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IMPACT OF VITAMIN D DEFICIENCY ON SEVERITY OF COMMUNITY ACQUIRED PNEUMONIA

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Abstract

Background: *Community acquired pneumonia (CAP) is a major infectious disease associated with significant morbidity and mortality worldwide. Vit D plays an important role in immune modulation and host defense against respiratory infections. Deficiency of Vit D has been linked with increased susceptibility to infections and poor clinical outcomes in patients with CAP.*

Objective: *To determine the impact of Vit D deficiency on severity of community acquired pneumonia.*

Study Design & Setting: *This cross-sectional study was conducted at the Department of Medicine of Isra University Hospital, Hyderabad from September 2024 to March 2025.*

Methodology: *A total of 140 patients diagnosed with community acquired pneumonia were enrolled through non-probability consecutive sampling. Patients aged 18–70 years of either gender with clinical and radiological evidence of CAP were included. Serum Vit D levels were measured and severity of CAP was assessed using CURB-65 score. Data regarding demographic and clinical variables were collected using a structured proforma. Data analysis was performed using SPSS version 26. Numerical variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentages. Chi-square test and one-way ANOVA were applied where appropriate. A p-value ≤0.05 was considered statistically significant.*

Results: *The mean age of patients was 51.27 ± 14.63 years. Vit D deficiency was observed in 62.9% patients. Severe CAP was present in 28.6% patients. Mean serum Vit D levels were significantly lower in severe CAP patients compared to mild and moderate CAP groups (10.85 ± 4.17 ng/mL vs 27.14 ± 6.21 ng/mL and 18.63 ± 5.44 ng/mL; p<0.001). Significant associations were also observed between severe CAP and smoking, diabetes mellitus, hypertension, and higher body mass index.*

Conclusion: *Vit D deficiency was highly prevalent among patients with CAP and was significantly associated with increased disease severity. Assessment of serum Vit D levels may help in early identification of high-risk patients with community acquired pneumonia.*

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INTRODUCTION

Community acquired pneumonia (CAP) is one of the leading infectious causes of morbidity and mortality worldwide.1 CAP is defined as an acute infection of the pulmonary parenchyma acquired outside hospital settings and is characterized by symptoms such asfever, cough, dyspnea, sputum production, and chest pain accompanied by radiological evidence of pulmonary infiltrates.2 Despite advances in antimicrobial therapy and supportive care, CAP continues to impose a substantial clinical and economic burden, particularly among children, elderly individuals, and immunocompromised patients.3 According to global estimates, lower respiratory tract infections account for millions of deaths annually, with pneumonia being a predominant contributor. The incidence and severity of CAP are higher in low- and middle-income countries due to limited healthcare resources, delayed diagnosis, malnutrition, and associated comorbidities.4

The etiology of CAP is diverse and includes bacterial, viral, and atypical pathogens. Among bacterial organisms, Streptococcus pneumoniae remains the most commonly identified causative agent worldwide, followed by Haemophilus influenzae, Staphylococcus aureus, and gram-negative bacilli. Viral pathogens such as influenza virus, respiratory syncytial virus, and coronaviruses are also increasingly recognized causes of CAP.5 The pathophysiology of CAP involves invasion of microorganisms into the lower respiratory tract, resulting in activation of inflammatory pathways, alveolar damage, impaired gas exchange, and systemic inflammatory response. Excessive inflammation can lead to severe complications including respiratory failure, sepsis, pleural effusion, and multi-organ dysfunction, thereby increasing hospitalization and mortality rates.6

Vitamin D (Vit D) is a fat-soluble vitamin that plays an essential role not only in calcium homeostasis and bone metabolism but also in modulation of the immune system. Vit D receptors are expressed on various immune cells including macrophages, dendritic cells, and lymphocytes, indicating its significant immunomodulatory function.7 Vit D enhances innate immunity by promoting the production of antimicrobial peptides such as cathelicidin and defensins, which help eliminate respiratory pathogens.8 Additionally, it regulates adaptive immune responses by reducing excessive pro-inflammatory cytokine release. Deficiency of Vit D has therefore been associated with increased susceptibility to respiratory tract infections, impaired immune response, and worse clinical outcomes in infectious diseases.9

