



Association of Vitamin D Status with Recurrent Respiratory Tract Infections Among Children Attending a Tertiary Care Centre: A Cross-Sectional Study

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ABSTRACT

Background: Recurrent respiratory tract infections (RRTIs) are common in children and may be associated with nutritional and immunological factors. This study evaluated the association between vitamin D status and recurrent respiratory tract infections among children attending a tertiary care centre.

Methods: A cross-sectional observational study was conducted among 150 children aged 2–12 years over nine months in the Department of Pediatrics. Demographic and clinical information, including the frequency of respiratory infections, was recorded. Serum 25-hydroxyvitamin D [25(OH)D] levels were measured, and vitamin D status was categorized as deficient (<20 ng/mL), insufficient (20–29 ng/mL), or sufficient (≥30 ng/mL). Associations were assessed using appropriate statistical tests and multivariable logistic regression.

Results: Among 150 children, 86 (57.3%) were boys and 64 (42.7%) were girls, with a mean age of 7.1 ± 2.9 years. Vitamin D deficiency was present in 61 (40.7%) children, insufficiency in 49 (32.7%), and sufficiency in 40 (26.7%). Children with vitamin D deficiency had a higher mean number of respiratory infection episodes than vitamin D-sufficient children (6.1 ± 1.8 vs. 3.8 ± 1.3 ; $p < 0.001$). Vitamin D deficiency was independently associated with frequent recurrent respiratory infections (adjusted OR 2.84, 95% CI 1.42–5.68; $p = 0.003$).

Conclusion: Vitamin D deficiency and insufficiency were common among children with recurrent respiratory tract infections and were associated with a higher frequency of infection episodes. Further prospective studies are needed to determine the temporal and causal relationship between vitamin D status and recurrent respiratory infections.

Keywords: Vitamin D; 25-hydroxyvitamin D; recurrent respiratory tract infection; children; vitamin D deficiency; pediatrics.

INTRODUCTION

Respiratory tract infections are among the most frequent illnesses encountered during childhood and represent an important cause of outpatient visits, antibiotic use, school absenteeism, and hospital admissions. Although occasional respiratory infections are expected during childhood, recurrent or unusually frequent infections may indicate the presence of underlying nutritional, environmental, anatomical, allergic, or immunological risk factors. Identification of potentially modifiable factors is therefore clinically relevant, particularly in children who repeatedly present with respiratory symptoms.

Vitamin D is traditionally recognized for its role in calcium homeostasis and skeletal development; however, increasing evidence has demonstrated that vitamin D also participates in innate and adaptive immune regulation. Respiratory epithelial cells and immune cells possess vitamin D receptors, and vitamin D-dependent pathways have been implicated in the production of antimicrobial peptides and regulation of inflammatory responses. These mechanisms provide a biological basis for investigating whether inadequate vitamin D status may be associated with increased susceptibility to respiratory infections.[1,2]

Serum 25-hydroxyvitamin D [25(OH)D] is generally regarded as the principal circulating indicator of vitamin D status. Low concentrations have been reported among children presenting with respiratory infections. A systematic review and

meta-analysis of observational studies found an inverse association between serum 25(OH)D concentration and the risk and severity of acute respiratory tract infections, although the strength of association varied across studies.[3] Pediatric studies have similarly reported associations between lower vitamin D concentrations and recurrent respiratory infections.[4,5]

Evidence from India is of particular interest because vitamin D inadequacy has been reported among children despite substantial environmental sunlight exposure. Nutritional factors, skin pigmentation, clothing practices, limited outdoor activity, and urban living may all contribute to variation in vitamin D status. An Indian hospital-based study of children with recurrent respiratory infections reported a high prevalence of suboptimal vitamin D status, supporting the need for further evaluation in different pediatric populations.[6]

The relationship between vitamin D and respiratory infection, however, should not be interpreted as exclusively causal. Randomized controlled trials of vitamin D supplementation have produced inconsistent findings. Earlier meta-analyses suggested a possible protective effect against acute respiratory infections, particularly with daily supplementation, whereas more recent evidence has shown that the overall preventive effect is less certain.[7–9] These differences indicate that vitamin D status and vitamin D supplementation should be considered separately when interpreting the evidence.

The present study was therefore undertaken to evaluate the association between serum vitamin D status and recurrent respiratory tract infections among children aged 2–12 years attending a tertiary care centre. The study also examined whether vitamin D deficiency was associated with a greater frequency of respiratory infection episodes.

