



Association between Vitamin D Deficiency and Clinical Severity of Pneumonia in Children

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KEYWORDS

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ABSTRACT:

Background: Pneumonia is a leading cause of morbidity and mortality in children worldwide, particularly in low- and middle-income countries. Vitamin D plays a crucial role in immune function, and deficiency may increase susceptibility to infections and influence disease severity. This study aimed to evaluate the association between serum vitamin D levels and clinical severity of pneumonia in children.

Methods: A case-control study was conducted in the Department of Paediatrics and Paediatric Pulmonology Division of Bangladesh Medical University, Dhaka, from July 2024 to June 2025. A total of 60 children were enrolled, including 30 cases with CAP and 30 healthy controls visiting for routine immunization. Demographic, nutritional, and clinical data were collected using a structured questionnaire. Blood samples were obtained to measure hemoglobin, total WBC count, and serum 25(OH) vitamin D levels. Statistical analysis was performed using SPSS version 25.0, and a p-value <0.05 was considered statistically significant.

Results: The majority of cases were aged 2–3 years (76.7%), while controls predominated in 4–5 years (50.0%). Malnutrition (50.0% vs. 23.3%, $p = 0.031$), limited sun exposure (60.0% vs. 23.3%, $p = 0.006$), and history of recurrent respiratory infections (63.3% vs. 26.7%, $p = 0.004$) were significantly higher in cases. Clinically, respiratory distress, wheezing, feeding difficulties, lethargy, cyanosis, and convulsions were more frequent in cases ($p < 0.05$). Hypoxia (60.0% vs. 13.3%, $p < 0.001$) and sepsis (40.0% vs. 6.7%, $p = 0.004$) were common complications. Vitamin D deficiency (<20 ng/mL) was significantly higher among cases (53.3% vs. 13.3%, $p = 0.002$), whereas sufficient levels were more prevalent in controls (43.3% vs. 16.7%, $p = 0.03$).

Conclusion: Vitamin D deficiency, malnutrition, limited sun exposure, and recurrent respiratory



infections are associated with increased susceptibility and severity of CAP in children under five. Early nutritional and vitamin D interventions may help reduce disease burden.

Introduction

Pneumonia remains one of the leading causes of morbidity and mortality among children worldwide, particularly in developing countries [1]. Pneumonia accounts for approximately 15% of all deaths among children under five years of age, with the highest burden observed in low- and middle-income nations [2]. Despite advances in antimicrobial therapy and preventive measures, the disease continues to pose a major public health challenge, largely due to nutritional deficiencies, poor living conditions, and limited healthcare access [3].

Vitamin D, a fat-soluble secosteroid hormone, is well known for its essential role in calcium and bone metabolism. However, emerging evidence has highlighted its significant immunomodulatory functions, particularly in the regulation of innate and adaptive immune responses [4]. Vitamin D enhances the synthesis of antimicrobial peptides such as cathelicidin and defensins, which play crucial roles in host defense against respiratory pathogens [5]. It also modulates inflammatory cytokine production, thereby influencing the body's immune response to infection.

Deficiency of vitamin D is widespread among children in South Asia, including Bangladesh, due to inadequate sunlight exposure, poor dietary intake, and darker skin pigmentation that reduces cutaneous synthesis [6]. Several observational studies have demonstrated a possible link between low serum vitamin D levels and an increased risk of acute respiratory tract infections, including pneumonia [7]. Furthermore, vitamin D deficiency may contribute not only to susceptibility but also to the severity of pneumonia, resulting in longer hospital stays, greater need for intensive care, and higher complication rates [8].

However, the available literature shows inconsistent results. While some studies have found a strong association between vitamin D deficiency and severe pneumonia, others have failed to demonstrate a significant relationship [9]. Differences in geographic location, sunlight exposure, nutritional status, and diagnostic cut-offs for vitamin D deficiency may

explain these discrepancies [10]. In Bangladesh, where both pneumonia and vitamin D deficiency are prevalent, data exploring this association remain limited.

Understanding the relationship between vitamin D status and the severity of pneumonia could have important implications for preventive and therapeutic strategies [11]. Identifying vitamin D deficiency as a potential modifiable risk factor may offer a simple, cost-effective intervention to reduce disease burden and improve outcomes in pediatric patients [12].

Therefore, the present study was designed to evaluate the association between serum vitamin D levels and the clinical severity of pneumonia in children admitted to Bangladesh Medical University, Dhaka. The findings of this study are expected to provide valuable insight into the potential role of vitamin D in the pathogenesis and progression of childhood pneumonia and may help guide future preventive healthcare policies.

