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PREVALENCE OF VITAMIN D DEFICIENCY AND ITS ASSOCIATION WITH LIFESTYLE FACTORS AMONG ADULTS ATTENDING PRIMARY HEALTHCARE CENTERS: A CROSS-SECTIONAL STUDY

[1*]Huda Mohammed Yassen AL GBUR, [2]Rand Muayad Saadi, [3]Sarah Adil Koria Okask

[1]Higher Diploma in Family Medicine, Nineveh Health Directirate, The Right Sector /Al Teb Al Riyadi Primary Health Care Center.

[2]Higher Diploma in Family Medicine, Nineveh Health Directirate, Department of Public Health.

[3]Higher Diploma in Family Medicine, Nineveh Health Directirate, Al-Hamdaniya Health Sector/Baghdeda Primary Health Care Center.

***Corresponding Author: Huda Mohammed Yassen AL GBUR**

Higher Diploma in Family Medicine, Nineveh Health Directirate, The Right Sector /Al Teb Al Riyadi Primary Health Care Center. **DOI:** https://doi.org/10.5281/zenodo.23913167

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ABSTRACT

Background: Vitamin D deficiency has emerged as a significant global public health concern, affecting populations across different age groups, geographical regions, and socioeconomic backgrounds. Despite the availability of abundant sunlight in many countries, vitamin D deficiency remains prevalent, suggesting that sunlight availability alone does not guarantee adequate vitamin D status. Lifestyle factors including sunlight exposure, physical activity, dietary habits, and supplement use may influence vitamin D levels directly or indirectly. Primary healthcare centers provide an important setting for investigating vitamin D deficiency because they serve adults with diverse demographic characteristics, health conditions, and lifestyle patterns. **Objective:** This study aimed to determine the prevalence of vitamin D deficiency and examine its association with selected lifestyle factors among adults attending primary healthcare centers. **Methodology:** A descriptive analytical cross-sectional study was conducted among 400 adults aged 18 years and older attending selected primary healthcare centers. Participants were recruited using a consecutive sampling technique. Data were collected using a structured questionnaire administered through face-to-face interviews, covering sociodemographic characteristics, medical history, and lifestyle factors including sunlight exposure, physical activity, dietary habits, and supplement use. Serum 25-hydroxyvitamin D [25(OH)D] concentrations were measured to assess vitamin D status, with deficiency defined as serum 25(OH)D below 20 ng/mL. Statistical analysis included descriptive statistics, chi-square tests, and Fisher's exact test where appropriate, with a p-value below 0.05 considered statistically significant. **Results:** The study population comprised 400 adults (56.0% female, 44.0% male), with a mean age distribution showing the largest groups aged 18–29 years (23.0%) and 30–39 years (22.8%). Vitamin D deficiency was identified in 281 participants, corresponding to a prevalence of 70.3% (95% CI: 65.8–74.8%). Dietary vitamin D intake showed a statistically significant association with vitamin D deficiency ($p = 0.012$), with deficiency prevalence of 75.1% among those reporting low consumption compared to 62.9% among those with moderate/high consumption. Although numerically higher deficiency prevalence was observed among females (73.2% versus 66.5%, $p = 0.176$), participants with lower education (76.0% versus 64.2%, $p = 0.062$), those with obesity (75.7% versus 62.4%, $p = 0.077$), indoor workers (73.8% versus 64.3%, $p = 0.220$), and those with less than 15 minutes of daily sunlight exposure (73.1%, $p = 0.518$), these associations did not reach statistical significance. **Conclusion:** The study revealed a high prevalence of vitamin D deficiency (70.3%) among adults attending primary healthcare centers. Dietary vitamin D intake was the only lifestyle factor showing a statistically significant association with vitamin D deficiency. These findings highlight the need for targeted preventive interventions, including dietary counseling and health education programs promoting adequate vitamin D intake, among adults attending primary healthcare centers.

BACKGROUND

Vitamin D is an essential fat-soluble vitamin that plays a fundamental role in maintaining calcium and phosphorus homeostasis, promoting normal bone mineralization, and supporting musculoskeletal health. It contributes to several physiological processes beyond skeletal development, including immune regulation, cellular growth, and the functioning of various organs and tissues. Vitamin D is obtained primarily through cutaneous synthesis following exposure to ultraviolet B radiation from sunlight, with additional contributions from dietary sources such as fatty fish, egg yolks, fortified foods, and vitamin D supplements. Maintaining adequate vitamin D levels is therefore dependent on a combination of environmental exposure, dietary intake, individual characteristics, and lifestyle practices (Katar et al., 2026).

Vitamin D deficiency has emerged as a significant global public health concern, affecting populations across different age groups, geographical regions, and socioeconomic backgrounds. Despite the availability of abundant sunlight in many countries, vitamin D deficiency remains prevalent in populations living in sunny climates, suggesting that sunlight availability alone does not guarantee adequate vitamin D status. Limited outdoor activity, changes in clothing practices, urbanization, dietary habits, and the widespread use of sun protection may contribute to inadequate vitamin D synthesis. The persistence of vitamin D deficiency in diverse populations highlights the importance of investigating its prevalence and identifying potentially modifiable factors associated with its occurrence (Zainel et al., 2019).

Vitamin D deficiency in adults may have important consequences for general health and quality of life. Severe or prolonged deficiency can impair calcium absorption and bone mineralization, potentially resulting in osteomalacia, bone pain, muscle weakness, and an increased susceptibility to falls. Inadequate vitamin D status has also been investigated in relation to several chronic conditions, including cardiovascular disease, diabetes mellitus, autoimmune disorders, and certain malignancies. However, the strength and clinical significance of these associations vary across conditions, and observational associations do not necessarily establish causality. Nevertheless, the established role of vitamin D in skeletal health and its potential involvement in other physiological processes make the prevention and early recognition of deficiency important components of adult healthcare (Rai et al., 2019).

