

Vitamin D deficiency and its association with age, sex, dietary habits, and thyroid–glycemic profile in an Indian population: A cross-sectional study

¹Dr. Nilesh Kumar Vyas, Assistant Professor, Department of General Medicine, Government Medical College Dungarpur, Rajasthan

²Dr. Arun Kumar Meena, Assistant Professor, Department of General Medicine, Government Medical College Dungarpur, Rajasthan

³Dr. Jayana Upadhyay, Associate Professor, Department of Life Sciences, GGTU Banswara, Rajasthan

⁴Mr. Aayush Panchal, Intern, Department of Computer Sciences, Dy Patil International University, Pune

Corresponding Author: Dr. Nilesh Kumar Vyas, Assistant Professor, Department of General Medicine, Government Medical College Dungarpur, Rajasthan.

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Abstract

Background: Vitamin D deficiency is a widespread but frequently under-recognized public health problem. Despite abundant year-round sunshine, deficiency remains highly prevalent across India, largely because of indoor lifestyles, skin pigmentation, dietary patterns, and low rates of food fortification. Age, sex, and dietary habit are commonly cited determinants of Vitamin D status, but evidence linking Vitamin D to thyroid function and glycemic control in the Indian population is comparatively limited.

Objectives: To determine the prevalence of Vitamin D deficiency in an adult Indian population attending the OPD or inpatient departments and to examine its

association with age, sex, dietary habits, glycated hemoglobin (HbA1c), thyroid hormones (FT3, FT4, TSH), and Vitamin B12.

Materials and Methods: This retrospective cross-sectional study was carried out among 200 patients attending Government Medical College Hospital, Dungarpur [Shree Haridev Joshi Hospital]. Serum Vitamin D3 was categorized as severe deficiency (<10 ng/mL), deficiency (10–19.9 ng/mL), insufficiency (20–29.9 ng/mL), and sufficiency (≥ 30 ng/mL). Associations were tested using the chi-square test, Welch's independent-samples t-test, Pearson and Spearman correlation analyses, and multivariable binary logistic

regression, with $p < 0.05$ taken as statistically significant.

Results: The mean age of participants was 48.7 ± 16.9 years, and the mean serum Vitamin D3 was 19.2 ± 10.1 ng/mL. Vitamin D deficiency or insufficiency (<30 ng/mL) was present in 177 of 200 participants (88.5%), including severe deficiency in 14.5% and deficiency in 46.0%. Neither sex ($\chi^2 = 0.000$, $p = 1.000$) nor dietary habit ($\chi^2 = 0.003$, $p = 0.954$) was significantly associated with Vitamin D status, and age did not differ significantly between deficient and sufficient groups ($t = -1.11$, $p = 0.276$). Serum Vitamin D3 correlated positively with free T4 ($r = 0.169$, $p = 0.017$) and, on rank correlation, with free T3 and Vitamin B12 (both $p < 0.01$). Mean TSH was significantly higher in the Vitamin D-deficient group than in the sufficient group (5.26 ± 13.41 vs 2.62 ± 1.41 mIU/L; $t = 2.52$, $p = 0.012$). On multivariable logistic regression incorporating age, sex, diet, HbA1c, TSH, and Vitamin B12, no single predictor reached independent statistical significance (pseudo $R^2 = 0.044$).

Conclusion: Vitamin D deficiency is highly prevalent in this population, and its severity does not appear to be explained by age, sex, or dietary habits alone. The observed association with thyroid indices, particularly the higher TSH and lower FT4 seen with lower Vitamin D levels, suggests a biologically plausible interplay between Vitamin D and thyroid function that merits confirmation in larger, prospective studies. Routine screening and targeted supplementation are warranted, especially in patients with coexisting thyroid dysfunction.

