https://doi.org/10.48047/AFJBS.6.16.2024.3239-3245

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Exploring Vitamin D Deficiency: Prevalence and Risk Factors in Children with Chronic Conditions

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Volume 6, Issue 16, Dec 2024

Received: 09 Nov 2024

Accepted: 29 Nov 2024

Published: 15 Dec 2024

doi:10.48047/AFJBS.6.16.2024.3239-3245

ABSTRACT

Background: 'Vitamin D deficiency is a prevalent global health issue, particularly in children with chronic illnesses. Despite its essential role in bone health, immunity, and growth, this deficiency remains under-recognized in vulnerable populations, including those with chronic conditions'. Limited local data exists on its 'prevalence and associated risk factors' in children in Pakistan. To determine the prevalence of vitamin D deficiency in children with chronic illnesses and identify associated demographic, clinical, and environmental risk factors'.

Methods: This cross-sectional study was conducted at Muhammad College of Medicine, Peshawar, from January 2023 to January 2024. A total of 101 children aged 1–16 years with chronic illnesses were included. 'Serum 25-hydroxyvitamin D (25(OH)D) levels were measured, and data on demographics, sunlight exposure, dietary habits, and clinical conditions were collected'. Vitamin D deficiency was defined as serum 25(OH)D levels below 20 ng/mL. Statistical analyses were performed to identify significant associations.

Results: 'The prevalence of vitamin D deficiency was' 65.3%. 'Children aged 5–10 years' exhibited the highest deficiency rates (44.6%), followed by those >10 years (30.7%) and <5 years (24.8%) (P=0.032). Significant risk factors included low socioeconomic status (P=0.041), limited sunlight exposure (<2 hours/week, P=0.015), urban residency (P=0.018), and chronic illnesses such as asthma '(P=0.027) and chronic kidney disease'. Vitamin D supplementation was a protective factor (P=0.002). Family history of deficiency and exposure to second-hand smoke were also significantly associated with deficiency.

Conclusion: Vitamin D deficiency is highly prevalent in children with chronic illnesses, with multiple modifiable risk factors identified. Targeted interventions, including increased sunlight exposure, dietary improvements, and routine supplementation, are essential to address this health concern.

Keywords: Vitamin D deficiency, chronic illnesses, children, risk factors, sunlight exposure, supplementation, Pakistan

INTRODUCTION

Vitamin D plays a critical role in maintaining bone health, immune function, and overall growth in children[1]. Despite its importance, vitamin D deficiency remains a widespread global health concern, particularly among children with chronic illnesses. This deficiency is not only a major cause of rickets and impaired bone mineralization but has also been linked to a range of other health complications, including increased susceptibility to infections, autoimmune diseases, and poor management of chronic conditions such as asthma and diabetes[2].

Children with chronic illnesses are particularly vulnerable to vitamin D deficiency due to several factors[3]. These include reduced outdoor activity, dietary restrictions, and the potential interference of certain medications with vitamin D metabolism. Additionally, socioeconomic and environmental factors, such as limited access to sunlight, urban living, and poor nutritional intake, further exacerbate this problem. 'Studies have consistently shown that the prevalence of vitamin D deficiency is higher in this group compared to healthy children, highlighting the need for focused research and intervention' [4, 5].

In Pakistan, 'vitamin D deficiency is a growing concern, yet data on its prevalence and associated risk factors in children with chronic illnesses is limited'. Understanding the extent of the problem and identifying key risk factors are crucial steps in developing effective prevention and management strategies. This study aims to assess the prevalence of vitamin D deficiency in children with chronic illnesses and explore the demographic, clinical, and environmental factors contributing to this deficiency. By shedding light on these aspects, the findings can inform targeted interventions to improve health outcomes in this vulnerable population.

METHODOLOGY

This study aimed to investigate the prevalence and risk factors of vitamin D deficiency in children with chronic illnesses. It was conducted at the Department of Pediatrics, Muhammad College of Medicine, Peshawar, over a one-year period from January 2023 to January 2024. The research design, participant selection, data collection, and analysis procedures were detailed below.

