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COMPARATIVE ASSESSMENT OF MICRONUTRIENT DEFICIENCIES AMONG PRESCHOOL CHILDREN IN RURAL AND URBAN COMMUNITIES: IDENTIFYING DIETARY, SOCIOECONOMIC, AND ENVIRONMENTAL RISK FACTORS

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Abstract

Background: *Preschool children continue to be a significant public health issue in low and middle income countries due to micronutrient deficiencies, and this is closely linked to environmental, nutritional and socioeconomic factors. Nutritional problems faced in rural and urban areas can be different because the food available in rural areas and the services and conditions in rural households may differ from those found in urban areas.*

Objective: *This study was aimed at comparing the micronutrient deficiency patterns among preschool children in rural and urban areas and determining factors associated with the micronutrient deficiency patterns.*

Methods: *A comparative cross sectional analytical study was carried out on 300 preschool children, age 2-5 years, at tertiary care hospital Lahore, Pakistan. There were equal numbers of people in rural and urban areas (n=150). Structured interviews, dietary assessment, anthropometric measurements and laboratory analysis of selected micronutrient indicators were used to collect data. Details of diet diversity, income status, education of parents, sanitation facilities and recurrent infections were gathered. Data were analyzed statistically, using SPSS software, including comparative tests and multivariable logistic regression for independent risk factors.*

Results: *There were higher prevalence rates of micronutrient deficiencies in rural children than in urban children. The prevalence*

of Iron Deficiency Anemia was 46.0% in rural group and 30.7% in urban group (p=0.008). The prevalence of vitamin D deficiency was 52.7% for rural children and 36.0% for urban children (p=0.006), and 38.7% for rural children and 24.7% for urban children were vitamin D deficient (p=0.012). Dietary diversity, household income, sanitation, and frequency of infections were significantly related to high risk of micronutrient deficiency. Multivariate logistic regression revealed that the following factors were independent risk factors for nutritional deficiency: rural residence, poor dietary diversity, and socioeconomic disadvantage.

***Conclusion**: Micronutrient deficiency burden in preschool children is higher in rural areas than in urban areas. The results reveal that early nutritional screening and community based nutrition interventions such as dietary improvement, maternal education, sanitation and equitable access to health services are important to combat micronutrient deficiencies among children in Pakistan. Introduction: Micronutrient deficiencies are a significant public health issue in preschool children, particularly in low-income countries.*

INTRODUCTION

Micronutrient inadequacies are one of the most significant yet under recognised childhood public health issues in low- and middle-income countries. These deficiencies are often referred to as "hidden hunger" because the affected child may look normal but suffer a number of severe biological and developmental impacts. The micronutrients such as iron, zinc, vitamin A, vitamin D, iodine and others are essential to immune function, brain development, growth, and disease resistance. Deficiency in early childhood may have long-term physical growth, learning and productivity impacts (Black et al., 2013).

The preschool years, especially 2-5 years old, are sensitive times in children's development. Children grow and develop quickly during these times and need enough food, or nutrients, in their bodies. But in many developing countries, children take a diet consisting of mainly cereals and carbohydrates with low diversity. This type of diet is inadequate in iron, zinc, vitamin A and other micronutrients needed for normal development (Bhutta et al., 2008).

Childhood nutrition deficits remain a serious problem in Pakistan. Nutritional inequalities between rural and urban populations still exist despite the economic development and improved health services in urban areas. Children in rural areas often do not have adequate access to health services, enough food diversity, and access to clean water, nor do they have enough income. In contrast, urban children could be dealing with other nutritional issues such as consumption of processed foods, poor food choices and lifestyle issues. Such disparities result in the uneven distribution of micronutrient deficiencies within communities, between rural and urban populations. Iron deficiency anaemia, vitamin A deficiency, zinc deficiency and vitamin D deficiency have been observed to be prevalent in young children in national and regional studies conducted in Pakistan. A national assessment revealed that anemia and micronutrient deficiency is a pervasive problem among children under 5 years in Pakistan and that socioeconomic status, maternal education, dietary habits and access to health services are driving nutrition outcomes. Iron deficiency anemia (IDA) is one of the most prevalent nutritional conditions in the world and is a significant problem in children in Pakistan. Iron is needed for oxygen carrying capacity, brain development and brain function. Chronic iron deficiency in childhood has been linked to decreased learning abilities and delayed developmental milestones, and impaired attention.

A recent study in Pakistan further revealed the association of anaemia, vitamin D deficiency, nutritional status and socioeconomic status in children. Increasingly vitamin D deficiency is being recognized as a significant health concern in children. Vitamin D deficiency has traditionally been associated with bone health, but is now linked to immunity, susceptibility to infections and overall development in childhood.