Keywords: Vitamin D Deficiency, Prevalence, Cross-Sectional Study, Thyroid Function, TSH; HbA1c, Dietary Habits, Indian Population

Introduction

Vitamin D is a fat-soluble secosteroid hormone that plays a central role in calcium and phosphate homeostasis, skeletal mineralization, neuromuscular function, and immune regulation. Beyond its long-established skeletal effects, a growing body of evidence links Vitamin D status to extra-skeletal outcomes, including glucose metabolism, cardiovascular risk, autoimmune disease, and thyroid function, through vitamin D receptors that are widely expressed in non-skeletal tissue, including thyroid follicular and pancreatic beta cells.

India lies largely between latitudes that receive abundant ultraviolet-B radiation throughout the year, and it is therefore often assumed, incorrectly, that Vitamin D deficiency should be uncommon in the Indian population. In practice, the opposite is true: numerous hospital- and community-based surveys from different regions of the country have reported deficiency in anywhere from half to nearly all of the adults screened. This apparent paradox has been attributed to a combination of factors, including urban indoor lifestyles, sun-avoidant clothing and cultural practices, atmospheric pollution that attenuates UV-B transmission, higher melanin content of Indian skin (which reduces cutaneous synthesis efficiency), low dietary intake of Vitamin D-rich foods, and the near-absence of mandatory food fortification programs.

Sex, age, and dietary pattern are the determinants most frequently examined in the Indian literature. Some studies report higher deficiency rates in women, attributed to purdah practices, sun-protective clothing, and repeated pregnancies and lactation, while others find no meaningful sex difference once confounders are accounted for. Similarly, vegetarian diets — which

predominate in large parts of India — provide little preformed Vitamin D, since the richest natural dietary sources (fatty fish, egg yolk, and liver) are of animal origin, yet several studies have failed to show a statistically significant difference between vegetarians and non-vegetarians, presumably because sunlight exposure, rather than diet, is the dominant source of Vitamin D for most individuals.

A comparatively less-explored area, and one that this study specifically addresses, is the relationship between Vitamin D status and thyroid function. Experimental work has shown that the vitamin D receptor and 1 α -hydroxylase enzyme are expressed in thyroid tissue, and clinical studies have reported associations between low Vitamin D and both autoimmune thyroiditis and subclinical hypothyroidism, possibly mediated through immunomodulatory effects on thyroid autoimmunity or through a direct effect on thyroid hormone synthesis. Likewise, Vitamin D has been proposed to influence insulin secretion and sensitivity, motivating interest in its relationship with glycated hemoglobin (HbA1c) and glycemic control status. Because our source dataset additionally captured HbA1c, free T3 (FT3), free T4 (FT4), thyroid-stimulating hormone (TSH), and Vitamin B12 alongside the core demographic variables, this study was extended beyond the original age–sex–diet framework to explore these metabolic and endocrine correlates as well.

Against this background, the present study was designed to estimate the prevalence of Vitamin D deficiency in an adult population undergoing routine laboratory evaluation in India, and to examine whether Vitamin D status varies meaningfully with age, sex, dietary habit, thyroid hormone levels, glycemic control, and Vitamin B12 status.

Related Work

Vitamin D deficiency has been the subject of extensive investigation both globally and within India. Holick's landmark review and the subsequent Endocrine Society clinical practice guideline established the widely used clinical cut-offs for severe deficiency, deficiency, insufficiency, and sufficiency that were adopted in the present study, and they remain the most commonly cited reference framework in the field¹.

Within India, systematic reviews synthesizing data from apparently healthy populations have reported deficiency prevalence figures in the range of roughly 70–90% across different states and age groups, figures that are broadly consistent with the 88.5% observed in the present sample². Regional studies from South India have similarly reported a high burden of hypovitaminosis D coexisting with low dietary calcium intake and high dietary phytate content, both of which impair calcium and Vitamin D utilization^{3,4}. Harinarayan and colleagues, in a series of studies spanning postmenopausal women and healthy South Indian adults, consistently found deficiency rates well above 70%, reinforcing the idea that abundant sunlight does not, by itself, protect against deficiency when behavioral and dietary factors are unfavorable.^{3,11,13}

Global reviews have placed the burden of Vitamin D deficiency in a broader context, noting that hypovitaminosis D is common not only in South Asia but also across the Middle East, and parts of Europe despite markedly different latitudes and sun-exposure patterns, pointing to lifestyle and dietary factors as dominant drivers rather than geography alone^{5,6,9}. Findings from Delhi-based cohorts of ostensibly healthy adults have echoed this pattern, reporting low 25-

hydroxyvitamin D concentrations even among individuals with no overt bone disease¹².

