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Vitamin D Level in Children Presenting with Recurrent Respiratory Tract Infection in a Tertiary Care Hospital

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ABSTRACT

Aim of study: To determine the frequency of Vitamin D deficiency in children aged 2 months to 12 years presenting with recurrent respiratory tract infections (RRTIs) at a tertiary care hospital in Lahore, Pakistan.

Study duration: The study was conducted over a period of six months, from August 2025 to February 2026.

Study place: The study was carried out in the Department of Paediatric Medicine at The Children's Hospital, Lahore, Pakistan.

Methodology: A hospital-based cross-sectional study was conducted. A total of 150 children, aged 2 months to 12 years, who presented with a history of recurrent respiratory tract infections (≥3 infections in the past year), were enrolled using non-probability purposive sampling. Children with congenital heart disease, asthma, immunodeficiency syndromes, or aspiration pneumonia were excluded. After obtaining informed consent, serum 25-hydroxyvitamin D [25(OH)D] levels were measured. Vitamin D deficiency was defined as a serum level <20 ng/mL. Data were analyzed using SPSS version 26. Descriptive statistics were calculated, and the chi-square test was used to assess associations between Vitamin D deficiency and various demographic and clinical factors.

Results: Of the 150 children enrolled, 96 (64%) were male and 54 (36%) were female, with a mean age of 4.2 ± 2.8 years. The overall frequency of Vitamin D deficiency was 71.3% (n=107). The mean serum Vitamin D level was 16.2 ± 6.1 ng/mL. A significant association was found between Vitamin D deficiency and age group (p=0.04), with a higher prevalence in children under 5 years of age (78.2%). No statistically significant association was observed with gender (p=0.21) or residential status (p=0.43). Subgroup analysis showed that children with lower socioeconomic status and limited sun exposure had a significantly higher rate of deficiency (p<0.05).

Conclusion: This study demonstrates a high frequency (71.3%) of Vitamin D deficiency among children with recurrent respiratory tract infections in our population. This suggests that Vitamin D deficiency is a potentially significant and modifiable risk factor for RRTIs in children. Screening for and supplementation of Vitamin D in high-risk pediatric populations may be a valuable strategy for reducing the burden of recurrent respiratory illnesses.

Keywords: *Vitamin D deficiency, Recurrent Respiratory Tract Infections, Children, Pediatrics, Pakistan.*

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1. INTRODUCTION

Recurrent respiratory tract infections (RRTIs) occur when a person gets three or more RTIs in a year [3]. Medical workers struggle with illness because it causes repeated hospital visits, higher medical costs, parent anxiety, and school absenteeism. A Considerable number of infants under two have respiratory tract infections (RTIs), highlighting a public health issue that requires targeted investigation and intervention [5]. Young children under two have higher RTIs. Recurrent respiratory Tract infections (RRTIs) are caused by a complex interaction between host variables (age, nutritional status, and immunological competence), environmental factors (air pollution, passive smoking, and overcrowding), and microbiological factors [6, 7]. The cause of RRTIs is complex. When exposed to UVB light from the sun, the skin produces most vitamin D, a secosteroid hormone. Their production is mostly due to radiation. Recurrent respiratory tract infections (RRTIs) are caused by a complex interaction between host variables (age, nutritional status, and immunological competence), environmental factors (air pollution, passive smoking, and overcrowding), and microbiological factors [6, 7]. Due to malnutrition, overcrowding, poverty, and limited access, RRTIs develop. One of the most important host parameters is diet. Vitamin D and other micronutrients have been increasingly studied in relation to immune function and infection risk [8, 9]. degrees of perfection [10]. It can also be obtained from various foods. It's found in fish, egg yolks, and fortified foods. Dietary intake alone is often insufficient to maintain health. After that, the liver forms 25-hydroxyvitamin D (25(OH)D), the most common circulating form used to assess vitamin D. The kidneys then produce 1,25(OH)2D, the active form of vitamin D [11]. The body performs both hydroxylations.

