



ROLE OF VITAMIN D DEFICIENCY IN SEVERITY AND RECOVERY OF COMMUNITY-ACQUIRED PNEUMONIA IN CHILDREN

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ABSTRACT

Background: Community-acquired pneumonia (CAP) has been a major challenge in morbidity and hospitalization in developing countries in children. Vitamin D is significant in immune response and respiratory host defense and its deficiency has been increasingly found to be susceptible to infections. Nevertheless, there is still limited evidence on its impact on the severity of the disease and recovery of pediatric CAP.

Objective: To evaluate the role of vitamin D deficiency in determining the severity and recovery outcomes of community-acquired pneumonia in children

Methodology: This is a prospective observational study that has been done in the Department of Pediatrics, Naseer Teaching Hospital, Peshawar, between January 2024 and January 2025. The number of children enrolled was 72 and they were diagnosed with community-acquired pneumonia. The level of serum 25-hydroxyvitamin D was quantified at admission, and the participants were defined as vitamin D deficient (<20 ng/mL) or non-deficient (≥20 ng/mL). There were comparisons of clinical severity, laboratory and radiographic results and recovery outcomes; such as oxygen requirement, hospitalization time and recovery time.

Results: Vitamin D deficiency was observed in 61.1% of children. Deficient children had a significantly higher proportion of severe or very severe pneumonia, lower oxygen saturation at presentation, and greater need for oxygen therapy. Recovery was slower in the deficient group, with longer duration of hospital stay and delayed fever clearance. Serum C-reactive protein levels were also significantly higher among vitamin D deficient children.

Conclusion: Vitamin D deficiency is associated with increased severity and delayed recovery in children with community-acquired pneumonia. Assessment of vitamin D status may be useful in identifying children at risk of severe disease and prolonged hospitalization.

Keywords: Vitamin D deficiency, community-acquired pneumonia, children, disease severity, recovery outcomes

INTRODUCTION

CAP is among the leading causes of hospital and child mortality among those of low and middle-income with children under the age of five years. CAP remains a significant clinical and economic burden to the health care system despite the progress in the vaccination program and antimicrobial treatment. Host-related factors such as nutritional and immunological status also have a role to play in determining the severity and outcome of pneumonia in addition to the pathogen causing such a disease (1-3).

Vitamin D has been found to be a significant modulator of immune activity in addition to its usual action in bone. It improves the natural defense against microorganisms by increasing the synthesis of antimicrobial peptides like cathelicidin and defensins that are important in the defense of the respiratory tract. Vitamin D also regulates inflammatory reactions, and it is useful to maintain good clearance of pathogens and prevent an unreasonable destruction of tissues. Vitamin D deficiency is prevalent among children especially in areas where sunlight is scarce, nutritional status is poor and supplementations are low (4-7).

A number of studies have indicated that it may be related to low levels of vitamin D and high rates of infection of the respiratory tract including pneumonia. Infection, disease severity, and poor outcome in different pediatric groups have been associated with vitamin D deficiency. Nevertheless, the evidence is still inconclusive, and the local data is scarce, especially in terms of its effects on clinical severity and clinical recovery outcomes in terms of oxygen demand and hospital stay (8-10). In Pakistan, vitamin D deficiency is highly prevalent among children, yet its role in pediatric CAP has not been adequately explored. Understanding this relationship is important, as vitamin D deficiency represents a potentially modifiable risk factor. This study was therefore conducted to assess the role of vitamin D deficiency in the severity and recovery of community-acquired pneumonia among children admitted to a tertiary care hospital in Peshawar.

METHODOLOGY

The research took place in the Department of Pediatrics, Naseer Teaching Hospital, Peshawar, during 12 months between January 2024 and January 2025. To analyze the effect of vitamin D deficiency in dictating severity and recovery outcomes of community acquired pneumonia (CAP) in children, a prospective observational study design was used.

Community-acquired pneumonia 72 children were enrolled using a non-probability consecutive sampling method. The study included children between the ages of 2 months and five years of age that showed clinical and radiological signs of CAP, according to the World Health Organization criteria. Children who had hospital-acquired pneumonia and/or congenital heart disease and chronic lung disease and/or known immunodeficiency and/or tuberculosis and/or receive long-term vitamin D supplementation were excluded to reduce confounding.