Evidence connecting Vitamin D with thyroid and metabolic outcomes is more heterogeneous. Several observational studies have reported inverse associations between Vitamin D and TSH, or positive associations with FT4, consistent with a modulatory role for Vitamin D in thyroid hormone regulation, although the mechanism is not fully established and results vary by population and study design. Similarly, work examining Vitamin D and glucose metabolism, including the pathophysiological role of Vitamin D in type 2 diabetes, has suggested plausible effects on insulin secretion and peripheral insulin sensitivity, though large-scale interventional evidence remains limited¹⁴.

Taken together, the existing literature establishes Vitamin D deficiency as a near-universal finding in Indian clinical populations, with inconsistent evidence for simple demographic predictors such as sex and diet, and an emerging but still-developing literature on its endocrine and metabolic correlates. This study contributes additional Indian data on the demographic determinants and, uniquely within this dataset, on the relationship between Vitamin D and thyroid–glycemic indices in the same cohort.

Materials and Methods

A. Study Design and Setting

This was a retrospective, cross-sectional observational study conducted among patients attending Government Medical College Hospital [Shree Haridev Joshi Hospital, Dungarpur] in the OPD and inpatient departments. The study conforms to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) reporting framework for cross-sectional studies.

B. Study Population and Sample Size

A total of 200 individuals who underwent simultaneous estimation of serum Vitamin D3, HbA1c, thyroid function tests, and Vitamin B12 were included. Records with missing values for the core study variables were excluded prior to analysis; the final analytic dataset was complete for all 200 participants across all variables considered.

C. Variables Studied

- Demographic: age (years), sex (male/female)
- Lifestyle: dietary habits (vegetarian/non-vegetarian)
- Biochemical: serum Vitamin D3 (25-hydroxyvitamin D, ng/mL), HbA1c (%), free T3 (pg/mL), free T4 (ng/dL), TSH (mIU/L), Vitamin B12 (pg/mL)
- Derived: Vitamin D category, Vitamin D deficiency status (<30 vs ≥ 30 ng/mL), glycemic control status (good control $<7.0\%$ vs poor control $\geq 7.0\%$ HbA1c)

D. Operational Definitions

Serum Vitamin D3 concentrations were classified according to widely used clinical cut-offs: severe deficiency (<10 ng/mL), deficiency (10 – 19.9 ng/mL), insufficiency (20 – 29.9 ng/mL), and sufficiency (≥ 30 ng/mL). For inferential analyses, participants were additionally dichotomized into a deficient/insufficient group (<30 ng/mL) and a sufficient group (≥ 30 ng/mL), consistent with common clinical practice of treating any value below 30 ng/mL as requiring attention. Glycemic control was defined as good (HbA1c $<7.0\%$) or poor (HbA1c $\geq 7.0\%$), in line with standard diabetes-care thresholds.