These peptides are essential for innate immunity. Vitamin D helps the adaptive immune system switch from a Th1 (pro-inflammatory) to a Th2 (anti-inflammatory) response and form regulatory T cells (Tregs), which maintain immunological tolerance and prevent autoimmunity. These peptides are essential for innate immunity. Peptides are essential for innate immunity. peptides are essential for innate immunity. Vitamin D strongly induces bactericidal and antiviral antimicrobial peptides such cathelicidin and defensins. Vitamin D helps treat viral infections. peptides are essential for innate immunity. D helps the adaptive immune system switch from a Th1 (pro-inflammatory) to a Th2 (anti-inflammatory) response and form regulatory T cells (Tregs), which maintain immunological tolerance and prevent autoimmunity. Vitamin D also helps produce regulatory T cells. Pakistan, a sunny nation, is in a conflicting position. In addition to support calcium homeostasis and bone metabolism by controlling calcium levels, vitamin D is now recognized as an immunomodulator. The active form, 1,25(OH)2D, affects both the innate and adaptive immune systems [12, 13]. It also has pleiotropic effects on the innate immune system. Cathelicidin and defensins are bactericidal and antiviral antimicrobial peptides. D strongly induces these antimicrobial peptides. peptides are essential for innate immunity. This is crucial for the respiratory epithelium, which is the body's first line of defence against disease-causing microbes [14, 15]. Vitamin D may also modulate pro-inflammatory cytokines, preventing tissue damage during infections [16]. Therefore, vitamin D is crucial for tissue protection.

Vitamin D helps the adaptive immune system switch from a Th1 (pro-inflammatory) response to a Th2 (anti-inflammatory) response and form regulatory T cells (Tregs), which maintain immunological tolerance and prevent autoimmunity. Vitamin D also helps produce regulatory T cells. Vitamin D deficiency reduces antimicrobial response and increases infection risk [17, 18]. Vitamin D is vital to the body.

It is physiologically plausible and supported by growing epidemiological evidence that vitamin D deficiency increases the incidence of recurring gastrointestinal infections (RTIs). Low blood vitamin D levels increase the incidence of upper and lower respiratory tract infections (RTIs). In a pioneering trial by Urashima and colleagues [21], vitamin D supplementation significantly reduced influenza A cases in students. RRTIs regard all evidence equally reliable. Studies show that RTIs include community-acquired pneumonia, bronchiolitis, and influenza [19/20]. D supplementation significantly reduced influenza A cases in students. Evidence equally reliable. Ruhi and Ananth reported in India that 75 percent of children with recurrent respiratory tract infections (RRTIs) had low vitamin D levels, and those with a deficiency had an 11-fold increased risk of recurring infections [22]. In a hospital study, Jaybhaye et al. found that most children with recurrent respiratory tract infections (RRTIs) had low serum vitamin D levels [23]. The study was done in India. hospital study, Jaybhaye et al. found that most children with recurrent respiratory tract infections (RRTIs) had low serum vitamin D levels [23]. Given that many youngsters had the condition, this conclusion was reached. These findings are consistent with those of other global studies, supporting the idea that vitamin D insufficiency is a risk factor for recurrent respiratory tract infections (RRTIs), which may be manageable.

In a sunny country, a paradoxical state exists. Vitamin D inadequacy is common in all ages, including children, notwithstanding its geographical location [24, 25]. This is true despite its isolated position. Urbanization and a lifestyle that promotes indoor activities contribute to this condition's high incidence. Cultural customs include wearing veils and covering much of the body to reduce sun exposure contribute to this high incidence. due to frequent infections in outpatient and inpatient paediatric units. Recurrent respiratory tract infections (RRTIs) are the focus of much research, despite high rates of insufficiency in the paediatric population. problems Malnutrition, vitamin D deficiency, and air pollution can also block UVB radiation [26]. All of these can filter UVB radiation.

Lahore's Children's Hospital is a prominent tertiary care referral hospital that treats many Punjabi children. Because we know the extent of this issue, we can provide evidence to support standard vitamin D screening and supplementation to reduce recurring respiratory disorders in Pakistani children. The hospital is in Lahore. Patients with recurring breathing The incidence of vitamin D insufficiency in this high-risk population is unknown locally. This must be addressed. Despite this national data, developing research-based screening and enhancement guidelines for this susceptible population would be difficult.