This was a 'descriptive cross-sectional study' designed to evaluate the prevalence of vitamin D deficiency and identify associated risk factors among children with chronic medical conditions. 'The study included a total of 101 children aged 1–16 years diagnosed with chronic illnesses, who were attending outpatient clinics or admitted to the pediatric ward during the study period'. Chronic illnesses were defined as conditions lasting more than three months, including but not limited to 'asthma, epilepsy, diabetes mellitus, and chronic kidney disease'. 'Ethical approval was obtained from the Institutional Review Board of Muhammad College of Medicine, Peshawar'. Written informed consent was obtained from parents or legal guardians of all participants before enrollment in the study. Confidentiality and anonymity of all participants were strictly maintained.

Inclusion criteria

- Children aged 1–16 years with a confirmed diagnosis of a chronic illness.
- 'Consent obtained from parents or legal guardians'.

Exclusion criteria

- Children already receiving high-dose vitamin D supplementation (more than 1,000 IU/day for over three months).
- Children with acute illnesses, malignancies, or genetic disorders affecting bone metabolism.

Participants were selected using a convenience sampling method.

1. Demographic and Clinical Data

Data were collected through structured interviews with parents/guardians and reviews of medical records. Demographic variables included age, sex, socioeconomic status, and urban/rural residency. Clinical data included the type and duration of chronic illness, sunlight exposure, dietary habits, physical activity levels, and vitamin D supplementation.

2. Laboratory Measurements
Blood samples were collected from all participants to measure serum 25-hydroxyvitamin D (25(OH)D), calcium, phosphorus, and parathyroid hormone (PTH) levels. Vitamin D deficiency was defined as serum 25(OH)D levels below 20 ng/mL.

3. Environmental Factors
Information on household size, exposure to secondhand smoke, and family history of vitamin D deficiency was recorded.

4. Sunlight Exposure and Diet
Data on weekly sunlight exposure were collected and categorized as <2 hours, 2–4 hours, and >4 hours per week. 'Dietary intake of vitamin D-rich foods, including milk, fish, and fortified products, was assessed using a food frequency questionnaire'.
Data were analyzed using SPSS version 26. Descriptive statistics were used to summarize demographic, clinical, and laboratory findings. Continuous variables were expressed as means and standard deviations, while categorical variables were presented as frequencies and percentages. Chi-square tests were performed to assess associations between categorical variables, and independent t-tests were used for continuous variables. A P-value <0.05 was considered statistically significant.

RESULT

The study included 101 children with chronic illnesses, and their demographic distribution highlighted several key points. Children aged 5–10 years represented the largest group, accounting for 44.6% of the sample, while those under 5 years made up 24.8%, and the remaining 30.7% were older than 10 years. The difference in vitamin D deficiency across these age groups was statistically significant (P=0.032), suggesting that younger children may have a higher vulnerability. In terms of sex distribution, the sample was nearly evenly split, with 55.4% being male and 44.6% female, 'but the difference was not statistically significant (P=0.213)'. Urban residents formed a substantial majority at 71.3%, with rural children making up only 28.7%. Interestingly, urban residency 'showed a significant association with vitamin D deficiency (P=0.018)'. Socioeconomic status was another important factor, as children from low-income families exhibited a significantly higher prevalence of deficiency (P=0.041).

Table 1 Demographic Characteristics of the Study Population

Variable	Frequency (n=101)	Percentage (%)	P-value
Age Group (years)			
<5	25	24.8	0.032*
5–10	45	44.6	
>10	31	30.7	
Sex			
Male	56	55.4	0.213
Female	45	44.6	
Geographical Location			
Urban	72	71.3	0.018*
Rural	29	28.7	
Socioeconomic Status (SES)			
Low	40	39.6	0.041*
Medium	45	44.6	
High	16	15.8	

Children in the study presented with diverse chronic illnesses, including asthma (29.7%), chronic kidney disease (24.8%), diabetes mellitus (19.8%), epilepsy (14.9%), and other conditions (10.8%). Among these, asthma 'showed a statistically significant association with vitamin D deficiency (P=0.027)'. The duration of illness was also relevant, with children experiencing illness for less than six months showing a higher deficiency prevalence (P=0.048). Vitamin D supplementation was a protective factor, as children who took supplements had significantly lower deficiency rates compared to those who did not (P=0.002). Sunlight exposure emerged as a critical factor, with children receiving less than two hours of sunlight per week being at a markedly higher risk (P=0.015). This finding underscores the importance of outdoor activity and adequate sunlight in maintaining healthy vitamin D levels.