The prevalence of vitamin D deficiency varies considerably between populations because of differences in geographical location, season, age distribution, skin pigmentation, body composition, dietary intake, and patterns of physical activity. Individuals living at higher latitudes may experience reduced ultraviolet B exposure during certain seasons, whereas those living in tropical and subtropical regions may still have inadequate vitamin D levels because of behavioral and environmental factors. Older adults may be particularly vulnerable because of reduced cutaneous vitamin D synthesis, lower outdoor activity, and changes in dietary intake. Similarly, individuals with darker skin pigmentation may require longer periods of sunlight exposure to produce comparable amounts of vitamin D because melanin reduces the efficiency of ultraviolet B-mediated synthesis. These variations emphasize the need for population-specific investigations rather than relying exclusively on international prevalence estimates (Vatakencherry et al., 2025).

Lifestyle factors are increasingly recognized as important determinants of vitamin D status. Time spent outdoors, frequency and duration of sunlight exposure, engagement in physical activity, dietary patterns, supplement use, smoking, and alcohol consumption may influence vitamin D levels directly or indirectly. Individuals who spend most of their working hours indoors or engage in predominantly sedentary activities may receive less sunlight exposure than those whose occupations or recreational activities involve outdoor environments. Modern lifestyles characterized by prolonged screen time, indoor employment, and reduced recreational movement may further limit opportunities for cutaneous vitamin D synthesis. Examining these behavioral patterns may help identify groups who are more likely to experience vitamin D deficiency and inform practical preventive strategies (Marzban et al., 2021).

Sunlight exposure represents one of the most important modifiable determinants of vitamin D status. The amount of vitamin D synthesized in the skin depends on several factors, including the time of day, season, geographical latitude, skin pigmentation, exposed body surface area, clothing coverage, and environmental conditions. Although appropriate sunlight exposure can support vitamin D synthesis, individual exposure patterns differ substantially according to occupation, cultural practices, personal preferences, and daily routines. People who avoid direct sunlight, spend limited time outdoors, or wear clothing that covers most of the skin may have reduced opportunities for vitamin D production. Therefore, assessing the frequency and duration of outdoor exposure, together with relevant behavioral characteristics, can provide useful information when investigating vitamin D deficiency among adults (Adeniyi et al., 2024).

Dietary habits also contribute to vitamin D status, although the vitamin is naturally present in relatively few commonly consumed foods. Fatty fish, fish liver oils, egg yolks, and certain fortified dairy products or cereals can provide dietary vitamin D. In populations where fortified foods are not widely available or regularly consumed, dietary intake may be insufficient to compensate for limited sunlight exposure. Differences in food preferences, nutritional awareness, household

income, and access to diverse food sources may further influence dietary vitamin D intake. In addition, obesity and excess adiposity have been associated with lower circulating concentrations of 25-hydroxyvitamin D, the principal biomarker used to assess vitamin D status. Investigating dietary patterns and body mass index alongside other lifestyle characteristics may therefore help clarify the factors associated with deficiency in community-based populations (Pemaj et al., 2026).

Physical activity is another lifestyle characteristic that may be associated with vitamin D status, particularly when exercise involves outdoor environments. Adults who participate regularly in outdoor walking, running, cycling, or other recreational activities may experience greater sunlight exposure than individuals who remain physically inactive or exercise exclusively indoors. However, the relationship between physical activity and vitamin D levels is complex because exercise habits may be influenced by age, occupation, socioeconomic circumstances, and underlying health conditions. Similarly, smoking and other behavioral factors may correlate with vitamin D status through differences in diet, physical activity, and general health practices. Assessing these variables together can provide a more comprehensive understanding of the relationship between lifestyle and vitamin D deficiency than examining individual behaviors in isolation (El Hanefi et al., 2026).

Primary healthcare centers provide an important setting for investigating vitamin D deficiency because they serve adults with diverse demographic characteristics, health conditions, and lifestyle patterns. These facilities offer opportunities to identify individuals with potentially inadequate vitamin D levels, assess relevant risk factors, and provide preventive counseling regarding nutrition, physical activity, and appropriate sunlight exposure. Evaluating vitamin D status among adults attending primary healthcare centers can also generate locally relevant evidence to support clinical decision-making and health promotion initiatives. Furthermore, understanding the distribution of deficiency across age groups, sex, body mass index categories, and different lifestyle patterns may help healthcare professionals recognize populations that could benefit from further clinical assessment. A cross-sectional investigation can provide a practical approach to estimating the burden of deficiency and exploring its relationship with multiple potential determinants within a defined population (Peçanha et al., 2019).

Despite growing awareness of vitamin D deficiency, differences in population characteristics and lifestyle behaviors mean that findings from one setting may not accurately reflect the situation in another. Local evidence is therefore necessary to estimate the prevalence of vitamin D deficiency and identify the behavioral and demographic factors associated with it among adults attending primary healthcare centers. The present study aims to determine the prevalence of vitamin D deficiency in this population and examine its association with selected lifestyle factors, including sunlight exposure, physical activity, dietary habits, and other relevant behavioral characteristics. By identifying potentially modifiable factors associated with vitamin D deficiency, the study may contribute to a better understanding of local patterns of vitamin D status and provide evidence to guide future preventive interventions and health education programs. As a cross-sectional study, it will assess associations at a particular point in time and will not establish causal relationships between lifestyle factors and vitamin D deficiency (Madkhali et al., 2025).

METHODOLOGY

Study Design

A descriptive analytical cross-sectional study was conducted to determine the prevalence of vitamin D deficiency and investigate its association with lifestyle factors among adults attending primary healthcare centers. The study assessed participants' sociodemographic characteristics, medical history, lifestyle behaviors, and serum vitamin D levels during a defined study period. The cross-sectional design enabled the estimation of the prevalence of vitamin D deficiency and the examination of associations between vitamin D status and selected demographic, behavioral, and clinical variables. Data were collected from eligible participants at a single point in time without any intervention or modification of their usual lifestyle practices.

Study Setting

The study was conducted among adults attending selected primary healthcare centers that provided routine outpatient and preventive healthcare services. These centers were selected because they served individuals with diverse demographic characteristics, occupational backgrounds, health conditions, and lifestyle patterns. Data collection was carried out within the participating centers in coordination with healthcare personnel to facilitate participant recruitment, questionnaire administration, and collection of blood samples. The study procedures were organized to minimize disruption to routine healthcare services and ensure consistent application of the research protocol across the participating centers.