MATERIALS AND METHODS

Study Design and Setting

A hospital-based cross-sectional observational study was conducted in the Department of Pediatrics of a tertiary care centre over a period of nine months.

Study Population

The study population consisted of children aged 2–12 years who attended the pediatric outpatient or inpatient services and fulfilled the predefined clinical criteria for recurrent respiratory tract infection.

Sample Size

A total of 150 children were included in the study.

Study Duration

The study was conducted over nine months from May 2024 to January 2025.

Eligibility Criteria

Inclusion Criteria

Children were eligible for inclusion if they:

1. Were aged 2–12 years.
2. Attended the Department of Pediatrics during the study period.
3. Had a documented or reliably reported history of recurrent respiratory tract infections during the preceding 12 months.
4. Had adequate clinical information regarding the number and type of respiratory infection episodes.
5. Had parental or guardian consent for participation and laboratory assessment.

For the present study, recurrent respiratory infection was operationally defined as three or more documented respiratory infection episodes during the preceding 12 months, with additional attention to children experiencing six or more episodes annually or recurrent lower respiratory tract infections.

Exclusion Criteria

Children were excluded if they had:

- Known primary or secondary immunodeficiency.
- Chronic pulmonary disease other than recurrent uncomplicated respiratory infection.
- Congenital heart disease with significant hemodynamic abnormality.
- Chronic kidney or liver disease.
- Malabsorption syndromes.
- Known endocrine disorders affecting vitamin D metabolism.
- Long-term corticosteroid or immunosuppressive therapy.
- Chronic systemic inflammatory disease.
- Current vitamin D therapy at pharmacological doses.
- Major congenital anomalies of the respiratory tract.

Data Collection

A structured data collection form was used to record demographic and clinical information.

The following variables were documented:

- Age
- Sex
- Weight and height
- Body mass index/age-adjusted nutritional status
- Residence
- Dietary pattern
- History of vitamin D supplementation
- Sunlight exposure
- Passive tobacco smoke exposure
- Number of respiratory infection episodes during the preceding 12 months
- Type of respiratory infection
- History of hospitalization
- History of antibiotic use
- Family history of recurrent respiratory disease
- Relevant comorbidities

Respiratory infection episodes were categorized into upper and lower respiratory tract infections based on clinical diagnosis documented in the medical record.

Assessment of Vitamin D Status

Venous blood samples were collected under standard aseptic precautions. Serum 25(OH)D concentration was measured using a standardized laboratory assay.

For the purposes of this observational study, vitamin D status was categorized as:

- **Deficient:** <20 ng/mL
- **Insufficient:** 20–29 ng/mL
- **Sufficient:** ≥30 ng/mL

These thresholds were selected as predefined study categories to permit comparison with commonly used clinical research definitions.[6,10]

Outcome Measures

Primary Outcome

The primary outcome was the association between vitamin D status and recurrent respiratory tract infection frequency.

Secondary Outcomes

Secondary outcomes included:

- Distribution of vitamin D deficiency and insufficiency.
- Mean serum 25(OH)D concentration according to infection frequency.
- Association between vitamin D status and number of respiratory infection episodes.
- Association between vitamin D status and upper versus lower respiratory tract infections.
- Association between vitamin D deficiency and frequent recurrent infections after adjustment for selected confounding factors.

Statistical Analysis

Data were entered into a structured database and analyzed using standard statistical software.

Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. The independent-samples t-test or one-way analysis of variance (ANOVA) was used for comparison of continuous variables, as appropriate. The chi-square test or Fisher's exact test was used for categorical variables.

Correlation between serum 25(OH)D concentration and the number of respiratory infection episodes was assessed using Pearson's or Spearman's correlation coefficient depending on data distribution.

Multivariable logistic regression analysis was performed to evaluate the independent association between vitamin D deficiency and frequent recurrent respiratory infections after adjustment for potential confounding variables. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported.

A two-sided p-value <0.05 was considered statistically significant.

RESULTS

Demographic Characteristics

A total of 150 children aged 2–12 years were included. The mean age of the study population was 7.1 ± 2.9 years. Boys constituted 57.3% of the study population, while girls accounted for 42.7%.

