Original Research Paper

Volume - 15 | Issue - 12 | December - 2025 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Biochemistry

TRENDS IN VITAMIN D STATUS AMONG ADULT PATIENTS ATTENDING A TERTIARY CARE HOSPITAL IN SILCHAR: A RETROSPECTIVE SEASON-BASED ANALYSIS

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ABSTRACT **Background:** Although India receives ample sunlight, vitamin D deficiency remains highly prevalent, with rates approaching 70% in South Asia. Limited sun exposure, dietary inadequacies and cultural practices contribute significantly to this paradox. Aim: To assess the seasonal variation in serum vitamin D levels among adult patients attending Silchar Medical College in Assam from April 2024 to March 2025. **Methods:** This retrospective, observational study was conducted in Silchar Medical College and Hospital. Serum 25(OH)D levels were estimated by competitive immunoassay and classified as deficiency, insufficiency, sufficiency and toxicity. Seasonal variation was analysed by dividing the year into five seasons. **Results:** In this study of 731 adults (≥18 years), males had higher mean serum 25(OH)D levels than females (49.6 vs. 42.3 ng/mL; $p<0.001$), with females showing nearly twice the prevalence of deficiency and insufficiency ($p<0.01$). Vitamin D sufficiency exceeded 75% across age groups, though deficiency was more frequent in individuals >60 years. Significant seasonal variation was observed, with sufficiency lowest during the monsoon (66.7%) and highest in winter (88.1%; $p<0.001$). Mean 25(OH)D concentrations were lowest in monsoon and highest in autumn ($p<0.001$). **Conclusions:** This study provides evidence of substantial seasonal and gender differences in vitamin D status based on a large tertiary-care sample with standardized measurement.

KEYWORDS : 25-Hydroxyvitamin D [25(OH)D], Vitamin D Deficiency (VDD), Seasonal Variation, UVB

INTRODUCTION

Despite India's abundant sunshine, multiple population-based studies have consistently demonstrated low 25(OH)D levels across different demographic group (Sreenivasulu et al., 2024). Globally, an estimated one billion people are affected by vitamin D insufficiency across all ages and ethnicities (Iqbal et al., 2019).

Vitamin D primarily regulates parathyroid hormone secretion, optimizes calcium absorption, and maintains bone and muscle health. In addition, it has pleiotropic effects on extra-skeletal systems, including immune modulation, cellular differentiation, endocrine balance, and cardiovascular function. Consequently, altered vitamin D levels have been implicated in diabetes, metabolic syndrome, cardiovascular disease, autoimmune disorders (e.g., rheumatoid arthritis, Crohn's disease), infectious diseases such as tuberculosis, and increased risks of breast, colon, ovarian, and prostate cancers (de Melo Bacha et al., 2022).

Among its metabolites, serum 25-hydroxyvitamin D [25(OH)D] is considered the most reliable marker of vitamin D status as it reflects both intake and circulating reserves. The biological half-live of the metabolite is nearly 3 weeks for 25(OH)D (Aparna et al., 2018).

Silchar (24.8°N, 92.8°E; ~25–30 m elevation) experiences very high UV exposure, with summer UV index levels reaching 13–14, suggesting that short sun exposure is generally adequate for endogenous vitamin D synthesis. However, region-specific data on seasonal variation in vitamin D status from Northeast India remain limited. To address this gap, the present study retrospectively evaluates seasonal trends in vitamin D status among adults tested at a tertiary care hospital in Silchar using routinely collected laboratory records.

METHODS

All patients aged ≥18 years who were referred for serum vitamin D estimation during the study period were included. A total of 731 subjects underwent testing. 3 mL of venous blood was collected in clot activator tubes and serum was separated by centrifugation at 3500 rpm for 10 minutes. Data were retrieved from the Laboratory Information System (LIS) of the Biochemistry section, Central Composite Laboratory.

To analyse seasonal variation, the calendar year was categorized into five seasons: winter (December–February), spring (March–April), summer (May–June), monsoon (July–September) and autumn (October–November). Patients with incomplete demographic details or with known chronic liver disease or renal disease were excluded from the study. Ethical approval was obtained from the Institutional Ethics Committee of Silchar Medical College and Hospital (Ref. No. SMC/ETHICS/M2/2025/39, Dated, Silchar, 20/08/2025).

Estimation of serum vitamin D was completed by competitive immunoassay using Vitros-5600 full auto analyser. Serum 25(OH)D levels were categorized according to established international guidelines: deficiency was defined as concentrations <20 ng/mL, insufficiency as 20–29 ng/mL, sufficiency as 30–100 ng/mL, and potential toxicity as >100 ng/mL. These thresholds are consistent with the criteria recommended by the Endocrine Society Clinical Practice Guidelines (Holick et al., 2011).

Statistical analysis was conducted in SPSS. Continuous variables were summarized as mean ± SD and categorical variables as frequencies (%). Gender differences in mean 25(OH)D were assessed using the independent t-test, and distributions of vitamin D status were compared using chi-square tests ($p<0.05$). Seasonal variation in mean levels was evaluated using one-way ANOVA with Tukey post-hoc tests. Effect sizes were reported as Cohen's d and Cramér's V.

RESULTS

Baseline characteristics: Analysis (n=731) revealed that males (41.1% of the cohort) had significantly higher mean serum 25(OH)D levels compared to females (49.6 ± 19.5 vs. 42.3 ± 19.1 ng/mL). This difference of approximately 7.4 ng/mL was confirmed by an independent samples t-test ($t=4.97$, $df=729$, $p<0.001$), suggesting a consistent gender disparity in vitamin D status despite comparable mean ages (41.3 vs. 40.6 years).