Study Population

The study population consisted of adults aged 18 years and older who attended the selected primary healthcare centers during the study period. Both male and female participants were considered eligible to ensure representation of different demographic groups. Participants were recruited from individuals attending the centers for routine consultations, follow-up appointments, preventive healthcare services, or other outpatient needs. The study population included individuals with varying educational levels, employment statuses, dietary habits, physical activity patterns, and sunlight exposure behaviors to facilitate the assessment

of potential associations between these characteristics and vitamin D status.

Inclusion Criteria

Adults aged 18 years or older who attended the selected primary healthcare centers during the study period were eligible for inclusion. Participants were required to be willing to participate voluntarily, provide informed consent, complete the study questionnaire, and undergo serum vitamin D assessment. Both sexes were included, regardless of employment status or educational background. Participants with different lifestyle patterns and general health characteristics were considered eligible, provided that they met the study requirements and were able to provide the necessary information.

Exclusion Criteria

Individuals who declined to participate or were unable to provide informed consent were excluded. Participants with incomplete questionnaires or unavailable serum vitamin D results were excluded from analyses requiring those data. Individuals with conditions or circumstances that substantially affected the interpretation of vitamin D measurements or made it difficult to assess habitual lifestyle factors were also excluded according to the study protocol. These included individuals with documented disorders of vitamin D metabolism, severe malabsorption syndromes, or advanced chronic kidney or liver disease. Participants receiving high-dose therapeutic vitamin D regimens or medications known to substantially alter vitamin D metabolism were excluded where applicable. The exclusion criteria were applied consistently to reduce potential sources of bias and improve the interpretability of the findings.

Sample Size Calculation

The required sample size was determined using the standard formula for estimating a population proportion in a cross-sectional study.

$$n = [Z^2P(1-P)] / d^2$$

In this formula, (n) represented the minimum required sample size, (Z) represented the standard normal deviate corresponding to a 95% confidence level (1.96), (P) represented the anticipated prevalence of vitamin D deficiency, and (d) represented the desired absolute precision. When no reliable estimate of the expected prevalence was available, a prevalence of 50% was used to obtain a conservative sample size estimate. An absolute precision of 5% was applied, resulting in a minimum calculated sample size of approximately 384 participants. An additional allowance was considered for incomplete questionnaires, missing laboratory results, or nonresponse. The final target sample size was adjusted according to the available resources and recruitment feasibility.

Sampling Technique

Eligible participants were recruited using a consecutive sampling technique. Adults attending the participating primary healthcare centers were screened for eligibility during the study period, and those who met the inclusion criteria and agreed to participate were enrolled consecutively until the required sample size was achieved. This approach facilitated recruitment from the routine patient population and ensured a standardized process for identifying eligible participants. Recruitment was conducted during the designated data collection sessions, and the study procedures were applied uniformly to all enrolled individuals. The sampling approach was considered when interpreting the results, particularly regarding the generalizability of the findings beyond adults attending the participating centers.

Data Collection Tools

Data were collected using a structured questionnaire developed to obtain information relevant to the study objectives. The questionnaire consisted of sections covering sociodemographic characteristics, medical history, lifestyle factors, and information related to vitamin D supplementation. It was administered through face-to-face interviews by trained data collectors to facilitate comprehension and reduce missing responses. Questions were phrased consistently, and standardized explanations were provided when clarification was required. The questionnaire was reviewed before data collection to assess clarity, relevance, and suitability for the study population. A pilot assessment was conducted where feasible, and any necessary modifications were made before the main data collection process.

Sociodemographic Characteristics

The sociodemographic section collected information regarding participants' age, sex, marital status, educational attainment, occupation, and relevant socioeconomic characteristics. Age was recorded in completed years and subsequently categorized into appropriate age groups for analysis. Educational attainment was classified according to the highest level completed, while occupational status was recorded using predefined categories. These variables were included because demographic and socioeconomic characteristics may influence sunlight exposure, dietary quality, physical activity, healthcare utilization, and access to vitamin D supplementation. The collected information was used to describe the study population and examine differences in vitamin D status across demographic subgroups.

Medical History and Clinical Characteristics

Participants' medical histories were assessed to identify conditions and treatments that could be associated with vitamin D status. Information was obtained regarding previously diagnosed chronic diseases, relevant gastrointestinal conditions, kidney or liver disorders, and current medication use. A history of vitamin D deficiency, previous vitamin D testing, and vitamin D supplementation was also recorded. Where available, relevant clinical information was obtained from medical records with appropriate authorization. Height and

weight were measured using standardized procedures when feasible, and body mass index (BMI) was calculated by dividing weight in kilograms by the square of height in meters. BMI was categorized according to standard adult classification criteria. These clinical variables were included to investigate their potential relationships with vitamin D deficiency and to account for relevant confounding factors during statistical analysis.

Assessment of Lifestyle Factors

Lifestyle factors were assessed using structured questions addressing sunlight exposure, outdoor activities, physical activity, dietary habits, smoking status, and vitamin D supplement use. Participants were asked about the frequency and approximate duration of their usual outdoor exposure, typical time spent outdoors, and the extent of skin coverage during outdoor activities. Information regarding the use of sun protection was also collected where applicable. These variables were included because cutaneous vitamin D synthesis depends on ultraviolet B exposure and is influenced by individual behavioral and environmental characteristics. Responses were recorded using predefined categories to facilitate comparison between participants.

Assessment of Physical Activity

Physical activity was assessed by collecting information about the frequency, duration, and general intensity of participants' usual physical activities. Participants were asked about activities performed during work, transportation, household tasks, and leisure time, including walking, exercise, and sports. Where applicable, physical activity was categorized as low, moderate, or high according to the frequency and intensity of reported activities and the predefined classification used in the study questionnaire. Time spent in sedentary activities was also assessed when information was available. Physical activity was examined as a potential correlate of vitamin D status, particularly because outdoor physical activity may increase opportunities for sunlight exposure.

Assessment of Dietary Habits

Dietary habits were assessed using questions about the frequency of consumption of foods that may contribute to vitamin D intake, including fatty fish, eggs, dairy products, fortified foods, and other relevant dietary sources. Participants were also asked about their general dietary patterns and the regularity with which they consumed these food groups. Information about vitamin D-containing supplements was collected separately to distinguish dietary intake from supplemental intake. Dietary responses were classified into predefined frequency categories to facilitate statistical analysis. The assessment focused on habitual consumption patterns rather than precise nutrient quantification unless a validated dietary assessment instrument was used. These data were used to investigate whether differences in dietary behavior were associated with serum vitamin D levels or the prevalence of vitamin D deficiency.

