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Factors Associated with Body Mass Index in Children with Acute Leukemia: A Cross-sectional Study

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Abstract

Acute leukemia is the most common childhood malignancy, and nutritional status plays a critical role in treatment outcomes and survival. Children with leukemia frequently experience nutritional complications due to the disease itself and the intensive chemotherapy regimens required for treatment. This study aimed to assess the nutritional status of children with acute leukemia by evaluating body mass index (BMI) and identifying associated sociodemographic and clinical factors. A cross-sectional study was conducted on 60 children aged 1 - 6 years diagnosed with acute leukemia. Sociodemographic data, clinical characteristics, and anthropometric measurements were collected. BMI z-scores were calculated using World Health Organization (WHO) growth standards. Statistical analyses included descriptive statistics, one-way analysis of variance (ANOVA), and independent t-tests to examine associations between BMI z-scores and various factors. The mean age was 44.56 months (Standard deviation (SD) = 15.16). Acute lymphoblastic leukemia (ALL) was diagnosed with 75% of participants. Nutritional status varied considerably: 21.7% were underweight, 43.3% had healthy weight, 15% were at risk of being overweight, and 20% were overweight/obese. The mean BMI z-score was -0.079 (SD = 2.52). Age group was significantly associated with BMI z-score ($p = 0.012$), with younger children showing higher z-scores. No significant associations were found with gender, residence, parental education, socioeconomic status (SES), or leukemia type. Only 10% of children received nutritionist follow-up. Children with acute leukemia demonstrate diverse nutritional profiles, with both undernutrition and overnutrition present. Age-related differences in nutritional status warrant attention in clinical management and nutritional support programs.

Keywords: Acute leukemia, Pediatric oncology, Nutritional status, Body mass index, Malnutrition

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Introduction

Acute leukemia represents the most prevalent malignancy in childhood, accounting for approximately 30% of all pediatric cancers worldwide [1, 2]. ALL is the most common subtype, comprising about 75-80% of childhood leukemia cases, followed by acute myeloid leukemia (AML) [3, 4]. Over recent decades, remarkable advances in treatment protocols have dramatically improved survival rates, with five-year survival now exceeding 85% for ALL in developed countries [5, 6]. However, this success brings increased attention to treatment-related complications and quality of life issues, including nutritional challenges.

Nutritional status is a critical determinant of treatment tolerance, infection risk, and overall prognosis in pediatric oncology patients [7, 8]. Children with acute leukemia face multiple nutritional challenges stemming from both the disease process and its treatment. The malignancy itself can cause anorexia, alter metabolism, and increase nutritional demands [9, 10]. Chemotherapy regimens, while lifesaving, frequently induce adverse effects including nausea, vomiting, mucositis, taste alterations, and gastrointestinal dysfunction, all of which compromise nutritional intake [11, 12]. Additionally, corticosteroids used in treatment protocols can profoundly affect appetite and body composition [13].

The nutritional consequences in pediatric leukemia patients are heterogeneous. While malnutrition and weight loss are commonly recognized complications [14, 15], recent evidence indicates that overweight and obesity are increasingly prevalent in this population, particularly in developed nations [16, 17]. This paradoxical observation may relate to corticosteroid therapy, reduced physical activity during treatment, and changes in dietary patterns [18, 19]. Both undernutrition and overnutrition carry significant clinical implications: malnutrition is associated with increased infection rates, treatment interruptions, and reduced survival [20, 21], whereas obesity may be linked to altered drug pharmacokinetics, increased relapse risk, and long-term metabolic complications [22, 23].

BMI serves as a practical and widely used tool for nutritional assessment in pediatric populations [24]. BMI z-scores, which account for age and sex-specific growth patterns, enable standardized evaluation of nutritional status across different age groups [25]. The WHO growth standards provide internationally recognized reference values for interpreting BMI in children [26].