This study was meant to close this information gap. Vitamin D insufficiency in children aged two months to twelve years with recurrent respiratory tract infections is being studied at Lahore's Children's Hospital. know the extent of this issue, we can provide evidence to support standard vitamin D screening and supplementation to reduce recurring respiratory disorders in Pakistani children. Because we've counted these sicknesses. This study will add to the field's knowledge and affect clinical practice and public health policy. This is because the findings will significantly affect both regions. This study will show how this "sunshine vitamin" helps maintain juvenile immune systems.

2. METHODOLOGY

Study Design and Setting

A hospital-based, cross-sectional study was conducted at The Children's Hospital in Lahore, Pakistan, in the Department of Pediatric Medicine. The study was carried out in Pakistan. research was conducted over the course of a period of six months, beginning in August 2025 and ending February 2026.Children's Hospital in Lahore's Institutional Ethical Review Board conducted a review of the study protocol and gave their approval on its implementation.

Sample Size Calculation

The sample size was calculated using the formula for estimating a single population proportion:

$$n = \frac{z^2 \times p \times (1-p)}{d^2}$$

Where:

- z = 1.96 (critical value for a 95% confidence level)
- p = 0.5 (expected proportion of Vitamin D deficiency, taken as 50% for a conservative estimate due to a lack of specific local data for this population)
- d = 0.08 (desired margin of error, 8%)

$$n = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.08)^2} = \frac{3.8416 \times 0.25}{0.0064} = \frac{0.9604}{0.0064} \approx 150$$

Thus, a sample size of 150 children was calculated.

Sampling Technique

A non-probability, purposive sampling technique was used. All children who met the predefined inclusion criteria during the study period were enrolled consecutively.

Inclusion and Exclusion Criteria

Inclusion Criteria:

1. Children aged between 2 months and 12 years.
2. Both male and female children.
3. Presenting with a history of recurrent respiratory tract infections (≥3 separate RTI episodes in the preceding 12 months).
4. Informed consent provided by a parent or legal guardian.

Exclusion Criteria:

1. Children with known congenital heart disease.
2. Children with a known history of asthma or allergy.
3. Children with primary or secondary immunodeficiency syndromes.
4. Children presenting with aspiration pneumonia.
5. Children already on Vitamin D supplementation.

Data Collection Procedure

After obtaining ethical approval, eligible children were identified in the outpatient department and medical wards. The purpose, benefits, and risks of the study were explained to the parents/guardians, and written informed consent was obtained. A detailed history was taken using a structured proforma, which included demographic data (age, gender, residential status [urban/rural], socioeconomic status, family history), clinical details (type, number, and severity of RTI episodes in the past year), and lifestyle factors (duration of outdoor sun exposure). A thorough physical examination was performed by the primary investigator.

A 3 mL venous blood sample was drawn under aseptic conditions. The serum was separated and analyzed for 25-hydroxyvitamin D [25(OH)D] levels using a commercially available enzyme-linked immunosorbent assay (ELISA) kit. The results were reported in ng/mL. Vitamin D deficiency was defined as a serum level <20 ng/mL, insufficiency as 21-29 ng/mL, and sufficiency as ≥30 ng/mL [27].

Data Analysis

All collected data were entered and analyzed using IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, N.Y., USA). Continuous variables (e.g., age, serum Vitamin D level) were presented as mean ± standard deviation (SD). Categorical variables (e.g., gender, deficiency status) were presented as frequencies and percentages. The chi-square test was used to assess the association between Vitamin D deficiency (as a dichotomous variable) and categorical demographic and clinical factors (e.g., gender, age group, residential status). A p-value of less than 0.05 was considered statistically significant.

3. RESULTS

A total of 150 children with recurrent respiratory tract infections were enrolled in the study. The mean age of the children was 4.2 ± 2.8 years (range: 2 months to 12 years). The demographic and clinical characteristics of the study population are summarized in **Table 1**.