At the time of admission, demographic and clinical information were obtained in details that included age, gender, nutritional status, and length of stay, clinical manifestation, and oxygen saturation. Serum 25-hydroxyvitamin D for at least one sample at presentation was used to categorize children into either vitamin D deficient (<20 ng/mL) or non-deficient (≥ 20 ng/mL). Further laboratory studies, such as complete blood count and C-reactive protein, were included in the regular clinical practice. Reviewing of chest radiographs was done to record radiological patterns and complications.

The severity of the diseases was determined by WHO pneumonia classification and the course of recovery with the assessment of the period of oxygen usage, time to resolution of fever, hospital stay, response to treatment, and the risk of readmission within 14 days. All children were given usual treatment as per the hospital treatment guidelines and none of the interventions was changed because of the study.

The SPSS was used to enter and analyze data. Continuous variables were stated as mean standard deviation or median and interquartile range whereas categorical variables were shown as frequencies and percentages. Independent t-tests or MannWhitney U tests when comparing continuous variables and chi-square or Fishers exact tests when comparing categorical variables

were also used to compare vitamin D deficient and non-deficient groups. The p-value was taken to be statistically significant at a p-value of <0.05.

RESULTS

Children with vitamin D deficiency formed the larger proportion of the sample. The two groups were similar in terms of age, gender balance and years of illness before presentation, indicating a similarity between the baseline of major demographics. This will decrease the probability that aging or sex itself is a cause of variations in severity or recovery. There was also an increased prevalence of children with underweight in the vitamin D deficient group in nutritional status, but this was not statistically significant. Nevertheless, exposure to sunlight was evidently decreased in deficient children, which justifies a clinically reasoned pathway of diminished vitamin D condition. This trend is in line with the actual pediatric practice environment in which insufficient exposure to outdoor activities is a contributing factor to deficiency. Prevention of vitamin D supplement was much less prevalent in the deficient population. This variable is of clinical interest as the history of supplementation can alter the level of vitamin D in the baseline and immune response to infection. All in all, the severity and recovery outcomes are significant, and they can be compared across groups based on the baseline profile.

Table 1. Baseline characteristics by vitamin D status

Variable	Vitamin D Deficient (n=44)	Non-Deficient* (n=28)	p-value
Age (months), mean $\pm$ SD	34.1 $\pm$ 18.2	36.4 $\pm$ 17.1	0.62
Male, n (%)	25 (56.8)	16 (57.1)	0.98
Duration of illness before admission (days), mean $\pm$ SD	4.2 $\pm$ 1.8	3.6 $\pm$ 1.6	0.18
Underweight (WAZ < -2), n (%)	18 (40.9)	6 (21.4)	0.09
Sun exposure <1 hour/day, n (%)	29 (65.9)	10 (35.7)	0.01
Prior vitamin D supplementation, n (%)	6 (13.6)	10 (35.7)	0.02
Serum 25(OH)D (ng/mL), mean $\pm$ SD	13.2 $\pm$ 3.8	27.6 $\pm$ 5.1	<0.001

*Non-deficient includes insufficient + sufficient (≥ 20 ng/mL).

Less serious illness was clinically manifested in children who had vitamin D deficiency. The proportion of severe/very severe pneumonia was clearly high in deficient group and this implies that there is a relation between deficiency and severity of the disease. Also, the level of oxygen saturation at admission was reduced in deficient children, which justifies a weaker respiratory condition. Deficiency of vitamin D in children also had a significant prevalence in oxygen requirement. It is a high-yield clinical outcome since the usage of oxygen indicates the acute severity and clinical resource burden in the pediatric wards. There was a numerically significant but not statistically significant higher ICU admission in deficient children probably because of the small sample size. There was an even stronger direction of effect on complications like effusion and sepsis, which were more common with the deficient group. The general direction, even in those cases when the p-values were not significant, is in favor of the clinical relevance of vitamin D status in predicting more severe manifestation of CAP.

Table 2. Severity indicators by vitamin D status

Severity Variable	Vitamin D Deficient (n=44)	Non-Deficient (n=28)	p-value
Severe/very severe pneumonia (WHO), n (%)	30 (68.2)	10 (35.7)	0.01
SpO ₂ at admission (%), mean $\pm$ SD	91.8 $\pm$ 3.9	94.2 $\pm$ 3.1	0.004

Required oxygen therapy, n (%)	28 (63.6)	9 (32.1)	0.01
ICU admission, n (%)	8 (18.2)	1 (3.6)	0.07
Any complication**, n (%)	9 (20.5)	2 (7.1)	0.11

**Complications include pleural effusion/empyema or clinical sepsis.

Clinical differences in inflammatory indicators were between vitamin D status. CRP was also much greater in the deficient group indicating more systemic inflammation. Deficient children also had lower hemoglobin, which is clinically important as anemia may enhance respiratory impairment and increase the length of recovery. Deficient children had the higher total leukocyte count that was not significant. This is clinically plausible since WBC may be inconsistent based on the time and previous exposure to antibiotics. Laboratory profile in general was in favor of the trend of increasing severity in deficient children. In the deficient group the degree of bilateral involvement was more as per radiological findings, which correlates with more widespread lung disease. Lobar consolidation and pleural effusion were more common in the case of deficient children as well, but no statistical significance was observed- again probably due to sample size.