Factors contributing to Vit D deficiency include inadequate dietary intake, limited sunlight exposure, aging, chronic illnesses, obesity, and malabsorption disorders.10 Several studies have suggested a relationship between low serum Vit D levels and increased severity of CAP, including prolonged hospital stay, greater need for intensive care, and higher mortality rates.11,12

Community acquired pneumonia (CAP) remains a major cause of hospitalization and mortality worldwide, particularly in developing countries like Pakistan. Vit D deficiency is highly prevalent in the Pakistani population due to poor nutritional status, limited dietary supplementation, and inadequate sunlight exposure. Emerging international evidence suggests that low Vit D levels may be associated with increased severity and poorer outcomes in CAP patients; however, local data from Pakistan are limited and inconsistent. Most previous studies have focused on the occurrence of pneumonia rather than evaluating the impact of Vit D deficiency on disease severity and clinical outcomes. This study will help identify whether Vit D deficiency can serve as a useful predictor of severe CAP in our population. The findings of this research may contribute to early risk stratification, better patient management, and development of preventive strategies including Vit D screening and supplementation in high-risk patients.

MATERIALS AND METHODS

This cross-sectional study was conducted at the Department of Medicine of Isra University Hospital, Hyderabad from September 2024 to March 2025 after approval from the institutional ethical review committee. Patients diagnosed with community acquired pneumonia (CAP) were

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enrolled through non-probability consecutive sampling. The sample size was calculated using the WHO sample size calculator by taking the expected frequency of severe Vit D deficiency among patients with CAP, 95% confidence level, 5% margin of error, and desired study power of 80%. A total of 140 patients were included in the study. Patients aged 18 to 70 years of either gender presenting with clinical and radiological evidence of CAP were included in the study. CAP was diagnosed on the basis of symptoms including fever, cough, sputum production, dyspnea, and chest radiograph showing new pulmonary infiltrates acquired outside hospital settings. Patients with hospital acquired pneumonia, pulmonary tuberculosis, chronic liver disease, chronic kidney disease, malignancy, autoimmune disorders, pregnancy, immunocompromised states, and those already receiving Vit D supplementation were excluded from the study.

After taking informed written consent, demographic information including age, gender, body mass index, smoking status, and comorbidities was recorded on a predesigned proforma. Venous blood samples were collected under aseptic measures for measurement of serum Vit D levels. Severity of CAP was assessed using CURB-65 score and patients were categorized into mild, moderate, and severe pneumonia groups accordingly. Serum Vit D levels were classified as deficient, insufficient, or sufficient according to standard laboratory reference ranges. All patients received management according to institutional treatment protocols for CAP.

Data were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 26. Numerical variables such as age, body mass index, serum Vit D levels, and CURB-65 score were presented as mean ± standard deviation. Categorical variables such as gender, smoking status, comorbidities, severity categories of CAP, and Vit D deficiency status were presented as frequency and percentages. Independent sample t-test or one-way ANOVA was applied for comparison of numerical variables where appropriate, while chi-square test was used for comparison of categorical variables. Stratification was done with respect to age, gender, smoking status, diabetes mellitus, hypertension, and body mass index to control effect modifiers. Post-stratification chi-square test and independent sample t-test were applied accordingly. A p-value of ≤0.05 was considered statistically significant

RESULTS

The mean age of the study participants was 51.27 ± 14.63 years, while the mean body mass index was 26.11 ± 4.28 kg/m². The mean serum Vit D level was 18.42 ± 7.95 ng/mL and the mean CURB-65 score was 2.31 ± 1.04. There were 82 (58.6%) males and 58 (41.4%) females. Smokers constituted 49 (35.0%) of the study population, while diabetes mellitus and hypertension were present in 54 (38.6%) and 47 (33.6%) patients respectively, as given in Table 1.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (n = 140)

