

Frequency of vitamin D deficiency in patients with pulmonary tuberculosis in Mardan, Pakistan: a hospital-based study

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ABSTRACT

Background: TB has remained a significant cause of morbidity and mortality. Vitamin D increases natural immunity by causing the activation of macrophages and the production of antimicrobial peptides. We want to determine the levels of vitamin D deficiency in pulmonary tuberculosis patients and to establish its correlation with demographic and clinical variables as well.

Methods: This study was conducted in 100 patients diagnosed with pulmonary TB. The demographic data, clinical characteristics, and sputum acid-fast bacilli (AFB) status were taken, as well as the results of chest X-rays. Serum vitamin D concentrations were measured and classified into three categories: deficiency (<20 ng/mL), insufficiency (20–29 ng/mL), and sufficiency (>30 ng/mL). Statistical analysis was performed using SPSS version 26. Data were stratified, and the Chi-square test was applied to assess associations. A p-value of <0.05 was considered statistically significant.

Results: The average level of serum vitamin D was 23.08 ± 8.45 ng/mL. The frequency of Vitamin D deficiency was observed in 36% of patients, while 41% had insufficiency, resulting in an overall hypovitaminosis D prevalence of 77%. There were significant relationships between the status of vitamin D and age ($p=0.020$), gender ($p=0.006$), socioeconomic status ($p=0.008$), sputum AFB positivity ($p=0.033$) and chest X-ray findings ($p=0.004$). There was no notable correlation with body mass index, smoking status, prior TB infection and BCG vaccination status.

Conclusion: Vitamin D deficiency was found to be very common among the pulmonary TB patients, and there was a significant association between the condition and markers of the severity of pulmonary TB. Vitamin D deficiency Routine screening and correction could be included in TB management plans.

Key Words: Hypovitaminosis D, Pulmonary Tuberculosis, Sputum AFB, Socioeconomic Status, Vitamin D Deficiency

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Introduction

Tuberculosis (TB) has been a significant global health issue and one of the most frequent causes of mortality due to single infectious agent globally. The World Health Organization (WHO) reports millions of new TB cases every year and a large

proportion of the burden falls in the low and middle-income countries with Pakistan being one of them (1). Although diagnosis and treatment have advanced; TB has remained a significant cause of morbidity and mortality, especially in resource-constrained circumstances (2).

Vitamin D has also become a significant immunomodulatory hormone whose role in host defense against *Mycobacterium tuberculosis* has become established. It increases natural immunity by causing the activation of macrophages and the production of antimicrobial peptides like cathelicidin that are vital to intracellular killing of mycobacteria (3,4). In the past sunlight exposure and cod liver oil were adjunctive treatments of TB, which indicates a possible biological connection between vitamin D and control of the illness (5).

A number of epidemiological researches have shown low levels of serum vitamin D to be associated with high vulnerability to active TB (6,7). Severity of the disease, sputum positivity, and cavitary pulmonary lesions have been also associated with vitamin D deficiency (7). The South Asian populations are particularly susceptible because of the restricted exposure to sunlight, malnutrition, socioeconomic inequalities, and cultural orientations on sunlight exposures (9).

Pakistan ranks among the high TB burden nations globally but locally there is limited data on the assessment of the prevalence of vitamin D deficiency among the pulmonary TB patients and especially the Khyber Pakhtunkhwa region. The importance of hypovitaminosis D in this population could be useful in determining the predictable risk factors and possible adjunctive measures in the management of TB. Due to the limited local data on the baseline status of vitamin D

among pulmonary TB patients in the Khyber Pakhtunkhwa region, there is a clear rationale to evaluate this burden locally. Understanding the frequency of hypovitaminosis D in this population can help identify predictable risk factors and potential adjunctive management strategies. Therefore, this study was conducted to evaluate the frequency of vitamin D deficiency among individuals with pulmonary tuberculosis in Mardan, Pakistan, and to determine its relationship with demographic and clinical variables such as age, gender, socioeconomic status, sputum acid-fast bacilli (AFB) positivity, and radiological findings.

Methods

This cross-sectional study was carried out in the Pulmonology unit of MTI Mardan Medical complex in Mardan, Pakistan between January and December 2025 and was granted the approval of the Institutional Ethical and Review Board of MTI Bacha Khan medical college Mardan with reference number 708/BKMC dated 05-12-2024. All participants were asked to provide informed consent in writing. One hundred adult patients (18 years and above) with newly diagnosed tuberculosis (TB) were recruited using non-probability consecutive sampling. The diagnosis of pulmonary TB was based on the sputum acid-fast bacilli (AFB) positivity and/or radiological evidence. The inclusion criteria were limited to newly diagnosed adults to assure homogeneity and to determine baseline vitamin D status before the treatment is substantially exposed.