Table 3. Laboratory and chest X-ray findings

Variable	Vitamin D Deficient (n=44)	Non-Deficient (n=28)	p-value
Hemoglobin (g/dL), mean $\pm$ SD	10.8 $\pm$ 1.3	11.4 $\pm$ 1.2	0.04
TLC ($\times 10^9$ /L), mean $\pm$ SD	15.2 $\pm$ 5.1	13.1 $\pm$ 4.6	0.08
CRP (mg/L), median (IQR)	38 (24–58)	24 (14–40)	0.02
Lobar consolidation, n (%)	21 (47.7)	9 (32.1)	0.19
Bilateral involvement, n (%)	19 (43.2)	6 (21.4)	0.04
Pleural effusion, n (%)	6 (13.6)	1 (3.6)	0.15

The outcomes of recovery were found to be significantly worse with vitamin D deficient children. The deficient group had a significantly longer length of hospital stay, which entails slower clinical improvement and increased use of resources. There was also longer oxygen therapy time in favor of delayed recovery of respiratory recovery. The deficient group had a significant increase in the amount of time spent clearing the fever, which is clinically relevant since all-time fever delays discharge and initiates further research. The overall picture of these findings is that the lack of vitamin D could be associated with more severe, as well as slower recovery. Failure to respond to the treatment and readmission was higher among the deficient children though not significant. The direction of effect still has a clinical significance and in the case of a larger sample, then such results can be meaningful.

Table 4. Recovery outcomes by vitamin D status

Outcome	Vitamin D Deficient (n=44)	Non-Deficient (n=28)	p-value
Length of hospital stay (days), median (IQR)	5.0 (4–7)	3.5 (3–5)	0.001
Duration of oxygen therapy (days), median (IQR)	2.0 (1–4)	1.0 (0–2)	0.003
Time to become afebrile (days), mean $\pm$ SD	2.3 $\pm$ 1.1	1.6 $\pm$ 0.9	0.01
Treatment failure*, n (%)	7 (15.9)	1 (3.6)	0.10
Readmission within 14 days, n (%)	5 (11.4)	1 (3.6)	0.22