Table 2 Clinical Characteristics and Risk Factors

Variable	Frequency (n=101)	Percentage (%)	P-value
Types of Chronic Illnesses			
Asthma	30	29.7	0.027*
Diabetes Mellitus	20	19.8	
Chronic Kidney Disease	25	24.8	
Epilepsy	15	14.9	
Others	11	10.8	
Duration of Illness (months)			
<6	35	34.7	0.048*
6–12	50	49.5	
>12	16	15.8	
Vitamin D Supplementation			
Yes	20	19.8	0.002*
No	81	80.2	
Sunlight Exposure (hours/week)			
<2	50	49.5	0.015*
2–4	35	34.7	
>4	16	15.8	

The laboratory results indicated that the mean serum 25-hydroxyvitamin D (25(OH)D) level among the children was 18.2 ± 5.6 ng/mL, with 65.3% of the sample falling below the recommended threshold. This highlights a significant prevalence of vitamin D deficiency in the study population (P=0.001). Elevated parathyroid hormone (PTH) levels were observed in 55% of the children and were significantly associated with vitamin D deficiency (P=0.041), suggesting a compensatory physiological response to low vitamin D levels. However, calcium and phosphorus levels, although measured, did not show a significant association with deficiency in this population, with P-values of 0.112 and 0.087, respectively.

Table 3 Laboratory Results of Study Participants

Variable	Mean ± SD	Deficiency Rate (%)	P-value
Serum 25(OH)D Levels (ng/mL)	18.2 ± 5.6	65.3	0.001*
Calcium Levels (mg/dL)	8.9 ± 0.8	–	0.112
Phosphorus Levels (mg/dL)	4.5 ± 0.6	–	0.087
Parathyroid Hormone (PTH) Levels (pg/mL)	75.4 ± 20.3	Elevated in 55%	0.041*

'Family and environmental factors also played a role in the prevalence of vitamin D deficiency'. 'A family history of deficiency was reported in 39.6% of the children, and this was significantly associated with their own deficiency status (P=0.033)'. Larger household sizes (more than six members) 'were associated with a higher risk, with the smallest households (<4 members) showing a statistically significant difference (P=0.044)'. Second hand smoke exposure was another critical risk factor, with 44.6% of the children exposed to it. This exposure was significantly linked to vitamin D deficiency (P=0.029), indicating a possible interaction between environmental pollutants and nutritional health.

Table 4 Family, Environmental, and Behavioral Risk Factors

Variable	Frequency (n=101)	Percentage (%)	P-value
Family History of Vitamin D Deficiency	Yes	40	39.6
	No	61	60.4
Household Size			
<4	30	29.7	0.044*
4–6	55	54.5	

>6	16	15.8	
Exposure to Secondhand Smoke	Yes	45	44.6
	No	56	55.4

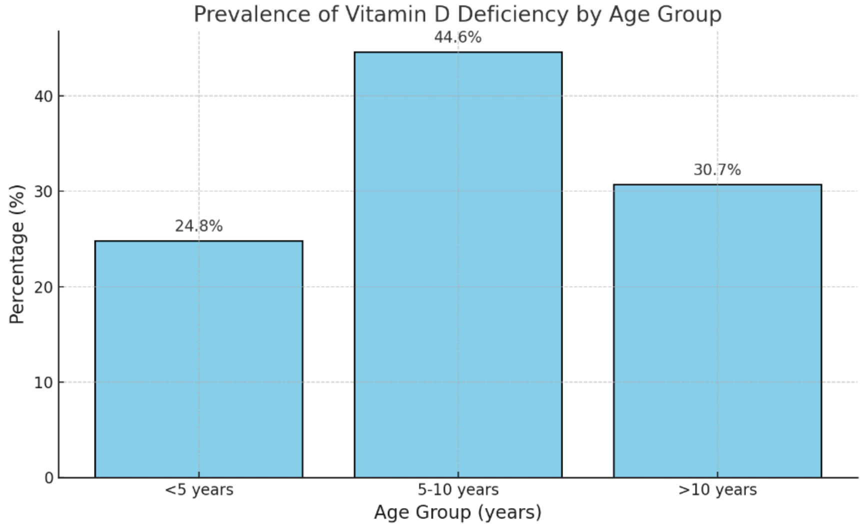

Figure 1: shows the prevalence of vitamin D deficiency across age groups. Children aged 5–10 years had the highest deficiency rate (44.6%), followed by those >10 years (30.7%) and <5 years (24.8%). The significant difference (P=0.032) highlights the vulnerability of school-aged children, likely due to increased growth demands and limited sunlight exposure. These findings 'emphasize the need for targeted interventions' like improved nutrition and outdoor activity tailored to age-specific requirements.