Variable	Mean ± SD / n (%)
Age (years)	51.27 ± 14.63
Body Mass Index (kg/m²)	26.11 ± 4.28
Serum Vit D Level (ng/mL)	18.42 ± 7.95
CURB-65 Score	2.31 ± 1.04
Male Gender	82 (58.6%)
Female Gender	58 (41.4%)
Smokers	49 (35.0%)
Non-Smokers	91 (65.0%)
Diabetes Mellitus	54 (38.6%)
Hypertension	47 (33.6%)

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Among the total 140 patients with community acquired pneumonia, 39 (27.9%) patients had mild CAP, 61 (43.6%) had moderate CAP, and 40 (28.6%) had severe CAP according to CURB-65 severity classification, as given in Figure 1.

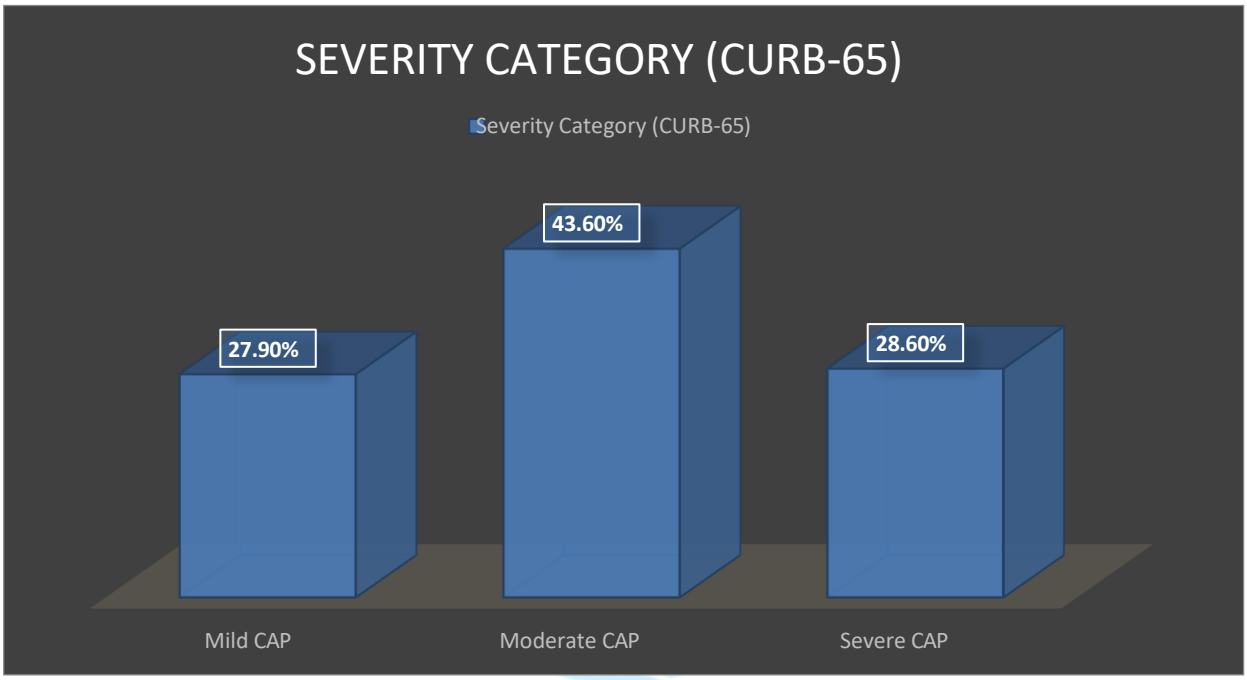


Figure 1: Distribution of Patients According to Severity of Community Acquired Pneumonia (n = 140)

Regarding serum Vit D status, deficiency was observed in 88 (62.9%) patients, insufficiency in 34 (24.3%) patients, while only 18 (12.9%) patients had sufficient Vit D levels, as given in figure 2.