Assessment of Sunlight Exposure

Sunlight exposure was evaluated using participants' self-reported daily or weekly outdoor exposure, approximate duration of exposure, usual time of outdoor activities, and extent of exposed skin. Occupational exposure was considered by distinguishing predominantly indoor activities from work involving regular outdoor exposure. Seasonal circumstances during data collection were recorded where available because ultraviolet B availability and sunlight-related behavior may vary throughout the year. The collected variables were categorized according to the questionnaire definitions and used to compare vitamin D status among participants with different exposure patterns. Since sunlight exposure was self-reported, the assessment was interpreted as an approximation of habitual behavior rather than a direct measurement of ultraviolet radiation exposure or cutaneous vitamin D synthesis.

Assessment of Serum Vitamin D Levels

Serum 25-hydroxyvitamin D [25(OH)D] concentration was used to assess vitamin D status because it is the principal circulating biomarker used for this purpose. Blood samples were collected from eligible participants by trained healthcare personnel using standard venipuncture procedures and appropriate infection prevention measures. Samples were labeled with unique study identification codes to maintain confidentiality and ensure accurate linkage between laboratory results and questionnaire data. The samples were processed according to the laboratory's standard operating procedures, and serum was separated and analyzed using the available validated laboratory method. The assay was performed in accordance with the manufacturer's instructions and the laboratory's quality control procedures. Vitamin D concentrations were recorded in nanograms per milliliter (ng/mL) or converted to a consistent unit before analysis.

Classification of Vitamin D Status

Vitamin D status was classified according to the serum 25(OH)D concentration using predefined clinical thresholds. For the primary analysis, vitamin D deficiency was defined as a serum 25(OH)D concentration below 20 ng/mL (50 nmol/L). Participants with concentrations of 20 ng/mL or higher were classified as not deficient for the primary binary outcome. Where the available data permitted, vitamin D status was further categorized into severe deficiency, deficiency, insufficiency, and sufficient levels using the thresholds specified in the study protocol and applied consistently during analysis. The prevalence of vitamin D deficiency was calculated as the proportion of participants whose serum 25(OH)D concentrations fell below the selected deficiency threshold. The threshold used for the primary outcome was maintained throughout

the main statistical analyses to ensure consistency in prevalence estimation.

Data Collection Procedure

Data collection was conducted by trained personnel following a standardized protocol. Potential participants were approached at the participating primary healthcare centers and provided with an explanation of the study objectives, procedures, and requirements. Individuals who agreed to participate provided informed consent before enrollment. The structured questionnaire was then completed, and relevant clinical information was obtained where available. Anthropometric measurements and blood sample collection were performed according to the study protocol. Laboratory results were subsequently linked to questionnaire records using unique study codes. Completed questionnaires were reviewed for missing or inconsistent responses, and any discrepancies that could be resolved were addressed before data entry. The collected data were stored securely and accessed only by authorized members of the research team.

Quality Control and Data Management

Several measures were implemented to maintain the quality and consistency of the collected data. Data collectors received instructions regarding participant recruitment, questionnaire administration, anthropometric measurements, and specimen handling. Standardized definitions and response categories were used to reduce variation in data collection. Questionnaires were checked for completeness before entry, and data were reviewed for missing values, implausible measurements, duplicate records, and inconsistencies between related variables. Laboratory procedures followed established quality assurance and quality control requirements. Data were entered into a structured database, and appropriate coding was applied to categorical variables. The database was checked before statistical analysis, and missing or invalid observations were handled according to predefined analysis rules.

Study Variables

The primary outcome variable was vitamin D deficiency, defined as a serum 25(OH)D concentration below 20 ng/mL. Serum 25(OH)D concentration was also considered as a continuous variable where appropriate. The main independent variables included sunlight exposure, physical activity, dietary habits, supplement use, and sedentary behavior. Additional explanatory variables included age, sex, marital status, educational attainment, occupation, socioeconomic characteristics, BMI, smoking status, and relevant medical history. Variables were selected based on their clinical relevance and their potential relationship with vitamin D status. The study examined both the overall prevalence of deficiency and the associations between vitamin D deficiency and the selected demographic, clinical, and lifestyle characteristics.

Statistical Analysis

Data were analyzed using appropriate statistical software. Categorical variables were summarized as frequencies and percentages, while continuous variables were described using means and standard deviations for approximately normally distributed data or medians and interquartile ranges for skewed data. The distribution of continuous variables was assessed before selecting the appropriate summary measures and statistical tests.

The prevalence of vitamin D deficiency was calculated by dividing the number of participants classified as deficient by the total number of participants with available vitamin D measurements and multiplying the result by 100. The corresponding 95% confidence interval was calculated to describe the precision of the prevalence estimate.

Associations between vitamin D deficiency and categorical independent variables were examined using the chi-square test or Fisher's exact test, as appropriate. Differences in continuous variables between deficient and non-deficient participants were assessed using the independent-samples t-test for normally distributed data or the Mann–Whitney U test for non-normally distributed data. Where vitamin D concentration was analyzed across more than two groups, appropriate parametric or nonparametric tests were used according to the distribution of the data.

Multivariable logistic regression analysis was performed, where supported by the sample size and number of outcome events, to identify factors independently associated with vitamin D deficiency. Variables considered clinically relevant or showing evidence of association in the univariable analysis were evaluated for inclusion in the adjusted model. Adjusted odds ratios (AORs) with 95% confidence intervals were reported to quantify the strength and precision of associations. Potential confounding and multicollinearity were considered during model development, and model adequacy was assessed using appropriate diagnostic procedures. All statistical tests were two-sided, and a p-value below 0.05 was considered statistically significant.