E. Statistical Analysis

Continuous variables are expressed as mean $\pm$ standard deviation, and categorical variables as frequencies and percentages. The chi-square test (with Yates' continuity

correction for 2×2 tables) was used to assess associations between categorical variables, namely sex, dietary habits, and glycemic control status, and Vitamin D deficiency status. Welch's independent-samples t-test, which does not assume equal variances, was used to compare continuous variables (age, HbA1c, TSH, and Vitamin B12) between the Vitamin D-deficient and Vitamin D-sufficient groups. Pearson correlation coefficients were computed to quantify linear associations between serum Vitamin D3 and continuous biochemical variables, and Spearman's rank correlation was used as a robustness check for variables with skewed distributions (TSH and Vitamin B12 in particular showed marked positive skew). A multivariable binary logistic regression model was fitted with Vitamin D deficiency (<30 ng/mL) as the dependent variable and age, sex, dietary habits, HbA1c, TSH, and Vitamin B12 as independent variables, and the results are reported as adjusted odds ratios (AORs) with 95% confidence intervals. A two-tailed p-value < 0.05 was considered statistically significant throughout. All analyses were performed using Python (pandas, SciPy, and statsmodels).

Results

A. Baseline Characteristics

Two hundred adult participants were included in the final analysis. The mean age was 48.7 ± 16.9 years (range 13–85 years). Females constituted 56.5% (n = 113) of the sample, and males constituted 43.5% (n = 87). Vegetarians formed the majority of the cohort (62.5%, n = 125), with non-vegetarians accounting for the remaining 37.5% (n = 75). Good glycemic control (HbA1c <7.0%) was present in 78.5% (n = 157) of participants, while 21.5% (n = 43) had poor glycemic

control (HbA1c $\geq 7.0\%$). Baseline characteristics are summarized in Table I.

Table 1: Baseline demographic and biochemical characteristics of study participants (N = 200)

Characteristic	Value
Sample size	200
Mean age (years)	48.7 ± 16.9
Female sex	113 (56.5%)
Male sex	87 (43.5%)
Vegetarian diet	125 (62.5%)
Non-vegetarian diet	75 (37.5%)
Mean serum Vitamin D3 (ng/mL)	19.2 ± 10.1
Mean HbA1c (%)	6.5 ± 2.0
Mean free T3 (pg/mL)	1.73 ± 0.60
Mean free T4 (ng/dL)	9.53 ± 2.51
Mean TSH (mIU/L)	4.96 ± 12.64
Mean Vitamin B12 (pg/mL)	399.8 ± 440.4
Good glycemic control (HbA1c <7.0%)	157 (78.5%)
Poor glycemic control (HbA1c $\geq 7.0\%$)	43 (21.5%)

B. Vitamin D Status Distribution

Vitamin D deficiency was highly prevalent in this population. Severe deficiency (<10 ng/mL) was observed in 14.5% (n = 29), frank deficiency (10–19.9 ng/mL) in 46.0% (n = 92), and insufficiency (20–29.9 ng/mL) in 28.0% (n = 56) of participants. Only 11.5% (n = 23) had sufficient Vitamin D levels (≥ 30 ng/mL). Overall, 177 of 200 participants (88.5%) had suboptimal Vitamin D status. The distribution is presented in Table II and Figure 1.

Table 2: Distribution of Vitamin D status categories

Vitamin D Category	n	%
Severe deficiency (<10 ng/mL)	29	14.5
Deficiency (10–19.9 ng/mL)	92	46.0
Insufficiency (20–29.9 ng/mL)	56	28.0
Sufficiency (≥30 ng/mL)	23	11.5
Total suboptimal (<30 ng/mL)	177	88.5

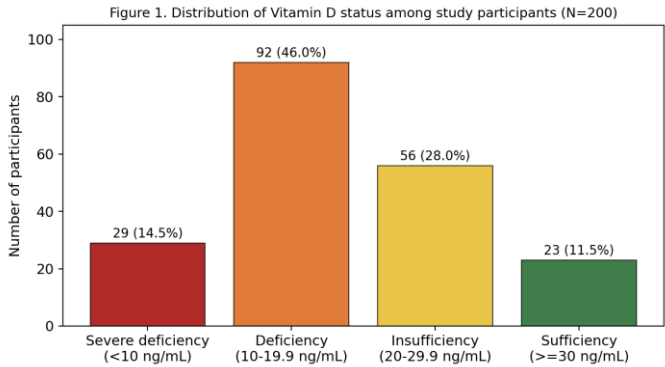


Figure 1: Distribution of Vitamin D status among study participants (N = 200).

