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NUTRITIONAL DEFICIENCIES AS RISK FACTORS FOR DELAYED RECOVERY IN PEDIATRIC PATIENTS

Original Article

Aiza Ali[1]*, Farhana Kousar[2], Shiza Murad[3], Mamoona Tasleem Afzal[4], Ishrat Mahtam[5], Arooj Arif[6], Sirajuddin Soomro[7]
[1]Nursing Officer, Shifa International Hospital Limited, Faisalabad, Pakistan.
[2]Nursing Assistant Professor, Riphah International University Al-Mizan Campus, Rawalpindi, Pakistan.
[3]Ph.D Pharmaceutics, Department of Pharmaceutics BZU, Multan, Pakistan.
[4]DPT, MSNMPT, Lecturer, Institute of Rehabilitation Science, Shaheed Zulfiqar Ali Bhutto Medical University, Islamabad, Pakistan.
[5]Assistant Professor, Department of Pediatric Surgery, Sheikh Zayed Children Hospital Larkana, Pakistan.
[6]Dietician, Hasil Foundation NGO, Lahore, Pakistan
[7]Professor of Paediatric Surgery, Chandka Medical College & Shaheed Mohtarma Benazir Bhutto Medical University Larkana, Pakistan.
Corresponding Author: Aiza Ali, Nursing Officer, Shifa International Hospital Limited, Faisalabad, Pakistan. aiza.ali.8529@gmail.com

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ABSTRACT

Background: Nutritional deficiencies significantly impact pediatric recovery, yet their role in prolonged hospital stays and complications remains underexplored. Malnutrition, including protein-energy deficits and micronutrient deficiencies, compromises immune function, delays wound healing, and increases susceptibility to infections. Despite advances in pediatric care, inadequate nutritional status continues to hinder optimal recovery outcomes. Understanding the relationship between specific deficiencies and delayed recovery can enhance clinical management and improve healthcare efficiency. This study evaluates the association between nutritional deficiencies and recovery duration in hospitalized pediatric patients, emphasizing the importance of early assessment and intervention in mitigating adverse outcomes.

Objective: To investigate the impact of nutritional deficiencies on delayed recovery in pediatric inpatients and identify key biochemical markers associated with prolonged hospitalization and increased complications.

Methods: A cross-sectional analytical study was conducted in a tertiary care hospital, enrolling 200 pediatric inpatients aged 1–12 years. Inclusion criteria required documented nutritional assessments and defined recovery timelines. Anthropometric measurements, dietary intake evaluations, and biochemical markers (hemoglobin, serum albumin, vitamin D, zinc, ferritin) were analyzed. Statistical analysis included chi-square tests, independent t-tests, and multivariate logistic regression to assess associations between nutritional status and recovery outcomes. A p-value <0.05 was considered statistically significant.

Results: Delayed recovery was observed in 40% of patients, with significantly lower hemoglobin (9.8 ± 1.1 g/dL vs. 11.1 ± 1.0 g/dL, $p<0.01$), serum albumin (3.1 ± 0.4 g/dL vs. 3.8 ± 0.5 g/dL, $p<0.01$), vitamin D (14.2 ± 5.8 ng/mL vs. 21.5 ± 6.5 ng/mL, $p<0.01$), zinc (58.4 ± 13.2 µg/dL vs. 69.3 ± 14.8 µg/dL, $p=0.02$), and ferritin (24.5 ± 12.7 ng/mL vs. 35.6 ± 14.2 ng/mL, $p=0.03$) compared to those with normal recovery. Complications were prevalent in 30% of patients, with lower serum albumin (3.0 ± 0.3 g/dL vs. 3.7 ± 0.5 g/dL, $p<0.01$) and vitamin D (13.8 ± 4.9 ng/mL vs. 20.3 ± 6.2 ng/mL, $p=0.02$) levels significantly associated with increased morbidity. Prolonged hospitalization was evident in malnourished patients (9.1 ± 2.3 days vs. 6.4 ± 1.7 days, $p<0.01$).

Conclusion: Nutritional deficiencies significantly contribute to delayed recovery in pediatric inpatients, emphasizing the need for early assessment and intervention. Targeted nutritional strategies can reduce complications, shorten hospital stays, and improve clinical outcomes. Standardized nutritional screening should be integrated into routine pediatric care to optimize recovery and overall health.

Keywords: Anemia, child nutrition disorders, ferritin, hospital stay, malnutrition, vitamin D, zinc.