Patients already treated with vitamin D supplementation or anti-tuberculous treatment longer than two weeks were not included in order to prevent the presence of confounding factors on serum vitamin D

levels. Additional exclusion criteria were CKD, CLD, malabsorption syndromes, malignancy, other granulomatous diseases and pregnancy as these conditions could have had a direct influence on the metabolism of vitamin D. The data were recorded using predesigned data collection forms. demographic (gender, age, and socioeconomic status, based on monthly family income); and clinical (body mass index (BMI), smoking, duration of symptoms, history of the past TB infection, status of BCG vaccination, results of the sputum AFB, and the results of the chest x-ray. The level of serum 25-hydroxyvitamin D [25(OH)D] was measured using a single standard laboratory. Patients were categorized based on their serum vitamin D levels into 3 categories i.e., the deficient (less than 20 ng/mL), the insufficient (20 to 29 ng/mL), and the adequate (30 and higher) category.

This research was had two major objectives. First, we determined the prevalence of vitamin D deficiency in patients with pulmonary tuberculosis. Second, we examined its relation with demographic and clinical variables of the participants. Data were analyzed using SPSS version 26. The summary of continuous variables was in the form of mean $\pm$ standard deviation or median, depending on the distribution of the data, and the categorical variables was represented as frequencies and percentages. Stratification was followed by Chi-square analysis test, and p-value less than 0.05 was considered to be significant.

Results

The study involved 100 patients of pulmonary tuberculosis. The mean age of the participants was 42 ± 14.9 years where as mean BMI was 20.3 ± 2.9 kg/m². Almost half

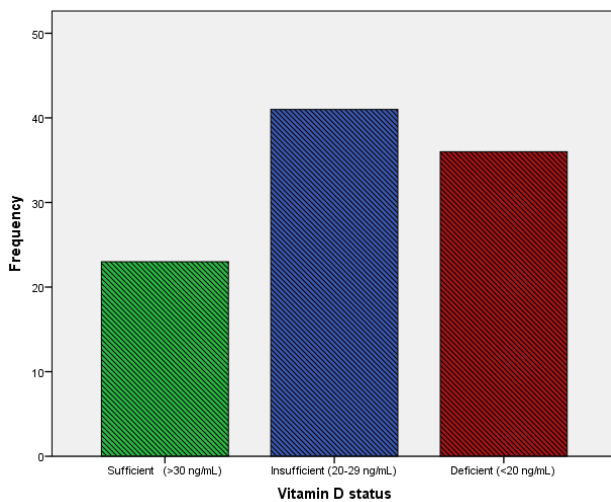
of the respondents (49 patients) were those of low socioeconomic group. Thirty four percent were smokers and 12% had a past history of tuberculosis infection as well. Vaccination against the BCG was reported in 88 percent of the patients (see Table I to obtain the details of the demographics of participants). 72 % of the participants had a positive report for sputum AFB. Cavitary lesions were observed in 56% of cases on chest X-ray, whereas infiltrates were observed in 32%. Rest of the enrolled patients had normal chest X-ray on presentation.

Table I: Demographic Profile and Clinical Features of Study Participants

Variables	n (%)
Age Group	
<25 years	20 (20.0)
26–40 years	30 (30.0)
41–55 years	26 (26.0)
>55 years	24 (24.0)
Gender	
Male	45 (45.0)
Female	55 (55.0)
BMI (kg/m ²)	
<18.5	40 (40.0)
18.5–24.9	54 (54.0)
25–29.9	6 (6.0)
Socioeconomic Status	
Low	49 (49.0)
Middle	38 (38.0)
High	13 (13.0)
Smoking history	34 (34.0)
Previous TB infection	12 (12.0)
BCG vaccinated	88 (88.0)

The mean serum vitamin D level was 23.08 ± 8.45 ng/mL (median 23 ng/mL). Overall, 77% of patients had hypovitaminosis D, including 36% with deficiency and 41% with insufficiency, while 23% had sufficient levels (Figure 1).

