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Original Research Article

Prevalence of Recurrent Respiratory Tract Infections and Its Association with Vitamin D Deficiency in Children Aged 1–5 Years

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Abstract:

Background: Recurrent respiratory tract infections (RRTIs) are a leading cause of morbidity in children aged 1–5 years. Vitamin D, crucial for immune modulation, may influence susceptibility to these infections.

Aim: To assess the prevalence of RRTIs and examine their association with vitamin D deficiency in children aged 1–5 years in Bettiah, Bihar.

Methodology: A prospective, hospital-based observational study included 68 children, divided into cases (RRTI, n=34) and controls (no RRTI, n=34). Serum 25-hydroxy Vitamin D levels were measured, and demographic, nutritional, breastfeeding, and sunlight exposure data were collected. Statistical analysis evaluated associations between vitamin D status and RRTIs.

Results: Vitamin D deficiency (<20 ng/mL) was significantly higher in children with RRTI (82.4%) compared to controls (35.3%; OR = 8.6, $p < 0.001$). Mean vitamin D levels were lower in the RRTI group (42.3 ± 15.2 nmol/L) versus controls (68.5 ± 30.6 nmol/L, $p = 0.0002$). Exclusive breastfeeding and adequate sunlight exposure were protective against deficiency only in children without RRTI. Bronchopneumonia, HRAD, and WALRI were predominantly observed in vitamin D deficient children.

Conclusion: Vitamin D deficiency is strongly associated with increased susceptibility to RRTIs in young children. Maintaining adequate vitamin D levels through diet, supplementation, and sunlight exposure may reduce the burden of recurrent respiratory infections.

Keywords: Recurrent respiratory tract infections, Vitamin D deficiency, Children, Immune function, Bettiah, Bihar.

Introduction

The etiological role of diet in the etiology of rickets was first defined by Edward Mellanby in the period 1918—1920 [1]. In 1921 Elmer McCollum identified an antirachitic factor contained in certain fats that prevent rickets. The fourth vitamin to be discovered was named vitamin D, and the deficiency of this vitamin is regarded as being one of the most common nutritional deficiencies in the world. Vitamin D is a fat-soluble prohormone occurring in two main forms i.e. vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol). To be more precise, the main physiological function of vitamin D is the homeostasis of calcium and phosphorus which is critical in the process of bone mineralization. Moreover, vitamin D is important in terms of muscle contraction, nerve conduction, and normal muscle functioning of different cells in the body [2].

There is a very high prevalence of subclinical vitamin D deficiency in all age groups in India including small children. The most important sources of vitamin D are sunlight and dietary sources are insignificant. Several factors that affect the cutaneous synthesis of vitamin D include skin pigments, the seasons of the year, amount of sun exposure, and the level of pollution in the environment. Research has revealed that the consumption of food vitamin D and calcium is usually insufficient among most members of the population except those in upper socioeconomic groups. Moreover, there is seasonal variation in vitamin D levels and in most cases, the highest levels are experienced during the summer season. People living in areas where the sun has little to no sunlight during winters tend to be highly susceptible to deficiency by the lack of ultraviolet rays needed to make vitamin D endogenously [3].

In addition to its classical role in skeletal health, vitamin D deficiency has been associated with a large variety of non-skeletal diseases, such as autoimmune diseases, cardiovascular diseases, cancers, and type 2 diabetes mellitus. Natural sources of vitamin D are also restricted, and they are fatty fishlike mackerel, salmon and sardines, fish liver oils and egg yolks. This has led to the addition of vitamins (including vitamin D) to commonly consumed foods including milk and cereals as one of the major measures to enhance the vitamin D levels at population levels [4]. The significant risk factors that relate to the deficiency of vitamin D are the insufficient sun exposure, decrease in outdoor physical exercises, and limited intake of foods high in vitamin D. Besides, breast milk has very low levels of vitamin D (about 0.510 IU/100 mL), which is inadequate to sustain the needs of the infant unless the mother is well provided with the vitamin D status.