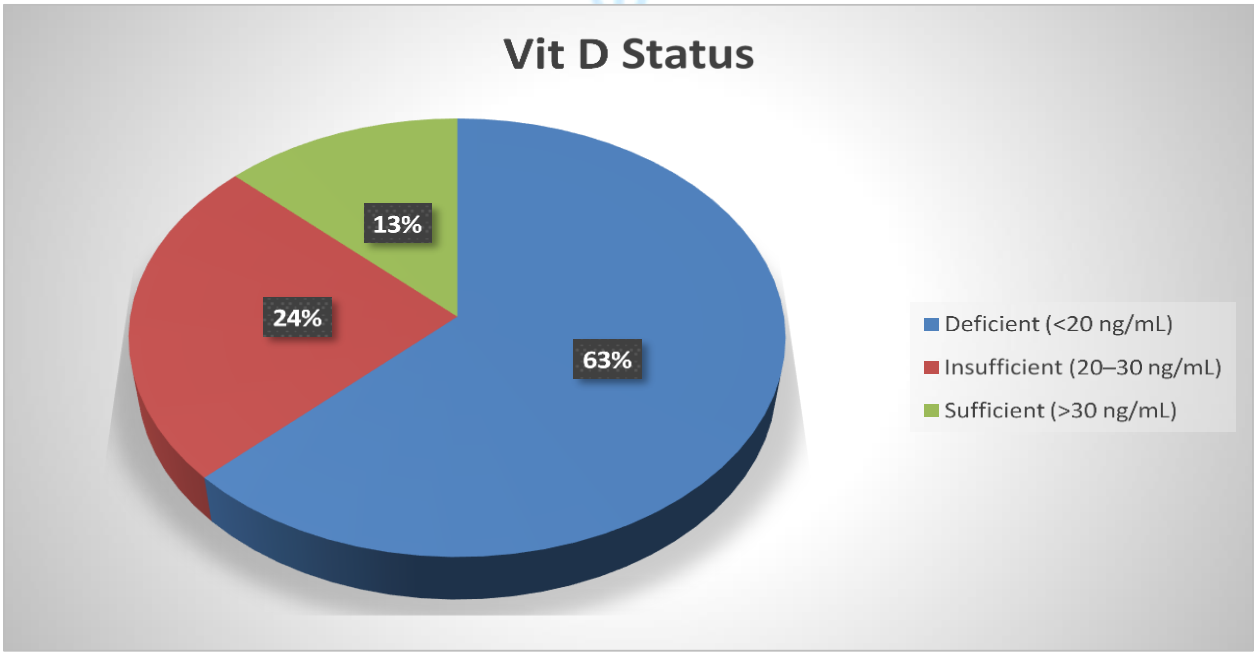


Figure 2: Distribution of Patients According to Vit D Status (n = 140)

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The mean serum Vit D level was significantly lower among patients with severe CAP (10.85 ± 4.17 ng/mL) compared to moderate CAP (18.63 ± 5.44 ng/mL) and mild CAP (27.14 ± 6.21 ng/mL). The difference was statistically significant with a p-value of <0.001, as given in Table 3.

Table 3: Comparison of Mean Serum Vit D Levels According to Severity of Community Acquired Pneumonia (n = 140)

Severity of CAP	Mean Serum Vit D Level (ng/mL)	p-value
Mild CAP	27.14 ± 6.21	<0.001
Moderate CAP	18.63 ± 5.44	
Severe CAP	10.85 ± 4.17	

A significant association was observed between Vit D status and severity of community acquired pneumonia. Among Vit D deficient patients, 37 (42.0%) had severe CAP, whereas no patient with sufficient Vit D levels had severe AP. The association was statistically significant (p <0.001), as given in Table 4.