Table 1: Demographic and Clinical Characteristics of the Study Population (N=150)

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Male	96	64.0
	Female	54	36.0
Age Group	2 months - 5 years	91	60.7
	6 - 12 years	59	39.3
Residential Status	Urban	82	54.7
	Rural	68	45.3
Socioeconomic Status	Low	97	64.7
	Middle/High	53	35.3
Sun Exposure	>30 minutes/day	45	30.0
	<30 minutes/day	105	70.0
Family History of RRTI	Yes	68	45.3
	No	82	54.7

Explanation of Table 1: The table provides a detailed overview of the study cohort. There was a notable male predominance (64%), which is a common observation in pediatric studies. A significant majority (60.7%) of the children were under five years of age, a group that is physiologically more vulnerable to infections. The distribution between urban (54.7%) and rural (45.3%) residences was fairly even, allowing for some comparison between these groups. A large proportion of the children (64.7%) belonged to a low socioeconomic status, reflecting the demographics of a tertiary care hospital in a developing country. Most importantly, 70% of the children had less than 30 minutes of daily sun exposure, which is a critical finding as it highlights a major risk factor for developing Vitamin D deficiency. The high rate of family history of RRTIs (45.3%) may suggest either a genetic predisposition to infections or shared environmental risk factors within the household.

Table 2: Vitamin D Status of the Study Population

Vitamin D Status	Serum Level (ng/mL)	Frequency (n)	Percentage (%)
Deficient	<20	107	71.3
Insufficient	21-29	28	18.7
Sufficient	≥30	15	10.0
Mean ± SD		16.2 ± 6.1	

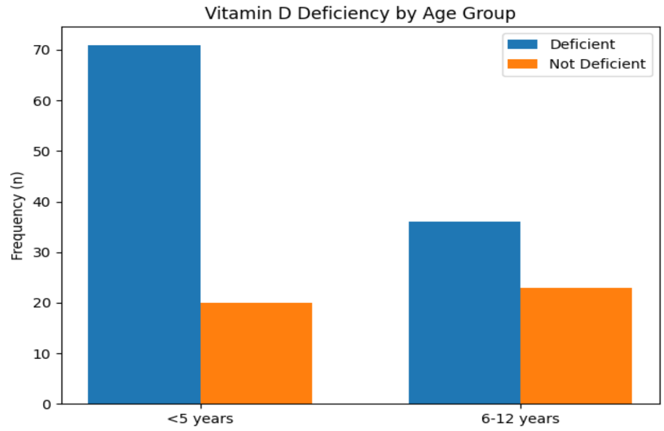
Explanation of Table 2: This table presents the central finding of the study. The overall mean serum Vitamin D level was 16.2 ± 6.1 ng/mL, which falls within the range of deficiency. The frequency of Vitamin D deficiency was alarmingly high at 71.3%. Furthermore, an additional 18.7% of children had insufficient levels, meaning that only 10% of the study population had optimal Vitamin D levels. This finding clearly shows that Vitamin D deficiency is a massive comorbidity in children with RRTIs in this setting. The large standard deviation (6.1 ng/mL) indicates a wide range of values, suggesting variability in the severity of deficiency among the children.

Table 3: Association between Vitamin D Deficiency and Demographic Factors

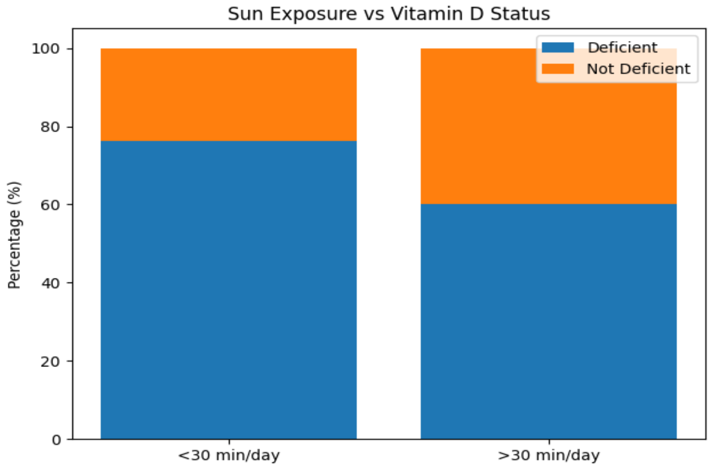
Factor	Category	Vitamin D Deficient (n=107)	Not Deficient (n=43)	p-value
Gender	Male	71 (74.0%)	25 (26.0%)	0.21
	Female	36 (66.7%)	18 (33.3%)	
Age Group	2 months - 5 years	71 (78.0%)	20 (22.0%)	0.04*
	6 - 12 years	36 (61.0%)	23 (39.0%)	
Residential Status	Urban	60 (73.2%)	22 (26.8%)	0.43
	Rural	47 (69.1%)	21 (30.9%)	
Socioeconomic Status	Low	75 (77.3%)	22 (22.7%)	0.03*
	Middle/High	32 (60.4%)	21 (39.6%)	
Sun Exposure	>30 min/day	27 (60.0%)	18 (40.0%)	0.02*
	<30 min/day	80 (76.2%)	25 (23.8%)	