Several studies in Pakistan have revealed high levels of vitamin D deficiency in children, especially those with nutritional anemia or poor nutrition. The etiology of micronutrient deficiencies is complex, with several interacting factors. Among the main factors, insufficient food intake is one, while other factors that affect nutritional status include household income, parental education, food security, use of sanitary facilities, use of health services and environmental conditions.

Limited access to nutrient-dense foods like meat, eggs, dairy products, fruits, and vegetables among children in low-income families. Unsafe water and poor sanitation can further exacerbate nutritional deficiencies through repeated infections, which can lead to an increase in nutrient requirements and/or decrease in nutrient absorption. In Pakistan, where there is a significant difference in living conditions and healthcare access between rural and urban areas, the rural–urban nutrition gap is especially noteworthy.

The children from rural communities have been found to suffer more from undernutrition in the past because of poverty, lack of food variety and poor access to health services. However, living in an urban area does not necessarily mean a better nutritional status as urban poverty and unhealthy dietary habits can also lead to deficiencies. Lahore has one of the largest urban populations in Pakistan with people coming in from the surrounding rural areas. Lahore has important population of tertiary hospitals which offer an opportunity to analyse nutritional difference between children from various socio-economic and environmental backgrounds.

Knowledge of these differences can inform specific prevention, screening, and nutrition intervention strategies. While a few studies have focused on single micronutrient deficiencies in Pakistani children, very few studies have looked at more than one micronutrient deficiency in both rural and urban pre-school children along with associated dietary, socioeconomic and environmental factors.

So, the aim of this study was to compare the micronutrient deficiency pattern in preschool children of rural and urban area attending a tertiary hospital of Lahore Pakistan. The results of this research can support the evidence for health care providers, policy makers and nutrition programs to create community specific strategies. To better design nutrition and preventive health services for vulnerable preschool children, the major risk factors for micronutrient deficiencies need to be identified to inform the development of better nutrition screening programs, nutritional counseling, food supplementation strategies and preventive health services

MATERIALS AND METHODS

Study Design and Study Setting

A comparative cross sectional analytical study was carried out to determine the prevalence and distribution of micronutrient deficiencies among preschool children of rural and urban areas with identification of associated dietary, socioeconomic and environmental risk factors. The study was conducted at Department of Pediatrics, TCC (Tertiary Care Center) Lahore, Pakistan.

The hospital is a referral hospital for a variety of families who are living in Lahore city and children referred from the surrounding rural districts. This environment enabled the comparison of the nutrition situation of children with varying social, economic, dietary and environmental backgrounds. The research period started from January 2026 to June 2026 (six months). Direct interviews with parents/primary caregivers, physical examination, anthropometric measurements and laboratory assessment of selected micronutrient indicators were conducted.

Study Participants and Sample Size

The study comprised pre-school children aged 2-5 years, who visited the paediatric outpatient department of their hospital during the study. There were 300 children enrolled and two classes set up on the basis of their home environments.

The urban group comprised of 150 children living in the urban areas of Lahore metropolitan areas and the rural group comprised of 150 children from the rural areas of Lahore and other surrounding districts. The sample size was determined with the assumption that the micronutrient deficiency prevalence is around 50% with the 95% confidence level and 5% margin of error. A consecutive sampling technique was employed and all children eligible during the study period were included for sampling.

Inclusion Criteria

Children were selected if they:

- Have an age range from 2-5 years.
- Living in rural or urban areas.
- Likely availability for clinical evaluation and laboratory testing.
- Parents/guardians who are willing to participate and have signed informed consent forms.

Exclusion Criteria

Children were excluded if they had:

- History of long-term health problems such as kidney disease, liver disease, congenital disease, cancer, or metabolic disease.
- Acute severe illness with intensive care management.
- Past three-months' history of blood transfusion.
- Prescribed micronutrient supplementation now in use.
- Inadequate clinical information or laboratory data.

These criteria were chosen to reduce the impact of disease-related nutritional changes and to emphasize community-related risk factors.

Data Collection Procedure

Information was gathered by a structured interviewer-administered questionnaire. It was developed based on the review of previously done nutrition assessment studies and was split into four sections: Demographic information, dietary assessment, socio-economic characteristics and environmental factors. Trained researchers conducted interviews with parents/caregivers. Data on age, sex, birth history, feeding practices, diet, family structure, parental education, occupation, household income, sanitation facilities and source of drinking water were gathered. Dietary factors were assessed. A 24-h dietary recall was used to collect dietary information. All foods and drinks that the child ate or drank in the last 24 hours were inquired about from the parents.

Dietary diversity was evaluated from the foods consumed comprising the following food groups:

- Cereals and grains.
- Dairy products. Meat, fish and eggs.
- Fruits.
- Vegetables.
- Legumes and nuts.