Table 4: Association of Vit D Status with Severity of Community Acquired Pneumonia (n = 140)

Vit D Status	Mild CAP n (%)	Moderate CAP n (%)	Severe CAP n (%)	p-value
Deficient	9 (10.2%)	42 (47.7%)	37 (42.0%)	<0.001
Insufficient	17 (50.0%)	14 (41.2%)	3 (8.8%)	
Sufficient	13 (72.2%)	5 (27.8%)	0 (0%)	

Stratification analysis showed that severe CAP was significantly more frequent among patients aged >50 years, males, smokers, diabetics, hypertensive patients, and those with body mass index >25 kg/m². Statistically significant associations were observed for age (p=0.041), gender (p=0.048), smoking status (p=0.002), diabetes mellitus (p=0.001), hypertension (p=0.029), and body mass index (p=0.011), as given in Table 4.

Table 5: Stratification of Severe Community Acquired Pneumonia with Respect to Effect Modifiers (n = 140)

Variable	Category	Severe CAP Present n (%)	Severe CAP Absent n (%)	p-value
Age	≤50 years	14 (20.6%)	54 (79.4%)	0.041
	>50 years	26 (36.1%)	46 (63.9%)	
Gender	Male	28 (34.1%)	54 (65.9%)	0.048
	Female	12 (20.7%)	46 (79.3%)	
Smoking Status	Smokers	22 (44.9%)	27 (55.1%)	0.002
	Non-Smokers	18 (19.8%)	73 (80.2%)	
Diabetes Mellitus	Present	24 (44.4%)	30 (55.6%)	0.001
	Absent	16 (18.6%)	70 (81.4%)	
Hypertension	Present	19 (40.4%)	28 (59.6%)	0.029
	Absent	21 (22.6%)	72 (77.4%)	
Body Mass Index	≤25 kg/m²	13 (18.8%)	56 (81.2%)	0.011
	>25 kg/m²	27 (38.0%)	44 (62.0%)	

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DISCUSSION

Despite advances in diagnosis and treatment, CAP continues to impose a substantial healthcare burden. Vit D plays an important role in immune regulation and host defense against respiratory pathogens through activation of antimicrobial peptides and modulation of inflammatory responses.13 Therefore, evaluating the impact of Vit D deficiency on severity of CAP may help improve early risk assessment and patient management.

The present study evaluated the impact of Vit D deficiency on severity of community acquired pneumonia (CAP) and demonstrated that deficient serum Vit D levels were significantly associated with increased disease severity. In our study, Vit D deficiency was observed in 62.9% of patients, while severe CAP was present in 28.6% patients. Mean serum Vit D levels were markedly lower among patients with severe CAP (10.85 ± 4.17 ng/mL) compared to moderate CAP (18.63 ± 5.44 ng/mL) and mild CAP (27.14 ± 6.21 ng/mL), with a highly significant association ($p<0.001$). Furthermore, among Vit D deficient patients, 42.0% had severe CAP, whereas none of the patients with sufficient Vit D levels developed severe disease. These findings support the hypothesis that Vit D plays a protective immunomodulatory role against respiratory infections and that its deficiency may contribute to worse clinical outcomes in CAP.

Our findings are in strong agreement with Talebi et al. (2019), who reported that pneumonia severity, mortality risk, and duration of hospital stay were significantly greater among Vit D deficient patients. Similar to our study, they also found that lower serum Vit D levels were associated with higher CURB-65 scores and severe CAP. The significant inverse relationship between serum Vit D levels and disease severity observed in both studies suggests that Vit D deficiency may influence the inflammatory cascade and immune dysfunction associated with severe pneumonia.14 Likewise, Mamani et al. (2017) demonstrated that patients with severe Vit D deficiency had significantly higher CURB-65 scores along with more severe clinical presentation and inflammatory response. Their findings closely parallel our results where severe CAP patients had considerably lower Vit D levels than mild and moderate cases.15