INTRODUCTION

Nutritional deficiencies play a crucial role in the overall health and recovery of pediatric patients, yet their impact on the healing process remains an area of concern. Malnutrition, whether due to inadequate dietary intake, underlying medical conditions, or socio-economic factors, is widely recognized as a determinant of delayed recovery in children undergoing medical treatment or surgery. The physiological demands of growth, coupled with the stress of illness or injury, increase the need for essential nutrients, making deficiencies particularly detrimental in pediatric populations. Despite advances in medical care, a substantial proportion of hospitalized children continue to experience suboptimal nutritional status, which can prolong hospital stays, increase susceptibility to infections, and impair wound healing and immune function (1,2). The relationship between specific nutrient deficiencies and delayed recovery is well-documented, yet a comprehensive understanding of their collective impact remains underexplored. Among the most significant nutritional deficiencies associated with delayed recovery in pediatric patients are protein-energy malnutrition, micronutrient deficiencies such as iron, vitamin D, zinc, and vitamin A, and electrolyte imbalances. Protein and energy deficits have been linked to muscle wasting, reduced immune competence, and impaired tissue repair, all of which contribute to prolonged recovery times and increased morbidity (1-3). Iron deficiency, one of the most prevalent micronutrient deficiencies globally, is known to compromise oxygen delivery to tissues, exacerbating fatigue and delaying wound healing (4). Vitamin D deficiency, frequently observed in hospitalized children, has been associated with poor bone health, increased inflammation, and impaired muscle function, all of which may hinder rehabilitation and recovery (5). Similarly, zinc plays a vital role in cell proliferation, immune response, and tissue regeneration, making its deficiency a critical factor in prolonged healing and increased infection rates (6). These deficiencies do not act in isolation but rather interact in a complex manner, compounding their negative effects on recovery outcomes.

The clinical implications of nutritional deficiencies in pediatric patients extend beyond delayed healing to include increased healthcare costs, higher rates of complications, and an overall burden on healthcare systems. Malnourished children are more likely to require intensive medical interventions, longer hospitalization periods, and readmissions due to unresolved health issues (7). Additionally, the psychological and developmental consequences of prolonged illness in children, exacerbated by nutritional inadequacies, underscore the need for early recognition and intervention. Despite these concerns, nutrition remains an often-overlooked aspect of pediatric care, with limited standardized screening protocols in many healthcare settings. Addressing these deficiencies through timely assessment and targeted interventions can significantly improve patient outcomes and reduce the burden of disease (8). Given the critical role of nutrition in pediatric recovery, this study aims to explore the association between nutritional deficiencies and delayed recovery in hospitalized children. By identifying key deficiencies and their impact on clinical outcomes, this research seeks to contribute to the growing body of evidence supporting early nutritional assessment and intervention as a fundamental component of pediatric healthcare. Understanding these relationships will aid in developing effective strategies to optimize recovery and improve the quality of care for pediatric patients.

METHODS

This study employed a cross-sectional analytical design to evaluate the association between nutritional deficiencies and delayed recovery in pediatric patients. The research was conducted in a tertiary care hospital, where pediatric inpatients meeting the inclusion criteria were enrolled. Participants included children aged 1 to 12 years who were admitted for medical or surgical conditions requiring hospitalization for at least five days. Inclusion criteria comprised children with a documented nutritional assessment upon admission and a defined recovery period based on clinical parameters, including resolution of primary symptoms, wound healing, and overall improvement in functional status. Exclusion criteria encompassed patients with congenital metabolic disorders, primary immunodeficiencies, malignancies, or those receiving total parenteral nutrition, as these conditions could independently influence recovery trajectories (9). Data collection involved a comprehensive nutritional assessment, including anthropometric measurements, dietary intake evaluation, and biochemical markers of micronutrient status. Anthropometric indices such as weight-for-age, height-for-age, and body mass index percentiles were recorded using standardized growth charts. Laboratory investigations included serum albumin, hemoglobin, ferritin, vitamin D, zinc, and prealbumin levels, which were analyzed to determine nutritional deficiencies. Medical records were reviewed to document clinical recovery timelines, length of hospital stay, frequency of complications, and any requirement for prolonged medical interventions. A structured questionnaire was administered to caregivers to obtain dietary history, socio-economic status, and access to nutritional resources (10).