C. Association Between Sex and Vitamin D Deficiency

Table 3: Sex versus Vitamin D status (chi-square test)

Sex	Vitamin D ≥30 ng/mL	Vitamin D <30 ng/mL
Female	13	100
Male	10	77

$\chi^2 = 0.000$, $df = 1$, $p = 1.000$. There was no statistically significant association between sex and Vitamin D deficiency status in this cohort.

D. Association Between Dietary Habit and Vitamin D Deficiency

Table 4: Dietary habit versus Vitamin D status (chi-square test)

Diet	Vitamin D ≥30 ng/mL	Vitamin D <30 ng/mL
Vegetarian	15	110
Non-vegetarian	8	67

$\chi^2 = 0.003$, $df = 1$, $p = 0.954$. Dietary habit was not significantly associated with Vitamin D deficiency status.

E. Age and Vitamin D Status

The mean age in the Vitamin D-deficient/insufficient group ($n = 177$) was 48.3 ± 16.9 years, compared with 51.8 ± 17.1 years in the sufficient group ($n = 23$). Welch's t-test showed no statistically significant difference between the groups ($t = -1.11$, $p = 0.276$), and the Pearson correlation between age and serum Vitamin D3 was weak and non-significant ($r = 0.103$, $p = 0.147$).

F. Correlation of Vitamin D with Metabolic and Endocrine Parameters

To extend the analysis beyond the original demographic framework, correlations between serum Vitamin D3 and HbA1c, FT3, FT4, TSH, and Vitamin B12 were examined (Table V). A significant positive correlation was observed between Vitamin D3 and FT4 (Pearson $r = 0.169$, $p = 0.017$; Figure 3). Spearman rank correlation additionally identified significant positive associations between Vitamin D3 and FT3 ($\rho = 0.186$, $p = 0.008$) and between Vitamin D3 and Vitamin B12 ($\rho = 0.221$, $p = 0.002$), suggesting that these relationships, while modest, are unlikely to be due to chance despite the non-normal distribution of the underlying laboratory values. No significant correlation was found between Vitamin D3 and HbA1c ($r = -0.004$, $p = 0.955$) or TSH ($r = -0.075$, $p = 0.291$) in the continuous correlation analysis.

Table 5: Correlation between serum Vitamin D3 and biochemical parameters (N = 200)

Parameter	Pearson r	p-value	Spearman ρ	p-value
Age (years)	0.103	0.147	0.098	0.168
HbA1c (%)	−0.004	0.955	−0.026	0.711
Free T3 (pg/mL)	0.061	0.387	0.186	0.008*
Free T4 (ng/dL)	0.169	0.017*	0.209	0.003*
TSH (mIU/L)	−0.075	0.291	−0.078	0.270
Vitamin B12 (pg/mL)	0.086	0.225	0.221	0.002*

*Statistically significant at $p < 0.05$.

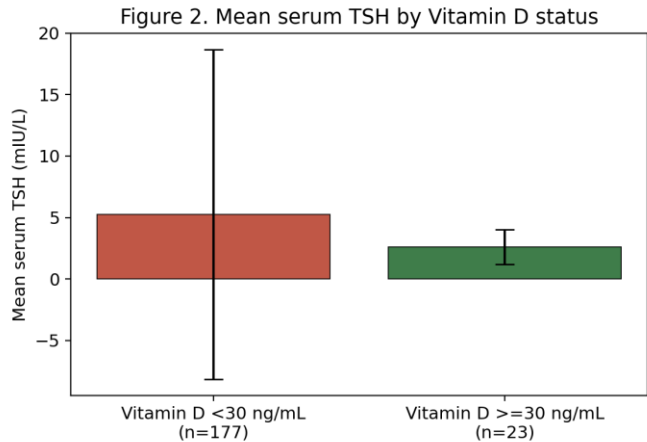


Figure 2. Scatter plot showing the correlation between serum Vitamin D3 and free T4 ($r = 0.169$, $p = 0.017$), with fitted linear trend line.