A less than four food groups were used to indicate inadequate dietary diversity in children. The frequency of eating nutrient-rich foods, skipping meals, and eating commercial snacks were also documented. Socio-economic and environmental assessment.

- Socio-economic factors were assessed based on the data on income, education of the parents, work status, family size and housing conditions. Household income was divided into three bands for monthly income: Low income: Less than 50,000 PKR/Month.
- Middle income: 50,000–100,000 Pakistani Rupees/month.
- Higher income: >100,000 PKR per month.

Environmental characteristics included:

- Source of drinking water.
- Availability of household sanitation facilities.
- Waste disposal practices.
- Household crowding.

- Past history of recurrent infections in last 6 months.

Anthropometric Measurements

Standardised procedures were used for Anthropometric measurements.

Children's body weights were obtained on a calibrated, digital weighing machine, in light clothing and without shoes. The height was measured with a portable stadiometer. The following indicators were calculated:

- Weight-for-age.
- Height-for-age.
- BMI-for-age.

Growth status was defined by the World Health Organization (WHO) child growth standards. Children were grouped according to their corresponding z score values into normal, stunted, underweight or wasted. A non-stretchable measuring tape was also used for measuring mid-upper arm circumference (MUAC). Laboratory Assessment

Venous blood samples were taken from all the participants under aseptic conditions after taking their consent. All samples were analysed in the hospital laboratory using standard quality control processes. These biochemical parameters were measured:

- Hemoglobin level.
- Serum ferritin.
- Vitamin D (25-hydroxyvitamin D) in the serum.
- Serum zinc level.

The concentration of hemoglobin was determined by automated hematology analyzer. Standard biochemical methods were used to determine serum ferritin, serum vitamin D and serum zinc.

The micronutrient deficiencies were categorised based on the internationally accepted paediatric reference values. When children had low levels of hemoglobin, with low serum ferritin concentration, Iron Deficiency Anemia was considered.

Vitamin D deficiency was identified as a serum 25-hydroxyvitamin D level below the recommended level. The diagnosis of zinc deficiency was determined using reference intervals for serum zinc levels.

Outcome Measures

The main finding of the study was the difference in micronutrient deficiency profile among the children in rural and urban preschool.

The following outcomes were assessed:

- Prevalence of iron deficiency anaemia
- Frequency of vitamin D deficiency.
- Frequency of zinc deficiency
- Multiple micronutrient deficiencies (MMDs). Link of nutritional deficiencies to nutrition, socio-economic, and environment.

Statistical Analysis

The data were analyzed with IBM Statistical Package for Social Sciences (SPSS) version 26.0.

All continuous variables, such as age, anthropometric data and biochemical parameters were presented as mean ± standard deviation. Categorical variables were displayed in frequencies and percentages.

Independent sample t-test was used for continuous variables and Chi-square test was used for categorical variables for comparison between rural and urban groups.

Using binary logistic regression, the factors associated independently with micronutrient deficiency was evaluated.

The variables which had significant association were included in the regression model in the preliminary analysis. Odds Ratios (ORs) were calculated and adjusted (AOR) with 95% confidence intervals (CI). The p-value was set at < 0.05 as statistically significant.

RESULTS

Participant Characteristics

A total of 300 preschool children were included in the study analysis. Participants were equally divided into rural and urban groups, with 150 children selected from each community. The overall mean age of children was 3.8 ± 1.1 years. The majority of participants were between 3 and 5 years of age.

Among the enrolled children, 158 (52.7%) were males and 142 (47.3%) were females. The distribution of gender was comparable between rural and urban groups, and no statistically significant difference was observed.

Children from rural communities showed comparatively lower socioeconomic conditions than urban participants. A higher proportion of rural families reported monthly household income below 50,000 Pakistani Rupees, lower parental education levels, and limited access to improved sanitation facilities.

Table 1. Demographic and Socioeconomic Characteristics of Preschool Children According to Residential Area (N = 300)

Variables	Total (n=300)	Rural Group (n=150)	Urban Group (n=150)	p-value
Age (years), Mean ± SD	3.8 ± 1.1	3.9 ± 1.1	3.7 ± 1.0	0.214
Age group				
2–3 years	96 (32.0%)	48 (32.0%)	48 (32.0%)	1.000
4–5 years	204 (68.0%)	102 (68.0%)	102 (68.0%)	
Gender				
Male	158 (52.7%)	81 (54.0%)	77 (51.3%)	0.646
Female	142 (47.3%)	69 (46.0%)	73 (48.7%)	
Monthly household income				
<50,000 PKR	136 (45.3%)	94 (62.7%)	42 (28.0%)	<0.001
50,000–100,000 PKR	118 (39.3%)	45 (30.0%)	73 (48.7%)	
>100,000 PKR	46 (15.4%)	11 (7.3%)	35 (23.3%)	
Mother education				
Primary or below	98 (32.7%)	67 (44.7%)	31 (20.7%)	<0.001
Secondary education	128 (42.7%)	61 (40.7%)	67 (44.7%)	
Higher education	74 (24.6%)	22 (14.6%)	52 (34.6%)	

