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ORIGINAL ARTICLE

Dietary Patterns, Food Intake Frequency, and Micronutrient Deficiencies in Malnourished Children: A Cross-Sectional Study in Umerkot, Pakistan

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Abstract

Background:
Malnutrition remains one of the most critical public health issues in Pakistan. The objective of the present study was to investigate dietary patterns and food frequency intake and their association with specific micronutrient deficiencies among undernourished children in Umerkot District.

Methods:
A cross-sectional study was carried out among children aged 6 months to 5 years of age who had been admitted to District Headquarter Hospital, Umerkot. Anthropometric measurements were collected along with dietary intake and clinical data, on the basis of which chi-square tests and logistic regression analyses were conducted for dietary factors against micronutrient deficiencies.

Results:
The overall prevalence of malnutrition was 34.6%, which consisted of 26.5% as moderate and 8.1% severe cases. Lack of dietary diversity was significantly associated with iron deficiency anemia, with odds ratio of 2.8 (95% CI: 1.9-4.1, p<0.001), and vitamin A deficiency, OR 2.3 (95% CI: 1.6-3.3, p<0.001). The low frequency of animal source food intake was associated with zinc deficiency, ORs being 3.1 (95% CI: 2.2-4.4, p<0.001).

Conclusions:
Nutrient deficiencies are strongly associated with dietary shortfalls for most relevant micronutrients in malnourished children. Dietary diversity and increased consumption of foods containing micronutrients are essential components of targeted nutritional interventions aimed at improving the nutritional status of malnourished children.

Keywords: Malnutrition, Dietary patterns, Micronutrient deficiencies, Children, Pakistan

Abstracts in عربی، اردو, 中国人, française, русский and español at the end of the article

Layman Summary

The study was designed to explore those dietary life styles of the malnourished children living in Umerkot that can be associated with deficiency of a particular nutrient. We studied 298 children who were admitted at the local hospital between ages of 6 months to 5 years and measured their height and weight, inquired about what all foods they usually eat, and looked for signs of poor nutrition; we came to know that one-third of them were undernourished. Children not consuming a large variety of foods were at a higher risk of iron and vitamin A deficiencies. Children not consuming meat, eggs, or dairy products regularly were at increased risk of a zinc deficiency. The findings suggested that lack of dietary diversity is highly associated with certain micronutrient deficiencies in malnourished children. Accordingly, to improve child health in this area, encouraging families to provide children with many types of foods, especially iron, vitamin A, and zinc-rich foods, would help. This may be achieved through the encouragement of more fruits, vegetables, and animal-based foods in children's diets.

INTRODUCTION

Malnutrition remains one of the persistent and critical public health challenges, especially in low- and middle-income countries. Malnutrition is a disorder resulting from deficiencies, excesses, or imbalances in a person's intake of energy and/or nutrients. It could also be manifested in children through stunted growth, being underweight or wasted, and deficiency in micronutrients [1,2]. According to the World Health Organization, at least 45 percent of the deaths of children less than five years old are estimated to be attributable to malnutrition [3].

Malnutrition in childhood poses a high burden in Pakistan [4,5]. The National Nutrition Survey of 2018 shows that 40% of children under five years of age have stunted growth, while wasting prevails among 17.7% of the lot [6,7]. These numbers signal not just a critical health emergency but also a very important reason for impairment of the human capital and economic development of the country [8]. It is even grimmer in the Umerkot district of the southeastern province of Sindh where more than half of the rural households have been reported as suffering from food insecurity [9,10].

The etiology of malnutrition is multiple and complex, involving interactions between factors such as poverty, food insecurity, poor dietary intake, very frequent infections, and a lack of health service utilization [11,12,13]. Among the factors above, dietetic ones have become central in the development of micronutrient deficiencies [14,15]. This encompasses micronutrients such as vitamins and minerals, which play a great role in the proper growth and development of a child [14,15], his immunity, and psychosocial life. Deficiency in some important micronutrients like iron, vitamin A, and zinc has wide-ranging and long-term effects on health, cognitive development, and welfare [16,17].

Understanding the relationship between dietary patterns, food intake frequency, and specific micronutrient deficiencies represents a very critical step in developing tailored interventions designed to eliminate malnutrition. Dietary patterns refer to the quantity, variety, and combination of different foods and beverages within a diet, whereas food intake frequency relates to how often certain foods are consumed. The two sides of diet can significantly influence the nutritional status of children, mostly so in resource-poor settings where access to a wide variety of nutrient-dense foods may be problematic [18-20].

Previous research has indicated that diet diversity is essential for adequate consumption of micronutrients among children [21-23]. For the child during the growing period, diets rich in diversified fruits, vegetables, whole grains, and animal-source foods are more likely to meet all their requirements for micronutrients [24]. In most low-income contexts, however, diets are monotonous and heavily dominated by staple foods, and those essentials of micronutrients are probably not being taken in adequately [25].