G. TSH in Relation to Vitamin D Status

Mean TSH was more than twice as high in the Vitamin D-deficient/insufficient group compared with the sufficient group (5.26 ± 13.41 mIU/L vs 2.62 ± 1.41 mIU/L). This difference reached statistical significance using Welch's t-test ($t = 2.52$, $p = 0.012$; Figure 2), indicating a possible association between low Vitamin D status and relatively higher TSH, consistent with a

subclinical shift toward reduced thyroid function in the Vitamin D-deficient group. Given the wide standard deviation in the deficient group, driven by a small number of participants with markedly elevated TSH, this finding should be interpreted with appropriate caution and warrants confirmation in a larger sample.

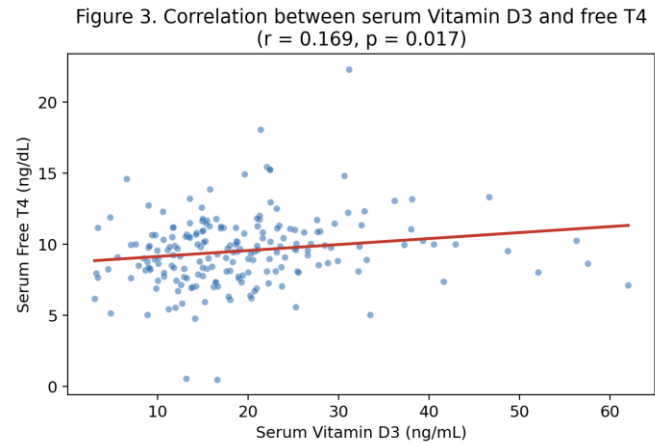


Figure 3: Mean serum TSH by Vitamin D status (error bars represent ± 1 standard deviation).

H. Vitamin B12 and Vitamin D Status

Mean Vitamin B12 was numerically lower in the Vitamin D-deficient group (383.3 ± 441.0 pg/mL) than in the sufficient group (527.1 ± 423.8 pg/mL); this difference did not reach statistical significance using the independent-samples t-test ($t = -1.52$, $p = 0.139$), although the Spearman rank correlation with continuous Vitamin D3 values was significant, as noted above, suggesting a modest positive relationship that a larger sample size may be better powered to confirm.

I. Vitamin D and Glycemic Control Status

Table 6: Glycemic control status versus Vitamin D status (chi-square test)

Glycemic Control	Vitamin D ≥ 30 ng/mL	Vitamin D < 30 ng/mL
Good control (HbA1c $< 7.0\%$)	17	140

Glycemic Control	Vitamin D ≥ 30 ng/mL	Vitamin D < 30 ng/mL
Poor control (HbA1c $\geq 7.0\%$)	6	37

$\chi^2 = 0.090$, $df = 1$, $p = 0.765$. Glycemic control status was not significantly associated with Vitamin D deficiency status in this cohort, and mean HbA1c did not differ significantly between the Vitamin D-deficient and sufficient groups ($6.45 \pm 1.94\%$ vs $6.95 \pm 2.61\%$; $t = -0.89$, $p = 0.382$).

J. Multivariable Logistic Regression

A multivariable binary logistic regression model was constructed with Vitamin D deficiency (< 30 ng/mL) as the outcome and age, sex, dietary habits, HbA1c, TSH, and Vitamin B12 as covariates (Table VII, Figure 4). None of the six predictors reached statistical significance at the multivariable level, although TSH showed the strongest trend toward an association (AOR = 1.129, 95% CI 0.899–1.417, $p = 0.294$), consistent with the unadjusted t-test finding in Section G. The overall model was not statistically significant (likelihood ratio $p = 0.393$; pseudo $R^2 = 0.044$), indicating that the six variables studied together explain only a small proportion of the variability in Vitamin D deficiency observed in this cohort and that unmeasured factors—most plausibly sunlight exposure, body mass index, physical activity, and supplementation history—are likely to be more important determinants.