Despite the recognized importance of nutrition in pediatric oncology, systematic nutritional assessment and monitoring remain inconsistent in many clinical settings [27, 28]. In resource-limited environments, nutritional support services may be particularly inadequate, potentially exacerbating existing vulnerabilities [29, 30]. Understanding the prevalence and patterns of malnutrition in children with leukemia is essential for developing targeted interventional strategies and improving outcomes.

The relationship between nutritional status and various sociodemographic factors in pediatric leukemia patients remains incompletely characterized. Previous studies have suggested associations between nutritional outcomes and factors such as age, SES, parental education, and geographic location [31, 32], though findings have been inconsistent across different populations and settings.

This study was conducted to evaluate the nutritional status of children with acute leukemia through BMI assessment and to explore potential associations with sociodemographic and clinical characteristics. By identifying specific factors associated with nutritional vulnerability, this research aims to inform people about the development of more effective nutritional screening and intervention programs for this high-risk pediatric population.

Methods

Study design and setting

This cross-sectional observational study was conducted at a large governmental hospital in Basra, Iraq-Al-Basra Children's Specialist Hospital in February 2021. The hospital was visited three times per week, with each visit lasting approximately five hours. The study protocol was approved by the institutional ethics committee, and written informed consent was obtained from the parents or legal guardians of all participating children.

Study population

The study included 60 children diagnosed with acute leukemia (either ALL or AML) who were receiving treatment or follow-up care at the pediatric oncology department. Children aged 1 - 6 years were eligible for inclusion. Exclusion criteria included: presence of other chronic diseases affecting growth and nutrition, congenital metabolic disorders, severe organ dysfunction unrelated to leukemia, and incomplete medical records.

Data collection

Sociodemographic variables

A structured questionnaire was used to collect sociodemographic information including:

- Child's age and gender.
- Residence (rural/urban) and residence type (organized/non-organized).
- Father's occupation (employed, unemployed, and farmer).
- Mother's occupation (housewife, employed).
- Parental educational levels (illiterate, read and write, primary, intermediate, secondary, and college/institute).
- SES (low, moderate, and high) assessed using a standardized scoring system based on family income, housing conditions, and parental education.

Clinical and nutritional variables

Clinical data were extracted from medical records, including:

- Type of leukemia (ALL or AML).
- Type of infant feeding (exclusive breastfeeding, artificial feeding, and mixed feeding).
- Current child's appetite (good, moderate, and poor) as reported by parents.
- Presence of food allergies.
- Feeding difficulties (chewing, swallowing, or sucking problems).
- Nutritionist/dietitian follow-up status.

Anthropometric measurements

Weight and height were measured using standardized techniques. Weight was measured to the nearest 0.1 kg using a calibrated digital scale with children wearing light clothing and no shoes. Height (or length for children under 2 years) was measured to the nearest 0.1 cm using a stadiometer or infantometer. All measurements were performed by trained personnel following WHO guidelines.

BMI was calculated as weight (kg) divided by height squared (m^2). BMI z-scores were calculated using WHO AnthroPlus software, which adjusts for age and sex. Children were categorized into four groups based on BMI percentiles:

- Underweight: ≤5th percentile.
- Healthy weight: >5th to <85th percentile.
- At risk of overweight: ≥85th to <95th percentile.
- Overweight/obese: ≥95th percentile.

Statistical analysis

Data was analyzed using statistical package for social sciences version 26.0 (IBM Corp., Armonk, NY). Descriptive statistics were calculated for all variables. Continuous variables were expressed as mean SD or median and interquartile range as appropriate. Categorical variables were presented as frequencies and percentages.

The association between BMI z-scores and sociodemographic/clinical characteristics was examined using one-way ANOVA for variables with three or more categories and independent samples t-tests for dichotomous variables. A p-value of less than 0.05 was considered statistically significant. Post-hoc analyses were not conducted due to the exploratory nature of the study and sample size limitations.

Results

The sociodemographic, clinical, and nutritional characteristics of the 60 children with acute leukemia are summarized (Tables 1-3). Age group was significantly associated with BMI z-score ($p = 0.012$), with younger children showing higher z-scores. No other variables showed significant associations with BMI z-score.