Methodology & Materials

This case-control study was conducted in the Department of Paediatrics and Paediatric Pulmonology Division of Bangladesh Medical University, Dhaka, Bangladesh, over a period of one year from July 2024 to June 2025. This case-control study included a total of 60 children, divided into two groups: 30 cases and 30 controls. The case group comprised children aged less than five years who were clinically and radiologically diagnosed with community-acquired pneumonia and admitted to the Department of Paediatrics and Paediatric Pulmonology Division of Bangladesh Medical University (BMU), Dhaka. The control group included healthy children of similar age and sex who visited the outpatient department or EPI centre of BMU for routine check-up or immunization and had no history of acute or chronic illness. Children with a history of chronic medical or surgical illness, rickets, congenital malformations, or those who had received vitamin D supplementation within the last six months were excluded. After obtaining informed consent from parents or guardians, detailed demographic and clinical information, including age, sex, nutritional status, breastfeeding history, exposure to sunlight, and



presence of atopy, was recorded using a predesigned questionnaire. Physical examination was performed for all participants, and 3 mL of venous blood was collected under aseptic precautions for estimation of serum 25-hydroxyvitamin D [25(OH)D] levels using an ELISA kit (DLD Diagnostika GmbH, Alderhost, Hamburg, Germany). Vitamin D status was categorized as deficient (<20 ng/mL), insufficient (20–29 ng/mL), or sufficient (\geq 30 ng/mL). All data were compiled and analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0. Descriptive statistics were presented as frequency and percentage for categorical variables and mean \pm standard deviation (SD) for continuous variables. The chi-square test was applied for categorical variables and the independent sample t-test for continuous variables, and a p-value of less than 0.05 was considered statistically significant.

Results

Table I: Socio-Demographic Characteristics of the Study Population (n = 60)

Variables	Categories	Case (n = 30)	Control (n = 30)	p-value
Age group (years)	2–3	23 (76.7%)	7 (23.3%)	< 0.001
	4–5	7 (23.3%)	15 (50.0%)	
	>5	0 (0.0%)	8 (26.7%)	
Gender	Male	19 (63.3%)	16 (53.3%)	0.432
	Female	11 (36.7%)	14 (46.7%)	
Residence	Urban	11 (36.7%)	15 (50.0%)	0.303
	Rural	19	15	

		(63.3%)	(50.0%)	
Monthly family income (BDT)	<15,000	12 (40.0%)	8 (26.7%)	0.526
	15,000–50,000	14 (46.7%)	19 (63.3%)	
	>50,000	4 (13.3%)	3 (10.0%)	

Data are expressed as number (%). Statistical analysis was performed using the Chi-square test. A p-value of <0.05 was considered statistically significant.

Table I presents the socio-demographic characteristics of the study population (n = 60), comparing 30 cases of children with community-acquired pneumonia and 30 healthy controls. The majority of cases were aged 2–3 years (76.7%) compared to controls (23.3%), while controls predominated in the 4–5 years (50.0% vs. 23.3%) and >5 years (26.7% vs. 0%) categories; this difference was statistically significant (p < 0.001) and male (cases: 63.3%, controls: 53.3%). Most participants were from rural areas (cases: 63.3%, controls: 50.0%) and had a monthly family income between 15,000–50,000 BDT (cases: 46.7%, controls: 63.3%). No statistically significant differences were observed between the groups for any of the socio-demographic variables (p > 0.05).

Table II: Distribution of Risk Factors and Nutritional Characteristics Among the Study Population (n = 60)

Variables	Categories	Case (n = 30)	Control (n = 30)	p-value
Nutritional status	Malnourished	15 (50.0%)	7 (23.3%)	0.031*
	Normal	15 (50.0%)	23 (76.7%)	



		(%))	
Breastfeeding history	Exclusive	14 (46.7%)	18 (60.0%)	0.298
	Not exclusive	16 (53.3%)	12 (40.0%)	
Sun exposure	<30 min/week	18 (60.0%)	7 (23.3%)	0.006*
	>30 min/week	12 (40.0%)	23 (76.7%)	
History of recurrent respiratory infection	Yes	19 (63.3%)	8 (26.7%)	0.004*
	No	11 (36.7%)	22 (73.3%)	
Family history of atopy	Present	13 (43.3%)	8 (26.7%)	0.187
	Absent	17 (56.7%)	22 (73.3%)	

Data are expressed as number (%). Statistical analysis was performed using the Chi-square test. A p-value of <0.05 was considered statistically significant.