Table 7: Multivariable logistic regression for predictors of Vitamin D deficiency (< 30 ng/mL)

Predictor	Adjusted OR	95% CI	p-value
Age (per year)	0.992	0.964–1.021	0.564
Male vs Female	1.053	0.414–2.679	0.913
Vegetarian vs	0.838	0.317–2.219	0.723

Predictor	Adjusted OR	95% CI	p-value
Non-vegetarian			
HbA1c (per %)	0.898	0.740–1.090	0.277
TSH (per mIU/L)	1.129	0.899–1.417	0.294
Vitamin B12 (per 10 pg/mL)	0.994	0.986–1.003	0.212

Model fit: pseudo $R^2 = 0.044$; likelihood ratio $p = 0.393$.

All confidence intervals crossed the null value (OR = 1), indicating that none of the predictors were independently statistically significant determinants of Vitamin D deficiency after mutual adjustment.

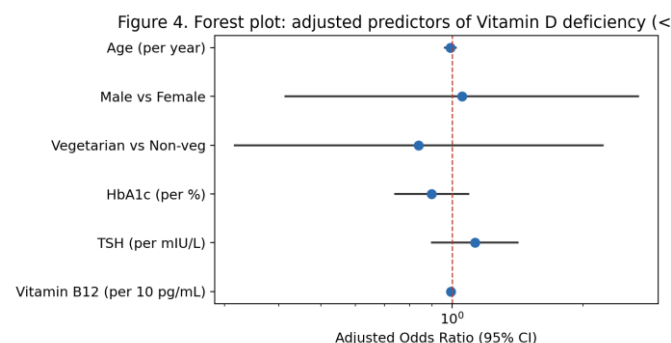


Figure 4: Forest plot of adjusted odds ratios (log scale) for predictors of Vitamin D deficiency (< 30 ng/mL), with 95% confidence intervals. The dashed reference line denotes an odds ratio of 1.

Discussion

This study found that nearly nine out of every ten adults in the study population had suboptimal Vitamin D status, with almost half falling into the deficient range and a further sizeable minority severely deficient. This prevalence is consistent with, and toward the upper end of, the range reported by earlier Indian surveys, reinforcing the now well-established observation that abundant sunlight does not translate into adequate Vitamin D status when behavioral, dietary, and possibly

genetic factors work against effective synthesis and absorption.

Neither sex nor dietary habits were significantly associated with Vitamin D deficiency in this cohort, a finding that diverges from some, but not all, earlier Indian reports. Several explanations are plausible. First, because cutaneous synthesis driven by incidental and occupational sun exposure is thought to be the dominant source of Vitamin D for most Indians, differences attributable to diet alone may be masked unless dietary intake is unusually extreme or systematically confounded with sun exposure (for example, women who observe more conservative dress and also happen to eat more or less meat). Second, the relatively modest sample size (200 participants, only 23 of whom were Vitamin D-sufficient) limits statistical power to detect small-to-moderate effect sizes, particularly for the sex comparison, where the observed difference in proportions was minimal. Third, hospital-based samples such as this one are not community-representative and may already be skewed toward individuals with broadly similar indoor lifestyles regardless of sex or diet, which would tend to attenuate any true underlying association.

The extended analysis undertaken in this study, incorporating thyroid function tests and Vitamin B12, adds a dimension not present in many comparable Indian reports. The positive correlation between Vitamin D3 and FT4, together with the significantly higher mean TSH in the Vitamin D-deficient group, is broadly consistent with a body of literature suggesting a bidirectional relationship between Vitamin D and thyroid function, potentially mediated by vitamin D receptor expression within thyroid tissue and by Vitamin D's broader immunomodulatory effects on thyroid autoimmunity. While this study cannot establish

causality, and while the wide variance in TSH in the deficient subgroup warrants caution, the pattern is directionally consistent with the hypothesis that Vitamin D deficiency and subclinical thyroid dysfunction may cluster together in this population, an observation that could inform combined screening strategies in clinical practice.

