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Original Research Article

Effect of a nutritional intervention on adverse events among pediatric cancer patients: a retrospective hospital-based study from Srinagar, India

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ABSTRACT

Background: Pediatric cancer significantly impacts child morbidity and mortality, with a notable incidence in low- and middle-income countries, including India. Nutritional status is a critical factor affecting treatment outcomes and quality of life in these patients. The current study assesses the effect of a comprehensive nutritional intervention on the occurrence of adverse events, nutritional status, and treatment completion rates among pediatric cancer patients.
Methods: A retrospective hospital-based study was conducted at the Sher-I-Kashmir Institute of Medical Sciences, Srinagar, India, between 2018 and 2022. Sixty-three newly diagnosed pediatric cancer patients, aged 1 to 18 years, who met the inclusion criteria and were accepted to be enrolled in the FOODHEALS™ program were selected as participants. The program is a comprehensive nutritional intervention including personalized nutrition counseling, dietary prescription, and follow-up, along with nutrition aid provided through hot meals, in-meals, supplements and monthly ration bundles. The impact of the invention was evaluated by assessing changes in nutritional status through 3 anthropometric measurements, analysed using the Cochran-Armitage trend test, the occurrence of adverse events, and treatment completion rates.
Results: The study observed a statistically significant decrease in undernourished patients from 65% to 41% ($p = 0.007$) and an increase in well-nourished patients from 32% to 54% ($p=0.012$) over six months. Undernourished patients at diagnosis had a higher occurrence of adverse events (67%) as compared to well-nourished patients (33%). The treatment completion rate was 73%, with a 19% mortality rate.
Conclusions: Early and comprehensive nutritional intervention significantly improved the nutritional status of pediatric cancer patients, contributing to reduced adverse events and higher treatment completion rates. Addressing undernutrition is crucial for enhancing treatment outcomes and quality of life in pediatric oncology patients.

Keywords: Nutritional intervention, Pediatric cancers, Adverse events, Nutritional status, Treatment completion rate

INTRODUCTION

Pediatric cancers contribute significantly to child morbidity and mortality globally, and the incidence is steadily increasing in both high-income and low and middle-income countries (LMICs).[1,2] More than 80% of pediatric cancer cases are from LMICs, including India.[3] The National Cancer Registry Program (NCRP) for India records 4% of all reported cancer cases among children in the age group of 0-14 years.[4] A recent Indian study

(2021) estimates that approximately 76,000 children (age group of 0-19 years) may develop cancer each year.[5]

Childhood is a vulnerable time in life. Protein and energy requirements during this time are higher in children than in adults during this growth and development phase.[6] Any hindrances in nutrition during this phase can have a major impact on growth and development. Children with cancer are particularly at risk of suffering from malnutrition as treatment related side-effects and the disease by itself can impact nutritional status.[7-9] A large number of patients in LMICs such as India are often undernourished at diagnosis. A study from Brazil has shown that the prevalence of undernutrition at the beginning of the intervention was 10.8% (based on BMI) and 24.5% (based on mid-upper arm circumference (MUAC)), respectively.[10]

In another study in Guatemala, 47% (of 1060 patients) had severe undernutrition at diagnosis.[11] In an Indian study that assessed the tolerance of patients to chemotherapy, 50% (n=17) of patients were moderately to severely malnourished at the start of the intervention.[2] As treatment progresses, the nutritional status can deteriorate further. Undernutrition is associated with worsened treatment effects, reduced tolerance to treatment and can lead to increased adverse events and infections.[2,8,12,13]

As a result, comprehensive nutritional intervention and constant nutrition monitoring at every stage of treatment are very important to improve overall outcomes. The International Society for Pediatric Oncology (SIOP) recommends that children be evaluated for their nutrition status at diagnosis and continue to be routinely evaluated during treatment.[14] 'Comprehensive and timely' nutritional support is crucial during pediatric oncology care.[6]

The nutritional buildup of pediatric cancer patients before starting chemotherapy is suggested in an Indian study to reduce life-threatening complications among Acute Lymphoblastic Leukemia (ALL) patients.[2] The current study retrospectively assesses the effect of a comprehensive nutritional intervention program on the occurrence of adverse events during treatment in pediatric cancer patients (1-18 years). The objective of the intervention aimed to bridge the nutrition gap in childhood cancer care and involved personalized nutrition counselling, dietary prescription and follow-up by a trained nutritionist.