Comparison of Dietary Characteristics Between Rural and Urban Children

Dietary assessment showed noticeable differences between the two groups. Rural children had lower dietary diversity scores compared with urban children. Consumption of animal-source foods, including eggs, meat, and dairy products, was less frequent among rural participants.

Inadequate dietary diversity was observed in 62.0% of rural children compared with 38.7% of urban children ($p < 0.001$). Similarly, irregular consumption of fruits and vegetables was more commonly reported among children from rural areas.

Children with low dietary diversity showed a higher frequency of multiple micronutrient deficiencies compared with children consuming a more varied diet.

Table 2. Dietary Characteristics of Preschool Children in Rural and Urban Communities

Dietary Variables	Rural Group (n=150)	Urban Group (n=150)	Total (n=300)	p-value
Inadequate dietary diversity	93 (62.0%)	58 (38.7%)	151 (50.3%)	<0.001
Adequate dietary diversity	57 (38.0%)	92 (61.3%)	149 (49.7%)	
Daily dairy intake	72 (48.0%)	104 (69.3%)	176 (58.7%)	<0.001
Regular egg/meat consumption	54 (36.0%)	89 (59.3%)	143 (47.7%)	<0.001
Daily fruit intake	41 (27.3%)	78 (52.0%)	119 (39.7%)	<0.001
Frequent processed snack intake	48 (32.0%)	87 (58.0%)	135 (45.0%)	<0.001

Prevalence of Micronutrient Deficiencies

The overall prevalence of micronutrient deficiencies was higher among children belonging to rural communities compared with urban communities.

Iron deficiency anemia was identified in 115 (38.3%) children. The prevalence was significantly higher among rural children, where 69 (46.0%) participants were affected compared with 46 (30.7%) urban children ($p = 0.008$).

Vitamin D deficiency was the most frequently observed micronutrient abnormality. A total of 133 (44.3%) children had insufficient vitamin D levels. Rural children showed a higher prevalence of vitamin D deficiency compared with urban children (52.7% vs. 36.0%, $p = 0.006$).

Zinc deficiency was detected in 95 (31.7%) children. The deficiency was present in 58 (38.7%) rural children and 37 (24.7%) urban children, showing a significant difference between groups ($p = 0.012$).

Multiple micronutrient deficiencies were observed in 80 (26.7%) participants. Rural children showed nearly double the frequency of combined deficiencies compared with urban children (34.0% vs. 19.3%, $p = 0.004$).

Table 3. Comparison of Micronutrient Deficiency Patterns Between Rural and Urban Preschool Children

Micronutrient Deficiency	Total (n=300)	Rural Group (n=150)	Urban Group (n=150)	p-value
Iron deficiency anemia	115 (38.3%)	69 (46.0%)	46 (30.7%)	0.008
Vitamin D deficiency	133 (44.3%)	79 (52.7%)	54 (36.0%)	0.006
Zinc deficiency	95 (31.7%)	58 (38.7%)	37 (24.7%)	0.012
Multiple micronutrient deficiencies	80 (26.7%)	51 (34.0%)	29 (19.3%)	0.004
No detected deficiency	89 (29.7%)	31 (20.7%)	58 (38.7%)	