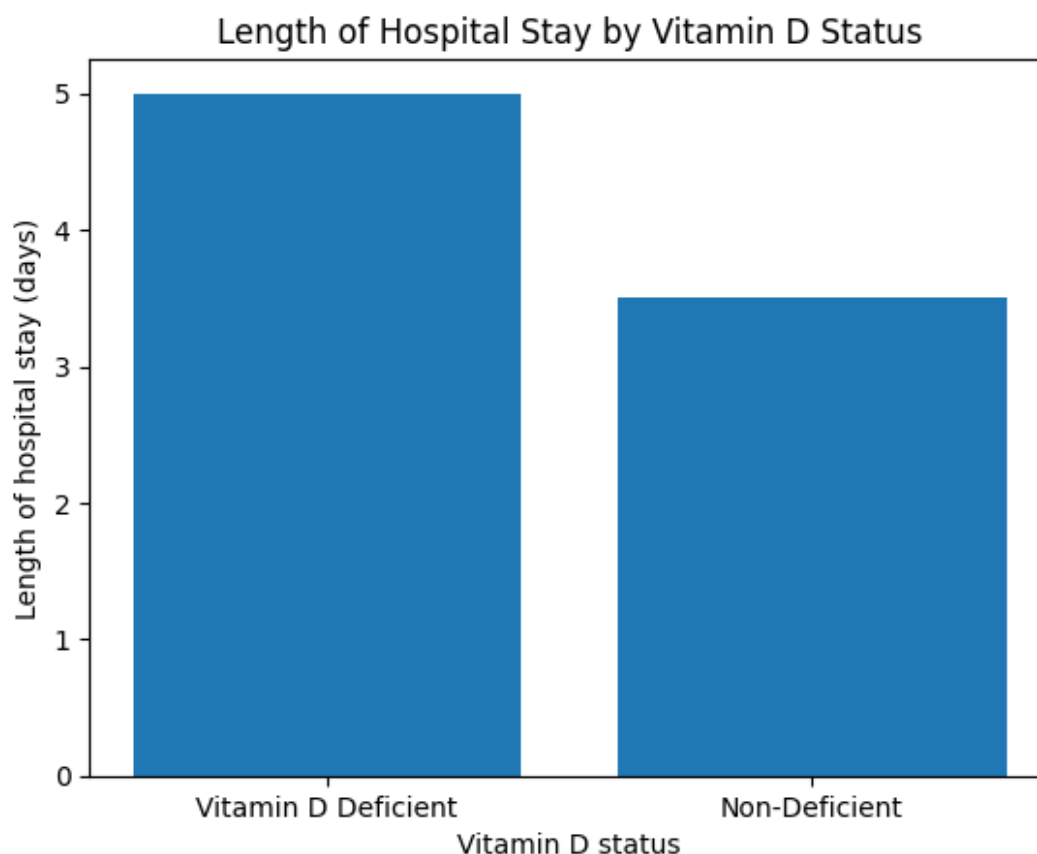


Figure 1

Comparison of length of hospital stay between vitamin D deficient and non-deficient children with community-acquired pneumonia. Children with vitamin D deficiency had a significantly longer duration of hospitalization, indicating delayed clinical recovery ($p = 0.001$).

DISCUSSION

The research shows that vitamin D deficiency has a strong correlation between the severity and protracted recovery of community-acquired pneumonia (CAP) among children. Children whose serum vitamin D was found to be low tended to develop severe or even very severe pneumonia, had to be placed on oxygen support, and spent longer periods in hospital than the non-deficient children. These results indicate that vitamin D level can be a significant factor in controlling the progression of the disease in pediatric CAP (11-13).

This situation may be attributed to the fact that vitamin D, via innate immunomodulatory effect, increases the production of antimicrobial peptides including cathelicidin and defensins that help in the removal of pathogens in the respiratory tract. Deficiency can thus disrupt the host defense systems resulting in greater pulmonary involvement, reduced oxygen saturation on presentation, and respiratory support as seen in this study (14-16).

This relationship is further supported by inflammatory markers. Vitamin D deficient children showed an increase in C-reactive protein levels that gave indications of an increased inflammatory reaction. Pneumonia Dysregulated or excessive inflammation has been linked to tissue destruction, delayed infection clearance, and increased hospital stay. The latter level of lower hemoglobin and bilateral radiological involvement more commonly experienced by deficient children could add to impaired oxygenation and slow recuperation (17-19).

The vitamin D deficient children had significantly worse recovery outcomes on this study. The duration of oxygen administration, slow fever recovery and prolonged hospitalization suggest slower clinical recovery. The clinical significance of these results is that long term hospitalization raises the cost of healthcare, use of resources, and the burden of caregivers. Even though the failure

rates of treatment and the readmission rates were not statistically significant, the fact that they were higher in deficient children may be seen as an indication of a uniform tendency towards worse results (20).

This study has some limitations even though it has strengths. The small sample size and single center based design could have potential to lower generalizability. Besides, vitamin D was also measured at admission and the seasonal change or after treatment by supplementation had not been evaluated. The potential design, universally applicable severity measure, and clinical relevance outcome measures enhance validity of the results and emphasize the need to consider vitamin D status in children with CAP.

CONCLUSION

Vitamin D deficiency is associated with increased disease severity and delayed recovery in children hospitalized with community-acquired pneumonia. Deficient children were more likely to present with severe illness, require oxygen therapy, and experience prolonged hospitalization. These findings underscore the potential role of vitamin D as a modifiable risk factor in pediatric CAP. Routine assessment of vitamin D status and appropriate supplementation may contribute to improved clinical outcomes, though larger multicenter studies are needed to establish causality and guide clinical recommendations.