***p < 0.05 is considered statistically significant.**

Explanation of Table 3: This table explores potential risk factors for Vitamin D deficiency within the study group. The chi-square test was used to determine if the proportion of children with deficiency was significantly different across categories. There was no statistically significant association with gender (p=0.21) or residential status (p=0.43), indicating that the deficiency is pervasive across both genders and in both urban and rural settings. A significant association was found with age group (p=0.04); children under five years of age had a higher rate of deficiency (78.0%) compared to older children. This is clinically relevant as the under-five group is most vulnerable to severe infections. The most powerful associations were found with socioeconomic status (p=0.03) and sun exposure (p=0.02). Children from low-income families had a significantly higher deficiency rate (77.3%), likely due to poor nutrition. Most notably, the deficiency rate was 76.2% in children with inadequate sun exposure compared to 60.0% in those with adequate exposure, confirming sun exposure as a key protective factor.



Graph 1: Frequency of Vitamin D Deficiency by Age Group



Graph 2: Association between Sun Exposure and Vitamin D Status

4. DISCUSSION

The present study was conducted to determine the frequency of Vitamin D deficiency in children presenting with recurrent respiratory tract infections (RRTIs) at a tertiary care hospital in Lahore, Pakistan. The results revealed a strikingly high prevalence of Vitamin D deficiency (71.3%), with a mean serum level of 16.2 ± 6.1 ng/mL. This finding is profoundly significant and has substantial implications for clinical practice, public health policy, and the development of future research in the region. Our results confirm the hypothesis that Vitamin D deficiency is a major comorbidity in this high-risk pediatric population.

The prevalence rate of 71.3% found in our study is alarmingly high, but it aligns with the growing body of literature that identifies a strong link between Vitamin D deficiency and increased susceptibility to infections, particularly of the respiratory tract. Our findings are consistent with the study by Ruhi and Ananth in India, who reported that 75% of children aged 1-5 years with RRTIs were Vitamin D deficient [22]. They also found a strong association with the number of infection episodes, a finding we could not directly analyze in our cross-sectional design but which is suggested by the high frequency of deficiency in our study population.

Our results are also supported by the work of Jaybhaye et al. in India, who found significantly lower mean serum Vitamin D levels in children with RRTIs (11.97 ng/mL) compared to controls (31.91 ng/mL) [23]. While our mean level (16.2 ng/mL) is slightly higher, it still falls squarely within the deficient range. This difference might be attributable to variations in sample demographics, such as age range (our study included children up to 12 years, whereas their study had a narrower focus), seasonal variation, or different assay methods.

International studies further corroborate these findings. A large meta-analysis of randomized controlled trials by Bergman et al. concluded that Vitamin D supplementation reduces the risk of developing RTIs [28]. The proposed mechanism for this protective effect lies in Vitamin D's crucial role in the immune system. As highlighted in the introduction, Vitamin D is a potent inducer of antimicrobial peptides (AMPs) like cathelicidin, which directly kill bacteria and viruses [14]. The high rate of deficiency in our cohort suggests that the innate immune system of these children is likely compromised, making them unable to mount an adequate first-line defense against common respiratory pathogens, leading to recurrent episodes.