The continuous follow-up facilitated dietary adjustments based on the patient's evolving clinical condition. In addition, the patients received nutrition supplements through hot meals, in-meals and ration bundles during the intervention. This paper delves into the change in nutritional status of the patients during the period of the intervention, the occurrence of adverse events and treatment completion rates.

METHODS

Study design and setting

This was a retrospective study conducted through Cuddles Foundation's partnership with the Pediatric Oncology Unit of Sher-I-Kashmir Institute of Medical Sciences in Srinagar, Kashmir, India, for implementation of the nutritional intervention program, FOODHEALS™. Under this program, the nutritionist evaluates the patient's clinical condition and nutritional status, designs a tailored nutrition intervention plan to meet appropriate energy and protein requirements based on age and gender, provides necessary nutritional supplements, and monitors the patient's nutritional progress throughout treatment.

Study population and sample size

A subset of patients who were newly diagnosed pediatric cancer patients between 2018 and 2022 were considered for this retrospective study. Of 93 patients fitting the inclusion criteria, 63 patients were included in the final analysis; 30 patients could not be considered because of a lack of at least three data points for anthropometric measurements.

Inclusion and exclusion criteria

Data from newly diagnosed patients who were Cuddles Foundation beneficiaries during 2018–2022 were included in the analysis. The selection criteria excluded beneficiaries who had previously been treated at another hospital and were transferred for further management, and those diagnosed with relapsed disease or who were critically ill.

Sampling technique and data collection

For each patient, anthropometric measurements (weight, height, and mid-upper arm circumference [MUAC]) were collected at enrollment, 3 months, and 6 months, in addition to data on demographics, diagnosis, treatment, and adverse events collected from case records. Age at diagnosis was calculated from the date of birth recorded in patient files, and patients were divided into two age groups (≤5 years and >5 years).

Nutritional status was categorized using age- and cancer-type-specific references: for children ≤5 years, MUAC (WHO references) was used irrespective of cancer type; for children >5 years with solid cancer. MUAC (Frisancho chart) was used; and for children >5 years with liquid/haematological cancer, BMI (WHO simplified tables for BMI vs. age) was used. Based on these measures, patients were classified as: well-nourished: MUAC >13 cm (children ≤5 years, WHO references) or ≥25th percentile (children >5 years, Frisancho charts, by sex); or BMI z-score between <-2 SD and >+1 SD (WHO simplified tables, by sex and age).

Undernourished: MUAC ≤13.5 cm (children ≤5 years, WHO references) or <25th percentile (children >5 years, Frisancho charts, by sex); or BMI z-score <-2 SD (WHO simplified tables, by sex and age), reflecting mild/moderate/severe malnutrition. Adverse events were recorded over a 6-month duration, and final outcomes (completed, death, relapse) at the end of treatment were obtained by checking hospital files.

Statistical analysis

Changes in nutritional status across the three time points (baseline, three months, and six months) were analysed using the Cochran-Armitage trend test, which was selected for its ability to detect statistically significant directional trends in ordered categorical data over sequential time points. A p-value of less than 0.05 was considered statistically significant. As data were captured at the level of individual adverse events rather than individual patients, with some patients experiencing multiple events, statistical significance testing was not appropriate. Findings are therefore presented descriptively as frequencies and percentages.

Ethical considerations

The study was approved by the Institutional Ethics Committee of Sher-I-Kashmir Institute of Medical Sciences (No: SIMS 131/IEC-SKIMS/2022-407) prior to the commencement of the study.

