Original Article

Prevalence and Risk Factors of Vitamin D Deficiency in Children Aged 6-12 Years: A Cross-Sectional Study

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ABSTRACT

Background: Vitamin D deficiency has become a common public health problem, especially in children. Globally, vitamin D deficiency is an important public health concern, especially in regions with sun exposure limited by climatic and other cultural practices or lifestyle habits. This study aims to determine the prevalence of vitamin D deficiency among children and explore the associated determinants, including sunlight exposure, dietary habits, socioeconomic status, parental education, and body weight.

Methods: This cross-sectional survey was conducted from January 2023 to July 2024 at Lahore General Hospital, Lahore, Pakistan. Four hundred and seventeen children visiting the pediatric outpatient department were recruited via convenience sampling technique. A health camp was established within the hospital premises to facilitate data collection. A structured questionnaire in English and Urdu was used to collect demographic details (age, gender, and socioeconomic status), dietary intake, sun exposure, and clinical history. Data were entered into SPSS version 22.0 for analysis. The chi-square test was applied to determine associations between Vitamin D deficiency and determinants.

Results: The average age for participants was 8.1±2.9 years. The children included in the study were predominantly boys (61.15% males), while 38.84% were females. Vitamin D deficiency (<20 ng/mL) was detected in 244 children out of 417. Among the 69 responders (16.54%), vitamin D insufficiency was defined, while 104 (24.9%) children were in normal vitamin D levels (>30 ng/mL).

Conclusion: The findings highlight the need for multi-faceted interventions, including public health campaigns promoting adequate sun exposure, dietary modifications, and potential fortification programs.

Keywords: Children, Determinants, Vitamin D, Vitamin D Deficiency.

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INTRODUCTION

Vitamin D is crucial for bones' health, the immune system's proper functioning, and general physiological health[1]. However, despite its importance, vitamin D deficiency has become a common public health problem, especially in children[2]. It has been associated with numerous adverse health outcomes such as rickets, growth failure, compromised immunity, and susceptibility to chronic diseases in later life. Globally, vitamin D deficiency is an important public health concern, especially in regions with sun exposure limited by climatic and other cultural practices or lifestyle habits[3]. According to several published studies, many children worldwide suffer from insufficient or deficient vitamin D levels, varying prevalence rates across different populations. In developing countries, malnutrition, lack of outdoor activities, and socioeconomic factors increase the risk. Even in sunny areas, the rising use of sunscreen, protective clothing, and indoor lifestyles contribute to an increasing burden of vitamin D deficiency. According to a study pooled analysis of 7.9 million participants globally from 2000 to 2022, 15.7% of participants had serum 25-hydroxyvitamin D levels below 30 nmol/l, 47.9% had levels below 50 nmol/l, and 76.6% had levels below 75 nmol/l[4].

In Pakistan, vitamin D deficiency is alarmingly high, with a reported prevalence of 56% out of 27,650 participants[5]. A recent meta-analysis of 37

studies with a population of 19,338 on vitamin deficiency levels in Pakistan revealed that children/adolescents show a greater pooled prevalence of 84%. Among province-wise subgroup analyses, Punjab province shows a higher pooled prevalence of 84%[6].

Calcium and phosphorus homeostasis is primarily achieved through the aid of vitamin D in maintaining bone mineralization and skeletal development[7]. Vitamin D helps increase intestinal calcium absorption and ensures easy deposition of calcium into bones, thus avoiding conditions like rickets in children and osteomalacia in adults[8]. Beyond its role in skeletal benefit, it plays an important part in modulating the immune, reducing inflammation, and building the body's defense mechanisms against infections.

The cultural practice of keeping children indoors and poor dietary intake of vitamin D-rich foods significantly contributes to this deficiency[9]. Inadequate sun exposure, poor diet-related deficiencies, socioeconomic status, and genetic predisposition all contribute to vitamin D deficiency in children. The primary natural source of vitamin D is sunlight, which UVB rays stimulate and induce production in the skin. However, the modern lifestyle in which children have intensely reduced outdoor time and, consequently, the amount of sunlight exposure[10]. Seasonal variations also come into play, whereby children from long-winter regions or those with high pollution-level cities are also likely to experience longer periods with lower UVB exposure, thus posing more significant risks of deficiency development[11].

Fatty fish, the yolk of eggs, and fortified dairy products are the primary dietary sources, which differ because of cultural background, economic status, and eating habits. More importantly, even breastfed children who are not given supplements will be at a higher risk since the vitamin D levels in breast milk are low[12]. Another factor is the socioeconomic disparities, which are critical in vitamin D deficiency. Children belonging to low strata have fewer chances of receiving proper nutritious foods and health services, lowering the chance of vitamin D supplementation or medical care for deficiency. Parental education also plays a role in diet choices and awareness of the significance of vitamin D. Parents with a better educational background have been shown to ensure their children receive the nutrition and sun exposure they need to reduce deficiency risks.