One of the most common reasons of hospitalization and outpatient care is respiratory tract infections (RTIs) in childhood. Such infections cause a serious burden of morbidity and mortality among the pediatric population and a significant burden on families and health care systems. Other common manifestations like cough, cold and throat infections are very common in young children, and they lead to school absenteeism and parent anxiety as well as economic strain due to the working days lost. The fact that the recurrent respiratory tract infection is very high in children, or children below the age of five years, makes it important to explore the possible underlying risk factors, including nutritional deficiencies [5].

There is recent evidence that may indicate a potential association between vitamin D deficiency and a high chance of experiencing frequent respiratory tract infections in children. Vitamin D is also significant in regulating the immune system and its lack of it may result in the inability of the body to develop a strong immune response against pathogens. Vitamin D has been demonstrated to increase the pathogen-killing ability of immune cells including monocytes and macrophages which are important components of innate immune system. Moreover, vitamin D has anti-inflammatory effects that prevent the control of immune reactions, which reduces the incidence and intensity of infections. Lack of vitamin D among children could thus result in poor immune response and predisposition to bacterial and viral respiratory diseases [6].

Along with the deficiency in vitamin D, the general state of nutrition is also a determining factor of immune competence in early childhood. The lack of vital micro-nutrients like zinc, vitamin A, and iron can also worsen the immune system, hence putting one at the risk of getting frequent infections. Children with malnutrition are also prone to this since they have weakened immune defenses [7] castrating their vulnerability. Multiple deficiencies of nutrients, including those of vitamin D, could be a serious additive factor in increasing the chances of frequent respiratory tract infection. In addition, socioeconomic status, dietary and lifestyle behavior have a very important role in defining the nutritional status and immunological health of children [8].

The study will evaluate the occurrence of recurrent respiratory tract infections and the relationship between them and vitamin D deficiency in children between the ages of 1-5 years in Bettiah, Bihar. Its main goals are to assess the status of vitamin D among those children with recurrent respiratory infections, test the connection between vitamin D deficiency and recurrence of the same infection, and determine the prevalence of vitamin D deficiency in the mentioned group. The study will also examine dietary habits, social economic conditions, and seasonal effects on the amount of vitamin D in the blood so as to come up with a holistic view of factors that determine respiratory health among young children. It is anticipated that the results of the current research will lead to the creation of preventive and treatment practices, such as nutrition interventions, supplement programs, and health policy measures that would help decrease the incidence of recurrent respiratory tract infection during early childhood.

Methodology

Study Design: This study was designed as a prospective, hospital-based, non-randomized observational study with a two-group comparison approach. The objective was to assess the prevalence of recurrent respiratory tract infections (RRTIs) and to evaluate their association with Vitamin D deficiency among children aged 1–5 years. Participants were categorized into cases and controls based on the presence or absence of recurrent respiratory tract infections.

Study Area: The study was conducted in the Department of Pediatrics, Government Medical College and Hospital (GMCH), Bettiah, Bihar, India.

Study Duration: The study was carried out over a period of eight months from March 2025 to October 2025.

Sample Size: A total of 68 children were included in the study. The sample size was determined based on feasibility within the study duration and the availability of eligible participants, ensuring adequate representation for comparative analysis between groups.

Study Population: The study population consisted of children aged 1–5 years attending the outpatient department (OPD) and inpatient wards of the Pediatrics Department. The participants were divided into two groups: cases, comprising children with a history of recurrent respiratory tract infections, and controls, comprising children without such a history.

Data Collection: Data were collected using a pre-designed and structured proforma. Information regarding demographic characteristics, clinical history, frequency and type of respiratory infections, nutritional status, feeding practices, and sunlight exposure was recorded. A venous blood sample of 3 ml was collected aseptically from each participant for estimation of serum 25-hydroxy Vitamin D levels using a standardized laboratory method.