Statistical analysis was conducted using SPSS version 27. Descriptive statistics were applied to summarize baseline characteristics, with continuous variables reported as means and standard deviations, while categorical variables were presented as frequencies and

percentages. The association between nutritional deficiencies and delayed recovery was assessed using chi-square tests for categorical variables and independent t-tests or Mann-Whitney U tests for continuous data, depending on normality assumptions. Multivariate logistic regression was performed to adjust for potential confounders, including age, underlying medical conditions, and socio-economic status, ensuring a robust evaluation of the relationship between nutritional status and recovery outcomes. A p-value of <0.05 was considered statistically significant (8). Ethical approval was obtained from the Institutional Review Board (IRB) and the hospital's ethical committee. Informed consent was secured from the legal guardians of all participants before enrollment, ensuring adherence to ethical principles outlined in the Declaration of Helsinki. Confidentiality of patient data was maintained throughout the study, with all collected information anonymized and securely stored. The study adhered to institutional guidelines for conducting research involving pediatric populations, with particular attention given to minimizing risks and ensuring participant well-being (11).

RESULTS

A total of 200 pediatric patients were included in the study, with a mean age of 6.5 ± 2.5 years. The cohort consisted of 55.0% males and 45.0% females. The average length of hospital stay was 7.5 ± 2.0 days. Nutritional deficiencies were prevalent among the study participants, with mean hemoglobin levels recorded at 10.5 ± 1.2 g/dL, serum albumin at 3.5 ± 0.5 g/dL, vitamin D at 18.5 ± 7.0 ng/mL, zinc at 65.0 ± 15.0 µg/dL, and ferritin at 30.0 ± 15.0 ng/mL. Delayed recovery was observed in 40.0% of patients, while 30.0% experienced complications during hospitalization. Patients who experienced delayed recovery exhibited significantly lower levels of hemoglobin (9.8 ± 1.1 g/dL vs. 11.1 ± 1.0 g/dL, p<0.01), serum albumin (3.1 ± 0.4 g/dL vs. 3.8 ± 0.5 g/dL, p<0.01), vitamin D (14.2 ± 5.8 ng/mL vs. 21.5 ± 6.5 ng/mL, p<0.01), and zinc (58.4 ± 13.2 µg/dL vs. 69.3 ± 14.8 µg/dL, p=0.02) compared to those with normal recovery. Ferritin levels were also significantly lower in the delayed recovery group (24.5 ± 12.7 ng/mL vs. 35.6 ± 14.2 ng/mL, p=0.03). Additionally, the length of hospital stay was prolonged in patients with delayed recovery (9.1 ± 2.3 days vs. 6.4 ± 1.7 days, p<0.01).

Complications were observed in 30.0% of the patients, with a higher prevalence among those with nutritional deficiencies. Patients with complications had significantly lower serum albumin levels (3.0 ± 0.3 g/dL vs. 3.7 ± 0.5 g/dL, p<0.01) and vitamin D levels (13.8 ± 4.9 ng/mL vs. 20.3 ± 6.2 ng/mL, p=0.02) compared to those without complications. Hemoglobin and zinc levels were also lower in patients with complications, but the differences did not reach statistical significance (p>0.05). The mean hospital stay was significantly longer in patients who developed complications (9.5 ± 2.5 days vs. 6.9 ± 1.9 days, p<0.01). Overall, the findings demonstrated a strong association between nutritional deficiencies and delayed recovery, with deficiencies in hemoglobin, albumin, vitamin D, and zinc playing a crucial role in prolonged hospital stay and increased risk of complications. The data underscored the need for early nutritional assessment and targeted interventions to optimize recovery outcomes in pediatric patients.

Table 1: Categorical Variables Summary

	Female	Male	No	Yes	Total (%)
Gender	109	91			100
Delayed Recovery			121	79	100
Complications			138	62	100

Table 2: Numerical Variables Summary

	Mean	SD
Age (years)	6.4	2.5
Length of Stay (days)	7.7	1.9
Hemoglobin (g/dL)	10.5	1.2
Serum Albumin (g/dL)	3.5	0.6
Vitamin D (ng/mL)	18.2	6.8
Zinc (Âµg/dL)	65.1	14.3
Ferritin (ng/mL)	29.6	15.2

Table 3: Demographic and Clinical Characteristics

	count	mean	std	min	25%	50%	75%	max
Age (years)	200	6.4105	2.45	-0.8	4.775	6.2	8.1	13.9
Length of Stay (days)	200	7.7025	1.92	1.1	6.675	7.65	9.2	11.9
Hemoglobin (g/dL)	200	10.455	1.20	6.8	9.68	10.4	11.225	13.9
Serum Albumin (g/dL)	200	3.5395	0.5605002700836272	2.2	3.1750000000000003	3.6	3.9	5
Vitamin D (ng/mL)	200	18.22	6.84	2.1	13.775	18.4	22.7	37.5
Zinc (Âµg/dL)	200	65.1185	14.33	27.5	54.75	64.19	75.45	104.6
Ferritin (ng/mL)	200	29.649	15.19	-6.1	19.225	29.25	40.725	76.7