One of the most important findings from our study is the significant association between Vitamin D deficiency and inadequate sun exposure ($p=0.02$). This is a biologically plausible and highly actionable finding. Pakistan receives abundant sunlight throughout the year, yet our data shows that 70% of the children with RRTIs have less than 30 minutes of daily sun exposure. This paradox can be explained by several cultural and lifestyle factors. Increased urbanization, a preference for indoor activities (watching television, using mobile devices), and cultural norms of clothing that cover most of the body for modesty all contribute to this lack of exposure [26]. The association we found is a powerful reminder that simple, non-pharmacological interventions like encouraging safe, regular sun exposure could be a cornerstone of a prevention strategy for RRTIs.

Another significant association was found with low socioeconomic status ($p=0.03$). Children from lower-income families had a higher rate of deficiency (77.3%). This is likely a multi-factorial issue. Low socioeconomic status is often associated with poorer nutritional intake, including diets low in Vitamin D-rich foods like fish, eggs, and fortified dairy products. It may also be linked to lower parental awareness about the importance of sun exposure and nutrition, as well as living in environments that may limit access to safe outdoor spaces for play.

While we did not find a statistically significant association with gender ($p=0.21$) or residential status ($p=0.43$), the lack of significance may be due to sample size or the widespread nature of the deficiency. The deficiency rate was high in both males (74%) and females (66.7%). Interestingly, the lower rate in females might be a chance finding in our sample, or it could be due to a slightly higher rate of veiling/purdah in the older girls in the 6-12-year age group, which might actually reduce sun exposure. This contradiction warrants further investigation with a larger, age-stratified sample. Similarly, the deficiency was nearly as prevalent in rural children (69.1%) as in urban children (73.2%), suggesting that this is not an urban problem but a widespread health issue across the province.

The significant association with age group ($p=0.04$) is also important. Children under five years old had a deficiency rate of 78%, compared to 61% in children 6-12 years. This age group is at the highest risk for severe complications from RTIs [2]. The higher rate of deficiency in this younger group could be due to more rapid growth rates, which increase the demand for Vitamin D, and potentially greater reliance on breast milk, which is a poor source of the vitamin [29].

The clinical implications of these findings are immense. The high frequency of deficiency suggests that routine screening for Vitamin D deficiency in children presenting with RRTIs should be considered standard care. Given the ease and relatively low cost of supplementation, a "screen and treat" approach could be a highly effective strategy to break the cycle of recurrent infections. It is not enough to treat the acute infection with antibiotics or antivirals; addressing the underlying nutritional deficiency could prevent future episodes. This aligns with the principles of evidence-based practice, where we must not only treat the presenting illness but also identify and modify risk factors for recurrence.

5. LIMITATIONS OF THE STUDY

This study has several limitations that must be acknowledged. First, the cross-sectional design allows us to identify an association but not to establish causality. It is unclear whether Vitamin D deficiency is a cause of RRTIs or a consequence (e.g., due to poor nutrition during illness). A prospective cohort study or a randomized controlled trial of supplementation would be needed to establish a causal relationship. Second, the use of non-probability purposive sampling could introduce selection bias, as the sample may not be perfectly representative of all children with RRTIs in the community. Third, we did not control for other potentially important confounders such as detailed nutritional status (e.g., zinc and iron levels), passive smoking, or number of siblings (crowding), which are known risk factors for RRTIs [6, 30]. Fourth, we did not collect data on the season in which the blood samples were drawn, which could influence Vitamin D levels due to seasonal variation in sun exposure. Finally, the study was conducted at a single tertiary care center, which may limit the generalizability of the findings to other populations or primary care settings.

6. CONCLUSION

This study demonstrates a high frequency of Vitamin D deficiency, affecting nearly three-quarters of children presenting with recurrent respiratory tract infections at a major tertiary care hospital in Lahore. The significant associations with inadequate sun exposure and low socioeconomic status highlight the multifactorial nature of this problem. The findings strongly suggest that Vitamin D deficiency is a potentially modifiable and significant risk factor for RRTIs in Pakistani children. Therefore, it is imperative to incorporate Vitamin D screening and supplementation into the clinical management protocols for children with recurrent infections. Public health initiatives should also be implemented to promote safe sun exposure and improve nutritional status, especially in vulnerable, low-income populations. Future research should focus on conducting randomized controlled trials to definitively establish the effectiveness of Vitamin D supplementation in preventing recurrent respiratory infections in this high-risk population.

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