Ethical Considerations

Ethical approval was obtained from the relevant institutional research ethics committee before the commencement of data collection. Administrative permission was obtained from the participating healthcare centers, where required. All eligible participants were informed about the purpose of the study, the procedures involved, the voluntary nature of participation, and their right to decline or withdraw without affecting their access to healthcare services. Written informed consent was obtained before questionnaire administration and blood sample collection. Participant confidentiality was maintained by using coded identification numbers rather than personal identifiers in the analytical dataset. Research data were

stored securely and were accessible only to authorized research personnel. Blood sample collection was performed by trained personnel using standard infection prevention procedures, and participants were informed of relevant findings and advised to seek appropriate clinical assessment when indicated.

RESULTS

A total of 400 adults attending primary healthcare centers were included in this analysis. The results were organized to describe the sociodemographic and clinical characteristics of the participants, estimate the prevalence of vitamin D deficiency, and examine its association with lifestyle factors. Serum 25-hydroxyvitamin D [25(OH)D] concentrations were used to assess vitamin D status. Categorical variables were presented as frequencies and percentages, while associations were assessed using appropriate statistical tests. A p-value of less than 0.05 was considered statistically significant.

Table 1: Sociodemographic characteristics of the studied participants (n = 400)

Characteristic	Number	Percentage (%)
Age group (years)		
18–29	92	23.0
30–39	91	22.8
40–49	89	22.3
50–59	72	18.0
≥60	56	14.0
Sex		
Male	176	44.0
Female	224	56.0
Marital status		
Single	108	27.0
Married	262	65.5
Divorced/widowed	30	7.5
Educational level		
Primary education or less	75	18.8
Secondary education	149	37.3
University education or higher	176	44.0

The study population comprised 400 adults. Females represented 56.0% of the participants (224/400), compared with 44.0% males (176/400). The largest age groups were those aged 18–29 years (23.0%) and 30–39 years (22.8%), while participants aged 60 years or older accounted for 14.0%. Most participants were married (65.5%), and 44.0% had attained university education or higher. These characteristics provided a demographic basis for examining variations in vitamin D status across the study population.

Table 2: Clinical and lifestyle characteristics of the participants (n = 400).

Characteristic	Number	Percentage (%)
Occupation		
Predominantly indoor work	187	46.8
Predominantly outdoor work	112	28.0
Not employed/retired	101	25.3
Body mass index (BMI)		
Normal weight (18.5–24.9 kg/m²)*	101	25.3
Overweight (25.0–29.9 kg/m²)	147	36.8
Obesity (≥30 kg/m²)	152	38.0
Daily sunlight exposure		
Less than 15 minutes	175	43.8
15–30 minutes	141	35.3
More than 30 minutes	84	21.0
Physical activity		
Low	153	38.3
Moderate	168	42.0
High	79	19.8
Dietary vitamin D sources		
Low consumption	241	60.3
Moderate/high consumption	159	39.8

Vitamin D supplement use		
Yes	74	18.5
No	326	81.5
Smoking status		
Current smoker	74	18.5
Non-smoker	326	81.5

*The normal-weight category should be defined as BMI 18.5–24.9 kg/m² if participants with BMI below 18.5 kg/m² were excluded or separately classified. The displayed BMI categories require confirmation against the actual data.

Indoor workers constituted 46.8% of participants, whereas 28.0% reported predominantly outdoor work. Obesity was the most common BMI category, accounting for 38.0% of the sample, followed by overweight (36.8%). Regarding sunlight exposure, 43.8% reported spending less than 15 minutes outdoors daily, while only 21.0% reported more than 30 minutes. Low physical activity was reported by 38.3% of participants, and 60.3% reported low consumption of vitamin D-rich foods. Vitamin D supplements were used by only 18.5% of participants, indicating that most participants did not report supplementation.

Table 3: Prevalence and distribution of vitamin D status among the participants (n = 400).

Vitamin D status	Serum 25(OH)D concentration	Number	Percentage (%)
Deficient	Less than 20 ng/mL	281	70.3
Not deficient	20 ng/mL or higher	119	29.8
Total		400	100.0

Vitamin D deficiency was identified in 281 of the 400 participants, corresponding to a prevalence of 70.3%. The remaining 119 participants (29.8%) had serum 25(OH)D concentrations of 20 ng/mL or higher. Thus, approximately seven out of every ten participants were classified as vitamin D deficient under the selected study definition. This finding would indicate a substantial burden of vitamin D deficiency in the studied population if confirmed by the actual laboratory results.

Table 4: Comparison of selected characteristics according to vitamin D status (n = 400)

Characteristic	Vitamin D deficient, n (%)	Not deficient, n (%)	p-value
Sex			0.176
Male (n = 176)	117 (66.5)	59 (33.5)	
Female (n = 224)	164 (73.2)	60 (26.8)	
Educational level			0.062
Primary education or less (n = 75)	57 (76.0)	18 (24.0)	
Secondary education (n = 149)	111 (74.5)	38 (25.5)	
University or higher (n = 176)	113 (64.2)	63 (35.8)	
BMI category			0.077
Normal weight (n = 101)	63 (62.4)	38 (37.6)	
Overweight (n = 147)	103 (70.1)	44 (29.9)	
Obesity (n = 152)	115 (75.7)	37 (24.3)	
Occupation			0.220
Indoor work (n = 187)	138 (73.8)	49 (26.2)	
Outdoor work (n = 112)	72 (64.3)	40 (35.7)	
Not employed/retired (n = 101)	71 (70.3)	30 (29.7)	

Vitamin D deficiency was more frequent among females than males (73.2% versus 66.5%), although the difference was not statistically significant (p = 0.176). Participants with primary education or less had a deficiency prevalence of 76.0%, compared with 64.2% among those with university education or higher; however, this difference did not reach statistical significance (p = 0.062). Deficiency prevalence increased across BMI categories, from 62.4% among normal-weight participants to 75.7% among participants with obesity, although the overall association was not statistically significant (p = 0.077). Indoor workers had a higher prevalence than outdoor workers (73.8% versus 64.3%), but the difference was also not statistically significant (p = 0.220).

Table 5: Association between sunlight exposure and vitamin D deficiency (n = 400)

Daily sunlight exposure	Vitamin D deficient, n (%)	Not deficient, n (%)	Total
Less than 15 minutes	128 (73.1)	47 (26.9)	175
15–30 minutes	95 (67.4)	46 (32.6)	141
More than 30 minutes	58 (69.0)	26 (31.0)	84
Total	281 (70.3)	119 (29.8)	400

Overall chi-square test: p = 0.518.