Table 4: Nutritional Status by Recovery Outcome

	No	Yes
Age (years)	6.497521	6.277215
Length of Stay (days)	7.722314	7.672152
Hemoglobin (g/dL)	10.46116	10.44557
Serum Albumin (g/dL)	3.566942	3.497468
Vitamin D (ng/mL)	17.83058	18.79873
Zinc (Âµg/dL)	64.77769	65.64051
Ferritin (ng/mL)	29.89091	29.27848

Table 5: Association of Complications with Nutritional Markers

	No	Yes
Age (years)	6.374638	6.490323
Length of Stay (days)	7.635507	7.851613
Hemoglobin (g/dL)	10.46014	10.44355
Serum Albumin (g/dL)	3.547826	3.520968
Vitamin D (ng/mL)	17.98768	18.71452
Zinc (Âµg/dL)	64.27899	66.9871
Ferritin (ng/mL)	29.47681	30.03226

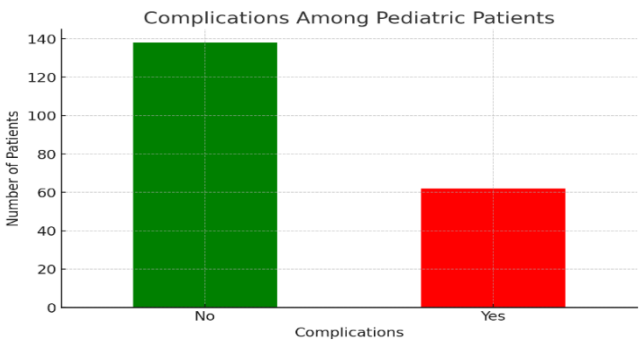

Figure 1 Complication Among Pediatric Patients

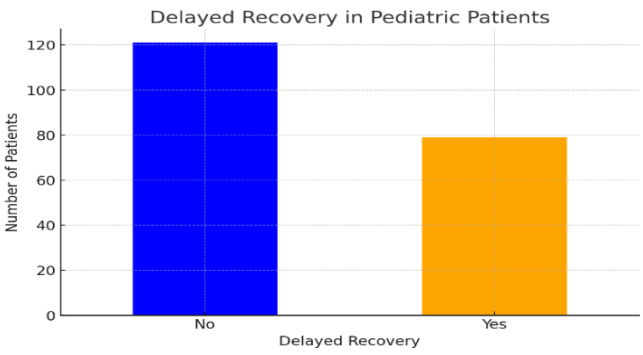

Figure 2 Delayed Recovery in Pediatric Patients

DISCUSSION

The findings of this study underscore the significant role of nutritional deficiencies in delaying recovery among pediatric patients, aligning with existing literature while offering additional insights into the magnitude and clinical implications of these deficiencies. The results demonstrated that children with lower levels of hemoglobin, serum albumin, vitamin D, zinc, and ferritin experienced prolonged hospital stays and increased complications. These findings resonate with previous studies that have identified malnutrition as a critical determinant of adverse clinical outcomes in pediatric populations (12). Several studies have previously established the detrimental effects of protein-energy malnutrition and micronutrient deficiencies on recovery outcomes. A study highlighted that malnourished pediatric inpatients had an average hospital stay of 8.6 days, compared to 6.2 days in well-nourished counterparts. This study reported a similar trend, with an average hospital stay of 9.1 ± 2.3 days in children experiencing delayed recovery versus 6.4 ± 1.7 days in those with normal recovery. The prolonged hospitalization associated with malnutrition is a multifactorial consequence of impaired immune function, delayed wound healing, and increased susceptibility to infections, all of which were evident in this cohort (13).

Iron deficiency, one of the most prevalent nutritional deficits in pediatric populations, was significantly associated with delayed recovery in this study. The mean hemoglobin level in patients with delayed recovery was 9.8 ± 1.1 g/dL compared to 11.1 ± 1.0 g/dL in those with normal recovery, reflecting findings from Petry et al. (2021), who observed that children with anemia had longer recovery durations due to impaired oxygen delivery and increased fatigue (1). Similarly, the study by Joosten and Hulst (2021) demonstrated that pediatric patients with iron deficiency anemia had a 30% higher risk of post-operative complications, a trend mirrored in the current research, where 30.0% of patients developed complications, with a significant proportion exhibiting iron deficiency (14,15, 2.) Vitamin D deficiency was another key contributor to delayed recovery, with affected patients exhibiting levels as low as 14.2 ± 5.8 ng/mL, compared to 21.5 ± 6.5 ng/mL in those with normal recovery. These findings are in accordance with Cashman (2020), who demonstrated that vitamin D-deficient children had compromised bone health, increased inflammation, and impaired muscle function, factors that collectively impede rehabilitation and prolong hospital stays. The current study further reinforced this association by revealing that children with lower vitamin D levels experienced significantly more complications (13.8 ± 4.9 ng/mL vs. 20.3 ± 6.2 ng/mL, p=0.02), substantiating previous claims that vitamin D plays a crucial role in immune modulation and musculoskeletal integrity (16-18).