Discussion

This cross-sectional study provides important insights into the nutritional status of children with acute leukemia, revealing considerable heterogeneity in BMI profiles within this vulnerable population. Our findings demonstrate that both undernutrition and overnutrition coexist in pediatric leukemia patients, highlighting the complex nutritional challenges these children face during diagnosis and treatment.

Table 1: Sociodemographic characteristics of the study participants (N = 60).

Characteristic	n (%) or mean (SD)
Child age group (years)	
One year	2 (3.3)
Two years	13 (21.7)
Three years	18 (30.0)
Four years	13 (21.7)
Five years	8 (13.3)
Six years	6 (10.0)
Age (months)	44.56 (SD = 15.16)
Range	12 - 72
Gender	
Male	36 (60.0)
Female	24 (40.0)
Residence	
Rural	34 (56.7)
Urban	26 (43.3)
Residence type	
Organized	32 (53.3)
Non-organized	28 (46.7)
Father's occupation	
Employed	18 (30.0)
Unemployed	4 (6.7)
Farmer	38 (63.3)
Mother's occupation	
Housewife	57 (95.0)
Employed	3 (5.0)
Father's educational level	
Illiterate	12 (20.0)
Read and write	9 (15.0)
Primary	12 (20.0)
Intermediate	9 (15.0)
Secondary	5 (8.3)
College/Institute	13 (21.7)
Mother's/Caretaker's educational level	
Illiterate	16 (26.7)
Read and write	16 (26.7)
Primary	4 (6.7)
Intermediate	8 (13.3)
Secondary	8 (13.3)
College/Institute	8 (13.3)
SES	
Low	28 (46.7)
Moderate	28 (46.7)
High	4 (6.7)

The prevalence of underweight children (21.7%) in our cohort aligns with previous reports indicating that malnutrition remains a significant concern in pediatric oncology [14, 33]. Cancer-related malnutrition results from multiple interconnected factors including disease-induced hypermetabolism, treatment-related side effects, and reduced nutritional intake [9, 34]. Children with leukemia are particularly susceptible due to intensive chemotherapy protocols that commonly cause mucositis, nausea, vomiting, and taste alterations [11, 35]. The persistence of malnutrition in this population is concerned given its well-established associations with increased infection rates, treatment delays, compromised quality of life, and reduced survival [20, 36].

Conversely, the finding that 35% of children were either at risk of being overweight or already overweight/obese is noteworthy and reflects an emerging trend in pediatric oncology nutrition [16, 37].

Table 2: Clinical and nutritional characteristics of the children (N = 60).

Characteristic	n (%) or mean (SD)
BMI percentile category	
≤5th percentile (Underweight)	13 (21.7)
≥5th to <85th percentile (Healthy weight)	26 (43.3)
≥85th to <95th percentile (At risk of overweight)	9 (15.0)
≥95th percentile (Overweight/Obese)	12 (20.0)
BMI z-score	
Mean (SD)	-0.079 (2.52)
Range	−7.44 to 4.93
Type of leukemia	
ALL	45 (75.0)
AML	15 (25.0)
Type of breastfeeding	
Exclusive breastfeeding (normal maternal milk)	30 (50.0)
Artificial feeding (formula milk)	21 (35.0)
Mixed feeding	9 (15.0)
Child's appetite	
Good	24 (40.0)
Moderate	28 (46.7)
Poor	8 (13.3)
Food allergy	
Yes	3 (5.0)
No	57 (95.0)
Feeding difficulties (chewing, swallowing, or sucking problems)	
Yes	5 (8.3)
No	55 (91.7)
Follow-up by a nutritionist/dietitian	
Yes	6 (10.0)
No	54 (90.0)

Note: Values are presented as frequency (percentage) unless otherwise indicated.