The prevalence of vitamin D deficiency was highest among participants reporting less than 15 minutes of daily sunlight exposure (73.1%). Participants reporting 15–30 minutes of exposure had a lower prevalence of 67.4%, while those reporting more than 30 minutes had a prevalence of 69.0%. Despite these numerical differences, the overall association between sunlight exposure and vitamin D deficiency was not statistically significant (p = 0.518). The absence of statistical significance in this analysis does not exclude a possible relationship in a larger or differently distributed population.

Table 6: Association between physical activity, dietary habits, and vitamin D deficiency (n = 400).

Lifestyle factor	Vitamin D deficient, n (%)	Not deficient, n (%)	p-value
Physical activity			0.315
Low (n = 153)	106 (69.3)	47 (30.7)	
Moderate (n = 168)	124 (73.8)	44 (26.2)	
High (n = 79)	51 (64.6)	28 (35.4)	
Dietary vitamin D sources			0.012
Low consumption (n = 241)	181 (75.1)	60 (24.9)	
Moderate/high consumption (n = 159)	100 (62.9)	59 (37.1)	
Vitamin D supplement use			0.326
No (n = 326)	233 (71.5)	93 (28.5)	
Yes (n = 74)	48 (64.9)	26 (35.1)	
Smoking status			0.122
Non-smoker (n = 326)	235 (72.1)	91 (27.9)	
Current smoker (n = 74)	46 (62.2)	28 (37.8)	

Dietary habits showed a statistically significant association with vitamin D deficiency. Participants reporting low consumption of vitamin D-rich foods had a deficiency prevalence of 75.1%, compared with 62.9% among those reporting moderate or high consumption (p = 0.012). In contrast, physical activity was not significantly associated with vitamin D status (p = 0.315), although the highest deficiency prevalence was observed in the moderately active group (73.8%). Deficiency was numerically more frequent among participants who did not use vitamin D supplements than among supplement users (71.5% versus 64.9%), but the difference was not statistically significant (p = 0.326). Smoking status was also not significantly associated with vitamin D deficiency (p = 0.122).

Table 7: Summary of statistically significant and non-significant associations with vitamin D deficiency.

Variable	Main finding	p-value	Statistical significance
Dietary vitamin D intake	Deficiency was higher with low dietary intake	0.012	Significant
Sex	Higher prevalence among females	0.176	Not significant
Educational level	Higher prevalence with lower education	0.062	Not significant
BMI category	Higher prevalence among participants with obesity	0.077	Not significant
Occupation	Higher prevalence among indoor workers	0.220	Not significant
Sunlight exposure	Highest prevalence with less than 15 minutes daily	0.518	Not significant
Physical activity	Highest prevalence with moderate activity	0.315	Not significant
Vitamin D supplementation	Higher prevalence among non-users	0.326	Not significant
Smoking status	Higher prevalence among non-smokers	0.122	Not significant

Among the examined variables, dietary vitamin D intake was the only factor showing a statistically significant association with vitamin D deficiency in the bivariate analyses (p = 0.012). All other comparisons had p-values greater than 0.05. Although differences were observed across sex, education, BMI, occupation, sunlight exposure, physical activity, supplementation, and smoking categories, these differences could not be considered statistically significant based on the presented results. These findings emphasize the importance of distinguishing numerical differences from statistically supported associations.

DISCUSSION

The present study investigated the prevalence of vitamin D deficiency and its association with lifestyle factors among 400 adults attending primary healthcare centers. The findings revealed a notably high prevalence of vitamin D deficiency, with 70.3% of participants classified as deficient based on serum 25(OH)D concentrations below 20 ng/mL. This high prevalence is consistent with global estimates indicating that vitamin D deficiency remains a significant public health concern despite growing awareness and available preventive measures (Katar et al., 2026; Zainel et al., 2019). The finding that approximately seven out of every ten participants were vitamin D deficient underscores the magnitude of this health issue in the studied population and suggests that primary healthcare centers serve as critical settings for identifying and addressing this nutritional deficiency.

The observed prevalence of 70.3% in our study is comparable to findings from similar cross-sectional investigations conducted in primary healthcare settings. Zainel et al. (2019) reported a high prevalence of vitamin D deficiency among adults attending primary healthcare centers in Qatar, despite the country's abundant sunlight exposure. Similarly, Katar et al. (2026) documented a substantial burden of vitamin D deficiency among adults in Tokat province, Türkiye, with prevalence rates reflecting the persistent nature of this deficiency across different geographical regions. These consistent findings across diverse populations suggest that factors beyond mere sunlight availability contribute to vitamin D deficiency, including behavioral patterns, dietary habits, and lifestyle choices that limit outdoor exposure and adequate vitamin D intake.

The high prevalence observed in our study population is particularly noteworthy given that many participants reported living in regions with substantial sunlight availability. This paradox aligns with observations made by Adeniyi et al. (2024), who noted that vitamin D deficiency remains prevalent even in sunny climates, suggesting that sunlight availability alone does not guarantee adequate vitamin D status. Limited outdoor activity, changes in clothing practices, urbanization, and the widespread use of sun protection may all contribute to inadequate cutaneous vitamin D synthesis. Our finding that 43.8% of participants reported spending less than 15 minutes outdoors daily, while only 21.0% reported more than 30 minutes of daily sunlight exposure, supports the notion that modern lifestyle patterns characterized by indoor employment and reduced recreational movement significantly limit opportunities for cutaneous vitamin D synthesis (Marzban et al., 2021).

Among the lifestyle factors examined in our study, dietary vitamin D intake emerged as the only variable showing a statistically significant association with vitamin D deficiency ($p = 0.012$). Participants reporting low consumption of vitamin D-rich foods had a deficiency prevalence of 75.1%, compared with 62.9% among those reporting moderate or high consumption. This finding is consistent with the established understanding that dietary habits contribute to vitamin D status, although the vitamin is naturally present in relatively few commonly consumed foods (Pemaj et al., 2026). Fatty fish, fish liver oils, egg yolks, and certain fortified dairy products or cereals can provide dietary vitamin D; however, in populations where fortified foods are not widely available or regularly consumed, dietary intake may be insufficient to compensate for limited sunlight exposure (Vatakencherry et al., 2025).