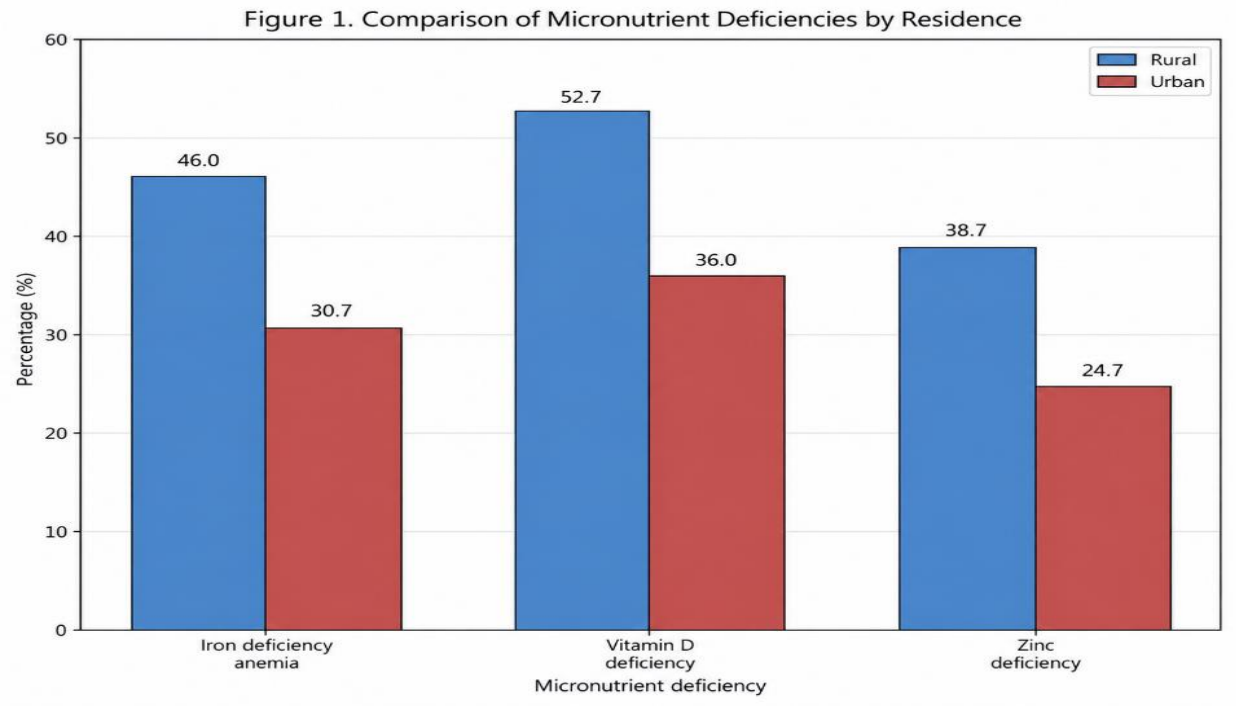


Figure 1: Distribution of micronutrient deficiencies among rural and urban preschool children

Association Between Socioeconomic Factors and Micronutrient Deficiency

Analysis of socioeconomic variables showed that children from lower-income households had increased frequency of micronutrient deficiencies.

Children belonging to families with monthly income below 50,000 Pakistani Rupees demonstrated higher rates of iron deficiency anemia and vitamin D deficiency compared with children from higher-income households.

Parental education was also associated with nutritional status. Children whose mothers had lower educational levels showed increased probability of inadequate dietary diversity and micronutrient deficiency.

Poor household sanitation and unsafe drinking water sources were more frequently reported among rural participants. These environmental conditions showed an association with increased occurrence of nutritional deficiencies.

Table 4. Anthropometric Characteristics of Preschool Children According to Residential Area

Anthropometric Indicators	Rural Group (n=150)	Urban Group (n=150)	p-value
Weight (kg), Mean ± SD	13.4 ± 2.8	14.1 ± 2.6	0.031
Height (cm), Mean ± SD	94.6 ± 8.4	97.8 ± 7.9	0.002
BMI (kg/m²), Mean ± SD	14.8 ± 1.7	15.2 ± 1.6	0.041
Stunting	49 (32.7%)	27 (18.0%)	0.004
Underweight	43 (28.7%)	21 (14.0%)	0.002
Wasting	22 (14.7%)	13 (8.7%)	0.098

Logistic Regression Analysis of Risk Factors

Multivariable logistic regression analysis was performed to identify independent factors associated with micronutrient deficiency.

After adjustment for age and gender, the following factors remained significantly associated with increased risk:

- Rural residence (Adjusted OR: 1.82; 95% CI: 1.16–2.87; p = 0.009)
- Inadequate dietary diversity (Adjusted OR: 2.34; 95% CI: 1.48–3.70; p < 0.001)
- Low household income (Adjusted OR: 1.96; 95% CI: 1.21–3.16; p = 0.006)
- Poor sanitation facilities (Adjusted OR: 1.71; 95% CI: 1.05–2.78; p = 0.031)

Table 5. Environmental Factors Associated with Micronutrient Deficiency

Environmental Factors	Deficient Children (n=211)	Non-deficient Children (n=89)	p-value
Unsafe drinking water	86 (40.8%)	19 (21.3%)	0.001
Poor sanitation facilities	79 (37.4%)	18 (20.2%)	0.004
Household overcrowding	112 (53.1%)	31 (34.8%)	0.006
Recurrent infections in previous 6 months	98 (46.4%)	24 (27.0%)	0.002