The frequency of food intake, especially nutrient-dense foods also determines the nutritional status [26]. For instance, adequate intakes of animal-source foods have been shown to enhance iron, zinc, and vitamin B12 status in children. Yet, in most resource-poor settings, these are consumed relatively infrequently because of economic constraint or cultural restrictions [27].

It would be extremely useful to understand these dietary patterns and its relation towards specific micronutrient deficiencies, particularly in the context of Pakistan and especially rural areas like Umerkot. Socio-economic and cultural settings of the region, along with very high rates of poverty, limited sources of diversely accessible food, and specific dietary practices, may lead to certain specific nutrient deficiencies among malnourished children in this context.

Despite its recognized importance, it has a relative scarcity in research focused specifically on the relationship of dietary patterns, frequency of food intake, and micronutrient deficiencies in the context of malnourished children in Pakistan at the district level. It is this gap in knowledge that damps the development of targeted, context-specific interventions to address malnutrition effectively.

This study, therefore aims at investigating the way dietary patterns and frequency of food intake relate to specific micronutrient deficiencies in malnourished children of Umerkot district, Pakistan. On articulating these associations, we might possibly throw light on important approaches toward developing targeted nutritional interventions alongside guiding public health policies to improve, ultimately, the nutritional status of children as well as their health on a large scale in this vulnerable population.

Findings of this research have the potential to address not only immediate child health needs in Umerkot but also advance the information that would be needed to expand understanding of the causes and consequences of malnutrition in comparable settings in Pakistan and elsewhere. Because this research identifies specific dietary factors associated with micronutrient deficiency, it can guide interventions in the field, prioritize resource allocation to target areas, and inform nutrition education programs that might hold the key to amelioration of child health and reductions in the burden of malnutrition.

MATERIALS AND METHODS

Study design and setting

The present study was cross-sectional in design and conducted at the District Headquarter Hospital (DHQ) in Umerkot, Pakistan. DHQ Umerkot is a 200-bed secondary health care facility serving approximately 1.2 million people from both the urban and the rural areas.

Study population

The study population was the children aged 6 months to 5 years admitted into male and female pediatric wards of DHQ Umerkot during the study period.

Sampling technique

A sample was recruited by employing a non-probability sequential sampling method until the desired sample size was obtained. All eligible cases with complete data are included in the final analysis.

Sample size calculation

To compute the sample size, the formula on the estimation of population proportion was utilized:

$$n = Z^2 * P(1-P) / d^2.$$

In this case, Z is the standard normal variate corresponding to a 95% confidence level in which P is the expected proportion in the population and d is the absolute error or precision. The report from the Government of Pakistan (2019) presents that the malnutrition prevalence has been estimated at 29% based on the National Nutrition Survey 2018. So, we used P = 0.29 and d = 0.05. Thus, the minimum sample size for the study was calculated as 316. In addition to this, we added 10% due to non-responses or partly filled questionnaires. Therefore, we needed 348 participants to be involved in the survey. In the current analysis, a sample size has been considered large enough in order to detect all of the significant dietary patterns and associations with potential micronutrient deficiency with adequate power.

Objectives of the research

Primary objective

The primary objective was to investigate whether food intake frequency relates to specific micronutrient deficiencies and dietary patterns found in malnourished children.

Secondary objective

Secondary objectives included:

1. To determine the prevalence of malnutrition among hospitalized children
2. To identify frequent dietary patterns and frequencies of food intake

Secondary objectives included:
3. To determine the prevalence of malnutrition among hospitalized children
4. To identify frequent dietary patterns and frequencies of food intake

Biases and confounders

The most appropriate potential biases and confounders associated with the study include selection bias, recall bias, measurement bias, and confounding factors. To minimize selection bias, all eligible children admitted during the study period were included. Recall bias was tackled by making use of standardized data collection questionnaires and using well-trained interviewers who can improve the accuracy of dietary recall. A reduction of measurement bias was achieved by engaging trained staff in taking anthropometric measurements with calibrated equipment. It is also important to note that confounding factors were documented, such as socio-economic status, education of parents, and birth order; these factors were later included in the multi-variable analysis to heighten the accuracy of results.

Data collection

Data collection involved a combination of questionnaire interviews with parents or guardians and anthropometric measurements, such as weight, height/length, and mid-upper arm circumference (MUAC). The review of medical records in addition provided the information on clinical diagnoses. For dietary assessment, a food frequency questionnaire was used and blood samples were withdrawn to have the key micronutrients-analyzed: hemoglobin, serum retinol, and serum zinc levels.

Quality control measures

To ensure quality data collection, several critical control measures were used. First, data collectors were trained on standardized protocols to maintain consistency and accuracy in the conduct of their work. Beyond this, the anthropometric equipment itself was regularly calibrated to ensure accurate measurements. Finally, the data entered by them was double-entered and then validated for discrepant information. Senior researchers supervised and did the spot checks on data collectors to ensure all requirements were met as per the protocol and, thus, ensure overall integrity in the data.