Comparable observations were also reported by Georgakopoulou et al. (2020), who demonstrated a significant negative correlation between serum 25-hydroxyvitamin D levels and pneumonia severity indices including CURB-65 score. Their study additionally showed prolonged hospital stay and higher mortality among Vit D deficient patients, indicating that lower Vit D levels may not only increase disease severity but also adversely affect prognosis. Although mortality and hospitalization duration were not assessed in our study, the significant association between Vit D deficiency and severe CAP supports the possibility of poorer outcomes in deficient patients.16

Mudipalli et al. (2024) also reported that severe Vit D deficiency was associated with increased CAP severity and prolonged hospitalization. They observed that patients with severe deficiency had significantly longer hospital stay (12.30±8.47 days) compared to those with mild deficiency (8.58±4.04 days). These findings further strengthen our results by suggesting that Vit D deficiency may increase disease burden and delay recovery.17 Similarly, Leow et al. (2011) observed that low serum Vit D levels were associated with impaired innate immune response and increased mortality in CAP patients. Their study emphasized the immunological role of Vit D in respiratory infections, which may explain why our Vit D deficient patients demonstrated higher frequency of severe pneumonia.18

The findings of our study are also supported by the large meta-analysis conducted by Zhou et al. (2019), which included 20,966 subjects and demonstrated that patients with Vit D deficiency had significantly increased risk of CAP with an odds ratio of 1.64 (95% CI: 1.00–2.67). They additionally reported that serum Vit D levels were 5.63 ng/mL lower in CAP patients compared to controls. The consistency between our findings and this meta-analysis strengthens the evidence regarding the association between Vit D deficiency and CAP severity.19 Similarly, Hegelund et al. (2025) found that deficient Vit D status was associated with poorer clinical outcom es and

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increased inflammatory burden among hospitalized CAP patients assessed using CURB-65 score, which corresponds well with our findings of increased severe CAP among Vit D deficient individuals.20

However, our results differ from those reported by Oktaria et al. (2021), who found no statistically significant association between Vit D status and pneumonia severity in their pediatric population despite observing Vit D deficiency in approximately one-fifth of hospitalized pneumonia patients. This discrepancy may be attributed to differences in study population, age group, nutritional status, geographic factors, sample size, and severity assessment criteria.

Our study involved adult patients with CAP, whereas Oktaria et al. focused on children, in whom immune responses and Vit D metabolism may differ considerably.21

In our study, stratification analysis further demonstrated that severe CAP was significantly more common among smokers, diabetic patients, hypertensive individuals, older age groups, and patients with higher body mass index. These findings indicate that Vit D deficiency may act synergistically with existing comorbidities and risk factors to worsen pneumonia severity. The high prevalence of Vit D deficiency observed in our population may reflect poor nutritional status, limited sunlight exposure, and lack of supplementation practices common in developing countries such as Pakistan. Overall, the findings of our study and previously published literature consistently suggest that low serum Vit D levels are significantly associated with increased severity of community acquired pneumonia and may serve as an important prognostic biomarker in CAP patients.

Study Limitations:

It was a single-center study with a relatively limited sample size, which may reduce generalizability of the findings. The cross-sectional design limited the ability to establish a causal relationship between Vit D deficiency and severity of CAP. Seasonal variations affecting serum Vit D levels were not evaluated in this study. In addition, dietary habits, sunlight exposure, and socioeconomic factors influencing Vit D status were not assessed.

CONCLUSION

Vit D deficiency was found to be highly prevalent among patients with community acquired pneumonia and was significantly associated with increased disease severity. Lower serum Vit D levels were observed in patients with severe CAP compared to mild and moderate disease. Assessment of Vit D status may therefore be useful in identifying high-risk patients and improving management outcomes in CAP.

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