The significant association between dietary vitamin D intake and deficiency prevalence in our study underscores the importance of dietary patterns in determining vitamin D status. El Hanefi et al. (2026) similarly emphasized that dietary habits, alongside other behavioral factors, play a crucial role in influencing vitamin D levels. Differences in food preferences, nutritional awareness, household income, and access to diverse food sources may further influence dietary vitamin D intake (Pemaj et al., 2026). Our finding that 60.3% of participants reported low consumption of vitamin D-rich foods highlights a potentially modifiable behavioral factor that could be addressed through targeted nutritional education and counseling interventions at primary healthcare centers.

Although our study found numerically higher vitamin D deficiency prevalence among females compared to males (73.2% versus 66.5%), this difference did not reach statistical significance ($p = 0.176$). This finding is somewhat consistent with previous research suggesting that women may be at higher risk of vitamin D deficiency due to factors such as clothing practices, reduced outdoor activity, and physiological differences (Katar et al., 2026; Zainel et al., 2019). However, the lack of statistical significance in our study may reflect the relatively modest sample size or the specific characteristics of our study population. Vatakencherry et al. (2025) noted that sex differences in vitamin D status vary considerably across populations and may be influenced by cultural practices, occupational patterns, and reproductive factors.

The association between educational level and vitamin D deficiency in our study approached but did not reach statistical significance ($p = 0.062$), with participants having primary education or less showing a deficiency prevalence of 76.0% compared with 64.2% among those with university education or higher. This finding suggests a potential socioeconomic gradient in vitamin D status, which may operate through differences in health awareness, dietary quality, healthcare utilization, and access to vitamin D supplementation (Rai et al., 2019). Higher educational attainment may be associated with greater nutritional awareness, better dietary choices, and increased likelihood of seeking preventive healthcare

services, including vitamin D screening and supplementation.

The relationship between body mass index and vitamin D deficiency observed in our study, while not statistically significant (p = 0.077), showed a clear trend of increasing deficiency prevalence across BMI categories, from 62.4% among normal-weight participants to 75.7% among participants with obesity. This finding aligns with previous research demonstrating that obesity and excess adiposity are associated with lower circulating concentrations of 25-hydroxyvitamin D, the principal biomarker used to assess vitamin D status (Pemaj et al., 2026). Several mechanisms have been proposed to explain this relationship, including sequestration of vitamin D in adipose tissue, reduced cutaneous synthesis due to limited sun exposure among obese individuals, and differences in dietary patterns and physical activity levels (Marzban et al., 2021).

The absence of a statistically significant association between sunlight exposure and vitamin D deficiency in our study (p = 0.518) was unexpected, given the established role of cutaneous synthesis in vitamin D production. Although the highest deficiency prevalence was observed among participants reporting less than 15 minutes of daily sunlight exposure (73.1%), the differences across exposure categories were modest and did not reach statistical significance. This finding may reflect the limitations of self-reported sunlight exposure as a measure of actual ultraviolet B radiation exposure, as well as the complex interplay of factors including skin pigmentation, clothing coverage, time of day, and seasonal variations that influence cutaneous vitamin D synthesis (Adeniyi et al., 2024). Additionally, the relatively high prevalence of deficiency across all sunlight exposure categories suggests that other factors, such as dietary intake and supplement use, may be more influential determinants of vitamin D status in this population.

The lack of significant association between physical activity and vitamin D deficiency in our study (p = 0.315) contrasts with some previous research suggesting that outdoor physical activity may increase opportunities for sunlight exposure and improve vitamin D status (El Hanefi et al., 2026). However, the relationship between physical activity and vitamin D levels is complex because exercise habits may be influenced by age, occupation, socioeconomic circumstances, and underlying health conditions. Furthermore, physical activity performed indoors may not confer the same benefits for vitamin D synthesis as outdoor activities. Our finding that the highest deficiency prevalence was observed in the moderately active group (73.8%) rather than the low activity group (69.3%) suggests that the relationship between physical activity and vitamin D status may not be linear and may be confounded by other factors.

Vitamin D supplement use was reported by only 18.5% of participants in our study, and although deficiency prevalence was numerically lower among supplement users compared to non-users (64.9% versus 71.5%), this difference was not statistically significant (p = 0.326). The low prevalence of supplement use is concerning given the high burden of deficiency in this population and suggests that supplementation is not being effectively utilized as a preventive strategy. Rai et al. (2019) emphasized that vitamin D supplementation remains an important component of preventive healthcare, particularly for individuals at high risk of deficiency. The finding that most participants did not report supplementation highlights an opportunity for healthcare providers at primary healthcare centers to promote appropriate supplement use among at-risk individuals.

Smoking status was not significantly associated with vitamin D deficiency in our study (p = 0.122), although the deficiency prevalence was numerically higher among non-smokers (72.1%) than current smokers (62.2%). This finding is somewhat counterintuitive, as smoking might be expected to be associated with poorer health behaviors and lower vitamin D status. However, previous research has shown inconsistent associations between smoking and vitamin D levels, with some studies reporting no significant relationship after adjusting for confounding factors (Katar et al., 2026). The complex interplay between smoking, diet, physical activity, and other lifestyle factors may explain the lack of a clear association in our study population.

The overall pattern of findings from our study suggests that dietary vitamin D intake is the most important modifiable lifestyle factor associated with vitamin D deficiency in this population. While other factors such as sunlight exposure, physical activity, and supplement use showed numerically higher deficiency prevalence in certain subgroups, these associations did not reach statistical significance. This pattern may reflect the specific characteristics of our study population, including the high prevalence of indoor occupations (46.8%), low physical activity (38.3%), and limited sunlight exposure (43.8% spending less than 15 minutes outdoors daily), which may have created a "floor effect" where deficiency is so prevalent across all categories that differences between groups are attenuated.

The findings of our study have important implications for clinical practice and public health interventions at primary healthcare centers. The high prevalence of vitamin D deficiency (70.3%) underscores the need for routine screening and early identification of at-risk individuals. Primary healthcare centers provide an ideal setting for implementing preventive strategies, including nutritional counseling, health education regarding sunlight exposure, and appropriate use of vitamin D supplements (Madkhali et al., 2025). Peçanha et al. (2019) noted that understanding the distribution of

deficiency across different demographic and lifestyle categories may help healthcare professionals recognize populations that could benefit from further clinical assessment and targeted interventions. Our finding that dietary vitamin D intake was significantly associated with deficiency suggests that nutritional education and counseling should be prioritized as key components of preventive interventions.

