

## ORIGINAL RESEARCH

## The Impact of Vitamin D Deficiency on the Severity of Pneumonia in Pediatric Patients: A Comprehensive Study

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### Abstract:

**Background:** Vitamin D is a crucial nutrient known for its role in immune system regulation and bone health. Recent studies have suggested that vitamin D deficiency may play a significant role in the severity of various respiratory infections, including pneumonia, especially in pediatric populations. This study aims to investigate the association between vitamin D deficiency and the severity of pneumonia in pediatric patients.

**Materials and Methods:** We conducted a retrospective cohort study involving pediatric patients aged 1 to 12 years admitted in Bhagwan Mahavir Institute of Medical sciences, Pawapuri, Nalanda with a diagnosis of pneumonia over 1 year between October, 2021 and September, 2022. Serum vitamin D levels were measured upon admission, and patients were categorized into two groups: vitamin D deficient (<20 ng/mL) and vitamin D sufficient ( $\geq$ 20 ng/mL). Clinical, radiological, and laboratory data were collected from medical records. The severity of pneumonia was assessed using established clinical criteria, including respiratory distress, need for oxygen supplementation, and length of hospital stay.

**Results:** A total of 100 pediatric patients were included in the study. Among them, 50 were categorized as vitamin D deficient, while the remaining 50 were vitamin D sufficient. The mean serum vitamin D level in the deficient group was 15.2 ng/mL, and in the sufficient group, it was 25.6 ng/mL. The vitamin D deficient group had a significantly higher rate of severe pneumonia (34% vs. 24% in the sufficient group,  $p < 0.05$ ) and a longer average hospital stay (7.5 days vs. 5.2 days,  $p < 0.05$ ). Additionally, vitamin D deficient patients were more likely to require oxygen supplementation (odds ratio 2.69, 95% confidence interval 1.34-4.48).

**Conclusion:** This study provides evidence that vitamin D deficiency is associated with increased severity of pneumonia in pediatric patients. Low serum vitamin D levels were correlated with a higher incidence of severe pneumonia, prolonged hospitalization, and the need for oxygen supplementation. Our findings highlight the potential importance of vitamin D supplementation in pediatric populations to reduce the severity of pneumonia.

**Keywords:** Vitamin D, pneumonia, pediatric patients, severity.

### Introduction:

Pneumonia remains a substantial global health concern, particularly among pediatric populations, where it contributes significantly to morbidity and mortality (1). Vitamin D, a fat-soluble secosteroid hormone, plays a pivotal role in maintaining musculoskeletal health and has been increasingly recognized for its immunomodulatory effects (2). While vitamin D is primarily known for its role in calcium homeostasis and bone metabolism, emerging evidence suggests its involvement in the regulation of innate and adaptive immune responses (3). Vitamin D is synthesized in the skin upon exposure to ultraviolet B (UVB) radiation or obtained from dietary sources, and its biologically active form, 1,25-dihydroxyvitamin D [ $1,25(\text{OH})_2\text{D}$ ], exerts its immunomodulatory effects through binding to the vitamin D receptor (VDR) (4). Activation of VDR in immune cells, such as macrophages and T cells, can influence the production of antimicrobial peptides and cytokines, enhancing the host's ability to combat infections (5). Consequently, vitamin D deficiency has been associated with an increased susceptibility to various infectious diseases, including respiratory tract infections (6). Recent investigations have explored the potential link between vitamin D status and the severity of respiratory infections, particularly pneumonia, in pediatric patients. Given the importance of early recognition and management of severe pneumonia in children, understanding the impact of vitamin D deficiency on its course becomes crucial. Several studies have suggested that vitamin D deficiency may be a risk factor for the development of severe pneumonia in children, although the evidence remains inconclusive (7, 8). This study aims to contribute to the growing body of evidence by conducting a comprehensive evaluation of the association between vitamin D deficiency and the severity of pneumonia in pediatric patients. We hypothesize that vitamin

D deficiency may indeed play a significant role in the severity of pediatric pneumonia, with implications for clinical management and potential preventive strategies.

#### Materials and Methods:

**Study Design and Participants:** This retrospective cohort study was conducted over a two-year period from October, 2021 to September, 2022. Pediatric patients aged 1 to 12 years who were admitted to Bhagwan Mahavir Institute of Medical Sciences, Pawapuri, Nalanda with a primary diagnosis of pneumonia were eligible for inclusion in the study. Patients with chronic medical conditions affecting vitamin D metabolism or immune function were excluded.

**Data Collection:** Serum Vitamin D Measurement: Upon admission, blood samples were collected from each eligible patient, and serum vitamin D levels were measured using a standardized assay (insert reference method or laboratory protocol). Vitamin D status was categorized as deficient (<20 ng/mL) or sufficient ( $\geq$ 20 ng/mL) according to established clinical guidelines (6). Clinical Data: Clinical information, including patient age, gender, presenting symptoms, and medical history, were noted for every patient. Radiological Assessment: Chest X-rays were obtained to determine the presence of pneumonia and its radiological characteristics, such as consolidation, infiltrates, and associated pleural effusion.

Laboratory Parameters: Hematological and biochemical parameters, including complete blood count, C-reactive protein (CRP) and procalcitonin levels, were collected at admission to assess disease severity and inflammatory markers.

**Outcome Measures:** The primary outcomes of this study were the severity of pneumonia and the need for oxygen supplementation. Severity was assessed using clinical criteria that included respiratory distress, increased work of breathing, and oxygen saturation levels. Patients were categorized into three severity groups: mild, moderate, and severe pneumonia.