DISCUSSION

The findings of 'this study revealed a high prevalence of vitamin D deficiency among children with chronic illnesses' with 65.3% of participants having serum '25-hydroxyvitamin D (25(OH)D) levels below 20 ng/mL'. These results align with previous studies, which report that children with chronic health conditions were at a greater risk of vitamin D deficiency due to factors such as limited sunlight exposure, dietary restrictions, and disease-specific metabolic disruptions[6-8].

Children aged 5–10 years were the most affected group in this study, with 44.6% showing significant deficiency. This trend has been corroborated by research highlighting that school-aged children are particularly vulnerable due to increased nutritional demands during growth spurts and reduced outdoor activity. A studies similarly reported that school-aged children often exhibit lower vitamin D levels compared to younger children, who benefit from closer parental monitoring of nutrition and supplementation[9-11].

'The study found a significant association between asthma and vitamin D deficiency (P=0.027)'. This finding supports research indicating 'that vitamin D plays an immunomodulatory role, and its deficiency is linked to increased inflammation and poorer respiratory outcomes in asthmatic children'. Chronic kidney disease also showed a high prevalence of deficiency, consistent with studies indicating impaired renal hydroxylation of vitamin D in such patients, which exacerbates the deficiency[12, 13].

Limited sunlight exposure (<2 hours per week) was significantly associated with vitamin D deficiency (P=0.015). This supports studies emphasized the role of ultraviolet B radiation in endogenous vitamin D synthesis. Urban residency was another significant factor (P=0.018), likely due to limited outdoor activity and the use of sun-protective clothing. These findings underscore the importance of outdoor play and adequate sunlight exposure, especially in urban environments[14-16].

Only 19.8% of children in this study reported using vitamin D supplements, and this group showed a significantly lower prevalence of deficiency (P=0.002). This aligns with evidence from studies advocating for routine supplementation in at-risk populations. Moreover, dietary intake of vitamin D-rich foods was low, consistent with global trends highlighting insufficient consumption of fortified products and natural sources like fatty fish and eggs[17, 18].

The significant association between family history of deficiency (P=0.033) and vitamin D levels aligns with genetic and environmental studies, suggesting that shared dietary and lifestyle habits may influence vitamin D status[19, 20]. Additionally, exposure to secondhand smoke (P=0.029) has been linked to altered metabolism and increased oxidative stress, which may further compound the deficiency.
The prevalence of deficiency observed in this study was comparable to findings, where rates range between 60–70% in children with chronic illnesses[21]. However, the results were slightly higher than those reported in Western countries, where routine supplementation and fortification practices are more common.
The findings of this study highlight the urgent need for targeted public health interventions, including awareness campaigns on the importance of sunlight exposure, dietary improvements, and routine vitamin D supplementation. Special attention should be given to school-aged children and those with chronic conditions like asthma and chronic kidney disease. Screening programs and policies aimed at fortifying staple foods with vitamin D could also help reduce the prevalence of deficiency.
This study was limited by its cross-sectional design, which precludes establishing causal relationships. 'Additionally, the use of convenience sampling may limit the generalizability of the findings to the wider pediatric population'. Future research should focus on longitudinal studies to better understand the interplay between chronic illnesses and vitamin D metabolism.

CONCLUSION

This study highlights a significant prevalence of vitamin D deficiency among children with chronic illnesses, with two-thirds of the participants having serum 25-hydroxyvitamin D levels below the recommended threshold. Age, sunlight exposure, urban residency, and chronic conditions like asthma and chronic kidney disease emerged as critical risk factors. The findings underscore the need for tailored interventions, including routine vitamin D supplementation, increased outdoor activities, and dietary modifications to improve vitamin D status. Additionally, addressing environmental factors, such as secondhand smoke exposure and urban living constraints, can further mitigate the risk.
By implementing targeted public health strategies and increasing awareness among caregivers and healthcare providers, the burden 'of vitamin D deficiency in this vulnerable population' can be significantly reduced, leading to better overall health outcomes. Future studies should aim to explore longitudinal trends and the impact of preventive measures in children with chronic illnesses.

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