Although a considerable body of literature exists regarding the importance of vitamin D, this deficiency among children remains prevalent globally, especially in developing countries. There is limited recent literature about the prevalence and determinants of vitamin D deficiency among children aged 6–12. This study aims to determine the prevalence of vitamin D deficiency among children and explore the associated determinants, including sunlight exposure, dietary habits, socioeconomic status, parental education, and body weight. Understanding these factors will give policymakers, healthcare professionals, and parents valuable insights to implement effective interventions and reduce the burden of vitamin D deficiency in children.

METHODOLOGY

Study Setting

This cross-sectional study was conducted from January 2023 to July 2024 at pediatric outpatient department of Lahore General Hospital, Lahore, Pakistan.

Sample Size

Three hundred seventy-nine participants were recruited via convenience sampling with an anticipated frequency of 56%5, a confidence interval set at 95%, and 80% power of the test. The calculated sample size was increased up to 10%, leading to a total of 417 participants.

Selection Criteria

Children aged between 6 and 12 years who came to a pediatric unit in the patient department whose parents/guardians provided informed consent were selected. Any children with diagnosed chronic illnesses (e.g., kidney disease, liver disease, malabsorption disorders) affecting Vitamin D metabolism and those on Vitamin D supplementation for the past 3 months were excluded from participation.

Study Protocol

Data collection was conducted by a trained research team, and permissions were obtained

from hospital administration and relevant health authorities. A structured questionnaire in English and Urdu was used to collect demographic details (age, gender, socioeconomic status), dietary intake, sun exposure, and clinical history.

Blood samples were collected from participants to measure serum 25-hydroxyvitamin D levels and analyzed at Chughtai Lab. Based on Endocrine Society Guidelines, vitamin D deficiency was defined as <20 ng/mL, insufficiency as 20-30 ng/mL, and sufficiency as >30 ng/mL.

Ethical Considerations

The study was approved by the institutional ethics committee of Lahore General Hospital, and written informed consent was obtained from parents/guardians before data collection. Participants' confidentiality and anonymity were maintained.

Data Analysis

Data were entered into SPSS version 22.0 for analysis. Descriptive statistics were used to summarize categorical variables as frequencies and percentages, while continuous variables (e.g., age, serum Vitamin D levels) were expressed as mean±standard deviation (SD). The chi-square test was applied to determine associations between Vitamin D deficiency and determinants such as sunlight exposure, dietary intake, and socioeconomic status. A p-value <0.05 was considered statistically significant.

RESULTS

Table-1 presents the baseline characteristics of the 417 children included in the study and their serum vitamin D levels. The average age for participants was 8.1±2.9 years, whereas individuals with vitamin D deficiency had a lower mean age of 7.1±1.2 years (p = 0.329). The children included in the study were predominantly boys (61.15% males), while 38.84% were females. Vitamin D deficiency (<20 ng/mL) was detected in 244 children out of 417. Among the 69 responders (16.54%), vitamin D insufficiency was defined as falling into the range of 21-29.9 ng/mL, while 104 (24.9%) children were in normal vitamin D levels (>30 ng/mL).

Table-2 summarizes the determinations of vitamin D deficiency among study participants. Significantly, less than 30 minutes of sunlight daily was associated with vitamin D deficiency, as 70% of vitamin D deficient and 60% of insufficient children fell into this category compared to 44.8% in the sufficient group (p = 0.026). Parental education was yet another factor. Primary education or lower was standard in 52.5% of vitamin D-deficient children, compared to 46.7% in the insufficient group and 52.2% in the sufficient group (p=0.027).

Table-1 Level of serum vitamin D levels among children

Baseline Characteristics	Total number of participants *n* = 417 (%)	Serum vitamin D levels ng/ml	p-value
Age in years (*Mean±SD)*	8.1±2.9	7.1±1.2	0.329
Gender			
Male	255 (61.15)		
Female	162 (38.84)		
Vitamin D Deficiency	244 (58.51)	< 20	< 1.30
Vitamin D Insufficiency	69 (16.54)	21 – 29.9	1.30 – 1.48
Vitamin D Sufficiency	104 (24.9)	> 30	> 1.48

DISCUSSION

As revealed by this study's findings, most children aged 6-12 years suffer from vitamin D deficiency, where 58.51% of them had serum vitamin D levels below 20 ng/mL. These findings are consistent with previous studies showing extensive vitamin D deficiency in children. Significant various determinants for vitamin D deficiency were identified. Sunlight exposure of less than 30 minutes daily correlated strongly with lower vitamin D levels. Previous studies also support this by stressing the importance of ultraviolet B (UVB) exposure for endogenous vitamin D synthesis.