RESULTS

Table 1 provides the baseline demographic and clinical characteristics of patients included in the study. Out of the total 63 patients (mean age- 7.3 years, age range=1-18 years), 43 (68%) were male and 20 (32%) were female. Twenty-five (40%) patients belonged to the age group of 5 years or less, whereas 38 (60%) were above 5 years of age. Thirty-four (54%, 23 males and 11 females) presented with haematological/ liquid cancers, whereas 29 (46%, 20 males and 9 females) presented with solid tumours. The detailed distribution of patients (n=63) based on the type and subtype of cancer is given in Table 2.

Primary treatment options for the patients included chemotherapy (56 patients, 89%), radiotherapy (17 patients, 27%) and surgery (7 patients, 11%). All the patients considered for the analysis were enrolled in the nutritional intervention. Almost all the enrollments occurred within one month of diagnosis. The changes in the nutritional status of the patients through the intervention are presented in Figure 1.

Across the course of the intervention, there was a statistically significant improvement in nutritional status among patients. The proportion of undernourished patients decreased from 65.1% at baseline to 50.8% at 3 months and further to 41.0% at 6 months, demonstrating a significant downward trend (Cochran–Armitage test, p=0.007).

Conversely, the proportion of well-nourished patients increased from 31.7% at baseline to 46.0% at 3 months and 54.1% at 6 months, reflecting a significant upward trend over time (p=0.012). No meaningful trend analysis was conducted for overnourished or indeterminate categories due to small sample sizes.

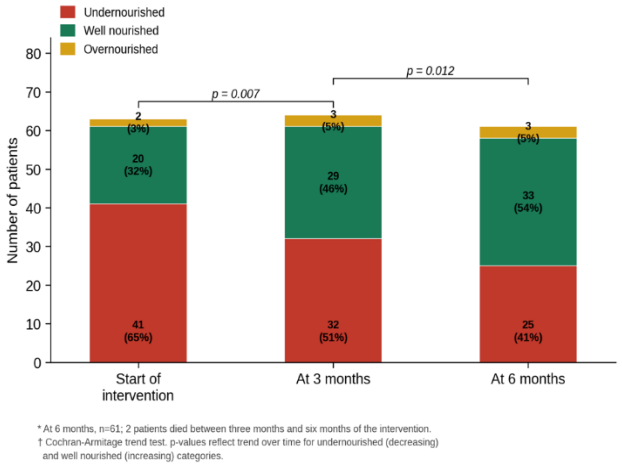


Figure 1: Nutritional status of patients during the intervention.

The analysis of the adverse events episodes shows that both well-nourished and undernourished patients suffered from adverse events, but the magnitude of the events was lower among well-nourished patients than among undernourished patients. Table 3 shows that 67% of the adverse events were seen among undernourished patients as compared to 33% among the well-nourished patients.

Table 1: Baseline demographic and clinical characteristics of patients (n=63).

Characteristic	Category	N (%)	Male	Female
Total patients	—	63 (100%)	43 (68%)	20 (32%)
Mean age (years)	7.3 (range 1–18)	—	—	—
Age group (years)	≤ 5	25 (40%)	—	—
	> 5	38 (60%)	—	—
Diagnosis	Haematological/liquid cancers	34 (54%)	23	11
	Solid tumours	29 (46%)	20	9

Values are presented as n (%) unless otherwise indicated.

Table 2: Distribution of patients (n=63) based on the type and subtype of cancer.

Category of cancer	Type of cancer	Subtypes	Number of patients	Percentage of patients (%)
Hematological / Liquid	Leukemia	ALL, AML, CML	34	54
Total hematological cancer patients			34	54
Solid	Lymphoma	Burkitt's Lymphoma, Hodgkin's Lymphoma, NHL, T-Lymphoblastic Lymphoma	10	34
Solid	Sarcoma	Ewing's Sarcoma, Osteosarcoma, Rhabdomyosarcoma, Round Cell Tumour, PNET	15	52
Solid	Others	Neuroblastoma, Teratoma	4	14
Total solid cancer patients			29	46
Total number of patients			63	100

Percentages for Lymphoma (34%), Sarcoma (52%), and Others (14%) represent proportions within the Solid cancer category. Data are presented as number (n) and percentage (%).

Table 3: Adverse events by nutritional status at the start of the intervention.