Prevalence of VDD: Vitamin D sufficiency exceeded 75% across all age groups, but individuals aged >60 years exhibited a modest rise in deficiency (8.9%) compared to younger age groups (≈6%). Insufficiency rates were similar across age bands, while sufficiency peaked in the 46–60 years group (79.4%).

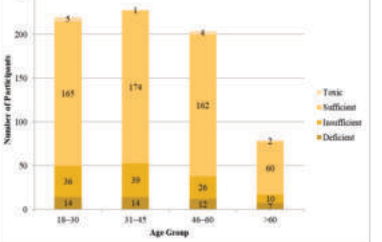

Figure 1: Age-group Wise Distribution of Vitamin D Status

When stratified by sex, females showed nearly double the prevalence of deficiency (8.1% vs. 4.0%) and insufficiency (18.8% vs. 10.0%) relative to males. The chi-square test confirmed this gender-based disparity to be statistically significant (χ^2=15.9, df=3, p<0.01). Serum 25(OH)D concentration >100 ng/mL (hypervitaminosis D) was seen in 12 (1.64%) assays (58.3% females and 41.6% males).

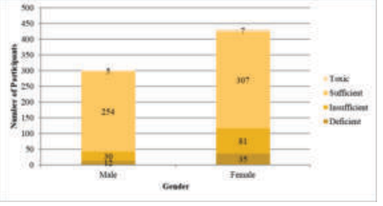

Figure 2: Gender-wise Distribution of Vitamin D Status

Seasonal variations of serum 25(OH)D levels: Sufficiency dropped sharply during the monsoon (66.7%) and spring (73.6%), while winter recorded the highest sufficiency (88.1%). Chi-square analysis confirmed a significant seasonal association (χ^2=42.7, df=12, p<0.001). Mean serum 25(OH)D levels also varied by season, ranging from 39.6 ± 17.1 ng/mL in monsoon to 52.9 ± 22.4 ng/mL in autumn. One-way ANOVA revealed significant differences between seasons (F=11.2, df=4, p<0.001). Post-hoc Tukey tests showed monsoon levels were significantly lower than both autumn (p<0.001) and winter (p<0.01), underscoring the strong seasonal influence on vitamin D status.

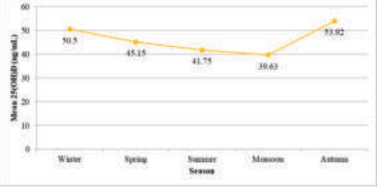

Figure 3: Mean Serum 25(OH)D Across Seasons

DISCUSSION

Our findings are partly consistent with, but also diverge from, earlier reports across India. The study of Raizada et al., 2020 from North India (n=26,339 assays) demonstrated significantly higher vitamin D levels in the rainy season compared to both winter and summer, alongside a gradual year-wise rise in mean 25(OH)D and a decline in deficiency prevalence, especially among females. Similarly, the study of Sreenivasulu et al., 2024 from northwestern India (n=11,428 assays) documented overall high deficiency (60%), with median levels significantly lower in winter (15.8 ng/mL) than in summer (18.7 ng/mL). By contrast, our analysis identified the monsoon as the period of greatest insufficiency.

The gender disparities we observed align with data from Sinha et al., 2022 where vitamin D deficiency was more prevalent in females, particularly within the 15–30 years age group, in whom sufficiency was reported in only 18.4%. Comparable trends have also been noted in Saikia et al., 2023 from Guwahati, where deficiency correlated significantly with duration of sun exposure and sunscreen use. Together, these findings underscore the vulnerability of women and younger adults to vitamin D insufficiency.

Seasonal variation in our cohort also resonates with findings from Marwah et al. in Chandigarh, who reported higher sufficiency in summer (72.5%) than in winter (50.7%) and significantly greater mean 25(OH)D levels at the end of summer compared with winter (52.9 vs. 31.8 ng/mL, p<0.001) in Ramakrishnan et al., 2011. However, while their data indicated summer as the period of maximum vitamin D status, our results suggest peaks in autumn and winter, highlighting the influence of geographical latitude, local climate and lifestyle differences on seasonal patterns.

The strength of our study includes its relatively large sample size, standardized assays and complete seasonal coverage over one year, which allow meaningful contrasts.

CONCLUSION

In our study, there is marked monsoon decline in vitamin D status which could be plausibly explained by persistent cloud cover, intense rainfall and reduced UVB penetration during this period. Females exhibited nearly twice the prevalence of vitamin D deficiency and insufficiency than males which may be attributed to cultural clothing practices, higher skin pigmentation, lower dietary intake and reduced uptake of supplementation. Behavioural adaptations—such as reduced outdoor activities, heavier clothing and increased time spent indoors—likely exacerbate these effects. The small number of cases in the toxic range suggests that over supplementation is uncommon.

These results support season-sensitive approaches to vitamin D management. Screening and counselling should be emphasized prior to or during the monsoon, when deficiency risk is greatest. Women and older adults should be prioritized for preventive strategies, including supplementation and lifestyle guidance. At the policy level, strengthening efforts in dietary fortification, promoting safe sun-exposure practices and continuing provider education are essential to mitigate observed disparities.

Limitations include its hospital-based sampling frame, restricting generalizability to the community; lack of data on supplementation, dietary intake, BMI, skin type, comorbidities and the retrospective design, which precludes causal inference. Future research should focus on community-based prospective studies incorporating behavioural covariates, objective assessments of sun exposure, atmospheric factors, dietary and supplementation histories.

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