A South Asian study reported that many children with minimal sun exposure are vitamin D deficient. Other barriers to sufficient vitamin D production include a lack of outdoor activities and overuse of sunscreens. These must be utilized to make

Table-2 Determinants of Vitamin D Deficiency

Variable	Vitamin D Deficient (<20 ng/mL) (n=200)	Vitamin D Insufficient (20-30 ng/mL) (n=150)	Vitamin D Sufficient (>30 ng/mL) (n=67)	p-value
Sunlight Exposure (<30 min/day) (%)	140 (70%)	90 (60%)	30 (44.8%)	0.026
Low Dairy Intake (%)	130 (65%)	85 (56.7%)	40 (59.7%)	0.033
Socioeconomic Status; n (%)				
Low	63 (31.5%)	75 (50%)	16 (23.88%)	0.042
Middle	114 (57.0%)	55 (36.7%)	39 (58.20%)	0.058
High	23 (11.5%)	20 (4.79%)	12 (17.91%)	0.072
Parental Education (Primary or below) (%)	105 (52.5%)	70 (46.66%)	35 (52.23%)	0.027
Underweight (%)	75 (37.5%)	65 (43.3%)	21 (31.34%)	0.036
Normal weight (%)	85 (42.5%)	55 (36.66%)	35 (52.23%)	0.021
Overweight/Obese (%)	40 (20%)	35 (23.3%)	11 (1.41%)	0.046

public health campaigns on outdoor activities happen, mainly when the sun is high above. Another principal factor was the dietrical consumption. Most of the vitamin D-deficient children were low in dairy consumption, which agrees with earlier studies indicating that the vitamin intake levels in the diet are directly associated with its deficiency. An African study reported that of 4509 children with a median age of 2.3 months, lower dietary vitamin intake in amounts was observed[13]. Fortified dairy products also account for a significant source of dietary vitamin D in many areas, and because of their insufficient intake, part of the serum is reduced.

On the contrary, a lower incidence of vitamin D deficiency is reported in countries where such interference with staple food fortification exists[14-15]. It indicates the importance of fortification or dietary supplementation in disfavored high-risk groups. It also turned out that socioeconomic status is related to vitamin D levels. There was a significantly higher prevalence of vitamin D deficiency among children from lower socioeconomic groups than their middle and high socioeconomic counterparts. Such factors, among others, form the basis for improving the standard of nutrition and limiting outdoor activity due to environmental conditions while remaining ignorant about how vitamin D is obtained. Other investigations within developing nations have also produced similar lines. Income constraints keep people away from vitamin D-rich foods and supplements[16]. Thus, children from more affluent families would be more likely to have sufficient vitamin D due to better access to health care and proper nutritional awareness[17].

The current study has a few strengths and limitations. One of the strengths of this study is its relatively large sample size, which enhances the generalizability of the findings. Additionally, the study incorporated multiple potential determinants of vitamin D deficiency, providing a comprehensive analysis of contributing factors. Including dietary and environmental factors offers a holistic understanding of the issue, which can inform targeted interventions. However, the study has certain limitations. First, it is a cross-sectional study, which limits the ability to infer causality between identified factors and vitamin D deficiency. Longitudinal studies would be required to establish definitive causal relationships. Second, self-reported measures of sun exposure and dietary intake may be subject to recall bias, potentially affecting the accuracy of the data. Third, genetic and ethnic factors influencing vitamin D metabolism were not accounted for, which may affect individual variations in vitamin D levels. Future studies could consider genetic predispositions and their interactions with environmental and dietary factors.

CONCLUSION

The findings highlight the need for multi-faceted interventions, including public health campaigns promoting adequate sun exposure, dietary modifications, and potential fortification programs.

Healthcare providers should educate parents about the importance of vitamin D, encourage routine screening in high-risk populations, and advocate for policies that ensure better nutritional support for children in low-income settings.

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None.

Author Contributions
Muhammad Asim Zahoor contributed to the conceptualization, study design, and drafting of the manuscript. **Iqra Aslam** was responsible for data collection and initial analysis. **Shumaila Fatima** conducted the literature review and assisted in manuscript editing. **Zulfiqar Ali** performed the statistical analysis and data interpretation. Hafiz **Muhammad Usman** contributed to data validation and provided a critical review. **Farhan Rasheed** supervised the study and gave final approval for the manuscript.

Ethical Approval
This study received approval from the Institutional Review Board (Ref No: LGH/IRB/2023-047) of Lahore General Hospital, Lahore, Pakistan.

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None.

Conflict of Interests
None.

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