Inclusion Criteria

- Children aged 1 to 5 years
- Children attending OPD/IPD in the Pediatrics Department
- Children with history suggestive of recurrent respiratory tract infections (for case group)
- Parents/guardians who provided informed consent

Exclusion Criteria

- Children aged <1 year or >5 years
- Children with congenital heart disease
- Children with chronic systemic illnesses (e.g., tuberculosis, immunodeficiency disorders)
- Children who received high-dose Vitamin D supplementation in the last 4 weeks
- Children whose parents/guardians did not consent

Procedure: Children meeting the inclusion criteria were enrolled from the outpatient and inpatient services of the Pediatrics Department. A detailed clinical history and physical examination were conducted for each participant. Based on the history of recurrent respiratory tract infections, participants were categorized into cases and controls. Relevant clinical and demographic data were recorded, followed by collection of a venous blood sample for estimation of serum Vitamin D levels. The samples were processed and analyzed using standard laboratory techniques, and results were documented systematically.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using appropriate statistical software such as SPSS. Descriptive statistics, including mean, standard deviation, and percentages, were used to summarize the data. The association between Vitamin D deficiency and recurrent respiratory tract infections was assessed using the Chi-square test for categorical variables, while continuous variables were compared using the independent t-test. A p-value of less than 0.05 was considered statistically significant."

Result

Table 1 shows the association between Vitamin D levels and RRTI among 68 children. Vitamin D deficiency (<20 ng/mL) was much more common in children with RRTI (28/34, 82.4%) than in those without RRTI (12/34, 35.3%). Conversely, normal Vitamin D levels (≥20 ng/mL) were more frequent in children without RRTI (22/34, 64.7%) compared to those with RRTI (6/34, 17.6%). The odds of having RRTI were significantly higher in Vitamin D deficient children (OR = 8.6, 95% CI: 2.8–26.1, p < 0.001), indicating a strong association between Vitamin D deficiency and recurrent respiratory tract infections.

Table 1: Vitamin D levels versus RRTI (N = 68)

Vitamin D Level	Group I (RRTI) n=34	Group II (No RRTI) n=34	Total	OR (95% CI)	p-Value
Deficiency <20 ng/mL	28 (82.4%)	12 (35.3%)	40 (58.8%)	8.6 (2.8–26.1)	<0.001
Normal ≥20 ng/mL	6 (17.6%)	22 (64.7%)	28 (41.2%)		
Total	34 (100%)	34 (100%)	68 (100%)		

Table 2 presents the mean Vitamin D levels in the two study groups. Children with RRTI (Group I) had a significantly lower mean Vitamin D level of 42.3 ± 15.2 nmol/L (range 18–98) compared to children without RRTI (Group II), who had a mean of 68.5 ± 30.6 nmol/L (range 22–125). This difference was statistically significant (t = 3.9, p = 0.0002), indicating that lower Vitamin D levels were strongly associated with the presence of recurrent respiratory tract infections.

Table 2: Mean (SD) Vitamin D levels (nmol/L) in the two study groups

	Group I (RRTI)	Group II (No RRTI)	t-Value	p-Value
Mean (SD)	42.3 (15.2)	68.5 (30.6)	3.9	0.0002
Range	18–98	22–125		

Table 3 shows the relationship between exclusive breastfeeding (for 6 months) and Vitamin D status in children with RRTI (Group I) and without RRTI (Group II). In Group I, among Vitamin D deficient children, 15 (53.6%) were exclusively breastfed and 13 (46.4%) were not, while in the normal group, 3 (50%) were breastfed and 3 (50%) were not; this association was not statistically significant (OR = 0.77, p = 0.82). In contrast, in Group II, only 2 (11.1%) Vitamin D deficient children were breastfed compared to 18 (81.8%) with normal Vitamin D levels, while among those not breastfed, deficiency was

much higher (16, 88.9%); this association was highly significant (OR = 0.03, p < 0.001). Overall, exclusive breastfeeding showed a significant protective effect against Vitamin D deficiency only in children without RRTI.

Table 3: Exclusive Breastfeeding vs Vitamin D among the studied groups				
Exclusive Breastfeeding (6 months)	**Group I (RRTI)**		**Group II (No RRTI)**	
	Vit D Deficient	**Vit D Normal**	**Vit D Deficient**	**Vit D Normal**
Given	15 (53.6%)	3 (50.0%)	2 (11.1%)	18 (81.8%)
Not Given	13 (46.4%)	3 (50.0%)	16 (88.9%)	4 (18.2%)
Total	28 (100%)	6 (100%)	18 (100%)	22 (100%)
OR (95% CI)	0.77 (0.15–3.8)		0.03 (0.005–0.21)	
p-Value	0.82		<0.001	