Table II shows the distribution of risk factors and nutritional characteristics among cases and controls. Malnutrition was more common in cases than controls (50.0% vs. 23.3%, $p = 0.031$). Limited sun exposure (<30 min/week) and history of recurrent respiratory infections were also significantly higher among cases (60.0% vs. 23.3%, $p = 0.006$; 63.3% vs. 26.7%, $p = 0.004$). Exclusive breastfeeding and family history of atopy did not differ significantly between the groups ($p > 0.05$).

Table III: Clinical Presentation and Complications among the Study Population (n = 60)

Variables	Categories	Case (n=30)	Control (n=30)	p-value
Fever	Present	29 (96.7%)	27 (90.0%)	0.29
	Absent	1 (3.3%)	3 (10.0%)	
Cough	Present	30 (100%)	30 (100%)	—
	Absent	0 (0%)	0 (0%)	
Respiratory distress	Present	28 (93.3%)	17 (56.7%)	0.002
	Absent	2 (6.7%)	13 (43.3%)	
Wheezing	Present	20 (66.7%)	8 (26.7%)	0.001
	Absent	10 (33.3%)	22 (73.3%)	
Feeding difficulties	Present	22 (73.3%)	10 (33.3%)	0.003
	Absent	8 (26.7%)	20 (66.7%)	
Lethargy	Present	18 (60.0%)	6 (20.0%)	0.001
	Absent	12 (40.0%)	24 (80.0%)	
Cyanosis	Present	15 (50.0%)	3 (10.0%)	<0.001
	Absent	15 (50.0%)	27 (90.0%)	
Convulsions	Present	9 (30.0%)	1 (3.3%)	0.01
	Absent	21 (70.0%)	29 (96.7%)	
Complications	Hypoxia	18 (60.0%)	4 (13.3%)	<0.001
	Dehydration	11 (36.7%)	6 (20.0%)	
Sepsis	Present	12 (40.0%)	2 (6.7%)	0.004
	Absent	18 (60.0%)	28 (93.3%)	



	Respiratory failure	6 (20.0%)	1 (3.3%)	0.1
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Data are expressed as number (%). Statistical analysis was performed using the Chi-square test. A p-value of <0.05 was considered statistically significant.

Table III presents the clinical presentation and complications among cases and controls. Fever and cough were common in both groups, but respiratory distress (93.3% vs. 56.7%, $p = 0.002$), wheezing (66.7% vs. 26.7%, $p = 0.001$), feeding difficulties (73.3% vs. 33.3%, $p = 0.003$), lethargy (60.0% vs. 20.0%, $p = 0.001$), cyanosis (50.0% vs. 10.0%, $p < 0.001$), and convulsions (30.0% vs. 3.3%, $p = 0.01$) were significantly more frequent among cases. Among complications, hypoxia (60.0% vs. 13.3%, $p < 0.001$) and sepsis (40.0% vs. 6.7%, $p = 0.004$) were significantly higher in cases, while dehydration and respiratory failure showed no statistically significant difference between groups.

Table IV: Laboratory Findings and Vitamin D Status among the Study Population (n = 60)

Variables	Categories	Case (n=30)	Control (n=30)	p-value
Hemoglobin level (Hb%)	<10 g/dL	14 (46.7%)	6 (20.0%)	0.03
	≥10 g/dL	16 (53.3%)	24 (80.0%)	
Total WBC count	Normal	9 (30.0%)	16 (53.3%)	0.07
	Raised	21 (70.0%)	14 (46.7%)	
Chest X-ray findings	Pneumonia confirmed	30 (100%)	—	—
Serum vitamin D level	Sufficient (≥30 ng/mL)	5 (16.7%)	13 (43.3%)	0.03
	Insufficient (20–29 ng/mL)	9 (30.0%)	13 (43.3%)	
	Deficient	16	4	

	<20 ng/mL	(53.3%)	(13.3%)	
Clinical severity of pneumonia	Non-severe	10 (33.3%)	—	—
	Severe	13 (43.3%)	—	—
	Very severe	7 (23.3%)	—	—

Data are expressed as number (%). Statistical analysis was performed using the Chi-square test. A p-value of <0.05 was considered statistically significant.