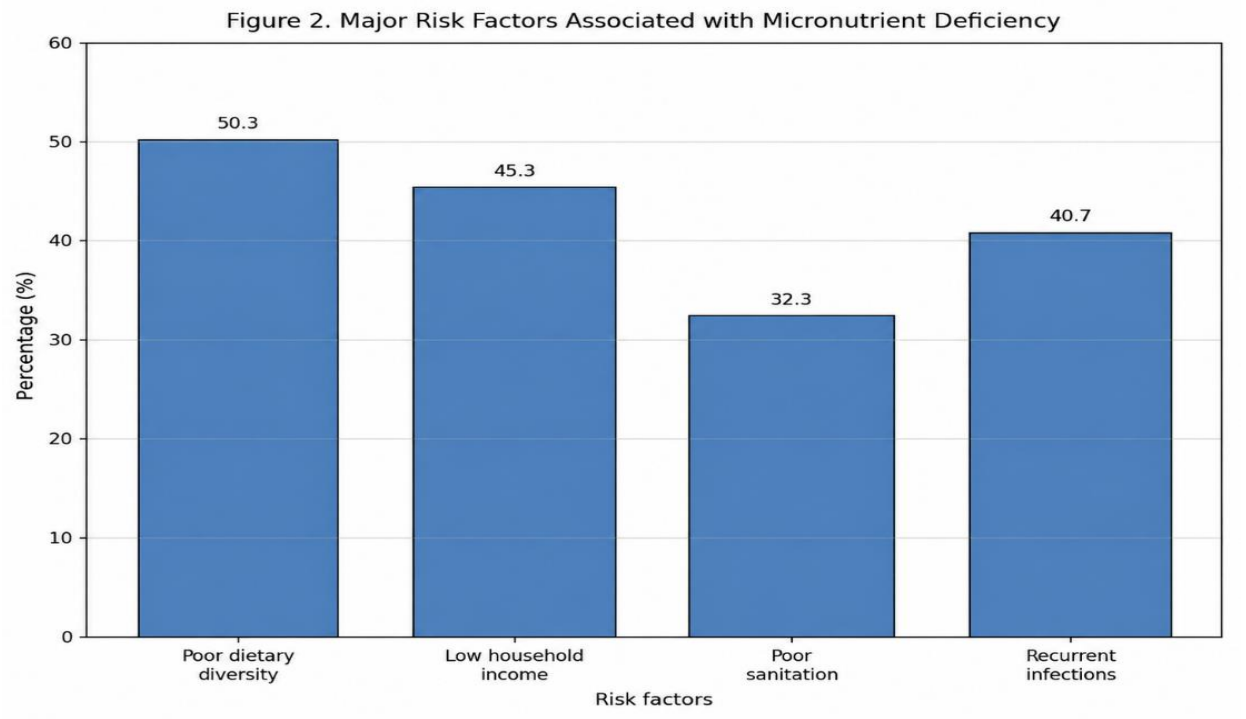


Figure 2: Major risk factors associated with micronutrient deficiency

Table 6. Multivariable Logistic Regression Analysis of Factors Associated with Micronutrient Deficiency

Risk Factor	Adjusted Odds Ratio (AOR)	95% Confidence Interval	p-value
Rural residence	1.82	1.16–2.87	0.009
Inadequate dietary diversity	2.34	1.48–3.70	<0.001
Low household income	1.96	1.21–3.16	0.006
Poor sanitation facilities	1.71	1.05–2.78	0.031
Low maternal education	1.64	1.02–2.65	0.041
Recurrent infections	1.88	1.17–3.02	0.009