Fig 1: Vitamin D status of Enrolled Patients



The stratification analysis showed statistically significant correlation between the status of vitamin D and age group ($\chi^2=15.02$, $p=0.020$). The prevalence of vitamin D deficiency among patients aged 26-55 years during active pulmonary tuberculosis was relatively greater; this indicates that middle-aged people in the area are more susceptible to hypovitaminosis D.

The correlation with gender was also found to be significant ($\chi^2=10.26$, $p=0.006$). A higher proportion of women had Vitamin D deficiency as compared to males of the same age, this could be due to the factors like limited exposures to sun as the cultural beliefs of the region and variation in nutritional status.

Socioeconomic status was significantly associated with vitamin D status ($\chi^2=13.78$, $p=0.008$). Patients belonging from low socioeconomic backgrounds were found to have higher percentage of vitamin D deficiency, probably reflecting their limited nutritional intake and limited access to healthcare facilities.

Notably, the study also found a significant link between the sputum AFB positivity and vitamin D status of the participants ($\chi^2=6.81$,

$p=0.033$). those who had positive AFB had higher proportions of deficiency, indicating that there could be a correlation between low vitamin D levels and high bacillary burden. Likewise, the vitamin D status was greatly linked with the findings of the chest X-ray ($\chi^2=15.15$, $p=0.004$), with more cases of vitamin D deficiency found in patients who had cavitary lesions on their chest X-rays. This helps in a potential relationship between hypovitaminosis D and worse radiological disease.

Conversely, vitamin D status and BMI ($p=0.417$), smoking history ($p=0.462$), previous TB infection ($p=0.081$), and BCG vaccination status ($p=0.835$) showed no statistically significant, showing that these factors did not significantly impact vitamin D levels in this group. (Table II).

Table II: Association Between Vitamin D Status and Demographic and Clinical Variables among pulmonary tuberculosis patients

Variables	χ^2	df	p-value
Age	15.02	6	0.020
Gender	10.26	2	0.006
BMI	3.91	4	0.417
Socioeconomic Status	13.78	4	0.008
Smoking history	1.54	2	0.462
Previous TB infection	5.03	2	0.081
BCG vaccination	0.36	2	0.835
Sputum AFB	6.81	2	0.033
Chest X-ray findings	15.15	4	0.004

Discussion

The current study shows that the **frequency** of hypovitaminosis D is very high (77%) among patients with pulmonary tuberculosis (TB) in Mardan, Pakistan. The mean serum vitamin D concentration (23.08 ± 8.45 ng/mL) demonstrates a widespread **frequency** of insufficiency in this patient group. These results are in line with similar research reporting a high association

between low vitamin D status and active TB. (10,11,12)

Vitamin D has an important immunomodulatory effect, improving the action of macrophages as well as production of antimicrobial peptides like cathelicidin that facilitates intracellular killing of *Mycobacterium tuberculosis*. (8,13,14) A number of meta-analyses have reported that individuals with reduced plasma vitamin D concentrations have a higher risk of developing active tuberculosis. TB. (6,7) Our results have been similar to established studies in South Asia where serum vitamin D deficiency was a common finding in TB patients. (8,9)

There was a considerable correlation between the status of vitamin D and the age, gender, and socioeconomic status. It is possible that higher deficiency in females can be attributed to lack of sunlight exposure and culture practices as reported earlier. (15,16) The high correlation with low socioeconomic status is due to poor nutrition and low activity outside, which are identified as predisposing factors to vitamin D deficiency. (17)

Notably, the deficiency of vitamin D was significantly related to the sputum AFB positivity and cavitory lesion, indicating that these two factors are related to the severity of the disease. Other reports have shown similar results, with low vitamin D level being associated with increased bacillary burden and radiological involvement. (1,2,18) These results indicate that vitamin D could have a role in host immune response and the course of the disease.

There was no meaningful correlation with BMI, smoking, BCG vaccination, or prior TB infection, as other studies have reported. (7,13). The results indicate the possible role that vitamin D screening can play as an

adjunct in the management of the TB disease. Nonetheless, a causal inference could not be made because of the cross-sectional design.

Conclusion: vitamin D deficiency is very common in pulmonary TB patients' Significant correlations with age, gender, socioeconomic status, sputum AFB positivity, and radiological severity indicate that there might be a relationship between low vitamin D levels and the burden of disease. The implications of these findings, which can be emphasized, are both the clinical significance of vitamin D status screening in TB patients and the potential contribution to the disease progression. Longitudinal studies should be further pursued to have therapeutic implications.

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