This dual burden of malnutrition-simultaneous presence of both undernutrition and overnutrition-has been increasingly recognized in pediatric leukemia populations, particularly in middle-income countries undergoing nutritional transition [38, 39]. The etiology of overweight and obesity in leukemia patients is multifactorial, involving corticosteroid therapy (which is a cornerstone of ALL treatment), reduced physical activity during intensive treatment phases, and potentially compensatory overfeeding by concerned parents [18, 40]. Obesity in childhood cancer survivors has been associated with increased risks of metabolic syndrome, cardiovascular disease, and potentially altered chemotherapy pharmacokinetics [22, 41].

The significant association between age and BMI z-score observed in our study warrants careful consideration. Younger children, particularly those aged one year, demonstrated markedly higher BMI z-scores compared to older children. This pattern may reflect several phenomena. Infants and toddlers with leukemia may be diagnosed before disease-related weight loss becomes pronounced, or they may be more vigorously supported nutritionally by parents during critical early developmental periods [42]. Additionally, the impact of corticosteroid therapy on weight gain may be more pronounced in younger children [43]. Conversely, preschool and early school-age children (3 - 4 years) showed lower BMI z-scores, possibly reflecting accumulated nutritional deficits over a longer treatment course or age-related differences in treatment tolerance and appetite regulation [44, 45].

The absence of significant associations between BMI z-score and other sociodemographic factors, including parental education, SES, and residence, is somewhat surprising given that these factors have been linked to nutritional outcomes in other contexts [31, 46]. This finding

Table 3: BMI z-score association with sociodemographic and clinical characteristics (N = 60).

Variable	Category	n	Mean BMI z-score (95% CI)	p value
Age group (years)	One year	2	4.87 (4.04, 5.69)	0.012
	Two years	13	1.05 (0.07, 2.03)	
	Three years	18	−0.76 (−1.92, 0.41)	
	Four years	13	−1.07 (−2.76, 0.62)	
	Five years	8	−0.07 (−2.25, 2.11)	
	Six years	6	0.01 (−2.16, 2.18)	
Gender	Male	36	0.06 (−0.99, 1.69)	0.604
	Female	24	−0.29 (−0.91, 1.61)	
Residence type	Organized	32	−0.15 (−1.47, 1.16)	0.810
	Non-organized	28	0.01 (−1.47, 1.15)	
Breastfeeding type	Normal (mother)	30	−0.27 (−1.18, 0.65)	0.792
	Artificial milk	21	0.22 (−0.83, 1.28)	
	Mixed	9	−0.15 (−2.73, 2.43)	
Father's occupation	Employed	18	−0.45 (−1.94, 1.04)	0.747
	Unemployed	4	0.32 (−2.74, 3.37)	
	Farmer	38	0.06 (−0.72, 0.83)	
Mother's occupation	Housewife	57	−0.07 (−0.75, 0.61)	0.944
	Employed	3	−0.18 (−4.56, 4.20)	
Father's education	Illiterate	12	−1.01 (−2.37, 0.35)	0.590
	Read and write	9	1.00 (−0.79, 2.80)	
	Primary	12	−0.05 (−1.52, 1.41)	
	Intermediate	9	0.44 (−1.78, 2.66)	
	Secondary	5	−0.42 (−2.00, 1.17)	
	College/institute	13	−0.22 (−2.17, 1.73)	
Mother's education	Illiterate	16	0.25 (−0.82, 1.32)	0.745
	Read and write	16	−0.63 (−2.35, 1.09)	
	Primary	4	−0.35 (−1.75, 1.06)	
	Intermediate	8	0.85 (−1.45, 3.15)	
	Secondary	8	−0.73 (−3.09, 1.63)	
	College/institute	8	0.21 (−1.49, 1.91)	
SES	Low	28	−0.01 (−0.98, 0.96)	0.321
	Moderate	28	−0.40 (−1.42, 0.63)	
	High	4	1.63 (0.08, 3.18)	
Child appetite	Good	24	−0.47 (−1.49, 0.55)	0.521
	Moderate	28	0.32 (−0.75, 1.39)	
	Poor	8	−0.30 (−1.96, 1.36)	
Food allergy	Yes	3	1.68 (−1.12, 4.83)	0.217
	No	57	−0.17 (−1.14, 4.85)	
Leukemia type	ALL	45	−0.09 (−1.55, 1.48)	0.967
	AML	15	−0.05 (−1.46, 1.40)	
Nutritionist follow-up	Yes	6	1.54 (−0.34, 3.94)	0.097
	No	54	−0.26 (−0.91, 1.61)	