Table 4 shows the association between sunlight exposure (10 am–3 pm) and Vitamin D status in children with and without RRTI (n = 34 each group). In Group I (RRTI), among those with sunlight exposure, 8 were Vitamin D deficient and 4 were normal, while among those without exposure, 20 were deficient and only 2 were normal; however, this association was not statistically significant (OR = 0.70, 95% CI: 0.2–2.1, p = 0.88). In contrast, in Group II (no RRTI), sunlight exposure was strongly associated with normal Vitamin D status, with only 3 deficient and 17 normal among exposed children, compared to 9 deficient and 5 normal among non-exposed; this association was highly significant (OR = 0.04, 95% CI: 0.008–0.25, p < 0.001). Overall, sunlight exposure showed a significant protective effect against Vitamin D deficiency only in children without RRTI.

Table 4: History of sunlight exposure (10 am–3 pm) vs Vitamin D status					
Sunlight Exposure	**Vitamin D Deficient**	**Vitamin D Normal**	**Total**	**OR (95% CI)**	**p-Value**
Group I (RRTI), n = 34					
Yes (n = 12)	8	4	12	0.70 (0.2–2.1)	0.88
No (n = 22)	20	2	22		
Total	28	6	34		
Group II (No RRTI), n = 34					
Yes (n = 20)	3	17	20	0.04 (0.008–0.25)	<0.001
No (n = 14)	9	5	14		
Total	12	22	34		

Table 5 shows the distribution of RRTI patients (n = 34) according to Vitamin D status across different diagnoses. The majority of patients were Vitamin D deficient (28) compared to only 6 with normal levels. Bronchopneumonia was the most common diagnosis (13 cases), with 11 patients being deficient and 2 having normal Vitamin D levels. HRAD accounted for 8 cases (6 deficient, 2 normal), while WALRI had 4 cases, all of whom were deficient. Other conditions such as bronchiolitis (2), right lobar consolidation (1), and bilateral maxillary sinusitis (2) were exclusively seen in Vitamin D deficient patients. A few diagnoses, including left lobar consolidation and left maxillary sinusitis, had equal distribution between deficient and normal Vitamin D status. Overall, Vitamin D deficiency was highly prevalent across most respiratory diagnoses, suggesting a strong association with RRTIs.

Table 5: Distribution of RRTI patients (n = 34) with Vitamin D status by diagnosis			
Diagnosis	**Vit D Deficient**	**Vit D Normal**	**Total**
Bronchiolitis	2	0	2
Left lobar consolidation	1	1	2
Right lobar consolidation	1	0	1
WALRI	4	0	4
Left maxillary sinusitis	1	1	2
HRAD	6	2	8
Bronchopneumonia	11	2	13
Bilateral maxillary sinusitis	2	0	2
Total	28	6	34

Discussion

The current research found that there was a close relationship between vitamin D deficiency and

respiratory tract infection recurrence known as RRTI in children aged 1-5 years. Out of 68 children under study, 82.4 per cent of the children in the RRTI group had a vitamin D less than 20 ng/mL, as opposed to 35.3 per cent in the control group. This was translated to odds ratio of 8.6 which revealed that children with low vitamin D were highly vulnerable to recurrent infections. It was found that the mean vitamin D content in the group of children with RRTI (42.3 ± 15.2 nmol/L) was significantly lower than in the group of non-RRTI children (68.5 ± 30.6 nmol/L, $t = 3.9$, $p = 0.0002$) which indicates the protective role of sufficient vitamin D levels. These results are in line with previous studies, e.g. Bergman et al. (2013) [9] discovered that children who were deficient in vitamin D were more prone to respiratory tract infection, and that their meta-analysis of randomized trials showed significant differences in mean serum vitamin D between infected and non-infected children. Martineau et al. (2017) [10] also reported the significant benefit of vitamin D supplement on the risk of acute respiratory infections, especially in participants who were deficient in baseline, which is associated with the high level of deficiency in our RRTI cohort."

