the pediatric cancer patients.*

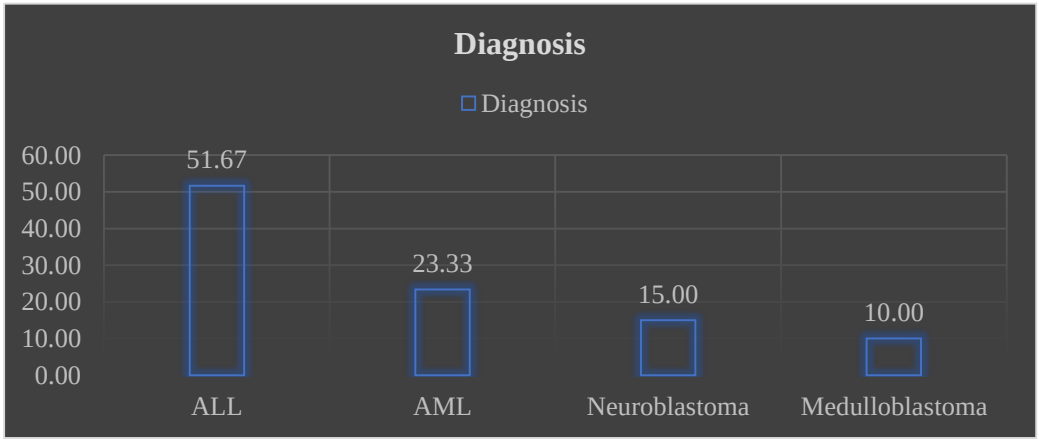

Figure 2. *Types of diagnosis of the pediatric cancer patients.*

Table 3. Association of diagnosis with nutritional status of the pediatric cancer patients.

Diagnosis	Underweight (N=13)		Normal (N=88)		Overweight (N=19)	
	n	%	n	%	n	%
ALL	5	38.46	47	53.41	10	52.63
AML	2	15.38	20	22.73	6	31.58
Neuroblastoma	4	30.77	12	13.64	2	10.53
Medulloblastoma	2	15.38	9	10.23	1	5.26

Table 4. *Association of diagnosis with treatment status and duration of survival of the pediatric cancer patients.*

Variables	Underweight (N=13)		Normal (N=88)		Overweight (N=19)	
	n	%	n	%	n	%
	Treatment					
Chemotherapy	6	46.15	44	50.00	9	47.37
Radiation	4	30.77	27	30.68	6	31.58
Surgery	3	23.08	17	19.32	4	21.05
	Duration of survival (years)					
Mean±SD	3.5±1.2		4.0±1.5		4.2±1.3	

4. DISCUSSION

This study aimed to assess the nutritional status of children with cancer. The prevalence of under nutrition varied between 8% and 23%, and overweight/obesity ranged from 5% to 20%, depending on the tumor type and nutritional indicator used. These variations highlight the differences in nutritional status classification methods and underscore the need for standardized methods to define malnutrition clearly. Additionally, the prevalence variation may reflect population diversity (e.g., different ages, diagnoses, and cancer stages) and socioeconomic inequality in the country.

According to a systematic review by Iniesta et al., the prevalence of under nutrition at cancer diagnosis is higher in low- and middle-income countries (LMICs) compared to high-income countries (HICs) [14]. In this study, Acute Myeloid Leukemia (AML) was diagnosed in 23.33% of cases, Neuroblastoma in 15%, and Medulloblastoma in 10%. Green et al. (2008) reported a high prevalence of under nutrition (50%) in Canadian children aged 1-5 years with neuroblastoma [15], while Small et al. (2015) found a 24% prevalence in a similar Australian group at diagnosis [16]. Neuroblastoma was the most common solid tumor diagnosis in this study. Under nutrition at diagnosis, as measured by MUAC, was slightly less than that assessed by BMI. Despite literature reports indicating a higher prevalence of under nutrition by BMI in patients with solid tumors [4,10], this study found the highest prevalence in CNS tumor patients (33.33%), followed by those with solid tumors (42.50%), similar to findings by Tazi et al. in Morocco [17]. Bakish et al. in Canada observed 31% under nutrition in CNS tumor patients at diagnosis [18], potentially reflecting high nutritional risk due to symptoms like nausea and vomiting leading to significant weight loss before diagnosis [18]. In this study, patients with solid tumors had the highest under nutrition prevalence when classified by MUAC, as also observed by Lemos et al. and Iniesta et al. [14,19]. Sala et al. found high under nutrition prevalence at diagnosis in over 1500 Central American children with cancer, particularly in those with solid tumors and leukemias, excluding ALL, using arm anthropometry [20]. Iniesta et al. also noted a higher prevalence of overweight and obesity in children with CNS tumors at diagnosis compared to other cancer forms [14]. Lemos et al. observed similar trends in overweight and obesity in children with solid tumors, assessed by both BMI and MUAC [19]. In this study, BMI identified a higher percentage of under nutrition and overweight in CNS tumor patients at diagnosis compared to MUAC, possibly influenced by hydration status due to common vomiting symptoms in these cases. Nutritional status distribution by tumor group differed significantly when assessed by MUAC but not by BMI, suggesting MUAC's greater sensitivity in distinguishing malnutrition prevalence among tumor types. This study supports the claim that BMI has limitations in classifying nutritional status in children with cancer, especially those with solid or hematological tumors. Malnutrition at diagnosis, classified by MUAC or BMI, did not significantly impact overall survival in this study. Similar studies have reported consistent results. However, a Central American study found a difference in 2-year event-free survival between eutrophic (65%) and undernourished