Table IV summarizes the laboratory findings and vitamin D status among cases and controls. Low hemoglobin (<10 g/dL) was more frequent in cases than controls (46.7% vs. 20.0%, $p = 0.03$). Vitamin D deficiency (<20 ng/mL) was significantly higher among cases (53.3% vs. 13.3%, $p = 0.002$), while sufficient levels were more common in controls (43.3% vs. 16.7%, $p = 0.03$). Raised WBC counts were more prevalent in cases (70.0% vs. 46.7%), although this difference was not statistically significant ($p = 0.07$). Chest X-ray confirmed pneumonia in all cases. Among cases, 43.3% had severe and 23.3% very severe pneumonia, indicating a considerable burden of disease.

Discussion

In this case-control study of 60 children under five years, we observed that vitamin D deficiency was significantly more prevalent in children with community-acquired pneumonia (53.3% vs. 13.3%, $p = 0.002$), supporting its potential role in susceptibility and severity of respiratory infections. This finding aligns with El Basha et al. and Pletz et al., who reported that low serum vitamin D levels were associated with more severe pneumonia in hospitalized children [8, 13]. Similarly, Rashad et al., found a high prevalence of vitamin D deficiency among infants and preschool children with pneumonia, highlighting the importance of adequate vitamin D for immune defense in early childhood [14].

Malnutrition was also significantly higher among cases than controls (50.0% vs. 23.3%, $p = 0.031$), consistent with Chisti et al., who reported that undernutrition



increases the risk of severe pneumonia and related complications [15]. Limited sun exposure (<30 min/week) was more frequent in cases (60.0% vs. 23.3%, $p = 0.006$), emphasizing the role of sunlight in endogenous vitamin D synthesis and subsequent immune function, in agreement with findings by Haugen et al., in Nepalese children [16].

Clinically, cases presented more often with respiratory distress (93.3% vs. 56.7%, $p = 0.002$), wheezing (66.7% vs. 26.7%, $p = 0.001$), feeding difficulties (73.3% vs. 33.3%, $p = 0.003$), lethargy (60.0% vs. 20.0%, $p = 0.001$), cyanosis (50.0% vs. 10.0%, $p < 0.001$), and convulsions (30.0% vs. 3.3%, $p = 0.01$). These findings are in line with Nasrin et al., who identified respiratory distress and hypoxia as common clinical features among under-five children with severe community-acquired pneumonia in Bangladesh [17]. Complications such as hypoxia (60.0% vs. 13.3%, $p < 0.001$) and sepsis (40.0% vs. 6.7%, $p = 0.004$) were significantly higher in cases, reflecting the added burden of comorbidities and severity associated with vitamin D deficiency and malnutrition.

Laboratory data revealed low hemoglobin (<10 g/dL) in 46.7% of cases versus 20.0% of controls ($p = 0.03$), consistent with Ahmed et al., who reported that anemia is a risk factor for acute respiratory infections [18]. Although raised WBC counts were more frequent in cases (70.0% vs. 46.7%), the difference was not statistically significant ($p = 0.07$), suggesting that WBC alone may not reliably differentiate severity. Vitamin D sufficiency (≥ 30 ng/mL) was more common among controls (43.3% vs. 16.7%, $p = 0.03$), emphasizing the protective role of adequate vitamin D levels. These findings are supported by Chowdhury et al., who demonstrated that vitamin D supplementation in hospitalized children reduced the risk of severe outcomes [19].

Among cases, 43.3% had severe and 23.3% very severe pneumonia, highlighting the considerable disease burden in vitamin D deficient children. Similar associations between low vitamin D levels and pneumonia severity have been reported by Kim et al., and Dhungel & Alam, confirming the link between deficiency and poor clinical outcomes [20, 21]. Furthermore, our findings resonate with Huang & Fu, who observed that age-related vitamin D deficiency

impairs immune response, predisposing children to more severe respiratory infections [22].

Limitations of the study

This study had a relatively small sample size ($n = 60$) and was conducted at a single tertiary care center, which may limit the generalizability of the findings. The case-control design allows for association but cannot establish causality between vitamin D deficiency and pneumonia severity.

Conclusion

Our study indicates that vitamin D deficiency, malnutrition, limited sun exposure, and recurrent respiratory infections are significant risk factors for both susceptibility and severity of community-acquired pneumonia in children under five years. These results underscore the importance of early nutritional interventions, vitamin D supplementation, and public health strategies to reduce morbidity and improve outcomes in pediatric populations, particularly in resource-limited settings like Bangladesh.

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Conflicts of interest

There are no conflicts of interest.

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