Statistical Analysis

SPSS version 22.0 was applied to analyze the data through different types of statistical tests. Descriptive statistics consisting of means, standard deviations, frequencies, and percentiles were used to summarize the data. Chi-square tests were used to determine associations between two categorical variables. We considered the use of an independent t-test for comparing means of two or more independent groups and one-way ANOVA for comparing means of three or more independent groups. We explored relationships between continuous variables through Pearson's correlation and used multiple logistic regression in the selection of predictors of micronutrient deficiencies adjusting for confounders. For analyzing the influence of independent variables for micronutrient status, multivariate analysis of variance (MANOVA) was employed, while hierarchical cluster analysis was used to classify dietary patterns. The Kruskal-Wallis test was used for non-parametric comparison; effect sizes were computed by Cohen's d for differences that were statistically significant. Overall, a p-value of less than 0.05 was considered statistically significant, and, in all such estimates, the corresponding 95% confidence interval was calculated.

Ethical considerations

An approval by the Institutional Review Board of SZABIST University was sought for the study. Informed consent was taken from the parents or guardians for all participants. All participants were assured confidentiality throughout the study and given an opportunity to withdraw at any point during the study.

RESULTS

Characteristics of the participants

A total of 316 children were analyzed in the final analysis. The mean age of participants was 20.3 ± 14.9 months, with males 195 (61.7%) and females 121 (38.3%). Most participants (157, 49.7%) were between 6 to 24 months of age, followed by 110 (34.8%) belonging to the 24 to 60 months age bracket and 49 (15.5%) less than 6 months of age. Residential distribution in this study revealed that 209 (66.1%) of cases were from rural areas around Umerkot, and 107 (33.9%) were from within the city.

Table 1. Demographic characteristics and nutritional status of study participants (N=316)

Characteristic	n (%)	Malnourished n (%)	Not Malnourished n (%)	p-value
Age Group				0.018
6-24 months	157 (49.7)	56 (35.7)	101 (64.3)	
>24 months	159 (50.3)	36 (22.6)	123 (77.4)	
Gender				0.342
Male	195 (61.7)	60 (30.8)	135 (69.2)	
Female	121 (38.3)	32 (26.4)	89 (73.6)	
Residence				0.021
Rural	209 (66.1)	69 (33.0)	140 (67.0)	
Urban	107 (33.9)	23 (21.5)	84 (78.5)	
Maternal Education				<0.001
No formal education	165 (52.2)	64 (38.8)	101 (61.2)	
Primary education	87 (27.5)	21 (24.1)	66 (75.9)	
Secondary or higher	64 (20.3)	7 (10.9)	57 (89.1)	
Household Food Security				<0.001
Food secure	119 (37.7)	20 (16.8)	99 (83.2)	
Moderately insecure	110 (34.8)	35 (31.8)	75 (68.2)	
Severely insecure	87 (27.5)	37 (42.5)	50 (57.5)	

Main findings

Prevalence of Malnutrition:

The total prevalence of malnutrition was found to be 29.0% (92/316); moderate acute malnutrition, 22.2% (70/316); and severe acute malnutrition, 6.8% (22/316), with the use of MUAC measurements. Stunting was identified in 22.5% (71/316) of the children, wasting in 13.3% (42/316), and underweight status in 27.8% (88/316).

Table 2. Prevalence of micronutrient deficiencies by dietary pattern

Dietary Pattern	n (%)	Iron Deficiency Anemia n (%)	Vitamin A Deficiency n (%)	Zinc Deficiency n (%)
Cereal-based	164 (51.9)	86 (52.4)	59 (36.0)	73 (44.5)
Mixed diet	118 (37.3)	37 (31.4)	27 (22.9)	31 (26.3)
Diverse diet	34 (10.8)	3 (8.8)	3 (8.8)	2 (5.9)
Total	316 (100)	126 (39.9)	89 (28.2)	106 (33.5)
p-value		<0.001	<0.001	<0.001

Dietary Patterns and Food Intake Frequency:

The number of three distinct dietary patterns within the study population was determined by hierarchical cluster analysis: cereal-based diet (51.9%, 164/316), mixed diet with moderate diversity (37.3%, 118/316), and diverse diet with frequent animal-source food consumption (10.8%, 34/316). Chi-square analysis documented an association of those dietary patterns with malnutrition status in the population ($\chi^2 = 26.9$, df = 4, $p < 0.001$, which implies that dietary diversity does influence the nutritional health of the population.

Prevalence of micronutrient deficiency was quiet notable, with anaemia due to iron deficiency counted as high as 39.9% (126/316), vitamin A deficiency in 28.2% (89/316) and prevalence of zinc deficiency of 33.5% (106/316). This information informs of the seriousness to which the deficiencies of micronutrients have reached and the necessity of both a diversified food intake and adequacy of their quantities to improve nutritional status.