(48%) patients ($p < 0.001$) at diagnosis [20]. A British study associated under nutrition at diagnosis with worse event-free survival, while over nutrition was not linked to unfavourable outcomes [21]. Patients in this study received nutritional care from diagnosis, with close monitoring and intervention as needed, possibly explaining the lack of impact on overall survival. Nutritional status is a modifiable risk factor, particularly in ALL patients [22,23]. Recently, a nutritional therapy algorithm and protocol developed and implemented by the institution's nutrition team improved care systematization and clinical support, potentially positively impacting overall survival. This underscores the importance of an established nutrition program as part of cancer treatment for children. Studies show that many children experience significant weight gain during treatment, with the prevalence of overweight and obesity increasing from approximately 7.2% at diagnosis to around 20.8% by the end of treatment. This trend indicates that childhood cancer survivors often do not return to their pre-treatment weight, resulting in a higher incidence of obesity compared to their non-cancer peers [24]. Another study shows that changes during the 3-12 months of treatment were not related to gender, age, diagnosis, initial nutritional status, energy intake, or treatment intensity. They observed a rapid increase in BMI and fat mass, as determined by bioelectrical impedance analysis, primarily in the first three months. These early increases in BMI could also be attributed to intensive tube feeding and inadequate physical activity [25]. Obese children undergoing chemotherapy are at a higher risk for treatment-related complications, including hypertension, hyperglycemia, and increased hospitalizations due to infections [26]. These complications can complicate cancer management and affect overall treatment efficacy. The relationship between obesity and survival rates in pediatric cancer patients is conflicting. Some studies indicate that obesity may correlate with poorer outcomes, including increased risks of relapse and reduced event-free survival [25,27]. However, this relationship can vary based on age and specific treatment regimens. The findings of our study showed chemotherapy was the most common treatment across all groups, used in 46.15% of underweight, 50.00% of normal, and 47.37% of overweight patients, with similar use of radiation (~30%) and surgery (~20%) across groups. No prior studies have investigated the correlation between nutritional status and treatment. Survival duration showed a slight increase with higher weight, with overweight patients having the longest average survival (4.2 years) compared to normal (4.0 years) and underweight (3.5 years). While underweight patients may face higher risks of complications, the lack of significant survival differences suggests that early nutritional interventions during treatment likely contributed to stable outcomes across all groups. These results emphasize the importance of ongoing nutritional support in improving treatment tolerance and outcomes.

5. Limitations of the Study

This study has several limitations. The retrospective design may introduce biases due to reliance on existing medical records, which can vary in completeness and accuracy. The sample size of 120 participants may limit the generalizability of the findings, as a larger and more diverse cohort could yield different results. Moreover, potential confounding factors, such as variations in treatment protocols and nutritional interventions, were not accounted for, which may influence the outcomes.

6. Conclusion

The study concludes that the nutritional status of pediatric cancer patients at diagnosis significantly impacts their treatment outcomes and survival rates. Chemotherapy was the most common treatment across all nutritional groups. While underweight patients had a slightly lower average survival (3.5 years) compared to normal (4.0 years) and overweight (4.2 years) patients, the study highlights the importance of early and ongoing nutritional interventions to improve treatment tolerance and outcomes. The findings emphasize the need for standardized nutritional assessments and targeted nutritional support in pediatric oncology care.

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Citation: *A Dr. Abu Naser Mohammad Al-Amin et al. Nutritional Status of Pediatric Cancer Patients at Diagnosis and Correlations with Treatment. ARC Journal of Cancer Science. 2024; 9(1):8-15. DOI: http://dx.doi.org/10. 20431/2455-6009.0901003.*