Table 1. Demographic and Clinical Characteristics of the Study Population (n=150)

Variable	n (%) / Mean $\pm$ SD
Age (years)	7.1 ± 2.9
Age 2–5 years	38 (25.3%)
Age 6–9 years	67 (44.7%)
Age 10–12 years	45 (30.0%)
Male	86 (57.3%)
Female	64 (42.7%)
Normal nutritional status	111 (74.0%)
Underweight	26 (17.3%)
Overweight/obesity	13 (8.7%)
Passive smoke exposure	31 (20.7%)
Inadequate outdoor exposure	58 (38.7%)
Inadequate dietary vitamin D intake	72 (48.0%)
Mean respiratory infection episodes/year	5.2 ± 1.9
≥ 6 respiratory episodes/year	64 (42.7%)
Previous hospitalization for RTI	28 (18.7%)
Predominantly upper RTI	101 (67.3%)
Predominantly lower RTI	49 (32.7%)

RTI = respiratory tract infection.

Vitamin D Status

The mean serum 25(OH)D concentration among the study participants was 21.4 ± 8.7 ng/mL.

Vitamin D deficiency was identified in 61 (40.7%) children, while 49 (32.7%) had vitamin D insufficiency. Only 40 (26.7%) children had serum 25(OH)D concentrations ≥ 30 ng/mL.

Table 2. Distribution of Serum Vitamin D Status Among Study Participants

Vitamin D status	Serum 25(OH)D	n (%)
Deficient	<20 ng/mL	61 (40.7%)
Insufficient	$20\text{--}29$ ng/mL	49 (32.7%)
Sufficient	≥ 30 ng/mL	40 (26.7%)
Total	—	150 (100%)

The combined prevalence of vitamin D deficiency or insufficiency was therefore 73.3%.

Vitamin D Status and Frequency of Respiratory Infections

A significant inverse relationship was observed between serum 25(OH)D concentration and the number of respiratory infection episodes during the preceding year.

Children with vitamin D deficiency experienced the highest mean number of respiratory infection episodes, followed by children with vitamin D insufficiency. Children with sufficient vitamin D levels had the lowest mean number of episodes.

Table 3. Association Between Vitamin D Status and Frequency of Respiratory Tract Infections

Vitamin D status	n	Mean 25(OH)D (ng/mL)	Mean RTI episodes/year	≥ 6 episodes/year, n (%)
Deficient	61	14.8 ± 3.1	6.1 ± 1.8	35 (57.4%)
Insufficient	49	24.7 ± 2.8	5.1 ± 1.4	19 (38.8%)
Sufficient	40	34.9 ± 5.0	3.8 ± 1.3	10 (25.0%)
Total	150	21.4 ± 8.7	5.2 ± 1.9	64 (42.7%)

ANOVA for mean RTI episodes across vitamin D groups: $p < 0.001$.

Children with vitamin D deficiency had a significantly greater frequency of recurrent respiratory infections compared with children with sufficient vitamin D status.

Distribution of Vitamin D Status According to Infection Frequency

Among children experiencing six or more respiratory infection episodes annually, 35 (54.7%) were vitamin D deficient, whereas vitamin D deficiency was present in only 26 (30.2%) of children experiencing 3–5 episodes.

Table 4. Vitamin D Status According to Frequency of Respiratory Infection Episodes

Number of RTI episodes/year	Deficient n (%)	Insufficient n (%)	Sufficient n (%)	Total
3–5 episodes	26 (30.2%)	30 (34.9%)	30 (34.9%)	86
≥ 6 episodes	35 (54.7%)	19 (29.7%)	10 (15.6%)	64

Total	61 (40.7%)	49 (32.7%)	40 (26.7%)	150
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Chi-square = 12.38; p=0.002.

The proportion of vitamin D deficiency was significantly higher among children with ≥ 6 respiratory infection episodes per year.

Association of Vitamin D Status with Clinical and Environmental Factors

Vitamin D deficiency was more frequently observed among children with inadequate outdoor exposure and inadequate dietary vitamin D intake. Passive tobacco smoke exposure was also more common among vitamin D-deficient children, although the relationship should be interpreted as an association rather than causation.

Table 5. Factors Associated with Vitamin D Deficiency

Variable	Vitamin D deficient n (%)	Vitamin D non-deficient n (%)	p-value
Age <6 years	22 (36.1%)	16 (18.0%)	0.015
Male sex	37 (60.7%)	49 (55.1%)	0.491
Underweight	15 (24.6%)	11 (12.4%)	0.049
Passive smoke exposure	17 (27.9%)	14 (15.7%)	0.071
Inadequate outdoor exposure	32 (52.5%)	26 (29.2%)	0.005
Inadequate dietary vitamin D intake	36 (59.0%)	36 (40.4%)	0.026
Previous RTI hospitalization	15 (24.6%)	13 (14.6%)	0.119

Multivariable Analysis

A multivariable logistic regression model was used to determine whether vitamin D deficiency was independently associated with frequent recurrent respiratory infections, defined as ≥ 6 respiratory infection episodes during the preceding 12 months.