Adverse event	Undernourished		Well nourished		Total number of adverse events
	N	%	N	%	
Febrile neutropenia	19	73	7	27	26
Mucositis	9	60	6	40	15
Diarrhea	4	67	2	33	6
Fungal infection	3	50	3	50	6
Vomiting	5	83	1	17	6
Critical thrombocytopenia	0	0	1	100	1
Total number of adverse events	40	67	20	33	60

Note: Percentages represent row proportions (i.e. the proportion of each adverse event occurring in undernourished vs well-nourished patients). As data were captured at the level of individual adverse events rather than individual patients, and given that some patients experienced more than one adverse event, formal tests of statistical significance could not be performed. Findings are therefore presented numerically.

Twenty-seven patients (44%) did not have any adverse events throughout the intervention. Among the remaining 36 patients, 60 episodes of adverse events were reported during the intervention. Febrile neutropenia (26 episodes, 43%) and mucositis- grade 1 to 4 (15 episodes, 25%) were among the most reported adverse events. Other adverse events included diarrhea, fungal infection, vomiting and critical thrombocytopenia.

Forty-six patients from the intervention (73%) completed their treatment eventually. Out of these, 29 patients (46%) completed the treatment despite reported adverse events during treatment. Deaths were reported among 19% (12 patients). Two deaths happened during the study period (within six months), 1 of which was caused by liver failure during induction therapy. Ten deaths were reported after six months. However, due to the retrospective nature of the study, the causes of death for these patients could not be ascertained.

DISCUSSION

Improvement in nutritional status has an effect on survival and treatment completion among pediatric cancer patients. Thus, a recent Indian study called malnutrition a 'modifiable risk factor'.[8,13,15] The current study shows that comprehensive nutritional invention was one of the key contributors to help reduce the proportion of undernourishment among pediatric cancer patients (from 65% to 41%). The nutritional intervention was started within a month of diagnosis for most of the patients. Such early nutritional intervention helps reduce long-term metabolic health complications and improve diets in the long run.[16]

The observed improvement in nutritional status over the course of the intervention is an important finding in the context of pediatric oncology, where undernutrition is both highly prevalent and associated with poorer treatment tolerance and outcomes.[9] The statistically significant reduction in the proportion of undernourished patients, alongside a corresponding increase in those who

were well-nourished, suggests that structured nutritional support delivered during treatment can positively influence patient status over time.

These findings are consistent with emerging evidence from low- and middle-income settings that targeted nutrition interventions can mitigate treatment-related nutritional decline and support recovery.[14] Importantly, in a population at high risk of treatment interruption and adverse outcomes, even incremental improvements in nutritional status may have meaningful clinical implications. While causality cannot be definitively established in the absence of a control group, the observed trends underscore the potential value of integrating nutrition as a core component of pediatric cancer care.

The study also demonstrates that undernourished patients at diagnosis have a higher occurrence of adverse events (67%) as compared to well-nourished patients (33%). Febrile neutropenia was the most frequently observed adverse event overall (n=26), with 73% of cases occurring in the undernourished group, which is consistent with the well-established relationship between malnutrition and immune compromise in pediatric oncology patients. Similar findings have been reported in a previous study which reveals significantly worse survival among undernourished pediatric cancer patients as compared to well-nourished or even over-nourished at diagnosis. The study also reports increased febrile neutropenic episodes with bacteremia among patients who have lost significant weight immediately after diagnosis.[17]

The number of vomiting episodes were also higher in the undernourished group (83%) compared to the well-nourished group and this is consistent with reports that show malnutrition and weight loss are significantly associated with higher incidence of chemotherapy induced nausea and vomiting.[18]

Notably, fungal infection was the only adverse event distributed equally between groups (50% each), suggesting that fungal susceptibility in this population may be driven more by chemotherapy-induced immune suppression.[19] The consistent numerical trend towards a higher adverse event burden in the undernourished group underscores the clinical importance of early and sustained nutritional intervention in pediatric oncology patients.[20] Table 4 presents the treatment completion in the current study in comparison with some recent Indian studies on nutritional intervention in cancer patients.