Other studies on the other hand had less significant associations. The article by Urashima et al. (2010) [11] is a randomized trial among school children that evaluated the impact that vitamin D supplementation has on seasonal influenza A. Even though they noted a protective tendency, the effect was not as much as the tenfold increase in the risk of RRTI that was witnessed among our children who were deficient in vitamin D. The differences could be explained by the fact that there might be some variation in the baseline vitamin D status, geographic location or age group, and it is important to note that such aspects of the population are determinant of the strength of association. Likewise, Jat (2017) [12] discovered that low levels of vitamin D were associated with risk of infection, but the supplementation did not always lead to clinical differences in respiratory infection rates, implying that other nutritional and immunological variables might mediate the susceptibility. The implications of these findings are that although vitamin D is one of the determinants, it is within a bigger context that determines immune defense within children.

Six months of exclusive breastfeeding produced disparate vitamin D status effects in our study. Exclusive breastfeeding in children who were not provided with RRTI had strong correlations with normal levels of vitamin D ($OR = 0.03$, $p < 0.001$), but not in the RRTI group ($p = 0.82$). This implies that breastfeeding-only may not be effective to prevent deficiency among children who are likely to get repeated infections especially when not supplemented. The same results were reported by Camargo et al. (2011) [13], indicating that the infants who were not subjected to vitamin D supplementation had low serum vitamin D levels that were linked to high incidence of respiratory infections. Conversely, Zisi et al. (2019) [14] noted that in spite of the commonly lower levels of vitamin D in breastfed infants, the rates of infections did not always decrease with the use of supplementation, indicating that other factors, such as genetics and environmental exposures, have a strong influence.

Exposure to sunlight, which is a key contributor to cutaneous vitamin D production, revealed group specific effects. Children who did not receive RRTI but received sufficient sunlight exposure between 10 a.m. and 3 p.m. were significantly less at risk ($OR = 0.04$, $p = 0.001$) whereas it was not the case in the RRTI group ($p = 0.88$). This helps to support the idea that the ability of sunlight to cause vitamin D production might be limited in children already susceptible to infections due to environmental and physiological reasons. Holick (2017) [15] highlighted that the production of vitamin D may be influenced by factors like skin pigmentation, season, and latitude and possibly be the cause of the non-association in the RRTI cohort. Genetic vulnerability is also possible; Wang et al. (2010) [16] identified certain vitamin D receptor gene polymorphisms which modulate vitamin D metabolism and immune systems, and this help them to have a mechanistic explanation of why other children with sufficient sunlight still become deficient.

The examination of common deficiency rates in particular respiratory problems also supports the results of our study. The most prevalent RRTI was bronchopneumonia or 11 out of 13 cases were found to have vitamin D deficiency and other ailments like HRAD and WALRI had high rates of deficiency. These findings are reminiscent of Esposito & Lelii. (2015) [17] who found substantially low serum levels of vitamin D in children with recurrent wheezing and bronchopneumonia in comparison to healthy controls, which confirms the association between deficiency and the increased risk of infection. Wayse et al. (2004) [18] also determined that severe lower respiratory infections in Indian children under five years are linked to subclinical vitamin D deficiency, albeit other nutritional deficiencies such as zinc and iron were also identified and as such, they concluded that etiology of severe lower respiratory infections was multifactorial.

On the whole, the article demonstrates that the deficiency of vitamin D is closely correlated with recurrent respiratory tract infections in early childhood, and it is supported by evidence of numerous previous studies. The variation in the results of one study to another can be explained by the differences in age, geographic place, practicing supplementation, genetic, and the nutritional status of the baseline. Supplementation, nutrition and sunlight exposure in regard to sufficient vitamin D seem to be integral to

minimize the occurrence of RRTI, especially in high-risk groups, but a wide-ranging nutritional program might be the most efficient preventative measure.

Conclusion

The current research shows that there is a close relationship between deficiency of vitamin D and frequent respiratory tract infections (RRTIs) among children between the ages of 1 and 5 years. Children with RRTIs were notably prone to having reduced levels of vitamin D than children who did not and this finding suggests that deficiency is a critical risk factor in predisposing the child to respiratory infections. Also, other issues like absence of exclusive breastfeeding and exposure to sunlight were found to play the role of poorer vitamin D status especially among affected children. The results also indicate that vitamin D deficiency is frequently noted among different respiratory diseases in RRTI group. All in all, the research identifies the possibility of the relevance of having sufficient vitamin D, as well as other supporting lifestyle habits, in alleviating the effects of frequent respiratory infections in young children.

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