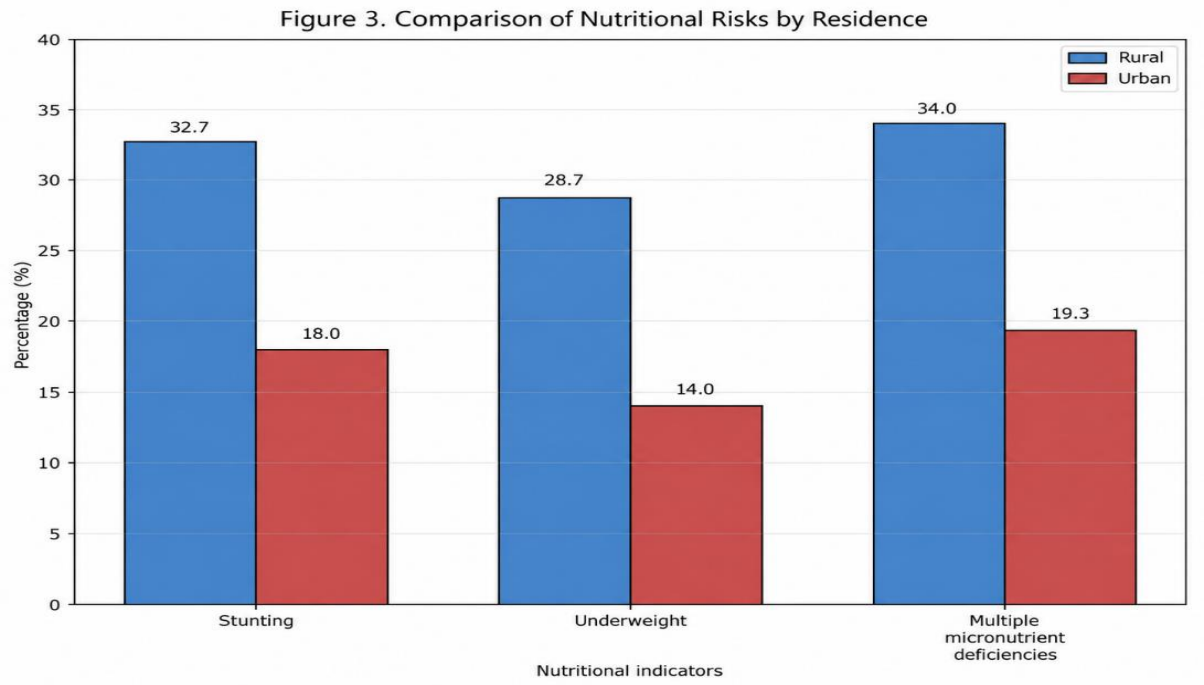


Figure 3: Rural vs Urban nutritional risk comparison

These findings indicate that micronutrient deficiencies were influenced by multiple interacting factors rather than a single nutritional cause.

Summary of Main Findings

The present study demonstrated that preschool children from rural communities experienced a higher burden of micronutrient deficiencies compared with children from urban areas. Rural children had greater frequency of iron deficiency anemia, vitamin D deficiency, zinc deficiency, and multiple micronutrient deficiencies.

The differences between communities were associated with dietary quality, socioeconomic conditions, parental education, and environmental factors. Children with poor dietary diversity and limited household resources showed the highest nutritional risk.

DISCUSSION

This cross sectional study compared and contrasted the burden of micronutrient deficiencies in preschool children in rural and urban areas. The main findings revealed the significantly higher prevalence of iron deficiency anemia, vitamin D deficiency, zinc deficiency and multiple micronutrient deficiency among rural children. Furthermore, low household income, inadequate dietary diversity, and recurrent infections were found to be important factors that contribute to greater nutritional risk, in addition to poor sanitation.

Micronutrient deficiencies in children were more prevalent in rural children in this study, which continues to highlight the ongoing nutritional disparities in low and middle-income countries, such as Pakistan. These trends are also observed in other National surveys conducted in the past, in which malnutrition with regard to anemia and vitamin D deficiency in children is still prevalent, despite the improvement of health services. The National Nutrition Survey of Pakistan further indicated that significant proportion of children under 5 years of age was suffering from anemia and Vitamin deficiencies with the rural population being at high risk due to socioeconomic constraints and limited access to nutritious foods.

One of the most common deficiencies observed in the present study was iron deficiency anemia, with 46.0% of the rural children suffering from it, while 30.7% of the urban children suffered from it. This result corroborates the earlier studies that have indicated that iron deficiency is a persistent nutritional

problem in children in Pakistan. Iron is a vital nutrient for oxygen delivery, brain development and immune health. Long-lasting iron deficiency in early childhood could have adverse effects on learning ability, attention, and developmental outcomes. Black et al. (2013) pointed out that micronutrient deficiencies in early childhood have a high impact on impaired growth and long-term developmental outcomes, especially for vulnerable groups.

The difference between rural and urban children observed may be attributable to differences in dietary intake. In the present study, the prevalence of poor dietary diversity was significantly greater in rural people. Rural households have often limited diversity of their diet with a high proportion of staple food components such as cereals and low intakes of animal source foods, fruits and vegetables. These types of diets lack adequate amounts of iron, zinc and other micronutrients. According to Bhutta et al. (2008), poor food consumption and low intake of nutrient rich foods are two key factors responsible for undernutrition in children in developing countries. The most prevalent micronutrient deficiency was vitamin D deficiency (52.7% of rural children and 36.0% of urban children).

Vitamin D deficiency is a common problem in Pakistan as it experiences a lot of sunlight throughout the year, but multiple factors such as less outdoor activity, less nutritional intake, cultural practices, and less dietary intake are responsible for this. In Pakistan, high prevalence of vitamin D deficiency was reported in children in previous studies, indicating that environmental exposure to sunlight is not sufficient to ensure vitamin D sufficiency. A correlation between vitamin D deficiency and nutritional issues in children was also identified by Abdul Razzaq et al. (2024), emphasizing the importance of regular nutritional screening in children.