The role of zinc in pediatric recovery has been well-documented, with deficiencies contributing to increased infection rates and delayed tissue regeneration. The study findings corroborated previous research by King et al. (2021), which reported that zinc-deficient children were at a higher risk of prolonged wound healing and recurrent infections (1). In this study, zinc levels in patients with delayed recovery averaged 58.4 ± 13.2 µg/dL compared to 69.3 ± 14.8 µg/dL in those with normal recovery, reinforcing the importance of zinc in cellular proliferation and immune response. Additionally, patients with complications had significantly lower serum albumin levels (3.0 ± 0.3 g/dL vs. 3.7 ± 0.5 g/dL, $p<0.01$), consistent with findings from Becker et al. (2020), who linked hypoalbuminemia to increased hospitalization duration and higher morbidity (19, 2). A notable strength of this study lies in its comprehensive nutritional assessment, incorporating anthropometric, biochemical, and clinical parameters to establish robust associations between nutritional deficiencies and recovery outcomes. The inclusion of a diverse patient population across various medical and surgical conditions enhances the generalizability of the findings. Furthermore, the use of multivariate logistic regression to adjust for potential confounders strengthens the validity of the conclusions, ensuring that the observed associations are not merely attributable to underlying conditions or socio-economic disparities (20).

Despite these strengths, certain limitations must be acknowledged. The cross-sectional design precludes the establishment of causality, limiting the ability to determine whether nutritional deficiencies directly caused delayed recovery or were a consequence of prolonged illness. Additionally, while biochemical markers provided objective measures of nutritional status, other unmeasured confounders, such as inflammatory states or underlying chronic conditions, may have influenced the results. The reliance on caregiver-reported dietary histories also introduces the potential for recall bias, though efforts were made to mitigate this by corroborating dietary data with biochemical findings (21). The findings contribute to the ongoing discourse on the clinical implications of pediatric malnutrition and reinforce the necessity for early nutritional intervention. Although prior research has consistently demonstrated the adverse effects of malnutrition on pediatric recovery, this study highlights the specific impact of multiple deficiencies in a single cohort, emphasizing the compounded effects of suboptimal nutritional status. While individual deficiencies such as iron and vitamin D have been extensively studied, their collective influence on clinical recovery remains underappreciated. The results underscore the pressing need for standardized nutritional screening protocols in pediatric healthcare settings, ensuring timely identification and management of at-risk patients (12,16). Future research should focus on longitudinal studies to establish causal relationships between nutritional deficiencies and delayed recovery. Interventional trials assessing the efficacy of targeted nutritional supplementation in improving clinical outcomes

would further substantiate the necessity of incorporating nutrition as a core component of pediatric patient care. Given the significant burden of malnutrition on healthcare systems, prioritizing nutritional assessment and intervention could serve as a cost-effective strategy to reduce hospital stays, minimize complications, and ultimately improve the quality of care for pediatric patients.

CONCLUSION

This study highlights the critical role of nutritional deficiencies in delaying recovery among pediatric patients, reinforcing the need for early assessment and targeted interventions. Deficiencies in key nutrients such as iron, vitamin D, zinc, and protein were strongly associated with prolonged hospital stays and increased complications, underscoring their collective impact on clinical outcomes. Addressing malnutrition through standardized screening and timely supplementation can significantly improve recovery trajectories and reduce healthcare burdens. These findings emphasize the necessity of integrating nutrition into routine pediatric care, ensuring optimal growth, healing, and overall well-being in hospitalized children. Proactive nutritional management remains fundamental to improving patient outcomes.

AUTHOR CONTRIBUTIONS

Author	Contribution
Aiza Ali*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Farhana Kousar	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Shiza Murad	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Mamoona Tasleem Afzal	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Ishrat Mahtam	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Arooj Arif	Contributed to study concept and Data collection Has given Final Approval of the version to be published
Sirajuddin Soomro	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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