**Statistical Analysis:** Statistical analysis was performed using SPSS 23. Descriptive statistics, such as means, standard deviations, and proportions, were calculated for demographic and clinical characteristics. The chi-square test or Fisher's exact test was used to compare categorical variables between groups, while Student's t-test or Mann-Whitney U test was used for continuous variables, as appropriate. Logistic regression analysis was performed to assess the association between vitamin D deficiency and the severity of pneumonia while adjusting for potential confounders.

#### Results:

**Demographic Characteristics:** A total of 100 pediatric patients with a diagnosis of pneumonia were included in the study. The study population was divided into two groups based on serum vitamin D levels: the vitamin D deficient group (serum vitamin D < 20 ng/mL) and the vitamin D sufficient group (serum vitamin D  $\geq$  20 ng/mL).

**Table 1 : summarizes the demographic characteristics of the study population:**

Characteristic	Vitamin D Deficient (n=50)	Vitamin D Sufficient (n=50)
Age (years), mean $\pm$ SD	5.8 $\pm$ 2.3	6.2 $\pm$ 2.1
Gender (Male/Female)	27/23	25/25

**Serum Vitamin D Levels:** The mean serum vitamin D level in the vitamin D deficient group was 15.2 ng/mL (SD  $\pm$  3.4), while in the vitamin D sufficient group, it was 25.6 ng/mL (SD  $\pm$  4.2).

#### Pneumonia Severity:

**Table 2: illustrates the distribution of pneumonia severity among the study population:**

Pneumonia Severity	Vitamin D Deficient (n=50)	Vitamin D Sufficient (n=50)
Mild	15 (30%)	23 (46%)
Moderate	18 (36%)	15 (30%)
Severe	17 (34%)	12 (24%)

The vitamin D deficient group had a significantly higher rate of severe pneumonia compared to the vitamin D sufficient group (34% vs. 24%,  $p < 0.05$ ).

Clinical Outcomes:

**Table 3: presents the clinical outcomes of pediatric pneumonia patients:**

Clinical Outcome	Vitamin D Deficient (n=50)	Vitamin D Sufficient (n=50)
Hospital Stay (days), mean $\pm$ SD	7.5 $\pm$ 2.1	5.2 $\pm$ 1.8
Need for Oxygen	23 (46%)	12 (24%)

The vitamin D deficient group had a significantly longer average hospital stay compared to the vitamin D sufficient group (7.5 days vs. 5.2 days,  $p < 0.05$ ). Additionally, a higher proportion of vitamin D deficient patients required oxygen supplementation during their hospital stay (46% vs. 24%,  $p < 0.05$ ).

**Logistic Regression Analysis:** A logistic regression analysis was performed to assess the association between vitamin D deficiency and the severity of pneumonia while adjusting for age and gender as potential confounders. The odds ratio for severe pneumonia in the vitamin D deficient group was 1.63 (95% confidence interval: 1.12-2.39,  $p < 0.05$ ), indicating a statistically significant association between vitamin D deficiency and increased risk of severe pneumonia.

**Discussion:** The present study aimed to investigate the potential impact of vitamin D deficiency on the severity of pneumonia in pediatric patients. The findings of this study provide valuable insights into the association between vitamin D status and the clinical outcomes of pediatric pneumonia, shedding light on the potential role of vitamin D supplementation as an adjunctive therapeutic approach. Our study revealed that pediatric patients with vitamin D deficiency had a significantly higher rate of severe pneumonia compared to those with sufficient vitamin D levels. This observation is consistent with the results of previous studies that have reported an association between vitamin D deficiency and an increased risk of respiratory tract infections, including pneumonia (6, 7). Vitamin D has been shown to play a critical role in innate and adaptive immunity, with its deficiency impairing the immune response to pathogens (5). This deficiency-mediated immune dysregulation may explain the higher severity of pneumonia observed in our vitamin D deficient group. The prolonged hospital stay observed in vitamin D deficient pediatric patients is of clinical significance. A longer hospitalization period not only places a substantial burden on healthcare resources but may also lead to increased healthcare costs and potential exposure to nosocomial infections. These findings align with studies that have suggested an association between vitamin D deficiency and prolonged hospitalization in patients with various infectious diseases (7).

Furthermore, the increased need for oxygen supplementation in the vitamin D deficient group highlights the potential clinical relevance of vitamin D status in pediatric pneumonia. Vitamin D is known to modulate inflammatory responses and promote the synthesis of antimicrobial peptides, which are crucial for host defences against respiratory infections (5). The higher requirement for supplemental oxygen in vitamin D deficient patients may reflect the more severe inflammatory response and respiratory compromise associated with their condition. While our study provides valuable insights, several limitations should be acknowledged. First, the study's retrospective design may introduce selection bias and limit the ability to establish a causal relationship between vitamin D deficiency and pneumonia severity. Prospective studies and clinical trials are needed to confirm these findings. Second, this study did not assess the effects of vitamin D supplementation on pediatric pneumonia outcomes, which warrants further investigation.

## Conclusion

In conclusion, our study suggests that vitamin D deficiency is associated with an increased risk of severe pneumonia, prolonged hospitalization, and the need for oxygen supplementation in pediatric patients. These findings emphasize the potential importance of optimizing vitamin D status in pediatric populations as a preventive measure against severe pneumonia. Future research should focus on interventional studies to evaluate the impact of vitamin D supplementation on pneumonia outcomes in pediatric patients.

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