Table 4: Recent studies from India comparing treatment completion for pediatric cancer patients.

Name of study	Number of participants	Age group	Year of publication	Outcome
Present study	63	1-18 years	-	Treatment completion rate: 73% Treatment completion rate (among malnourished patients): 78% Reported deaths: 19%
Gupta et al[21]	962	<18 years	2022	Deaths (for malnourished based on MUAC): 47.4% Deaths (for malnourished based on weight-height parameters): 45.7%
Sakthikumar et al[13]	306	<18 years	2021	Treatment completion rate with positive survival outcome (for malnourished group): 37.1% Reported deaths (in overall sample): 13.3%
Linga et al[2]	34	Mean age 7.1 years	2012	Reported deaths (in overall sample): 18%

MUAC = Mid-upper arm circumference. denotes not yet published. The present study row is highlighted for ease of comparison.

The completion rate in the current study (73%) is higher compared to other Indian studies in the past few years, particularly among malnourished patients (78%). Studies by Gupta et al. reported substantially higher mortality among malnourished children (45–47%), while Sakthikumar et al observed lower treatment completion (37.1%) despite a comparatively lower overall mortality (13.4%).[13,21] Similarly, Linga et al reported lower mortality (11.8%) but in a much smaller cohort.[2] A study about barriers to curing pediatric cancer patients reports that 64-90% of patients in India abandon treatment during the first month of diagnosis due to several reasons, including financial constraints. The study also lists food supplementation for poor families as one of the resource investments to stop early treatment abandonment.[22] Therefore, the higher completion rate in the current study could be explained by the personalized and continuous nutritional counselling immediately post-diagnosis by trained personnel that led to an improvement in nutritional status within the first few months of treatment. Overall, the current study findings indicate comparatively better treatment adherence and outcomes, highlighting potential improvements in nutritional and supportive care strategies.

The discussion highlights that undernutrition is one of the important factors affecting treatment outcomes, adverse events and quality of life for pediatric cancer patients. Several studies have shown that better nutritional status in pediatric oncology patients results in better tolerance to chemotherapy, fewer treatment delays, and less morbidity.[13,23] This in turn, reduces the financial burden and enables better compliance and higher treatment completion rates. Given the importance of addressing malnutrition in pediatric cancer, the WHO Global Initiative emphasizes the need for comprehensive actions in nutrition assessment, support, and education in pediatric oncology.[24]

Limitations

The findings of the current study must be interpreted in light of a smaller sample size and limitations of a retrospective study, such as recall bias and lost follow-ups. In addition, the duration of the study overlaps with the COVID-19 pandemic and could also contribute to lower reporting of infections during the study population. The stringent COVID safety guidelines adopted in hospitals could have made the patients less exposed to infections. It is also important to acknowledge that not all patients demonstrated weight gain over the course of the intervention. This may be attributable to several factors, including the nature and aggressiveness of the underlying malignancy, as patients with high-risk cancers are known to have significantly higher metabolic demands and catabolic states that are difficult to overcome through nutritional support alone. Additionally, some patients may have required closer and more frequent nutritional monitoring than was feasible within the constraints of routine clinical care, highlighting the need for more intensive, individualised dietetic follow-up in high-risk cases. Finally, as adverse event data were captured at the event level rather than the patient level, with some patients experiencing more than one adverse event, formal tests of statistical significance could not be performed for the adverse events analysis. Future prospective studies with larger sample sizes and patient-level data collection are warranted to validate these findings.

CONCLUSION

This study is notable for following pediatric cancer patients through to treatment completion, thereby offering a comprehensive real-world assessment of outcomes beyond treatment-related complications. Compared with earlier Indian studies, this study demonstrates higher treatment completion indicating improved overall treatment retention. Comprehensive nutritional intervention, including personalized counseling, continuous monitoring and more importantly provision of nutritional supplements and ration bundles, contributed to addressing undernourishment and sustaining nutritional gains. These findings highlight the importance of integrated nutritional support in improving quality of life and treatment outcomes in pediatric cancer patients.

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