Similarly, the modest but statistically significant rank correlation between Vitamin D and Vitamin B12 raises the possibility of a shared nutritional or lifestyle pathway—for instance, individuals with generally poorer dietary diversity, more restrictive vegetarian intake, or lower engagement with fortified foods and supplements might be simultaneously at risk for both deficiencies. This is a hypothesis-generating observation rather than a confirmed mechanism and would benefit from dietary-intake data that were not available in the present dataset.

In contrast, no meaningful relationship was observed between Vitamin D and either HbA1c or overall glycemic control status, and the multivariable model incorporating all six candidate predictors together explained only a small fraction of the variability in Vitamin D deficiency. This is a useful negative finding: it suggests that, at least in this cohort, glycemic status should not be assumed to be a major correlate of Vitamin D status and that clinicians should not rely on glycemic control alone as a proxy indicator for Vitamin D risk stratification.

Taken as a whole, these findings support two practical conclusions. First, given the very high background prevalence of deficiency and the inability of simple demographic variables to reliably identify who is at highest risk, routine biochemical screening for Vitamin D, rather than selective screening based on age, sex, or diet, may be the more pragmatic approach in similar

clinical settings. Second, the thyroid-related findings suggest that patients being evaluated for either Vitamin D deficiency or thyroid dysfunction may benefit from concurrent assessment of the other, pending confirmation in larger, prospective, and ideally interventional studies.

Limitations

- This was a single-center, hospital-based study, which limits generalizability to the wider community population.
- The cross-sectional design precludes any causal interpretation of the observed associations, including the Vitamin D–TSH and Vitamin D–FT4 relationships.
- Important potential confounders — sunlight exposure duration, body mass index, socioeconomic status, physical activity level, and use of Vitamin D or calcium supplements — were not available in the source dataset and could not be adjusted for.
- Seasonal variation in Vitamin D synthesis was not captured, as sampling dates were not available for stratification.
- The relatively small number of Vitamin D–sufficient participants ($n = 23$) limits statistical power for subgroup comparisons and widens confidence intervals around several estimates.
- Dietary habit was recorded as a binary vegetarian/non-vegetarian category without quantification of actual Vitamin D or calcium intake.

Conclusion

Vitamin D deficiency was highly prevalent in this adult Indian population, affecting 88.5% of participants, with nearly half classified as frankly deficient. Age, sex, and dietary habits—the classical demographic determinants examined in most prior Indian studies—were not

significantly associated with Vitamin D status in this cohort, suggesting that these variables alone are insufficient to identify individuals at risk and that broad-based screening may be more useful than targeted screening by demographic profile. Extending the analysis to thyroid and metabolic parameters revealed a statistically significant association between lower Vitamin D and higher TSH, along with a positive correlation with FT4 and Vitamin B12, pointing toward a potential endocrine and nutritional interplay that warrants further prospective investigation. In contrast, no significant relationship was found between Vitamin D and glycemic parameters. These findings collectively support routine Vitamin D screening in adults attending healthcare facilities in India, closer clinical attention to Vitamin D status in patients with thyroid dysfunction, and continued public health efforts toward nutritional and lifestyle interventions—including food fortification, safe sun-exposure counselling, and targeted supplementation—to reduce the substantial burden of Vitamin D deficiency documented here.

Future Scope

Future work should prioritize multicentric, community-representative sampling; prospective or longitudinal designs capable of establishing temporal and causal relationships between Vitamin D and thyroid function; adjustment for sunlight exposure, body mass index, and supplement use; and interventional trials evaluating whether Vitamin D supplementation measurably improves thyroid indices or glycemic parameters in deficient individuals.

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