The prevalence of zinc deficiency was also more among rural children in the present study. The function of zinc includes immune response, growth regulation, and cellular development. This can be attributed, in part, to differences in the consumption of zinc food sources, including less consumption of both meat and dairy products. In the Pakistani population, Soofi et al. (2013) have found that micronutrient supplementation such as zinc and iron could have a positive impact on child health outcomes.

The results highlight the need for dietary improvement and targeted supplementation programs to address childhood deficiencies. Yet another significant finding of this research was the association between socioeconomic status and micronutrient status. Someone from low-income family had higher likelihood of micronutrient deficiencies in the children. Poverty affects nutritional status in several ways including its effects on access to food for purchase, access to health services, maternal education and sanitation. Childhood undernutrition was defined by Victora et al. (2008) to be a consequence of issues of social and economic factors instead of just a nutritional issue.

The education of the mother was also an important child nutrition association. The children whose mothers had a low education level had increased prevalence of dietary inadequacy and micronutrient deficiency. Better educated mothers have better knowledge of appropriate feeding practices, early nutritional problem detection, and use of health care services when necessary. In other similar studies in countries from South Asia, maternal education has been found to be significantly related to better child feeding practices and a decreased malnutrition risk in children.

Nutritional status was also found to be related with environmental conditions in the present study. Poor sanitation facilities, unsafe drinking water, and recurrent infections were more frequently reported among children with micronutrient deficiencies. Re-infection can exacerbate nutritional status as it may decrease appetite, increase the need for nutrients and impact nutrient absorption. When malnutrition and infection occur together, they enter a vicious circle, with malnutrition increasing susceptibility to infection and then, infection further depleting nutrition.

The high prevalence of stunting and underweight children in rural areas also underlines this link between chronic nutrition inadequacy and micronutrient deficiency. Growth failure in preschool years is frequently caused by chronic exposure to poor nutrition, frequent illness and poor living environments. Dewey and Begum (2011) found that early childhood impairment of growth can result in consequences for lifelong physical development and health outcomes.

The results of this research have far reaching implications for paediatric care in Pakistan. Mass screening for micronutrient deficiencies should not be restricted to severely malnourished children, since many micronutrient deficiencies are not clinically apparent. Regularly assessing a child's nutritional status,

advising on diet and good nutrition and carrying out routine laboratory screening may help to identify children in need of protection before the occurrence of complications.

This study also highlights the need for community-specific interventions. Better access to nutrition education, food supplementation programmes, maternal education programmes and better water and sanitation services in rural areas can all benefit the rural communities. Urban populations should not be neglected, as dietary habits are changing and more processed foods are being eaten which can present different nutrition problems.

The results should be interpreted considering some limitations. The hospital-based design might restrict the applicability of the findings to all preschool children from Pakistan since children visiting a tertiary care center may differ from those in the general population in terms of health characteristics. Also, dietary data were based on a self-reported diet by the caregiver, which could result in recall bias. A comparison of the different designs and evaluations of various nutritional, socioeconomic and environmental factors, however, is useful in understanding the variations in childhood nutrition between rural and urban areas.

CONCLUSION

The present study suggests that micronutrient deficiencies are still a major nutritional problem in preschool children and the prevalence of micronutrient deficiencies is greater in rural populations than in urban populations. There were persisting inequalities with iron deficiency anemia, vitamin D deficiency, zinc deficiency, and multiple micronutrient deficiencies being more prevalent in rural children.

The results indicate that micronutrient deficiency is not only associated with low food consumption, but is also greatly affected by socio-economic and environmental factors. The dietary diversity was a limiting factor, low household income, poor parental education, poor sanitation facilities, and recurrent infections were important associated factors with increased nutritional risk.

These findings show that micronutrient deficiency in the childhood is a multi-faceted phenomenon, resulting from multiple nutritional, social and environmental risks rather than a single risk. The first 1,000 days from conception to age two are a time of rapid physical development, brain maturation and immune system development. If growth is stunted or inadequate in this period, it can have adverse effects on mental development and the quality of life. Consequently, the nutritional screening of preschool children, especially from vulnerable rural communities, should be a part of the routine care for children.

The study highlights the importance of comprehensive strategies that incorporate dietary interventions, nutrition education, micronutrient supplementation, maternal sensitisation, and basic living conditions enhancement. Supplementation interventions alone may not be effective in the long-term without improving the socioeconomic and environmental conditions. Finally, the mitigation of micronutrient deficiencies in preschool children in Pakistan should rely on the community-based approaches, taking into account the difference between rural and urban children. It is easy to see that early detection, access to nutrient-rich food, feeding practices and provision of preventive care services can play a major role in improving nutrition status and future health outcomes of children.

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