Table 3. Association between food intake frequency and micronutrient status

Food Group	Frequency	Iron Deficiency Anemia OR (95% CI)	Vitamin A Deficiency OR (95% CI)	Zinc Deficiency OR (95% CI)
Animal-source foods	Daily	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
	2-3 times/week	1.7 (1.1-2.6)*	1.5 (1.0-2.3)*	2.0 (1.3-3.0)**
	<1 time/week	3.0 (2.0-4.5)**	2.5 (1.7-3.8)**	3.3 (2.2-5.0)**
Fruits and vegetables	Daily	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
	2-3 times/week	1.4 (0.9-2.1)	1.8 (1.2-2.7)**	1.3 (0.8-2.0)
	<1 time/week	2.3 (1.5-3.4)**	2.9 (2.0-4.3)**	1.8 (1.2-2.7)**
Legumes	Daily	1.0 (Reference)	1.0 (Reference)	1.0 (Reference)
	2-3 times/week	1.2 (0.8-1.8)	1.1 (0.7-1.7)	1.4 (0.9-2.1)
	<1 time/week	1.6 (1.1-2.4)*	1.4 (0.9-2.1)	1.9 (1.2-2.8)**

OR: Odds Ratio; CI: Confidence Interval; $p < 0.05$, ** $p < 0.001$

Multiple logistic regression analysis

Multiple logistic regression analysis revealed significant associations of all the dietary patterns with micronutrient deficiencies. Using a cereal-based diet, the prevalence of iron deficiency anemia was significantly higher, with an odds ratio of 2.6 (95% CI: 1.8–3.8, p < 0.001) compared to the users of the diverse diet, who were used as the reference group. Mixed diet attendees had a possible association with iron deficiency anemia; however, this association was borderline nonsignificant (OR = 1.4, 95% CI: 0.9–2.1, p = 0.058). Similarly, vitamin A deficiency was significantly associated with cereal-based diet (OR = 2.2, 95% CI: 1.5–3.2, p < 0.001), but the mixed diet did not present a meaningful association (OR = 1.3, 95% CI: 0.9–2.0, p = 0.132) as compared with the reference group.

The evidence established a strong association between both cereal-based and mixed diets with zinc deficiency. In both the cereal-based diet, the incidence of zinc deficiency was substantially higher (OR = 2.9, 95% CI: 2.0–4.2, p < 0.001), and that in the mixed diet led to greater likelihood of deficiency compared to the diversified diet (OR = 1.6, 95% CI: 1.1–2.4, p = 0.015). Results reveal the vital role of diversity in diet towards preventing micronutrient malnutrition, which is especially prevalent in populations consuming cereal-based or mixed diets.

Food Intake Frequency and Micronutrient Status:

Pearson's correlation analysis showed that significantly negative correlations existed between frequency of animal-source food intake and micronutrient deficiencies. Average inverse relationship between frequency of animal source food consumption and iron deficiency anemia appeared to be r = -0.40, p < 0.001 which means that high frequencies of animal-based food consumption relate to a lower prevalence of iron deficiency anemia. Vitamin A deficiency had a very strong negative correlation with animal-source food intake (r = -0.36, p < 0.001). There was also a stronger negative correlation between animal-source food intake and zinc deficiency: (r = -0.43, p < 0.001). The results indicate that increasing the frequency of consumption of animal-source foods may work towards reducing these micronutrient deficiencies.

Multivariate analysis of variance (MANOVA)

MANOVA revealed a significant effect of food intake frequency on overall micronutrient status with (Wilks' λ = 0.80, F(9, 754) = 8.1, p < 0.001).

Socio-demographic Factors and Nutritional Status:

Several significant predictors of malnutrition were identified through multiple logistic regression analysis: In rural areas, odds of being malnourished were 1.8 fold greater in comparison to those who resided in urban settings; OR = 1.8, 95% CI: 1.2-2.7, p = 0.003. The second strong predictor was low maternal education, where children of less educated mothers were 2.1 times likely to be malnourished (OR = 2.1, 95% CI: 1.4-3.1, p < 0.001). Moreover, food insecurity in households was statistically linked with malnutrition, as the chance of the affected households experiencing malnutrition compared with food secure ones was twice as high as the latter (OR = 2.5, 95% CI: 1.7-3.8, p < 0.001). That is, these findings indicate that socio-economic and environmental factors play a more important role in outcome-related child malnutrition.

Table 4. Multivariate logistic regression analysis of factors associated with malnutrition

Variable	Adjusted OR (95% CI)	p-value
Age (months)		
6-24	1.8 (1.2-2.7)	0.003
>24	1.0 (Reference)	
Residence		
Rural	1.6 (1.0-2.5)	0.021
Urban	1.0 (Reference)	
Maternal Education		
No formal education	2.9 (1.9-4.5)	<0.001
Primary education	1.7 (1.0-2.8)	0.032
Secondary or higher	1.0 (Reference)	
Household Food Security		
Severely insecure	2.7 (1.8-4.1)	<0.001
Moderately insecure	1.6 (1.0-2.5)	0.024
Food secure	1.0 (Reference)	
Dietary Pattern		
Cereal-based	3.1 (2.0-4.8)	<0.001
Mixed diet	1.5 (0.9-2.4)	0.062
Diverse diet	1.0 (Reference)	
Animal-source food intake		
<1 time/week	2.3 (1.5-3.6)	<0.001
2-3 times/week	1.3 (0.8-2.1)	0.184
Daily	1.0 (Reference)	

OR: Odds Ratio; CI: Confidence Interval

DISCUSSION

This study provides valuable insights into the complex relationships between dietary patterns, food intake frequency, and micronutrient deficiencies among malnourished children in Umerkot, Pakistan. The findings reveal a prevalence of malnutrition of 29.0% among hospitalized children, which is consistent with previous studies conducted in similar settings in Pakistan and other developing countries. For instance, two studies by Asim M. (2018) and Khaliq A. (2021) in Sindh province reported a malnutrition prevalence of 48% among children under five [28], while Khattak et al. (2017) found a 37% prevalence in Khyber Pakhtunkhwa province [4,5].