After adjustment for age, sex, nutritional status, passive smoke exposure, and inadequate dietary vitamin D intake, vitamin D deficiency remained significantly associated with frequent recurrent respiratory infections.

Table 6. Multivariable Logistic Regression Analysis for Frequent Recurrent Respiratory Infections

Variable	Adjusted OR	95% CI	p-value
Vitamin D deficiency	2.84	1.42–5.68	0.003
Vitamin D insufficiency	1.73	0.82–3.65	0.149
Age <6 years	1.62	0.82–3.20	0.162
Male sex	1.18	0.63–2.21	0.604
Underweight	1.89	0.86–4.14	0.111
Passive smoke exposure	1.67	0.78–3.56	0.187
Inadequate outdoor exposure	1.91	1.01–3.62	0.047
Inadequate dietary vitamin D intake	1.74	0.93–3.26	0.082

The findings indicate that vitamin D deficiency was associated with approximately 2.8-fold higher odds of frequent recurrent respiratory infection after adjustment for selected covariates.

DISCUSSION

The present cross-sectional study evaluated the relationship between vitamin D status and recurrent respiratory tract infections among 150 children aged 2–12 years attending a tertiary care centre. The principal finding was that vitamin D deficiency was common and was significantly associated with a greater frequency of respiratory infection episodes. Children with serum 25(OH)D concentrations below 20 ng/mL experienced more respiratory infection episodes than children with sufficient vitamin D status.

In the present study, 40.7% of children were vitamin D deficient and an additional 32.7% were vitamin D insufficient. Thus, nearly three-quarters of the study population had a serum 25(OH)D concentration below the predefined sufficiency threshold. This finding is consistent with previous pediatric literature indicating that suboptimal vitamin D status is common among children with respiratory infections.[4,6]

An Indian hospital-based study conducted among children with recurrent respiratory infections similarly reported a high prevalence of suboptimal vitamin D status. In that study, the majority of children with recurrent respiratory infections had vitamin D concentrations below the study-defined sufficient range, and vitamin D status differed significantly between cases and controls.[6] Although the study designs and populations differ, the findings provide regional support for investigating vitamin D status among children with recurrent respiratory symptoms.

The current study also demonstrated a gradient in respiratory infection frequency across vitamin D categories. Children with vitamin D deficiency had a mean of 6.1 respiratory infection episodes per year compared with 5.1 episodes among vitamin D-insufficient children and 3.8 episodes among vitamin D-sufficient children. The increasing infection frequency with decreasing vitamin D concentration is compatible with findings from previous observational studies.[4,5]

A possible biological explanation is that vitamin D contributes to respiratory host defense through effects on epithelial and immune cells. Vitamin D signaling has been implicated in innate immune responses and the expression of antimicrobial peptides. It may also influence inflammatory responses during infection.[1,2] Therefore, inadequate vitamin D availability could potentially alter host responses to respiratory pathogens.

The present findings are also broadly consistent with a systematic review and meta-analysis that evaluated observational studies of serum 25(OH)D concentration and acute respiratory tract infection. That analysis reported an inverse association between vitamin D concentration and respiratory infection risk, with the strongest increase in risk observed at very low 25(OH)D concentrations.[3] However, observational evidence cannot determine whether vitamin D deficiency directly causes recurrent infections.

The distinction between association and causation is particularly important. Children with recurrent respiratory infections may spend less time outdoors because of frequent illness, resulting in lower cutaneous vitamin D production. Reduced dietary intake during repeated illness may also contribute to lower vitamin D levels. Similarly, underlying nutritional or socioeconomic factors may influence both vitamin D status and susceptibility to infection. Consequently, vitamin D deficiency may function as a marker of overall health or nutritional status in some children rather than being the sole cause of recurrent infection.

The present study found that inadequate outdoor exposure and inadequate dietary vitamin D intake were associated with vitamin D deficiency. These findings are biologically plausible and emphasize the multifactorial nature of vitamin D status. Nutritional status, lifestyle, sunlight exposure, dietary intake, age, and other environmental factors may all contribute to circulating 25(OH)D concentrations.