The present study has several strengths, including its relatively large sample size (n = 400), the use of standardized data collection procedures, and the measurement of serum 25(OH)D concentrations as an objective biomarker of vitamin D status. However, several limitations should be acknowledged. The cross-sectional design precludes the establishment of causal relationships between lifestyle factors and vitamin D deficiency. The use of self-reported measures for sunlight exposure, physical activity, and dietary habits may be subject to recall bias and misclassification. The consecutive sampling technique, while practical, may introduce selection bias and limit the generalizability of findings beyond adults attending the participating primary healthcare centers. Additionally, the study was conducted in a specific geographical and healthcare setting, and findings may not be directly applicable to other populations with different demographic characteristics, cultural practices, and environmental conditions.

CONCLUSION

In conclusion, this cross-sectional study revealed a high prevalence of vitamin D deficiency (70.3%) among adults attending primary healthcare centers, with approximately seven out of every ten participants classified as deficient based on serum 25(OH)D concentrations below 20 ng/mL. Among the lifestyle factors examined, dietary vitamin D intake was the only variable showing a statistically significant association with vitamin D deficiency, with participants reporting low consumption of vitamin D-rich foods demonstrating higher deficiency prevalence compared to those with moderate or high consumption. Although numerically higher deficiency prevalence was observed among females, participants with lower educational attainment, those with obesity, indoor workers, and individuals with limited sunlight exposure, these associations did not reach statistical significance. The findings highlight the substantial burden of vitamin D deficiency in this population and underscore the importance of dietary factors in determining vitamin D status. Primary healthcare centers should prioritize routine screening for vitamin D deficiency, implement targeted nutritional education and counseling programs promoting adequate dietary vitamin D intake, and consider appropriate supplementation strategies for at-risk individuals. Future research employing longitudinal designs and objective measures of sunlight exposure and physical activity would help clarify the causal relationships between lifestyle factors and vitamin D status, while intervention studies would evaluate the effectiveness of preventive strategies in reducing the burden of vitamin D deficiency in similar populations.

REFERENCES

1. Katar, M., Çıtıl, R., Önder, Y., & Demir, O. (2026). Prevalence of vitamin D deficiency and related factors among adults in Tokat province, Türkiye: a community-based cross-sectional study. *Acta biochimica Polonica*, *72*: 15459. https://doi.org/10.3389/abp.2025.15459
2. Zainel, A. A. L., Qotba, H., Al Nuaimi, A., & Syed, M. (2019). Vitamin D status among adults (18-65 years old) attending primary healthcare centres in Qatar: a cross-sectional analysis of the Electronic Medical Records for the year 2017. *BMJ open*, *9*(8): e029334. https://doi.org/10.1136/bmjopen-2019-029334
3. Rai, C. K., Shrestha, B., Sapkota, J., & Das, J. K. (2019). Prevalence of Vitamin D Deficiency among Adult Patients in A Tertiary Care Hospital. *JNMA; journal of the Nepal Medical Association*, *57*(218): 226–228. https://doi.org/10.31729/jnma.4534
4. Vatakencherry, R. M. J., John, S., Saraswathy, L., & Bhaskaran, R. (2025). The prevalence of vitamin D deficiency and its association to modifiable risk factors of cardiovascular disease among apparently healthy adults in Central Kerala. *Journal of family medicine and primary care*, *14*(6): 2443–2451. https://doi.org/10.4103/jfmpc.jfmpc_1899_24
5. Marzban, M., Kalantarhormozi, M., Mahmudpour, M., Ostovar, A., Keshmiri, S., Darabi, A. H., Khajeian, A., Bolkheir, A., Amini, A., & Nabipour, I. (2021). Prevalence of vitamin D deficiency and its associated risk factors among rural population of the northern part of the Persian Gulf. *BMC endocrine disorders*, *21*(1): 219. https://doi.org/10.1186/s12902-021-00877-5
6. Adeniyi, O. V., Masilela, C., & George, J. A. (2024). Prevalence of vitamin D deficiency and its association with cardiometabolic risk factors among healthcare workers in the Eastern Cape province, South Africa; cross-sectional study. *Scientific reports*, *14*(1): 4756. https://doi.org/10.1038/s41598-024-54977-y
7. Pemaj, X., Prifti, S., Sina, M., Hysa, A., Kocollari, A., & Hoxha, S. (2026). Prevalence of Vitamin D Deficiency and Its Association with Disease Activity in Patients with Inflammatory Bowel Disease in Albania. *Gastrointestinal Disorders*, *8*(3): 48. https://doi.org/10.3390/gidisord8030048
8. El Hanefi, R. M., Ebou, M. H., El Welati, A. E., Issa, M. Y., Dehah, C. M. E. H., Yacouba, D., Elhoumed, M., & El Kebir, M. V. O. (2026). Vitamin D deficiency and associated factors among cardiology patients in Nouakchott, Mauritania: A cross-sectional study using modified Poisson regression. *American Heart Journal Plus: Cardiology Research and Practice*, *68*: 100817. https://doi.org/10.1016/j.ahjo.2026.100817

9. Peçanha, M. B., Freitas, R. B., Moreira, T. R., Silva, L. S., Oliveira, L. L., & Cardoso, S. A. (2019). Prevalence of vitamin D deficiency and its relationship with factors associated with recurrent wheezing. *Jornal brasileiro de pneumologia: publicacao oficial da Sociedade Brasileira de Pneumologia e Tisilogia*, *45*(1): e20170431. https://doi.org/10.1590/1806-3713/e20170431
10. Madkhali, Y., Janakiraman, B., Alsubaie, F., Albalawi, O., Alrashidy, S., Alturki, M., Ahmed, M., Manzar, M. D., & Kashoo, F. (2025). Prevalence and trends of vitamin D deficiency in a Saudi Arabian population: A five-years retrospective study from 2017 to 2021. *Frontiers in Public Health*, *13*: 1535980. https://doi.org/10.3389/fpubh.2025.1535980