Our results highlight the significant association between dietary patterns and micronutrient deficiencies. The predominance of cereal-based diets (51.9%) in our study population is particularly concerning, as these diets were strongly associated with higher odds of iron deficiency anemia, vitamin A deficiency, and zinc deficiency. This finding aligns with research by Akhtar et al. (2018) [18], who reported that cereal-based diets in rural Pakistan were often lacking in essential micronutrients.

The strong negative correlation between the frequency of animal-source food intake and micronutrient deficiencies observed in our study is consistent with global evidence. A study by White J. (2023) [29] found that animal-source foods were particularly effective in reducing stunting and micronutrient deficiencies in children from low- and middle-income countries. Our findings reinforce the importance of promoting diverse diets that include regular consumption of animal-source foods to improve micronutrient status among children in Pakistan.

The socio-demographic factors associated with malnutrition in our study, including rural residence, low maternal education, and household food insecurity, are well-documented in the literature [30,31]. These findings underscore the need for multisectoral approaches to address malnutrition that go beyond just focusing on diet.

Our study's strengths lie in its comprehensive assessment of dietary patterns, food intake frequency, and multiple micronutrient deficiencies in a vulnerable population. The use of robust statistical analyses, including multivariate logistic regression and MANOVA, provides a nuanced understanding of the relationships between these factors.

However, several limitations should be acknowledged. The cross-sectional design limits our ability to establish causal relationships. The hospital-based sampling may not be fully representative of the general population, potentially overestimating the prevalence of malnutrition and micronutrient deficiencies. Additionally, the reliance on parental recall for dietary information may introduce some bias.

Despite these limitations, our findings have important implications for public health interventions and policies aimed at reducing malnutrition and micronutrient deficiencies in Pakistan. The results suggest that interventions should focus on promoting dietary diversity, increasing the consumption of animal-source foods, and addressing broader social determinants of health such as maternal education and household food security.

Study strengths and limitations

Strengths:

1. Comprehensive assessment of multiple micronutrient deficiencies
2. Use of robust statistical analyses including multivariate techniques
3. Inclusion of both dietary and socio-demographic factors in the analysis
4. Adequate sample size providing sufficient statistical power

Limitations:

1. Cross-sectional design limiting causal inference
2. Hospital-based sampling potentially overestimating prevalence rates
3. Reliance on parental recall for dietary information
4. Lack of longitudinal data to assess long-term impacts of dietary patterns

CONCLUSION AND RECOMMENDATIONS

This study demonstrates a clear and significant association between dietary patterns, food intake frequency, and specific micronutrient deficiencies among malnourished children in Umerkot, Pakistan. The prevalence of malnutrition (29.0%) and micronutrient deficiencies, particularly iron deficiency anemia (39.9%), zinc deficiency (33.5%), and vitamin A deficiency (28.2%), underscores the critical need for targeted interventions to improve child nutrition in this region.

Key findings include:

1. Cereal-based diets are associated with higher odds of micronutrient deficiencies.
2. Frequency of animal-source food intake is negatively correlated with micronutrient deficiencies.
3. Socio-demographic factors, including rural residence, low maternal education, and household food insecurity, significantly contribute to malnutrition risk.

Based on these findings, we recommend the following actions:

1. Promote dietary diversity: Develop and implement nutrition education programs that emphasize the importance of diverse diets, particularly the inclusion of animal-source foods, fruits, and vegetables.
2. Strengthen micronutrient supplementation programs: Enhance existing programs and explore innovative delivery mechanisms to ensure wider coverage and adherence to micronutrient supplementation, especially for iron, vitamin A, and zinc.
3. Address social determinants: Implement multi-sectoral interventions that target broader social determinants of malnutrition, including improving maternal education, enhancing household food security, and reducing rural-urban disparities in healthcare access.
4. Enhance food fortification efforts: Scale up food fortification programs, particularly for staple cereals, to address micronutrient deficiencies at a population level.
5. Improve healthcare system capacity: Strengthen the capacity of healthcare providers to assess, prevent, and treat malnutrition and micronutrient deficiencies in children.
6. Conduct community-based interventions: Develop and implement community-based programs that promote optimal infant and young child feeding practices, including appropriate complementary feeding.
7. Enhance monitoring and surveillance: Establish robust nutrition surveillance systems to track progress and inform policy decisions.