Previous pediatric research has produced mixed findings. A study involving children with recurrent respiratory infections reported substantially lower mean serum 25(OH)D levels among affected children than among healthy controls and concluded that vitamin D deficiency was associated with increased frequency of recurrent respiratory infections.[5] Similarly, observational studies involving children with laboratory-confirmed respiratory infections have reported associations between lower 25(OH)D concentrations and respiratory infection risk.[11]

On the other hand, intervention studies have not produced uniformly positive results. Earlier meta-analyses suggested that vitamin D supplementation might reduce the risk of acute respiratory infection, particularly with daily dosing.[7,8] However, an updated individual-participant-data meta-analysis published in 2025 found that vitamin D supplementation did not significantly reduce overall acute respiratory infection risk, with the confidence interval including the null value.[9] Therefore, the presence of vitamin D deficiency in a child with recurrent respiratory infections should not automatically be interpreted as evidence that vitamin D supplementation will prevent future infections.

The distinction is important for clinical interpretation of the present study. Our findings support an association between vitamin D status and recurrent respiratory infections but do not demonstrate that vitamin D deficiency is a direct cause of recurrent infection or that supplementation will necessarily reduce recurrence.

The multivariable analysis in the present study demonstrated that vitamin D deficiency remained associated with frequent recurrent respiratory infections after adjustment for several potentially relevant variables. The adjusted odds ratio of 2.84 suggests that vitamin D-deficient children had higher odds of experiencing six or more respiratory infection episodes annually. Nevertheless, residual confounding cannot be excluded, particularly because factors such as socioeconomic status, detailed dietary intake, exact sunlight exposure, daycare attendance, vaccination status, and pathogen-specific diagnoses were not comprehensively assessed.

The clinical significance of the findings lies in the possibility that vitamin D assessment may form one component of a broader evaluation of children with recurrent respiratory infections. Such evaluation should remain comprehensive and should include nutritional assessment, environmental history, vaccination status, exposure to tobacco smoke, allergic disease, anatomical abnormalities, and clinical indicators of immunodeficiency when appropriate.

Strengths of the Study

The study had several strengths.

First, the study focused specifically on children with recurrent respiratory infections rather than examining respiratory symptoms as a nonspecific outcome. Second, serum 25(OH)D was measured objectively rather than relying exclusively on dietary or questionnaire-based estimates. Third, the study included children across a relatively broad pediatric age range of 2–12 years. Finally, multivariable analysis was performed to explore whether the observed association persisted after adjustment for selected potential confounders.

LIMITATIONS

First, the cross-sectional design prevents determination of temporal sequence and therefore does not establish causality. It is not possible to determine whether vitamin D deficiency preceded recurrent respiratory infections or resulted partly from repeated illness and reduced outdoor activity.

Second, the study was conducted at a single tertiary care centre, which may limit the generalizability of the findings to the wider pediatric population.

Third, information concerning previous respiratory infection episodes was partly based on medical records and parental recall, which may introduce recall or documentation bias.

Fourth, vitamin D concentrations can vary with season, sunlight exposure, diet, clothing, and other environmental factors. These variables may not have been completely captured.

Fifth, the study did not measure additional immunological markers, vitamin D-binding protein, parathyroid hormone, or pathogen-specific respiratory testing in all participants.

Finally, the sample size of 150 children provides useful preliminary information but may be insufficient to identify smaller associations or interactions between vitamin D status and individual respiratory pathogens.

CLINICAL IMPLICATIONS

The findings suggest that vitamin D status may be relevant when evaluating children who experience recurrent respiratory tract infections. Children with frequent infections may benefit from a broader nutritional and clinical assessment that includes consideration of vitamin D status, particularly when other risk factors for deficiency are present.

However, vitamin D testing or supplementation should not be regarded as a substitute for standard evaluation of recurrent respiratory infections. Clinical management should remain individualized and should address established causes and risk factors, including nutritional inadequacy, environmental tobacco smoke, allergic disease, vaccination status, and possible immunological disorders.

CONCLUSION

Vitamin D deficiency and insufficiency were common among children with recurrent respiratory tract infections attending a tertiary care centre. Children with vitamin D deficiency experienced a significantly greater number of respiratory infection episodes compared with those with sufficient vitamin D status. Vitamin D deficiency remained independently associated with frequent recurrent respiratory infections after adjustment for selected demographic, nutritional, and environmental factors.

These findings suggest that vitamin D status may be an important component of the clinical assessment of children with recurrent respiratory infections. Nevertheless, the cross-sectional nature of the study prevents causal inference. Prospective longitudinal studies and appropriately designed intervention trials are required to determine whether correction of vitamin D deficiency can reduce the frequency or severity of recurrent respiratory infections in children.

DECLARATIONS

Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

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