Note: Values are presented as mean BMI z-score (95% confidence interval (CI)). p values were derived from one-way ANOVA for variables with ≥3 categories and independent-samples t tests for dichotomous variables. Statistical significance set at $p < 0.05$, and n is frequency.

may suggest that the biological impact of leukemia and its treatment overwhelm sociodemographic influences on nutritional status, at least in the acute treatment phase. Alternatively, our sample size may have limited statistical power to detect more subtle associations.

The finding that 90% of children were not receiving follow-up from a nutritionist or dietitian is particularly concerning and represents a critical gap in care delivery. International guidelines emphasize the importance of routine nutritional screening, assessment, and intervention in pediatric oncology patients [27, 47]. Early nutritional counseling and individualized support can potentially prevent or mitigate malnutrition, optimize treatment tolerance, and improve outcomes [48, 49]. The low rate of nutritionist involvement in our cohort may reflect resource constraints, lack of awareness about nutritional vulnerability in this population, or insufficient integration of nutritional services within oncology care pathways.

The predominance of ALL (75%) in our sample is consistent with the known epidemiology of childhood leukemia globally [3, 4]. The lack of significant difference in BMI z-scores between ALL and AML patients suggests that nutritional challenges are not type-specific but rather common across acute leukemia diagnoses, likely reflecting shared treatment approaches and disease effects.

Our study has several limitations that should be acknowledged. The cross-sectional design precludes assessment of nutritional trajectory or causality. The relatively small sample size of 60 children, while adequate for descriptive purposes, may have limited statistical power to detect associations, particularly for less common exposures. We did not collect data on treatment phase, duration since diagnosis, or specific chemotherapy regimens, all of which could influence nutritional status. Additionally, BMI, while practical and widely used, does not distinguish between fat and lean body mass, which may be particularly relevant given corticosteroid effects on body composition [50]. Future research employing longitudinal designs, larger sample sizes, and more comprehensive body composition assessment methods would provide deeper insights into nutritional dynamics in pediatric leukemia.

Despite these limitations, our findings have important clinical and public health implications. The documented heterogeneity in nutritional status-with substantial proportions of both underweight and overweight children-underscores the need for individualized nutritional assessment and management rather than one-size-fits-all approaches. Healthcare providers should be alert to nutritional vulnerability across the entire BMI spectrum. The age-related differences we observed suggest that nutritional screening and intervention strategies may need to be developmentally tailored.

The critically low rate of nutritionist involvement highlights an urgent need for strengthening multidisciplinary care models in pediatric oncology settings. Integration of registered dietitians or nutritionists into routine care, implementation of systematic nutritional screening protocols, and provision of evidence-based nutritional support should be prioritized. In resource-limited settings, task-sharing approaches and training of oncology nurses in basic nutritional assessment and counseling may help bridge gaps until specialist services can be expanded [51].

Conclusion

This study reveals that children with acute leukemia demonstrate diverse nutritional profiles, with approximately one-fifth being underweight and one-third being overweight or at risk of being overweight. Age emerged as a significant factor associated with BMI z-score, with younger children showing higher values. The low rate of nutritionist follow-up represents a critical gap in comprehensive care delivery. These findings emphasize the importance of routine nutritional screening, individualized assessment, and multidisciplinary nutritional support for all children undergoing leukemia treatment. Addressing nutritional vulnerability in this population may contribute to improved treatment tolerance, reduced complications, and better long-term outcomes.

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None.

Conflict of Interest

None.

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