Future research implications

1. Longitudinal studies to assess the long-term impact of dietary interventions on micronutrient status and overall child health.
2. Implementation research to evaluate the effectiveness and scalability of integrated nutrition interventions in resource-limited settings.
3. Exploration of innovative approaches to improve dietary diversity and increase consumption of nutrient-dense foods in culturally acceptable ways.
4. Investigation of the role of gut health and environmental enteric dysfunction in micronutrient absorption and utilization among malnourished children.

In conclusion, addressing the complex interplay between dietary patterns, food intake frequency, and micronutrient deficiencies is crucial for improving child nutrition in Umerkot and similar settings in Pakistan. A comprehensive, multi-sectoral approach that combines nutrition-specific and nutrition-sensitive interventions is essential to tackle the persistent challenge of childhood malnutrition and its associated micronutrient deficiencies.

SUPPORTING INFORMATION

File 1: Questionnaire/tool [Detailed food frequency questionnaire and socio-demographic data collection form]
File 2: Anthropometric measurement protocol [Standardized protocol for weight, height, and MUAC measurements]
File 3: Laboratory analysis methods [Detailed methods for hemoglobin, serum retinol, and serum zinc analysis]
File 4: Statistical analysis code [SPSS code used for the advanced statistical analyses, including multivariate logistic regression and MANOVA]
File 5: Supplementary tables [Additional tables showing detailed breakdowns of dietary patterns, micronutrient levels, and subgroup analyses]
File 6: Ethical approval documentation [Copy of the ethical approval letter from the Institutional Review Board of SZABIST University]

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AUTHORS CONTRIBUTIONS

Conceptualization: MBS, JMV, HSM
Data Curation: MBS, JMV, HSM
Formal Analysis: MBS, JMV, HSM
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Investigation: MBS, JMV, HSM
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Validation: MBS, JMV, HSM
Writing – Original Draft Preparation: MBS, JMV, HSM
Writing – Review & Editing: MBS, JMV, HSM

MBS-Muhammad Bilal Siddiqui; **JMV**- Jan Muhammad Vistro; **HSM**-Hafiza Summaiyah Mughal

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy or ethical restrictions.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest.

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Multi-Lingual Abstracts

Abstract in عربى (Arabic)

خلاصة

خلفية:
لا يزال سوء التغذية أحد أهم قضايا الصحة العامة في باكستان. كان الهدف من هذه الدراسة هو دراسة الأنماط الغذائية وتكرار تناول الطعام وارتباطها بنقص المغذيات الدقيقة المحددة بين الأطفال الذين يعانون من سوء التغذية في منطقة أومركوت.

طُرق:
تم إجراء دراسة مقطعية بين الأطفال الذين تتراوح أعمارهم بين 6 أشهر إلى 5 سنوات والذين تم إدخالهم إلى مستشفى المقاطعة الرئيسي، أوميركوت. تم جمع قياسات الجسم البشري جنبًا إلى جنب مع المدخول الغذائي والبيانات السريرية، والتي تم على أساسها إجراء اختبارات مربع كاي وتحليلات الانحدار اللوجستي للعوامل الغذائية ضد نقص المغذيات الدقيقة.

نتائج:
وبلغ معدل انتشار سوء التغذية الإجمالي 34.6%، يتألف من 26.5% كحالات معتدلة و8.1% للحالات الشديدة. ارتبط نقص التنوع الغذائي بشكل كبير بفقر الدم الناجم عن نقص الحديد، مع نسبة الأرجحية 2.8 (فاصل الثقة 95%: 1.9-4.1، p<0.001)، ونقص فيتامين أ، OR 2.3 (فاصل الثقة 95%: 1.6-3.3، p<0.001). ارتبط التردد المنخفض لتناول الأغذية ذات المصدر الحيواني بنقص الزنك، وكانت نسب الأرجحية 3.1 (فاصل الثقة 95%: 2.2-4.4، قيمة الاحتمال <0.001).

الاستنتاجات:
يرتبط نقص المغذيات ارتباطًا وثيقًا بالنقص الغذائي لمعظم المغذيات الدقيقة ذات الصلة لدى الأطفال الذين يعانون من سوء التغذية. يعد التنوع الغذائي وزيادة استهلاك الأطعمة التي تحتوي على المغذيات الدقيقة مكونات أساسية للتدخلات التغذوية المستهدفة التي تهدف إلى تحسين الحالة التغذوية للأطفال الذين يعانون من سوء التغذية.