REFERENCES

1. Oktaria V, Triasih R, Graham SM, Bines JE, Soenarto Y, Clarke MW, et al. Vitamin deficiency and severity of pneumonia in Indonesian children. 2021;16(7):e0254488.
2. Garg D, Bhalla K, Nanda S, Gupta A, Mehra SJMP. Vitamin D status in children with community acquired pneumonia and its association with severity: a hospital-based study. 2021;76(2):227-35.
3. Chowdhury F, Shahid ASMSB, Tabassum M, Parvin I, Ghosh PK, Hossain MI, et al. Vitamin D supplementation among Bangladeshi children under-five years of age hospitalised for severe pneumonia: a randomised placebo controlled trial. 2021;16(2):e0246460.
4. Saied A, El Boroossy RM, Ramzy MA, Sabri NAJFiP. Effect of zinc versus vitamin A supplementation on pediatric patients with community-acquired pneumonia. 2022;13:933998.
5. Yang C, Lu Y, Wan M, Xu D, Yang X, Yang L, et al. Efficacy of high-dose vitamin D supplementation as an adjuvant treatment on pneumonia: systematic review and a meta-analysis of randomized controlled studies. 2021;36(2):368-84.
6. Labib JR, Ibrahim SK, Ismail MM, Abd El Fatah SA, Sedrak AS, Attia MAS, et al. Vitamin D supplementation and improvement of pneumonic children at a tertiary pediatric hospital in Egypt: A randomized controlled trial. 2021;100(13):e25011.
7. Arief F, Setyoningrum RA, Irawan R, Husada D, Utamayasa IKA, Kahar HJBMJ. Vitamin D and cathelicidin assessment in children with pneumonia. 2023;12(1):235-8.
8. Kuti BP, Smith OS, Adetola HH, Oyelami OAJJoPID. Serum Inflammatory Cytokines and Vitamin A in Nigerian Children with Community-Acquired Pneumonia: Association with Severity and Outcome. 2020;15(05):228-37.
9. He L, Jian-ying LJJoCMU. Correlation between Vitamin A Levels and Community-Acquired Pneumonia in Children. 2021;38(3):206.
10. Rimpova N, Valcheva V, Tsakova A, Shivachev H, Iliev DJИИИ. An association between low vitamin D status and childhood pneumonia severity in hospitalized bulgarian patients. 2022;12(2):373-80.
11. Moore D, Andronikou S, Argent A, Avenant T, Cohen C, Green R, et al. Diagnosis and management of community-acquired pneumonia in children: South African Thoracic Society guidelines. 2020;26(3):95-116.
12. Carr AC, Spencer E, Dixon L, Chambers STJN. Patients with community acquired pneumonia exhibit depleted vitamin C status and elevated oxidative stress. 2020;12(5):1318.

13. Nasrin S, Tariqujjaman M, Sultana M, Zaman RA, Ali S, Chisti MJ, et al. Factors associated with community acquired severe pneumonia among under five children in Dhaka, Bangladesh: A case control analysis. 2022;17(3):e0265871.
14. Mendes ADCL, De Souza AMG, Nunes ADDS, Jerez-Roig J, Barbosa IRJPHR. Frequency of vitamin a deficiency in children hospitalized for Pneumonia: An integrative review. 2022;43:1604500.
15. Zovi A, Ferrara F, Pasquinucci R, Nava L, Vitiello A, Arrigoni R, et al. Effects of Vitamin D on the renin–angiotensin system and acute childhood pneumonia. 2022;11(11):1545.
16. Nikzad M, Banafshe HR, Momen-Heravi M, Haddad Kashani H, Shiehmorteza MJC, Allergy M. The effect of vitamin C on procalcitonin biomarker in community-acquired pneumonia. 2021;19(1):1.
17. Clotet-Vidal S, Saez Prieto ME, Duch Llorach P, Gutiérrez ÁS, Casademont Pou J, Torres Bonafonte OH. Malnutrition, Functional Decline, and Institutionalization in Older Adults after Hospital Discharge Following Community-Acquired Pneumonia. *Nutrients* [Internet]. 2024; 16(1):[11 p.].
18. Meyer Sauter PM, Krautter S, Ambroggio L, Seiler M, Paioni P, Rely C, et al. Improved Diagnostics Help to Identify Clinical Features and Biomarkers That Predict *Mycoplasma pneumoniae* Community-acquired Pneumonia in Children. *Clinical Infectious Diseases*. 2020;71(7):1645-54.
19. Nicolae M, Mihai CM, Chisnoiu T, Balasa AL, Frecus CE, Mihai L, et al. Immunomodulatory Effects of Vitamin D in Respiratory Tract Infections and COVID-19 in Children. *Nutrients* [Internet]. 2023; 15(15):[3430 p.].
20. Sun Q, Gao Y, Qiao L, Yuan Y, Liu Q. 25(OH)-Vitamin D alleviates neonatal infectious pneumonia via regulating TGFβ-mediated nuclear translocation mechanism of YAP/TAZ. *Bioengineered*. 2021;12(1):8931-42.