الكلمات المفتاحية: سوء التغذية، الأنماط الغذائية، نقص المغذيات الدقيقة، الأطفال، باكستان

Abstract in اردو (Urdu)

خلاصہ

پس منظر:
غذائیت کی کمی پاکستان میں صحت عامہ کے سب سے اہم مسائل میں سے ایک ہے۔ موجودہ مطالعے کا مقصد ضلع عمرکوٹ میں غذائی قلت کے شکار بچوں میں خوراک کے نمونوں اور خوراک کی فریکوئنسی کی مقدار اور ان کی مخصوص مائیکرو نیوٹرینٹ کی کمی کے ساتھ وابستگی کی تحقیقات کرنا تھا۔

طریقے:
6 ماہ سے 5 سال کی عمر کے بچوں کے درمیان ایک کراس سیکشنل مطالعہ کیا گیا جنہیں ڈسٹرکٹ ہیڈ کوارٹر ہسپتال عمرکوٹ میں داخل کیا گیا تھا۔ غذائی انٹیک اور طبی اعداد و شمار کے ساتھ اینتھروپومیٹرک پیمائشیں جمع کی گئیں، جس کی بنیاد پر مائیکرو نیوٹرینٹ کی کمی کے خلاف غذائی عوامل کے لیے چی اسکوائر ٹیسٹ اور لاجسٹک ریگریشن تجزیے کیے گئے۔

نتائج:
غذائی قلت کا مجموعی پھیلاؤ 34.6% تھا، جس میں 26.5% اعتدال پسند اور 8.1% شدید کیسز شامل تھے۔ غذائی تنوع کی کمی نمایاں طور پر آئرن کی کمی انیمیا کے ساتھ منسلک تھی، جس میں 2.8 (95% CI: 1.9-4.1، p <0.001)، اور وٹامن A کی کمی، یا 2.3 (95% CI: 1.6-3.3، p <0.001) ۔ جانوروں کے ذریعہ کھانے کی کم تعدد زنک کی کمی سے منسلک تھی، (95% CI: 2.2-4.4، p <0.001) ORs 3.1۔

نتیجہ:
غذائیت کی کمی کا تعلق غذائی قلت کے شکار بچوں میں زیادہ تر متعلقہ مائیکرو نیوٹرینٹس کے لیے غذائی کمی سے ہے۔ غذائی تنوع اور مائیکرو نیوٹرینٹس پر مشتمل کھانے کی بڑھتی ہوئی کھپت ابدافی غذائی مداخلتوں کے ضروری اجزاء ہیں جن کا مقصد غذائیت کے شکار بچوں کی غذائی حالت کو بہتر بنانا ہے۔

مطلوبہ الفاظ: غذائیت، غذائیت کے نمونے، مائیکرو نیوٹرینٹ کی کمی، بچے، پاکستان

Abstract in 中国人 (Chinese)

抽象的

背景：
营养不良仍然是巴基斯坦最严重的公共卫生问题之一。本研究的目的是调查乌梅尔科特地区营养不良儿童的饮食模式和食物摄入频率及其与特定微量营养素缺乏的关系。

方法：
对乌默科特地区总部医院收治的 6 个月至 5 岁儿童进行了一项横断面研究。收集人体测量数据以及饮食摄入量和临床数据，在此基础上针对微量营养素缺乏的饮食因素进行卡方检验和逻辑回归分析。

结果：
营养不良的总体患病率为34.6%，其中中度营养不良占26.5%，重度营养不良占8.1%。缺乏饮食多样性与缺铁性贫血显着相关，优势比为 2.8 (95% CI: 1.9-4.1, p<0.001)，维生素 A 缺乏 OR 2.3 (95% CI: 1.6-3.3, p<0.001))。动物源性食物摄入频率低与锌缺乏有关，OR 为 3.1（95% CI：2.2-4.4，p<0.001)。

结论：
营养缺乏与营养不良儿童中大多数相关微量营养素的饮食不足密切相关。膳食多样性和增加含有微量营养素的食物的消费是旨在改善营养不良儿童营养状况的有针对性的营养干预措施的重要组成部分。

关键词： 营养不良、饮食模式、微量营养素缺乏、儿童、巴基斯坦

Abstrait

Abstract in française (French)

Arrière-plan:
La malnutrition reste l'un des problèmes de santé publique les plus critiques au Pakistan. L'objectif de la présente étude était d'étudier les habitudes alimentaires et la fréquence de consommation alimentaire, ainsi que leur association avec des carences spécifiques en micronutriments chez les enfants sous-alimentés du district d'Umerkot.

Méthodes :
Une étude transversale a été réalisée auprès d'enfants âgés de 6 mois à 5 ans admis à l'hôpital du siège du district d'Umerkot. Des mesures anthropométriques ont été collectées ainsi que l'apport alimentaire et des données cliniques, sur la base desquelles des tests du chi carré et des analyses de régression logistique ont été effectués pour déterminer les facteurs alimentaires en rapport avec les carences en micronutriments.

Résultats:
La prévalence globale de la malnutrition était de 34,6 %, dont 26,5 % de cas modérés et 8,1 % de cas graves. Le manque de diversité alimentaire était significativement associé à l'anémie ferriprive, avec un rapport de cotes de 2,8 (IC à 95 % : 1,9-4,1, p<0,001) et à une carence en vitamine A, OR 2,3 (IC à 95 % : 1,6-3,3, p<0,001).). La faible fréquence de consommation d'aliments d'origine animale était associée à une carence en zinc, les OR étant de 3,1 (IC à 95 % : 2,2-4,4, p<0,001).

Conclusions :
Les carences nutritionnelles sont fortement associées aux carences alimentaires en micronutriments les plus importants chez les enfants malnutris. La diversité alimentaire et la consommation accrue d'aliments contenant des micronutriments sont des éléments essentiels des interventions nutritionnelles ciblées visant à améliorer l'état nutritionnel des enfants malnutris.

Mots clés: Malnutrition, modèles alimentaires, carences en micronutriments, enfants, Pakistan

Абстрактный

Abstract in русский (Russian)

Фон:
Недоедание остается одной из наиболее острых проблем общественного здравоохранения в Пакистане. Целью настоящего исследования было изучение особенностей питания и частоты приема пищи, а также их связи с конкретным дефицитом микроэлементов среди недоедающих детей в Умеркотском районе.

Методы:
Поперечное исследование было проведено среди детей в возрасте от 6 месяцев до 5 лет, поступивших в центральную районную больницу Умеркота. Антропометрические измерения были собраны вместе с данными о пищевом рационе и клиническими данными, на основе которых были проведены тесты хи-квадрат и анализ логистической регрессии для определения диетических факторов, препятствующих дефициту микроэлементов.

Результаты:
Общая распространенность недостаточности питания составила 34,6%, из которых 26,5% составляли умеренные и 8,1% тяжелые случаи. Отсутствие разнообразия в питании было значимо связано с железодефицитной анемией с отношением шансов 2,8 (95% ДИ: 1,9–4,1, p<0,001) и дефицитом витамина А, ОШ 2,3 (95% ДИ: 1,6–3,3, p<0,001).). Низкая частота потребления продуктов животного происхождения была связана с дефицитом цинка, ОШ составило 3,1 (95% ДИ: 2,2–4,4, p<0,001).

Выводы:
Дефицит питательных веществ тесно связан с нехваткой в рационе большинства важных микроэлементов у детей, страдающих от недоедания. Разнообразие рациона питания и повышенное потребление продуктов, содержащих микроэлементы, являются важными компонентами целевых мер в области питания, направленных на улучшение состояния питания детей, страдающих от недоедания.

Ключевые слова: Недоедание, Образцы питания, Дефицит микроэлементов, Дети, Пакистан.

Abstracto

Abstract in español (Spanish)

Fondo:
La desnutrición sigue siendo uno de los problemas de salud pública más críticos en Pakistán. El objetivo del presente estudio fue investigar los patrones dietéticos y la frecuencia de la ingesta de alimentos y su asociación con deficiencias de micronutrientes específicos entre los niños desnutridos en el distrito de Umerkot.

Métodos:
Se llevó a cabo un estudio transversal entre niños de 6 meses a 5 años de edad que habían sido ingresados en el Hospital Central del Distrito de Umerkot. Se recogieron mediciones antropométricas junto con la ingesta dietética y datos clínicos, sobre la base de los cuales se realizaron pruebas de chi-cuadrado y análisis de regresión logística para factores dietéticos contra deficiencias de micronutrientes.

Resultados:
La prevalencia general de desnutrición fue del 34,6%, de la cual el 26,5% era moderada y el 8,1% grave. La falta de diversidad dietética se asoció significativamente con la anemia por deficiencia de hierro, con odds ratio de 2,8 (IC 95%: 1,9-4,1, p<0,001), y la deficiencia de vitamina A, OR 2,3 (IC 95%: 1,6-3,3, p<0,001).). La baja frecuencia de ingesta de alimentos de origen animal se asoció con la deficiencia de zinc, siendo las OR 3,1 (IC 95%: 2,2-4,4, p<0,001).

Conclusiones:
Las deficiencias de nutrientes están fuertemente asociadas con deficiencias dietéticas de los micronutrientes más importantes en los niños desnutridos. La diversidad dietética y el aumento del consumo de alimentos que contienen micronutrientes son componentes esenciales de las intervenciones nutricionales específicas destinadas a mejorar el estado nutricional de los niños desnutridos.

Palabras clave: Desnutrición, Patrones dietéticos, Deficiencias de micronutrientes, Niños, Pakistán

What is already known in study's context

- Malnutrition is a significant public health problem in Pakistan, with high rates of stunting and wasting among children under five.
- Micronutrient deficiencies, particularly iron, vitamin A, and zinc, are prevalent in low-income settings and contribute to poor child health outcomes.
- Dietary diversity is an important factor in ensuring adequate micronutrient intake among children.
- Socio-demographic factors, including maternal education and household food security, play a crucial role in determining nutritional status.

What this study adds to the existing literature

- This study provides detailed insights into the relationship between specific dietary patterns and micronutrient deficiencies in a high-risk population in Umerkot, Pakistan.
- The research quantifies the strong association between cereal-based diets and increased odds of iron, vitamin A, and zinc deficiencies in malnourished children.
- The study demonstrates a significant negative correlation between the frequency of animal-source food intake and the prevalence of micronutrient deficiencies.
- Our findings highlight the complex interplay between dietary factors, socio-demographic characteristics, and micronutrient status, providing a comprehensive picture of malnutrition determinants in this setting.

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